Computed Tomography

104th Scientific Assembly and Annual Meeting
November 25–30 | McCormick Place, Chicago
Complications of Urinary Tract Surgical Procedures: CT-Urographic Patterns

All Day Room: NA Digital Education Exhibit

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TEACHING POINTS

1) To review the most frequent urinary tract postoperative complications.
2) To illustrate CT-Urographic patterns of urinary tract postoperative complications.
3) To describe the usefulness of CT-Urography in the diagnosis and follow-up of urinary tract postoperative complications.

TABLE OF CONTENTS/OUTLINE

1) Most frequent urinary tract postoperative complications:
   a) Urinary leaks
   b) Uretero-vesical anastomosis dehiscence
   c) Ureterocutaneous fistulas
   d) Bleeding / hematoma
   e) Peritoneal and retroperitoneal fluid collections
   f) Urinary tract stenosis
2) Best CT techniques in the evaluation of urinary tract postoperative complications
3) Conventional and urographic CT patterns of urinary tract postoperative complications
4) CT imaging follow-up of urinary tract postoperative complications

Ureteral lesions, retroperitoneal hematomas and/or bleeding and fluid collections are the most frequent urinary tract postoperative complications. Urographic images combined with conventional CT imaging allow an accurate diagnosis and follow-up of urinary tract postoperative complications. Source axial images and MPR of the urographic acquisition show a better identification of urinary tract lesions. 3D MIP reconstructions are useful in summarising urographic axial images.
Adult Ureteropelvic Junction Obstruction Revisited

TEACHING POINTS

Review causes and radiological findings of ureteropelvic junction obstruction (UPJO) by means of US, CT, MR and nuclear medicine imaging (renogram and gammagraphy), reviewing the strengths and weaknesses of each technique. Depict the importance of specific CT split bolus protocols and two- and three-dimensional reconstructions (including 3D impression) as a better presurgical map for precise therapeutic approach. Correlate clinical symptoms with radiological findings in pre and postsurgical images and depict secondary UPJO structures (inflammatory, iatrogenic, tumoral, complications of renal transplantation).

TABLE OF CONTENTS/OUTLINE

Update of CT Urography: Current Techniques, Clinical Utility, and New Applications

All Day Room: NA Digital Education Exhibit

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TEACHING POINTS
We focus on matters which have changed for these several years about CTU. First, we describe clinical background. Second, we show CT protocol and its diagnostic capability of CTU when considering an exposed problem. Third, we introduce urothelial carcinoma (UC) staging criteria and pitfall with indicating several actual cases. We also make a clear when we should perform MR for detecting UC. Finally, we introduce renal applications of Dual-Energy CT for CTU.

TABLE OF CONTENTS/OUTLINE
Concise description review clinical background. The current diagnostic capability of CTU when considering an exposed problem Staging of urothelial carcinoma by using CT and pitfall When should we perform MR? Dual-Energy applications for CTU
Interactive 3D Volume Rendering of Cervical Paragangliomas: Current Applications in Vascular Surgery

All Day Room: NA Digital Education Exhibit

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TEACHING POINTS
1. To describe the utility of volume rendering of CT angiography for the evaluation of cervical parangangliomas. 2. To identify the typical and atypical imaging appearances of cervical paragangliomas in CT angiography and 3D reconstruction. 3. To discuss the potential of 3D volume rendering of cervical parangangliomas for pre surgical evaluation that may assess local vascular compromise and predict intraoperative complications. 4. To recognize the classification of cervical paragangliomas used in vascular surgery in order to describe the imaging findings in CT angiography and 3D volume rendering.

TABLE OF CONTENTS/OUTLINE
1. Appearances of cervical parangliomas in CT angiography and 3D volume rendering imaging
2. Classification for cervical parangliomas in vascular surgery and its correlation with CT angiography and 3D volume rendering imaging
3. The role of 3D volume rendering in establishing vascular compromise of cervical parangliomas
4. The interaction of vascular surgeons with 3D volume rendering for cervical parangliomas, and its potential in pre surgical planning.
Multidetector Computed Tomography Evaluation of Spontaneous Non-Arteriosclerotic Coronary Dissection Associated with Fibromuscular Dysplasia: Spectrum of Disease

All Day Room: NA Digital Education Exhibit

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TEACHING POINTS
Discuss the clinical spectrum of spontaneous non-arteriosclerotic coronary dissection (SCAD) and their association with fibromuscular dysplasia (FMD). Describe a new dedicated multidetector CT (MDCT) protocol for evaluation of SCAD. Review the imaging findings of SCAD and their association with FMD.

TABLE OF CONTENTS/OUTLINE
Background: SCAD has been considered as a rare disease reported more frequently in women. There is a strong association between extracoronary FMD and SCAD. Patients selection with SCAD for FMD screening in our hospital: patients with unknown etiology for SCAD such as arteriosclerosis, hormonal treatment, pregnancy or systemic diseases. MDCT protocol: MDCT synchronized from the carotid bifurcation to the common femoral arteries. Utility of our MDCT protocol on FMD screening: the synchronization and the acquisition with a thickness <1 mm allow to realize a non-invasive coronary angiography and an analysis of the arterial territories without artefacts of arterial pulsatility. MDCT image findings: coronary dissection, signs of FMD such as 'string of beads' pattern, visceral arterial aneurysms or ectasia. Conclusions: synchronization MDCT allows to carry out a non-invasive coronary angiography and exhaustive analysis of the arterial territories for diagnose diseases related to SCAD such as FMD.
Preoperative Evaluation of Autogenous Tissue Flap Reconstruction Techniques: What Radiologists Need to Know

All Day Room: NA Digital Education Exhibit

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**TEACHING POINTS**

• Overview of Autogenous tissue flap reconstruction techniques  
• Review the perforators vascular anatomy by using CTA  
• Description of required preoperative localizations and measurements by CT

**TABLE OF CONTENTS/OUTLINE**

• Review autogenous tissue flap reconstruction techniques: Thoracodorsal (TDAP), Deep inferior epigastric (DIEP), Superficial inferior epigastric (SIEA) and Gluteal artery perforator (S-GAP) flaps  
• Review imaging CT protocols for preop evaluation  
• Role of CT 3D reformats in evaluation of perforators  
• What radiologists need to report to assist the surgeons
CT Angiography Acquisition Timing: Advantages and Disadvantages of Clinical Options

All Day Room: NA Digital Education Exhibit

Awards
Identified for RadioGraphics

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TEACHING POINTS
• Individual cardiac and vascular physiological differences in patients may significantly affect circulation time and the intra-arterial contrast bolus, potentially leading to suboptimal acquisition timing for CTA exams. • Individualizing the initiation of CTA acquisition becomes more important as injection rate and amount of iodine contrast are lowered. • Understand alternatives and trade-offs associated with each method for timing CTA acquisition

TABLE OF CONTENTS/OUTLINE
• Introduce basic principles of current CTA acquisition timing techniques, including: o Sequential monitoring o Automatic bolus triggering o Fixed vs. individualized delays after bolus triggering o Test bolus utilization o 4D CTA acquisition and post-processing o Explain the effect of injection amount, rate and duration of the intra-arterial bolus of contrast o Explain the effect of saline chaser on the contrast bolus • Introduce basic principles of individualized delay prototype software for CTA acquisitions. • How does the use of a test bolus or individualized delay after bolus triggering compare to the use of conventional bolus tracking tools? • Discuss benefits and limitations of each timing technique

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Terri J. Vrtiska, MD - 2016 Honored Educator
Complications Mimics in the Post-Surgical Aorta

Awards
Certificate of Merit

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TEACHING POINTS

The purpose of this exhibit is to: Review various surgical procedures of the aorta with expected appearances that mimic pseudoaneurysm, abscess, or dissection. Demonstrate the role of pre-contrast imaging, particularly in distinguishing a felt pledget or oversewn side graft from a pseudoaneurysm and a perigraft hematoma from an abscess. Emphasize the importance of the patient’s medical record, such as operative reports progress reports, which may clarify unusual imaging appearances.

TABLE OF CONTENTS/OUTLINE

Mimics of pseudoaneurysm:
- Felt pledget used to improve hemostasis
- Coronary button in modified Bentall procedure
- Occluded coronary artery bypass graft
- Oversewn side graft used for antegrade perfusion in total arch and hemiarch repair

Mimics of perigraft abscess:
- Perigraft hematoma with peripheral hyperattenuation
- Perigraft seroma after inclusion graft
- Perigraft fluid when a muscle flap is used after replacement of an infected graft
- Perigraft space in original Cabrol procedure

Mimics of dissection:
- After stage 1 of the elephant trunk procedure and reverse elephant trunk procedure, the elephant trunk is a linear filling defect
- In the modern day Cabrol procedure, the left coronary artery graft can mimic a linear filling defect along the aorta graft
Hemorrhagic Complications of Pancreatitis: The Role of Multidetector CT and Interventional Radiology

Awards
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TEACHING POINTS

1. Review pathophysiology and various patterns of hemorrhagic complications associated with acute or chronic pancreatitis.
2. Describe the role of multidetector CT in the management of hemorrhagic complications of pancreatitis.
3. Discuss the current management of hemorrhagic complications of pancreatitis, with emphasis on the role of interventional radiology.

TABLE OF CONTENTS/OUTLINE

1. Epidemiology and pathophysiology of hemorrhagic complications of pancreatitis
2. Patterns of hemorrhagic complications of pancreatitis (arterial: bleeding into the retroperitoneal cavity, gastrointestinal system, and pseudocyst. Venous: variceal bleeding or splenic infarction related to splenic vein thrombosis)
3. Multidetector CT technique and the role in diagnosing hemorrhagic complications and planning for endovascular management
4. Current management of hemorrhagic complications of pancreatitis (management algorithm)
5. Angiographic findings and techniques used for endovascular management (coil embolization proximal and distal to the site of bleeding, continuous coil embolization of the diseased artery, coil packing of the aneurysmal sac, stent-graft placement, and splenic artery embolization)
6. Clinical outcomes and complications (splenic/liver infarction or abscess, worsening of pancreatitis, etc.) of endovascular management
Detection of Post-operative Complications after Thoracic and Abdominal Aortic Intervention Using 4-Dimensional Dynamic Computed Tomographic Angiography

All Day Room: NA Digital Education Exhibit

Awards
Certificate of Merit

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TEACHING POINTS
Post-operative complications following surgical and endovascular repair of thoracic and abdominal aortic aneurysms and dissections may be challenging to delineate on static computed tomographic angiography (CTA). Frequently, while complications may be identified on static imaging, accurate characterization and classification is difficult; delaying treatment of potentially life-threatening complications. The purpose of this exhibit is to showcase the methods of acquisition and advantage of the addition of 4-Dimensional (4-D) CTA to assess for post-operative complications including paravalvular and para-anastomotic leaks, endoleaks, and persistent filling of the false lumen; using a variety of CT images, dynamic videos, 3-D reconstructions and intra-operative surgical photos.

TABLE OF CONTENTS/OUTLINE
Review of the image acquisition technique and troubleshooting CTA protocols. Outline of common post-operative complications that require dynamic imaging for accurate diagnosis including: paravalvular leaks, para-anastomotic leaks, endoleaks, and sources of persistent false lumen filling in aortic dissection. Showcasing the advantage of 4-D CTA in detecting and classifying post-operative complications. What a Radiologist should report to assist surgeons and interventionalist. Common pitfalls with 4-D CTA.
**Background Parenchymal Enhancement at Contrast-Enhanced Spectral Mammography (CESM) as a Breast Cancer Risk Factor**

**Purpose**
To assess the extent of background parenchymal enhancement (BPE) at contrast-enhanced spectral mammography (CESM), inter-reader agreement in BPE classification, and correlation between BPE and breast cancer.

**Method and Materials**
Between 2012 and 2015 a total of 516 women underwent CESM imaging for screening and diagnostic purposes. BPE on CESM images was retrospectively, independently and blindly graded by 4 reviewers using the following scale: minimal, mild, moderate or marked. Inter-reader agreement was evaluated using correlation coefficient (ICC). Associations between BPE and clinical factors, biopsy rate and histopathology results were examined using a multivariate logistic regression analysis.

**Results**
A total of 412 (80%) of women underwent CESM for screening purposes. Mean age was 53 (range 28-77) years and 86.2-94% had a breast density BI-RADS score of C-D. Most women (76.4-90.5%) had minimal or mild BPE at CESM. Overall inter-reader agreement on BPE scores was good (ICC 0.88, 95%CI 0.81-0.92). A total of 122 (24%) biopsies were performed with a malignant histopathology result in 45 (37%) cases. On a multivariate analysis BPE demonstrated a significant association with age (P=0.004, OR 0.942, 95%CI 0.905-0.981) and with biopsy performance rate (P=0.006, OR 2.646, 95%CI 1.319-5.307). Moderate or marked BPE was predictive of a malignant biopsy result (P=0.002, OR 3.105, 95%CI 1.541-6.259).

**Conclusion**
CESM BPE is correlated with age and biopsy rate. Moderate or marked BPE is associated with malignant biopsy results, and hence may predict an increased risk for breast cancer.

**Clinical Relevance/Application**
CESM BPE grading may be used as an additional risk assessment tool for breast cancer.

**Contrast Enhanced Digital Mammography (CEDM) Helps to Safely Reduce Benign Breast Biopsies**

**Purpose**
To assess the extent of background parenchymal enhancement (BPE) at contrast-enhanced digital mammography (CEDM), inter-reader agreement in BPE classification, and correlation between BPE and breast cancer.

**Method and Materials**
Between 2012 and 2015 a total of 516 women underwent CEDM imaging for screening and diagnostic purposes. BPE on CEDM images was retrospectively, independently and blindly graded by 4 reviewers using the following scale: minimal, mild, moderate or marked. Inter-reader agreement was evaluated using correlation coefficient (ICC). Associations between BPE and clinical factors, biopsy rate and histopathology results were examined using a multivariate logistic regression analysis.

**Results**
A total of 412 (80%) of women underwent CEDM for screening purposes. Mean age was 53 (range 28-77) years and 86.2-94% had a breast density BI-RADS score of C-D. Most women (76.4-90.5%) had minimal or mild BPE at CEDM. Overall inter-reader agreement on BPE scores was good (ICC 0.88, 95%CI 0.81-0.92). A total of 122 (24%) biopsies were performed with a malignant histopathology result in 45 (37%) cases. On a multivariate analysis BPE demonstrated a significant association with age (P=0.004, OR 0.942, 95%CI 0.905-0.981) and with biopsy performance rate (P=0.006, OR 2.646, 95%CI 1.319-5.307). Moderate or marked BPE was predictive of a malignant biopsy result (P=0.002, OR 3.105, 95%CI 1.541-6.259).

**Conclusion**
CEDM BPE is correlated with age and biopsy rate. Moderate or marked BPE is associated with malignant biopsy results, and hence may predict an increased risk for breast cancer.

**Clinical Relevance/Application**
CEDM BPE grading may be used as an additional risk assessment tool for breast cancer.
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PURPOSE
One criticism of breast imaging is the harm caused by the relatively high rate of biopsy of benign breast lesions -- particularly BI-RADS 4A and 4B lesions. The purpose of this project is to assess if CEDM during diagnostic evaluation could increase biopsy PPV for soft tissue density lesions by reducing benign biopsies while not impacting biopsy of cancers.

METHOD AND MATERIALS
This HIPPA compliant IRB approved protocol accrued 57 consenting women aged 34-74 (avg 49) years with 60 BI-RADS 4A or 4B soft tissue lesions scheduled for ultrasound (US), stereotactic or tomosynthesis (DBT) directed biopsy from April 2016-November 2017. CEDM was performed immediately prior to biopsy. The cohort included 46 masses, 6 asymmetries and 8 distortions. Pathology confirmed 9 cancers and 51 benign concordant lesions. Four MQSA qualified radiologists reviewed and provided a BI-RADS score for each lesion: first for mammography (M)/DBT only, next with US added and third with CEDM added. Readers recorded if the lesion enhanced, how enhancement compared to background and background parenchymal enhancement. Differences in BI-RADS ratings were compared.

RESULTS
After M/DBT and US, prior to CEDM, 173/240 (72%) ratings were classified as > BI-RADS 4. After viewing CEDM, 60 of these were re-classified as < BI-RADS 3; a 35% average [range 0-59%] reduction in biopsy recommendation (p<0.05). Cancers enhanced in 32/36 (89%) ratings and 32/36 cancers were rated as BI-RADS >4 before and after CEDM. Benign lesions enhanced in 77/204 (38%) (false positives). With US 3/36 cancer and 44/204 benign were converted to BI-RADS>4 and 2/36 cancer and 10/204 benign to BI-RADS <3 rating. With CEDM, 1/36 cancer and 8/204 benign were converted to BI-RADS>4 and 1/36 cancer and 60/204 benign to BI-RADS<3. Hence 1/36 cancer ratings (2.7%) were adversely affected (false negative) by CEDM.

CONCLUSION
CEDM use during diagnostic evaluation of BI-RADS 4A or 4B lesions may result in a significant increase in PPV with minimal impact on cancer diagnosis rates.

CLINICAL RELEVANCE/APPLICATION
CEDM use during diagnostic evaluation of BI-RADS 4A or 4B soft tissue lesions may significantly reduce the number of women recommended for benign biopsy while missing very few cancers.

SSA02-03  Diagnostic Performance of Contrast-Enhanced Spectral Mammography for Suspicious Malignant Microcalcifications (BI-RADS 4)

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PURPOSE
To assess the diagnostic performance of contrast-enhanced spectral mammography (CESM) for evaluation of suspicious malignant microcalcifications (BI-RADS 4) comparing with full-field digital mammography (FFDM).

METHOD AND MATERIALS
Patients with mammographic calcifications without associated mass or distortions and were originally reported as BI-RADS 4 during Jan 2015 to Jan 2018 were retrospectively collected. Lesions that proven through pathological diagnosis either by biopsy or operation were included in the study and grouped as FFDM or CESM according to the examination they received. The microcalcification morphology and associated enhancement (CESM group) were reviewed by two radiologists to analyse the accuracy of the diagnosis. Diagnostic accuracy was assessed respectively for FFDM and CESM versus the results of pathology. Statistical differences of the two methods were compared using Chi-square test.

RESULTS
48 lesions (13 malignant and 35 benign) from 48 patients were enrolled in FFDM group, and 31 lesions (10 malignant and 21 benign) from 30 patients were in CESM group. The diagnostic sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 92.3%, 42.9%, 37.5%, 93.8%and 56.3% for FFDM group, and were 100%, 71.4%, 62.5%, 100% and 80.6% for CESM group, respectively. The specificity and accuracy of CESM were significantly higher than that of FFDM (p<0.05). All 10 cancers including 8 DCIS in CESM group were judged as enhancement (table 1).

CONCLUSION
Comparing with FFDM, CESM improve the diagnostic performance on BI-RADS 4 mammographic calcifications, especially on specificity and overall accuracy. The detectability of all DCIS lesions in this small cohort may validate its potential use in previously “calcification only” disease, but still need further large sample to confirm.

CLINICAL RELEVANCE/APPLICATION
CESM improve the diagnostic performance on BI-RADS 4 mammographic calcifications, and decrease unnecessary biopsies.

SSA02-04  Participants
Quantitative Objective Evaluation of Contrast-Enhanced Spectral Mammogram in Predicting Response to Neo-Adjuvant Chemotherapy: A Comparative Study with RECIST 1.1 and Combined Evaluation Methods

Sunday, Nov. 25 11:15AM - 11:25AM Room: E450B

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PURPOSE

Initiating a new objective quantitative tool for evaluation of residual disease after neoadjuvant chemotherapy using CESM in comparison to RECIST 1.1 and combined evaluation methods.

METHOD AND MATERIALS

The study was approved by the ethical committee of a multidisciplinary breast cancer hospital. It included 42 patients scheduled for receiving NAC. They underwent 2 CESM examinations; prior to and after NAC and maximum 10 days prior to surgery. All patients were assessed using the RECIST 1.1 criteria, a combined approach (RECIST+ qualitative subjective assessment) and a new quantitative approach using an image analysis software (MATLAB and Simulink, Release 2013b). The technique consists of 3 main steps: 1- preprocessing 2. extracting the region of Interest (ROI) and 3- Assessing the response to chemotherapy depending on the analysis of the tumour number of pixels included within the ROI. The difference in the intensity of enhancement between the pre and post NAC enhancement is calculated and compared between the 3 assessment methods in correlation to postoperative pathology using the Miller-Payne grading. For statistical evaluation, patients were classified into responders and non-responders.

RESULTS

The calculated correlation coefficient when comparing the residual disease on CESM and Miller Payne grade using RECIST 1.1, the combined approach and the proposed quantitative method was 0.59. 0.89 and 0.69 respectively. According to Miller Payne grading 39/42 cases were classified as responders (Miller Payne III, IV, and V). Using the new quantitative approach all 39/39 cases (100%) were considered responders and in comparison to 38/39 using the combined RECIST 1.1 criteria. The calculated sensitivity, positive and negative predictive values of the quantitative objective evaluation (100, 97.5, 100 % respectively) was higher than the RECIST method (87.2%, 97.1% 28.6%) and the combined response method (97.4%,97.4% and 66.7%).

CONCLUSION

Quantitative objective analysis of CESM allows accurate objective evaluation of the response of breast cancer to chemotherapy and evaluation of residual tumor prior to surgery.

CLINICAL RELEVANCE/APPLICATION

Objective analysis of CESM is an accurate tool for evaluation of the response of breast cancer post neo-adjuvant chemotherapy and is recommended as part of pre-operative work up

SSAO2-05 Diagnostic Value of Contrast-Enhanced Spectral Mammography in Comparison to MRI in a Population of Breast Lesions

Sunday, Nov. 25 11:25AM - 11:35AM Room: E450B

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PURPOSE

To evaluate the diagnostic value between contrast-enhanced spectral mammography (CESM) and breast magnetic resonance imaging (MRI).

METHOD AND MATERIALS

Between July 2017 and February 2018, 235 patients who were suspected of breast abnormalities by clinical examination or mammography were underwent CESM and MRI examination. The image of CESM and MRI and the pathological specimens were analyzed. All lesions were evaluated independently by three experienced radiologists. Using histopathological results as the gold standard, the diagnostic performance of CESM and MRI were investigated. The areas under ROC curves was applied to analyze diagnostic efficiency. The data on maximum tumor size measurements were gathered on CESM and MRI. The Pearson's correlation coefficients and 95% confidence intervals between CESM vs. pathology and MRI vs. pathology were calculated.

RESULTS

263 breast lesions were found in 235 patients, in which 177 were malignant and 86 were benign. By evaluating the diagnostic value,
the sensitivity, positive prediction value, negative predictive value, and false-negative from CESM examination was comparable to that from MRI (91.5%, 94.7%, 83.7%, 8.5% versus 91.5%, 90.5%, 82.1%, 8.5%). Importantly, the accuracy and the specificity were higher for CESM than that for MRI (81%, 89.5% Vs. 80.2%, 71.7%) while the the false-positive was lower (10.5% Vs. 19.8%). The areas under ROC curves of CESM and MRI were 0.950 and 0.939, displaying the equivalent diagnostic efficiency (p=0.48). For the agreement between measurements, mean tumor size was 3.1 (range 0-16) cm for CESM and 3.4 (range0-17) cm for MRI compared with 3.2 (range 0-16) cm on histopathological results, the average difference of diameters between CESM, MRI and Histopathologic size was -0.01, -0.05cm, respectively, with 95% consistency interval range of -0.34 to 0.31, -0.87 to 0.22cm, respectively. The Pearson’s correlation coefficients of CESM versus histopathology (r=0.774, p=0.000) was consistent with MRI (r=0.771, p=0.000).

CONCLUSION

Our results show better accuracy, specificity and the lower false-positive of CESM in breast cancer detection than MRI. CESM displayed a good correlation with histopathology in assessing the lesion size of breast cancer, which is consistence with MRI.

CLINICAL RELEVANCE/APPLICATION

CESM provides additional enhancement information for diagnosing breast lesions and measuring cancer sizes with high correlation to surgicohistology.

SSA02-06 Usefulness of Low-Dose Perfusion Breast CT: Quantification of Tumor Vascularity and Prediction of Histologic Biomarkers in Invasive Breast Cancer

Sunday, Nov. 25 11:35AM - 11:45AM Room: E450B

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PURPOSE

To investigate the usefulness of low-dose perfusion breast computed tomography (CT) for quantification of tumor vascularity and for prediction of histologic biomarkers in invasive breast cancer.

METHOD AND MATERIALS

This prospective study was approved by IRB with informed consent. A total of 139 patients with invasive breast cancers were enrolled. Low-dose perfusion CT was performed in the prone position with a spectral CT (iQon, Philips Healthcare) after contrast injection (Xenetix350, Guerbet). Effective dose was less than 1.2 mSv. Perfusion parameters were measured using a Philips Advanced Perfusion and Permeability application prototype in breast cancers, normal breast tissue, and fat; peak enhancement intensity (HU), perfusion on deconvolution model (mL/min/100/g), mean transit time (sec), time to peak (sec), blood volume (mL/100/g), permeability (mL/min/100/g), and blood volume permeability on Patlak model (mL/100/g). CT perfusion parameters of cancers and normal tissue or fat were compared using Mann-Whitney test. Correlation analysis was performed between CT perfusion parameters of cancers and histologic biomarkers including tumor grade, estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (HER2), and Ki67 using Mann-Whitney or Kruskal-Wallis test.

RESULTS

In breast cancers, peak enhancement intensity, perfusion, blood volume, permeability, and blood volume permeability were significantly higher, and mean transit time, time to peak were shorter than those values in normal glandular tissues and fat (P<.001 for all). Peak enhancement intensity significantly increased in cancers with ER+, PR-, HER2+, Ki67+ or more than 20 mm (P<.05 for all). Time to peak decreased in cancers with ER+, PR-, HER2+, Ki67+, high grade, or more than 20 mm (P<.05 for all). Blood volume permeability increased in cancers with ER+, PR-, Ki67+, or high grade (P<.05 for all). HER2-enriched cancers showed higher peak enhancement intensity and blood volume permeability than luminal type cancers (P<.02 for all).

CONCLUSION

Low-dose perfusion breast CT can be useful in quantifying tumor vascularity and predicting prognostic biomarkers of invasive breast cancer.

CLINICAL RELEVANCE/APPLICATION

Low-dose perfusion breast CT can be used to quantify tumor vascularity and to predict biomarkers of invasive breast cancer and for patients who have difficulty with magnetic resonance imaging.

SSA02-07 Contrast-Enhanced Cone-Beam Breast-CT without Prior Non-Contrast Scan: Can We Reduce Radiation Exposure While Maintaining Diagnostic Accuracy?

Sunday, Nov. 25 11:45AM - 11:55AM Room: E450B

Participants
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Contrast-enhanced cone-beam breast-CT (CE-CBCT) is a novel breast imaging technique with comparably high radiation dose. The current diagnostic standard includes one non-contrast scan (NC-CBCT) followed by intravenous contrast media injection and a contrast-enhanced scan (CE-CBCT). Performing only the CE-CBCT scan might reduce radiation exposure. Our study aims to evaluate whether CE-CBCT alone is comparable to combined NC + CE-CBCT regarding diagnostic accuracy while reducing radiation exposure.

METHOD AND MATERIALS
This prospective IRB-approved study included 48 women (61 breasts, 100 lesions) with median age 57.9 years (IQR: 49-66 years) and BI-RADS 4/5 lesions diagnosed on mammography/ultrasound in ACR density types c/d breasts. Two blinded breast radiologists read CE-CBCT alone versus NC-CBCT + CE-CBCT in consensus. Intra-observer variability was assessed by one reader performing independent double reading. Sensitivity, specificity and AUC were measured separately for CE-CBCT alone versus NC + CE-CBCT.

RESULTS
Of 100 lesions, 51 were rated as malignant, 6 as high risk and 43 as benign. Histopathological assessment was performed in 63 breast lesions and imaging follow-up over at least 1 year in another 37 lesions. Diagnostic accuracy for both CBCT approaches was comparable: AUC, sensitivity and specificity showed no significant differences comparing CE-CBCT alone versus NC + CE-CBCT (AUC: 0.84 vs. 0.83, p=0.643; sensitivity: 0.89 vs. 0.85, p=0.158; specificity: 0.73 vs. 0.76, p=0.655). Inter- and intra-observer agreement on BI-RADS readings were excellent (ICC=0.76, ICC=0.83, respectively). Radiation dose was significantly lower for CE-CBCT alone versus NC + CE-CBCT (median average glandular radiation dose 5.9 mGy vs. 11.7 mGy, p<0.001).

CONCLUSION
The diagnostic accuracy of CE-CBCT alone is comparable to that of combined NC + CE-CBCT in ACR type c/d breast. At the same time, CE-CBCT significantly reduces radiation exposure to the breast. Further research is warranted to confirm these findings in a larger and generalizable population.

CLINICAL RELEVANCE/APPLICATION
Assessment of CE-CBCT alone yields comparable diagnostic accuracy to combined NC + CE-CBCT and reduces radiation exposure by up to 50%. Additional acquisition of NC-CBCT might therefore be unnecessary.

SSA02-08 Automatic Classification of Breast Lesions in Contrast Mammography Using Deep Learning in Conjunction with Multimodal Information: BI-RADS Lexicon Features and Raw Image Features

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PURPOSE
To assess the combined usage of BI-RADS lexicon and pixel data for multimodal automatic classification of breast lesions in dual energy contrast enhanced spectral mammography (CESM) and evaluate its potential for biopsy sparing in benign breast lesion.

METHOD AND MATERIALS
130 biopsy proven CESM breast lesions, (65 benign and 65 malignant) were manually contoured and described by the BI-RADS lexicon. BI-RADS data was encoded by a binary vector for each lesion which, together with the lesion pixels, formed a multimodal representation. A deep neural network was designed to process pixel data from its entry layer and merge it with BI-RADS data in its deepest layers to better balance between low-level pixel information and high-level BI-RADS data that need to be merged. The network was validated in a 5-folds cross-validation (CV) scheme, to tell apart benign/malignant lesions. In each fold, a different subset of 25 lesions was used for testing, and the rest for training. This CV was conducted using 3 different configurations, in order to assess and compare the contributions of different information modalities: (a) BI-RADS-only classifier using SVM (BOC), (b) pixel-only network (PON), (c) and the multimodal BI-RADS+pixels network (MBPN).

RESULTS
The results are shown in Fig.1, where blue is benign and red is malignant. The classification score (γ axis) reflects malignancy probability. We seek a threshold, below which there are only benign lesions, so that no malignancy is missed, i.e. sensitivity=100% (green line Fig.1). With this condition in mind, the maximal specificities (SP) are: (a) BIRADS only, SP=12%; (b) pixel-only network, SP=37%; (c) multimodal BI-RADS and pixel network (MBPN), SP=60%. This means that with MBPN we can safely spare unnecessary biopsy for 60% of benign lesions without missing any malignancies.

CONCLUSION
This research showed that the combined usage of BI-RADS data, provided by the radiologist, with pixel data extracted from CESM strongly improves the specificity obtained for automatic lesion classification on pixel or BI-RADS data alone.
Multimodal lesion classification in CESM may significantly reduce benign breast biopsies, thus reducing cost and improving patient experience.

Preoperative Diagnosis of Metastatic Axillary Sentinel Lymph Nodes in Breast Cancer with Quantitative Parameters Derived from Dual-Energy Spectral CT

Sunday, Nov. 25 12:05PM - 12:15PM Room: E450B

Participants
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Jun Shen, MD, Guangzhou, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
The purpose of this study was to evaluate the diagnostic performance of gemstone spectral imaging (GSI) quantitative parameters derived from dual-energy spectral computed tomography (DEsCT) for the preoperative diagnosis of metastatic sentinel lymph nodes (SLNs) in patients with breast cancer.

METHOD AND MATERIALS
This prospective study was approved by the ethics committee, and all patients provided written informed consent. From June 2015 to December 2017, dual-phasic contrast-enhanced DEsCT was performed in 193 female patients with breast cancer. Quantitative GSI and morphological parameters were compared between metastatic and non-metastatic SLNs. The quantitative parameters were fitted to univariate and multiple logistic regression models. Their diagnostic abilities were analyzed by receiver operating characteristic curves and compared by the McNemar test.

CONCLUSION
DEsCT can be used as a complementary means for the preoperative identification of SLN metastases in patients with breast cancer.

CLINICAL RELEVANCE/APPLICATION
The slope of the Hounsfield unit curve in venous phase derived from dual-energy spectral CT, can be used to differentiate metastatic from non-metastatic axillary sentinel lymph nodes of breast cancer.
**SSA03-01 The Relationship of Coronary Endothelial Shear Stress (ESS) at Baseline and Hyperemia, and Its Association to Invasive Fractional Flow Reserve (FFR) and Computed Tomography Angiography FFR (CT-FFR)**

**Sunday, Nov. 25 10:45AM - 10:55AM Room: S404AB**

**Participants**
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**Sub-Events**

**Awards**
Trainee Research Prize - Medical Student

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**PURPOSE**
Low baseline ESS promotes development of high-risk plaque features. High ESS in one CTA-based hyperemic simulation technology (Heartflow FFRCT) was also recently shown to predict invasive FFR<=0.8. We determined the relationship of resting to hyperemic ESS using non-proprietary CTA-based rest/stress simulation algorithms, and whether flow state affects the ability of ESS to predict FFR<=0.8. Neither of these relationships have been previously assessed for data derived entirely from CTA.

**METHOD AND MATERIALS**
Computational fluid dynamics (CFD) was performed for 63 adults from CTA prior (<90d) to invasive FFR. Rest-state CFD used only CTA data (myocardial mass, Murray's law). Stress CFD coupled the epicardial arteries to a microvascular resistance model using 1/4 the resistance values obtained by the rest CFD. Only commercial CTA segmentation and CFD software was used. Rest and stress ESS at relevant locations (eg, coronary segments, across lesion, min lumen diameter, every 3 mm, min/max ESS) were compared (t-test) between FFR<=0.8 vs >0.8 vessels. Receiver operating characteristic area-under-the-curve (AUC) to predict FFR<=0.8 in all vessels was compared for diameter stenosis (%DS) and plaque volume (%PV) by CTA, CT-FFR, and rest and stress ESS.

**RESULTS**
In vessels where CT-FFR differed <0.05 from FFR (ie, stress CFD matched the patient's true hyperemic conditions), most ESS metrics differed significantly for FFR<=0.8 vs >0.8 vessels, eg lesion rest ESS=4.2 vs 1.9 Pa (p=0.012) and stress ESS=17.0 vs 9.6 (p=0.001), or, maximum ESS (rest: 9.5 vs 4.1, p=0.001; stress: 37.0 vs 19.6, p=0.001). Notably, the minimum ESS did not differ for FFR<=0.8 vs >0.8 vessels (rest p=0.184, stress p=0.454), but the location of minimum ESS differed in 31 of 40 vessels between rest and stress. AUC to detect FFR<=0.8 was 0.57 for CTA %DS, 0.74 for %PV, 0.9 for CT-FFR, and 0.86 for rest and stress ESS. The AUC of rest and stress ESS was not inferior to that of CT-FFR (p=0.446); CT-FFR statistically significantly improved only upon the AUC of %PV.

**CONCLUSION**
High ESS across a lesion at either baseline or hyperemia is associated with lesion-specific ischemia, and both have similar diagnostic accuracy as CT-FFR to detect FFR<=0.8. Low ESS regions differ between rest and stress.

**CLINICAL RELEVANCE/APPLICATION**
ESS from CTA can detect lesion-specific ischemia similarly to CT-FFR, with or without the need to simulate hyperemia.

**Honored Educators**
SSA03-02 Comparison Between Stress Cardiac Computed Tomography Perfusion versus Fractional Flow Reserve CT Derived in the Evaluation of Suspected Coronary Artery Disease: PERFECTION Prospective Study

Sunday, Nov. 25 10:55AM - 11:05AM Room: S404AB

Participants
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PURPOSE
The PERFECTION study is a longitudinal, prospective and consecutive cohort study to compare the feasibility and accuracy of FFRCT versus stress-CTP for the diagnosis of functionally significant CAD.

METHOD AND MATERIALS
One-hundred-forty-seven consecutive symptomatic patients (Mean age: 65.8±9.2; Male: 105) for chest pain who were referred for non-emergent, clinically indicated ICA plus invasive FFR were enrolled. The primary endpoint was to compare the diagnostic accuracy of cCTA versus cCTA+FFRCT versus cCTA+stress-CTP for the detection of significant CAD in a vessel and patients-based analysis defined by ICA with an invasive FFR <= 0.80 or coronary artery stenoses >= 80% or totally occluded vessels.

RESULTS
Rest cCTA was successfully performed in all patients, FFRCT was performed in 143 out of 147 patients and stress-CTP was performed in 144 out of 147 patients. cCTA demonstrated a vessel and patient-based sensitivity (SE), specificity (SP), negative predictive value (NPV), positive predictive value (PPV) and diagnostic accuracy (ACC) of 99%, 76%, 100%, 61%, 82% and 95%, 54%, 94%, 63%, 74%, respectively. The diagnostic performance of integrated protocol of rest cCTA+FFRCT showed a vessel and patient-based SE, SP, NPV, PPV and ACC of 88%, 94%, 95%, 84%, 92% and 90%, 85%, 92%, 83%, 87%, respectively. Finally, the diagnostic performance of integrated protocol of rest cCTA+stress-CTP showed a vessel and patient based SE, SP, NPV, PPV and ACC of 92%, 95%, 95%, 87%, 94% and 98%, 87%, 99%, 86%, 92%, respectively. Both FFRCT and stress-CTP significantly improved SP, PPV and overall ACC in both per-vessel and per-patient based model when added to cCTA, while no differences were found between cCTA+FFRCT versus cCTA+stress CTP.

CONCLUSION
Both FFRCT and stress-CTP are valid tool in addition to cCTA to evaluate the functional relevance of CAD. Based on these results, in patients with suspected CAD, cCTA alone or with integrated FFRCT might be sufficient to exclude relevant stenosis with the advantage to require a single acquisition with a low radiation exposure and low amount of contrast agent. Nevertheless, it might be reasonable to combine stress-CTP data in some patients with positive integrated cCTA+FFRCT exam thanks to the better specificity.

CLINICAL RELEVANCE/APPLICATION
FFRCT and CTP in addition to cCTA can be helpful to evaluate the functional relevance of CAD.

SSA03-03 CT Myocardial Perfusion Imaging and CT Angiography-Derived Coronary Fractional Flow Reserve for the Prediction of Major Adverse Cardiac Events in Patients with Coronary Artery Disease

Sunday, Nov. 25 11:05AM - 11:15AM Room: S404AB

Participants
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The "grey-zone" lesions, which have CT-FFR values ranging from 0.7 to 0.8, showed lower diagnostic performance. A stepwise

**CONCLUSION**

lesions were evaluated with Vratio/MLD instead of CT-FFR. respectively. For lesions with CT-FFR values ranging from 0.70 to 0.79, the accuracy could be improved to 80.0% (44/55) if these

0.89, and above 0.89, diagnostic accuracy of CT-FFR was 92.6%(25/27), 61.8%(34/55), 83.9%(47/56), 94.8%(55/58),

parameters and for diagnosing functionally significant stenosis. For vessels with CT-FFR values below 0.70, 0.70 to 0.79, 0.80 to

curve (AUC) of V ratio/MLD was comparable to that of CT-FFR (AUC=0.84 vs 0.88; p=0.28) and was significantly better than other

the hemodynamic significant subgroup and insignificant subgroup with respect to the risky plaque features The area under the

RESULTS

Of the 81 total patients included, 25 (31%) experienced MACE during the follow up period. CCTA alone had an area under the curve (AUC) of 0.653 for predicting MACE, with a corresponding sensitivity and specificity of 56% and 75%, respectively. The CT-FFR AUC for the prediction of MACE was 0.703 with a sensitivity and specificity of 64% and 80%, respectively. The optimal threshold computed with the Youden index was 0.75. Dynamic CTMPI had an AUC of 0.812 using the index MBF with a sensitivity and specificity of 88% and 75%, respectively. Using the Youden index, the optimal threshold for index MBF was 0.88. In cases with a negative CTMPI and positive CT-FFR, index MBF was most predictive of outcome (83% of patients). The combination of CCTA, CT-FFR, and CTMPI resulted in an improved AUC of 0.857 compared to CT-FFR and CTMPI alone.

**CONCLUSION**

Combined CT-FFR and dynamic CTMPI analysis based on cardiac CT imaging is a promising approach for the prediction of MACE in patients with coronary artery disease. While both techniques individually demonstrate good diagnostic accuracy, an integrated approach using both modalities improved the diagnostic accuracy for predicting MACE.

**CLINICAL RELEVANCE/APPLICATION**

This study shows the benefit of a combined CT-FFR/CTMPI approach to predict MACE. The correct identification of patients at risk of MACE can improve the efficiency and cost-effectiveness of treatment.

**SSA03-04** Machine Learning Based CT-FFR Integrating With Quantitative Myocardial Mass Subtended By Coronary Stenosis Outperforms Plaque Features for Predicting Hemodynamical Significance of Lesions

**Sunday, Nov. 25 11:15AM - 11:25AM Room: S404AB**

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**PURPOSE**

To study the diagnostic performance of the ratio of subtended myocardial mass to the minimal lumen diameter (MLD) at coronary computed tomographic angiography (CCTA) and machine learning based CT-FFR for differentiating functionally significant from insignificant lesions, with reference to fractional flow reserve (FFR).

**METHOD AND MATERIALS**

Patients who underwent both coronary CTA and FFR measurement at invasive coronary angiography (ICA) within 2 weeks were retrospectively included in our study. CT-FFR, subtended myocardial mass (V sub), percentage of V sub, V ratio/MLD, along with other parameters, including minimal luminal area (MLA), MLD, lesion length (LL), diameter stenosis, area stenosis, plaque burden, and remodeling index, low attenuation plaque, napkin-ring sign, spotty calcification of lesions were recorded. Lesions with FFR <= 0.8 were considered to be functionally significant.

**RESULTS**

One hundred and seventy-two patients with 196 lesions were ultimately included for analysis. The LL, diameter stenosis, area stenosis, plaque burden, V sub, V ratio and V ratio/MLD were all significantly longer or larger in the group of FFR <= 0.8 (p < 0.001 for all), while smaller MLA, MLD and CT-FFR value were also noted (p < 0.001 for all). There were no significant differences between the hemodynamic significant subgroup and insignificant subgroup with respect to the risky plaque features The area under the curve (AUC) of V ratio/MLD was comparable to that of CT-FFR (AUC=0.84 vs 0.88; p=0.28) and was significantly better than other parameters and for diagnosing functionally significant stenosis. For vessels with CT-FFR values below 0.70, 0.70 to 0.79, 0.80 to 0.89, and above 0.89, diagnostic accuracy of CT-FFR was 92.6%(25/27), 61.8%(34/55), 83.9%(47/56), 94.8%(55/58), respectively. FFR values with CT-FFR values ranging from 0.70 to 0.79, the accuracy could be improved to 80.0%(44/55) if these lesions were evaluated with Vratio/MLD instead of CT-FFR.

**CONCLUSION**

The "grey-zone" lesions, which have CT-FFR values ranging from 0.7 to 0.8, showed lower diagnostic performance. A stepwise
approach, reserving Vratio/MLD for "grey-zone" lesions instead of CT-FFR, can improve diagnostic accuracy.

**CLINICAL RELEVANCE/APPLICATION**

integrating ML based CT-FFR and V ratio/MLD allowed the most accurate discrimination between flow-limiting and non flow-limiting coronary lesions.

**SSA03-05**  
**Coronary Computed Tomography Angiography-Derived Fractional Flow Reserve in Anomalous Origin of the Right Coronary Artery from the Left Coronary Sinus**

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**PURPOSE**  
To examine fractional flow reserve derived from computed tomographic angiography (FFRCT) in patients with anomalous origin of the right coronary artery from the left coronary sinus with interarterial courses (AORLIC), its relationship with patient demographics, anatomical features of AORLIC on coronary computed tomographic angiography (CCTA) images, and its clinical relevance.

**METHOD AND MATERIALS**

Ninety-four patients with AORLIC who underwent CCTA were retrospectively included. Anatomic features (including RCA ostium location relationship with the pulmonary valve [high or low interarterial courses], takeoff angle, degree of stenosis, etc.) associated with abnormal FFRCT values (<0.8) on CCTA were analyzed. Patient demographics and anatomical data were analyzed using binary logistic regression analysis. Receiver operating characteristic analyses were performed to describe the diagnostic performance in detecting AORLIC with normal or abnormal FFRCT values.

**RESULTS**

Compared to patients with normal FFRCT values, more patients with high interarterial courses and greater proximal RCA stenosis were found to have abnormal FFRCT values (all P < 0.05). AORLIC with high interarterial courses was found to be the main contributor to abnormal FFRCT values (odds ratios =4.61, 95% confidence interval [CI], 1.51-14.08; P=0.007). The corresponding sensitivity and specificity for predicting abnormal FFRCT were 57.4% and 76.6% respectively (area under the curve=0.670, 95% CI: 0.560-0.781). AORLIC patients with abnormal FFRCT values showed a higher prevalence of typical angina (19.1% vs 4.3%, P=0.025) and atypical angina (23.4% vs 6.4%, P=0.026) compared to patients with normal FFRCT values.

**CONCLUSION**

AORLIC patients with abnormal FFRCT values have a higher prevalence of high interarterial courses, typical angina, and atypical angina than patients with normal FFRCT values.

**CLINICAL RELEVANCE/APPLICATION**

Patients with AORLIC were more likely to have abnormal FFRCT, showing a higher prevalence of typical angina and atypical angina compared to patients with normal FFRCT values. Thus, this noninvasive FFRCT method may have potential to identify patients at risk for sudden cardiac death.

**SSA03-06**  
**Building-Block-Based 3D Deep Learning: Fully Automated Estimation of Fractional Flow Reserve from Coronary CT Angiography**

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**PURPOSE**

To evaluate the accuracy of a building-block-based fully automated 3D deep-learning model for estimating fractional flow reserve.
**METHOD AND MATERIALS**

This HIPAA-compliant, IRB-approved retrospective study of 1052 consecutive patients (mean age, 63 ± 17 years) included 131 patients whose CCTA studies showed 30%-90% stenosis in at least one segment and underwent catheter FFR, and 921 patients who underwent clinically indicated CCTA without catheter FFR. We designed a fully automated building-block-based 3D deep-learning model that inputs whole CCTA data and outputs FFR without requiring any manual segmentations. The model was trained with all 1052 CCTAs. The model comprised lumen extraction, residual extraction, and prediction blocks. In the first and second blocks, a conditional generative adversarial network and a 3D convolutional ladder network, respectively, were used to extract specific features from the CCTA by eliminating image inputs less related to FFR estimation. The prediction block estimated FFR via two independent neural networks with integrated virtual adversarial training and a self-consistency check to reduce overfitting. We used Monte Carlo cross-validation to evaluate the accuracy of the deep-learning model for estimating FFR, with catheter FFR as the reference standard.

**RESULTS**

Abnormal catheter FFR values (<=0.8) were observed in 55% of the labeled data (72/131). The deep-learning FFR achieved area under the curve (AUC) of the receiver-operating curve of 0.72 for detection of abnormal FFR, which is significantly higher than for CTA > 50% stenosis (AUC = 0.56). The deep-learning FFR model achieved 76% accuracy for detecting abnormal FFR, with sensitivity of 86.2% (95%CI: 80.5%-90.7%) and specificity of 61.2% (52.4%-69.5%).

**CONCLUSION**

The building-block-based 3D deep-learning model, performing fully automatic estimation of FFR from whole cardiac CT data, achieved accuracy of 76% for the detection of abnormal FFR.

**CLINICAL RELEVANCE/APPLICATION**

Our deep-learning model estimates FFR without time-consuming vessel segmentation and may greatly improve the clinical workflow when selecting patients suitable for revascularization procedures.
Inc; Consultant, Bayer AG; Consultant, Siemens AG; ;

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SSA05

High-Resolution Chest CT Imaging of the Lung: Impact of High Matrix Reconstruction and Photon-Counting-Detector CT

Sunday, Nov. 25 10:45AM - 10:55AM Room: E451A

Participants

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Sub-Events

SSA05-01 High-Resolution Chest CT Imaging of the Lung: Impact of High Matrix Reconstruction and Photon-Counting-Detector CT

Sunday, Nov. 25 10:45AM - 10:55AM Room: E451A

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PURPOSE

To evaluate the impact of 1024 matrix size and photon-counting-detectors (PCDs) relative to 512 matrix size and energy-integrating-detectors (EIDs) for chest CT.

METHOD AND MATERIALS

22 adult patients undergoing clinically indicated chest CT received dose-matched PCD CT after written informed consent. 1.5 mm images were reconstructed at a 1mm overlap with our routine clinical kernel (B46) at both 512 and 1024 matrix sizes for EID scans. For PCD, B46 and an additional sharp kernel (Q65, not available for EID) was reconstructed at a 1024 matrix. Two chest radiologists compared only the right lung of B46/EID/1024; B46/PCD/1024 and Q65/PCD/1024 images in a side-by-side fashion to the routine clinical B46/EID/512 images, noting the highest level bronchus clearly identified in each lobe. The 3rd and 4th order bronchi were specifically evaluated and any lung nodules were compared to the B46/EID/512 images using a 5 point Likert scale (+2 = improved detection confidence, +1=preferred but no confidence change, 0 = similar, -1=worse but no confidence change, -2=worse with decreased confidence). Statistical analysis was performed using a Wilcoxon signed rank test with a p <0.05 considered significant.

RESULTS

Compared to B46/EID/512, readers detected higher order bronchi using Q65/PCD/1024 images for every lung lobe (p<0.002). For B46/EID/1024 reconstruction, higher order bronchi were only significantly better seen in the right middle lobe (p=0.007). Readers were able to better identify bronchial walls of the 3rd and 4th order bronchi better using Q65/PCD/1024 (mean Likert-scores of 1.1 and 1.5), which was significantly higher compared to B46/EID/1024 or B46/PCD/1024 (mean difference 0.8; p<0.0001). Of 49 non-calcified pulmonary nodules (8 part solid, 41 solid), Q65/PCD/1024 had a slightly but significantly higher mean visualization score of 0.8 compared to 0 for B46/EID/1024 and 0.2 for B46/PCD/1024 (p<0.0002).

CONCLUSION

Lung PCD-CT with 1024 matrix using a sharp Q65 kernel increase visualization of higher order bronchi and bronchial walls without compromising nodule detection. Softer kernels and further work are needed to examine the internal density characteristics of nodules at PCD-CT.

CLINICAL RELEVANCE/APPLICATION

PCD-CT with 1024 matrix improves visualization of medium and small bronchi compared to current routine chest CT, creating an opportunity for radiologists to better characterize lung pathology.
Normalized Emphysema Score Progression: An Improved CT Biomarker for Mortality

Sunday, Nov. 25 10:55AM - 11:05AM Room: E451A

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PURPOSE
Normalized emphysema score (normES) is a protocol-robust and validated CT biomarker for mortality. We aimed to improve mortality prediction by modelling its change over time.

METHOD AND MATERIALS
CT scans from all 1810 deceased participants from the National Lung Screening Trial were selected. Of these, 445 died from lung cancer. A random selection of 4190 surviving participants were sampled with replacement up to 24432 to approximate the full cohort. The normES was obtained by computing the emphysema scores after resampling, normalization, and bullae cluster analysis.

The reference models contained solely the baseline (T0) normES. To investigate if progression of emphysema provides additional information, normES from the first (T1) and second annual screening rounds (T2) and normES progression (normESprog) were added to the base model. normESprog was calculated by subtracting the T0 log(normES) from the T1 or T2 log(normES) and dividing by the time in between. Proportional hazard models predicting all-cause and lung cancer mortality were compared by calculating the continuous net reclassification improvement (NRI) for each year of follow-up.

RESULTS
The analysis of T0 and T1 data was performed on 22695 samples; 3547 lacked T0 or T1 scans, or had corrupted data. NRI improvement for all-cause and lung cancer mortality prediction compared to the base models were 4.5% (95%CI: -7.3 to 8.4%) and 4.1% (-9.3 to 14.6%) 3 years after baseline, 6.1% (-5.3 to 9.4%) and 0.1% (-7.1 to 12.2%) after 5 years, and 6.1% (-6.2 to 8.7%) and -0.4% (-5.6 to 11.3%) after 7 years, respectively. When modelling the T0 to T2 interval, another 2603 samples were excluded. For all-cause mortality, the 3, 5, and 7 year time points showed respective NRI improvements of -0.5% (-6.7 to 8.0%), 10.8% (5.5% to 14.7%), and 12.2% (7.1% to 15.6%). Improvements in lung cancer mortality prediction were -6.1% (-24.0 to 12.6%), 19.6% (10.6 to 29.2%), and 24.1% (15.4% to 31.7%), respectively. All hazard models had a logrank test p<.001.

CONCLUSION
Two normES measurements are better than one at predicting mortality over longer periods of time. The time between normES measurements should be sufficiently distant to account for the slow progression of emphysema.

CLINICAL RELEVANCE/APPLICATION
Normalized emphysema score progression is an automatic emphysema quantification method which can better predict the long-term mortality than a single baseline measurement.

Comparison of Two Independent Visual Assessment Protocols for the Detection of Emphysema in the National Lung Screening Trial Cohort

Sunday, Nov. 25 11:05AM - 11:15AM Room: E451A

Participants
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PURPOSE
To investigate the variability in assessing the presence of emphysema in a lung cancer screening population using low-dose CT scans and compare this to rates of spirometry-detected airflow obstruction.

METHOD AND MATERIALS
Baseline low-dose CT scans from 6,352 NLST participants enrolled in the CT arm who also underwent spirometry were evaluated. Emphysema was visually assessed in NLST as present or absent. In our study, two readers visually assessed CT scans using a modified NECTT protocol that divided the lung into upper, middle, and basal zones and graded emphysema as none (0%), trace (1-25%), mild (25-50%), moderate (50-75%), or severe (75%). In this protocol, a subject was scored as positive if any region was scored trace or greater. Results were compared to emphysema and spirometry data from the Pittsburgh Lung Screening Study (PLuSS).
RESULTS
Among the 6,352 subjects, emphysema was identified in 55.4% (3518/6352) of subjects in NLST and 40.4% (2566/6352) of subjects using our protocol (agreement Kappa=0.4990). Emphysema severity in the current study was reported as none, trace, mild, moderate, and severe in 59.6%, 27.4%, 7.0%, 4.1%, and 1.9% of the subjects, respectively. Inter-reader agreement for the presence of emphysema between the two readers in our study in 200 CT scans was moderate to substantial (K=0.6073). Using the McNemar test statistic, there was a statistically significant difference between our visual assessment of emphysema and the NLST assessment of emphysema (p < 0.001). Spirometry-detected airflow obstruction was reported in 32.0% of the NLST subjects. In PLuSS (n=3638), emphysema and airflow obstruction were identified in 42.5% and 42.7% of the subjects, respectively.

CONCLUSION
Our study revealed a significant disagreement in emphysema assessment between two independent visual interpretations of low-dose CT scans. The discrepancy between emphysema and airflow obstruction (55.4% versus 32.0%) in the NLST-ACRIN subcohort appears to be from overdetection of emphysema. Our visual emphysema assessment of NLST CT scans is more consistent with rates of spirometry-detected airflow obstruction and with published rates of emphysema in lung cancer screening populations.

CLINICAL RELEVANCE/APPLICATION
Since emphysema is recognized as a significant risk factor for lung cancer, our study demonstrates the need to standardize and improve emphysema assessment in low-dose lung cancer screening CT scans.

SSA05-04 Visual Presence of Emphysema Predicts Progression of Emphysema and Air Trapping in Cigarette Smokers

Sunday, Nov. 25 11:15AM - 11:25AM Room: E451A

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PURPOSE
Visual categorization of emphysema on CT has been shown to correlate with symptomatic impairment and with mortality. However, the relationship between presence of emphysema and subsequent progression of disease has not previously been evaluated.

METHOD AND MATERIALS
We studied 4126 subjects enrolled in the COPDGene study, who had visual CT scores at baseline, and quantitative inspiratory and expiratory CT at baseline and at 5 years. Trained research analysts performed visual classification of parenchymal emphysema on baseline volumetric CT scans of these subjects using the Fleischner Society classification system. Each scan was independently evaluated by two analysts; discordances between analysts were adjudicated by a thoracic radiologist. Statistical analysis used a linear mixed model, adjusted for age, height, gender, race, smoking status, scanner make, and reconstruction algorithm, with dependent variables being inspiratory lung density at 15th percentile (adjusted for lung volume) as a measure of emphysema, and % of lung voxels < -856 HU on expiratory CT (LAA-856) as a measure of air trapping. Analysis was stratified by presence or absence of COPD at baseline.

RESULTS
In subjects with COPD, those with emphysema at baseline showed a lung density decline of 4.7 g/l (95% CI 3.9, 5.4, p<0.0001), compared with 1.4 g/l (0.5, 2.4, p=0.003) for those without emphysema. For subjects without COPD, corresponding values were 4.0 (3.2, 4.9, p<0.0001) and 0.8 (0.25, 1.4, p=0.005). In subjects with COPD, those with baseline emphysema showed increase of 3.8% (2.9, 4.6, p<0.0001) in LAA-856, compared with 0.5% (-0.6, 1.5, n.s.) for those without. For subjects without COPD, those with emphysema had an increase in LAA-856 of 1.7% (1.1, 2.4, p<0.0001), while those without emphysema had a slight decrease of 0.5% (0.1, 0.9, p=0.01).

CONCLUSION
The presence of parenchymal emphysema at baseline is associated with a higher rate of progression in emphysema and air trapping at 5 year follow-up, in cigarette smoking subjects with and without COPD.

CLINICAL RELEVANCE/APPLICATION
The presence of visible emphysema on CT in cigarette smokers is an important predictor of subsequent progression.

SSA05-05 3D Oxygen-Enhanced MRI at 3T System versus Thin-Section CT: Quantitative Capability for Pulmonary Functional Loss Assessment and Clinical Stage Classification in Smokers

Sunday, Nov. 25 11:25AM - 11:35AM Room: E451A

Participants
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RESULTS

The area under the receiver operating characteristic curve (AUC) was used to compare the capability for pulmonary functional loss assessment and both indexes were correlated. Then, both indexes were compared against four clinical stages by Tukey's HSD test. Finally, discrimination analyses were performed, and accuracy was compared each other by McNemar's test.

RESULTS

ΔT1 and LAA% were significantly correlated with FEV1/FVC% (ΔT1: r=-0.70, p=0.0006; LAA%; r=-0.75, p=0.0002), %FEV1 (ΔT1: r=-0.84, p<0.0001; LAA%; r=-0.67, p=0.0013) and %DLCO/VA (ΔT1: r=-0.69, p=0.0009; LAA%; r=-0.63, p=0.0029). ΔT1 had significant difference between 'Severe or very severe COPD' group and others (p<0.05), although LAA% had significant difference between 'Severe or very severe COPD' and 'Without COPD' (p<0.05) or 'Mild COPD' (p<0.05) groups. Discrimination accuracies of ΔT1 (73.7 [14/19] %) was significantly higher than that of LAA% (42.1 [8/19] %, p=0.03).

CONCLUSION

3D O2-enhanced MRI has a better capability for pulmonary functional loss assessment and clinical stage classification in smokers than quantitative CT.

CLINICAL RELEVANCE/APPLICATION

3D O2-enhanced MRI has a better capability for pulmonary functional loss assessment and clinical stage classification in smokers than quantitative CT.

To prospectively and directly compare the quantitative capability for pulmonary functional loss assessment and clinical stage classification between 3D oxygen-enhanced MR imaging (O2-enhanced MRI) and thin-section CT in smokers.

METHOD AND MATERIALS

Twenty consecutive smokers (12 men and 8 women; age range 56-85 years) underwent 3D O2-enhanced MRI, thin-section CT and pulmonary function test (FEV1/FVC%, %FEV1% and %DLCO/VA). All smokers were classified into four stages (‘Without COPD’, ‘Mild COPD’, ‘Moderate COPD’, ‘Severe or very severe COPD’) according to the GOLD guideline. For 3D O2-enhanced MRI in each smoker, 3D Fast Field Echo sequence with variable flip angles was performed with and without 100% oxygen inhalation at a 3T MR system. With non-rigid registration software, regional T1 value change map was generated from O2-enhanced MR data by pixel by pixel analyses. Then, ROIs were placed over the lung on all slices, and averaged to determine mean T1 value change (ΔT1) in each subject. On quantitative CT in each subject, percentage of low attenuation area within entire lung (LAA%) was also measured. To compare the capability for pulmonary functional loss assessment, both indexes were correlated with each parameter. Then, both indexes were compared for four clinical stages by Tukey's HSD test. Finally, discrimination analyses were performed, and accuracy was compared each other by McNemar's test.
Per slice prediction for the entire lung region, the top 50%, and the bottom 50% produced an AUC of 0.76 (SE: 0.01), 0.77 (0.01), and 0.74 (0.01), respectively. Per case prediction produced an AUC of 0.84 (0.03), 0.83 (0.03), and 0.80 (0.03). The higher AUCs for per case prediction demonstrates that aggregating the predictions on slices help reduce the effect of labeling errors. The AUCs for the bottom 50% are lower, but still on par, which is likely due to the fact emphysema does not completely spare the bottom lobes.

CONCLUSION
We have demonstrated the potential of transfer learning to predict the presence of emphysema on LDCT scans. Fine-tuning work is currently on-going, and given the high performance already achieved with transfer learning, fine-tuning is likely to achieve even higher performance.

CLINICAL RELEVANCE/APPLICATION
LDCT provides an opportunity to identify other pathologies that may otherwise go undiagnosed. Having a suite of algorithms that automatically searches for multiple incidental findings has the potential to increase efficiency and prevent missing important findings.

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PURPOSE
To prospectively evaluate the utility of 3D lung motion assessment on inspiratory/expiratory xenon-enhanced area-detector CT (Xe-enhanced ADCT) for pulmonary functional loss assessment and clinical stage evaluation of chronic obstructive pulmonary disease (COPD).

METHOD AND MATERIALS
Twenty-eight consecutive patients with and without COPD (18 men and 10 women; mean age, 72 years old) prospectively underwent inspiratory/expiratory Xe-enhanced ADCT examinations as well as pulmonary function tests. Then, all patients were classified by GOLD classification as follows: 'Without COPD', 'Mild COPD', 'Moderate COPD' and 'Severe or Very Severe COPD'. In each subject, Xe-enhanced ADCT data was transferred to our proprietary software to generate xenon ventilation maps such as wash-in (WI), wash-out (WO) and ventilation ratio (VR: VR=[WI-WO]/WI) maps as well as 3D motion magnitude maps at X-, Y- and Z-axes as well as expansion rate (ER) map by Jacobian method by pixel-by-pixel analyses. Then, each regional index was assessed by ROI measurements, and each final value was determined as averaged value. To determine the relationship between xenon ventilation- and 3D motion-based indexes, Pearson's correlations were performed. Then, step-wise regression analyses were performed between all indexes and %FEV1. Finally, discrimination accuracies were performed among xenon-ventilation indexes, 3D-motion based indexes and combined method by McNemar's test.

RESULTS
WO had significant correlations with X, Y and Z-axis motion magnitudes (-0.53

CONCLUSION
3D lung motion assessment is useful for pulmonary functional loss and clinical stage classification of COPD.

CLINICAL RELEVANCE/APPLICATION
Inspiratory/expiratory xenon-enhanced area-detector CT with 3D lung motion assessment is more useful than that without 3D lung motion assessment for pulmonary functional loss and clinical stage classification of COPD.

Awards
Student Travel Stipend Award

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Purpose

Chronic obstructive pulmonary disease (COPD) affects over 16 million Americans and 251 million people worldwide. Multiple patterns of pathology exist, and imaging measurements are increasingly important for identifying COPD subtypes and prognosis. We hypothesized that a convolutional neural network (CNN) could predict volumetric measurements relating to pulmonary function, based on a subset of chest CT images.

Method and Materials

With HIPAA compliance and IRB approval, we retrospectively identified inspiratory CT scans for 160 COPD patients from our institution enrolled in the COPDGene multicenter study. We used a CNN based on VGG19 to develop regression-based inference predictions of total lung capacity (TLC), functional residual capacity (FRC), and percentage of emphysema. Measurement of these parameters was obtained previously as part of the larger COPDGene dataset, and has been discussed by other groups. A subset of 10 equally spaced axial chest images were selected from the full chest CT and used to train the network, with assessment by five fold cross validation. Correlations between CNN and ground truth are given as R², and bias was assessed with Bland-Altman plot analysis.

Results

CNN predicted measurements of TLC were correlated with those from the COPDGene dataset with an R² value of 0.86 (slope 1.10), and mean difference of 0.14L ± 0.57L. FRC was correlated with an R² value of 0.84 (slope 1.26), and mean difference of -0.06L ± 0.56L. Percent emphysema was correlated at an R² value of 0.82 (slope 1.04), and mean difference of 0.15% ± 3.34%.

Conclusion

Here we show the ability of a CNN to produce well correlated predictions of pulmonary volume measurements, inferred from a subset of chest CT images. Refinement of this CNN can expand it to additional structures or volumes, and may allow automation of quantitative pulmonary function measurements and volumes to streamline disease monitoring.

Clinical Relevance/Application

We present a convolutional neural network capable of making well-correlated, inference-based, predictions of pulmonary volume measurements in COPD patients, based on a subset of 10 chest CT slices.
SSA06

Science Session with Keynote: Emergency Radiology (Imaging Algorithms, Modalities and Techniques)
Sunday, Nov. 25 10:45AM - 12:15PM Room: S405AB

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Sub-Events

SSA06-01 Emergency Radiology Keynote Speaker: Impact of Dual Energy CT on ED Workflow and Downstream Utilization
Sunday, Nov. 25 10:45AM - 10:55AM Room: S405AB

Participants
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PURPOSE
To investigate the correlation between iodine concentration and clinical severity of acute pancreatitis (AP) through the quantitative evaluation with dua-energy spectral computed tomography (DESCT), so as to find out an effective imaging technology in the evaluation of clinical severity of AP.

METHOD AND MATERIALS
Sixty patients with AP confirmed clinically (AP group) and 30 patients with normal pancreas (control group) were retrospectively analyzed. All the patients underwent enhanced CT scan in the spectral imaging mode. Iodine concentration and normalized iodine concentration (NIC) were respectively measured during arterial phase and portal phase in the material-decomposition images by using a spectral imaging viewer (GSI Viewer).

RESULTS
Iodine concentration and NIC were significantly higher in the control group than in the AP group (P<0.05, P<0.001). In the AP group, according to Ranson grading, 24 patients were in the mild grade, 20 patients were moderate, and 16 patients were severe. Iodine concentration and NIC decreased along with the increase of their Ranson grade. There were significant difference in iodine concentration and NIC among the three subgroups (iodine concentration on arterial phase: F=8.776, P<0.01; iodine concentration on portal phase: F=12.700, P<0.001; NIC on arterial phase: F=8.732, P<0.01; NIC on portal phase: F=8.732, P<0.01). Iodine concentration on arterial and portal phases, and NIC on arterial phase in the severe grade group were significantly lower than those in the moderate grade group (P<0.05).

CONCLUSION
DESCT can analyze hemodynamic changes in AP quantitatively, which is of great value in evaluating changes in AP of each grade.

CLINICAL RELEVANCE/APPLICATION
The quantitative evaluation of iodine with dua-energy spectral computed tomography (DESCT) provide a new method for the prognosis of patients with acute pancreatitis.

SSA06-02 Acute Pancreatitis: A Quantitative Analysis of Iodine with Dual-Energy Spectral Computed Tomography
Sunday, Nov. 25 10:55AM - 11:05AM Room: S405AB

Participants
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SSA06-03 Diagnostic Performance of Dual Energy CT Characterization of Incidental Renal Lesions in Emergency
To assess the impact of socioeconomic status on CT findings and the management of acute appendicitis.

**METHOD AND MATERIALS**

The study cohort included patients with an indeterminate lesion on portal venous phase DECT (homogeneous lesion of greater than 20 HU, or complex cystic lesion), with reference standard imaging (renal mass protocol CT or MRI) of the lesion performed within 2 years. All DECT scans were performed in the ER setting on the same dual source DECT scanner. Two radiologists with DECT experience used DECT post-processed iodine selective images to characterize lesions as: definitely non-enhancing, equivocal/possible enhancement, or definitely enhancing. They also measured iodine concentration within lesions. Two expert abdominal radiologists evaluated reference standard imaging of each lesion, categorizing each as definitely non-enhancing (Bosniak I and II cysts), equivocal/possible enhancement (Bosniak IIF or other lesions needing follow up), and definitely enhancing (solid mass, Bosniak III/IV cysts).

**RESULTS**

66 lesions were included in the study cohort, on reference standard imaging 44 were non-enhancing (11 Bosniak I and 33 Bosniak II cysts) and 22 were lesions with equivocal or definite enhancement (7 Bosniak IIF cysts, 3 Bosniak III cysts, 3 Bosniak IV cysts, 9 solid masses). Qualitative assessment of lesions as enhancing on DECT readers on iodine selective images had a sensitivity of 100%, specificity of 43%, positive predictive value of 47%, negative predictive value of 100%, and accuracy of 62%.

**CONCLUSION**

Characterizing incidental indeterminate renal lesions on portal venous phase DECT as non-enhancing with DECT post-processing was successfully able to exclude enhancement in these lesions (NPV of 100%), indicating that incidental lesions without enhancement on DECT are highly likely to be Bosniak I or II cysts. However, the specificity and positive predictive value of enhancement seen on DECT were relatively low. Further research is needed to assess methods to mitigate false positive enhancement with DECT.

**CLINICAL RELEVANCE/APPLICATION**

Qualitative assessment of enhancement of incidental renal lesions with DECT had a high negative predictive value, indicating that lesions without enhancement on DECT post-processed images are highly likely to be Bosniak I or II cysts.

**Honored Educators**

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**SSA06-04 The Impact of Socioeconomic Status on CT-Imaging and Management of Acute Appendicitis**

Sunday, Nov. 25 11:05AM - 11:15AM Room: S405AB

**Participants**

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**PURPOSE**

To assess the impact of socioeconomic status on CT findings and the management of acute appendicitis.
METHOD AND MATERIALS
Informed consent was waived for this IRB-approved, HIPAA compliant, retrospective study of 18-64 year old patients with acute appendicitis at our institution by MDCT from 1/1/2006-12/31/2016 (n=1886). Insurance, race/ethnicity, primary language, and education level were obtained from the electronic medical record. Multivariate linear regression was performed to determine crude and adjusted parameter estimates for length of stay. For each metric, the estimates generated from linear regression are interpreted as difference in length of stay associated with one unit change in each covariate. Logistic regression models were run and crude and adjusted odds ratio (OR) were calculated for each categorical outcome. A P value of less than 0.05 was considered statistically significant for all analyses. Statistical computations were performed on SAS 9.3 system (SAS Institute, Cary, NC).

RESULTS
Free care/Medicaid/Medicare subjects had 0.4 days increase in length of stay as compared to private insurance (p=0.039). Free care/Medicaid/Medicare subjects were also found to have increase odds of surgical site infection or re-operation (OR=1.93, 95% CI=1.03-3.63, p=0.041), as compared to private insurance patients. Hispanics were associated with lower odds of complicated CT findings (OR=0.55, 95% CI=0.335-0.898, p=0.017), and both Hispanic and Blacks had lower odds of perforation, abscess, or gangrene by intraoperative report (OR=0.67, 95% CI=0.47-0.97, p=0.035; OR=0.68, 95% CI=0.48-0.97, p=0.033, respectively), as compared to Whites. There were no statistically significant differences in CT findings, length of stay, or post-operative complication by primary language or education level.

CONCLUSION
Acute appendicitis is a common emergent illness presenting across the socioeconomic spectrum. Free care, Medicaid and Medicare patients have increased length of stay and increased odds of post-operative complication. Hispanics show lower odds of complicated CT findings on initial presentation. Hispanics and Blacks have lower odds of having complicated intraoperative findings.

CLINICAL RELEVANCE/APPLICATION
Further investigation on the impact of socioeconomic status within radiology and the potential for radiologists to join the fight in combating health disparity are necessary to eliminate health inequality.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Stephan W. Anderson, MD - 2018 Honored Educator

SSAO6-05 Virtual Monoenergetic Dual-Energy CT for Evaluation of Hepatic and Splenic Lacerations

Sunday, Nov. 25 11:25AM - 11:35AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
Ellen X. Sun, MD, Boston, MA (Presenter) Nothing to Disclose
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Roger Lacson, Boston, MA (Abstract Co-Author) Institutional research agreement, Siemens AG; Speaker, Siemens AG; Speaker, General Electric Company

PURPOSE
To evaluate the utility of virtual monoenergetic imaging in assessing splenic and hepatic lacerations and to determine the optimal energy level to maximize laceration contrast-to-noise ratio.

METHOD AND MATERIALS
We retrospectively examined 26 contrast-enhanced abdominal CT studies performed on a dual-source dual-energy CT (DECT) scanner in our Emergency Department from 2013 to 2017, with liver and/or splenic lacerations. All studies included portal venous phase imaging acquired simultaneously at low (80 or 100 kVp) and high (140 kVp with tin filtration) energy levels. Conventional 120 kVp-equivalent mixed images were generated for routine review by blending the low and high energy acquisitions. Virtual monoenergetic reconstructions were retrospectively generated in 10 keV steps from 40-90 keV. Liver or splenic laceration attenuation, background parenchymal attenuation and noise were measured on each set of monoenergetic and mixed images. Injury-to-parenchyma contrast and contrast-to-noise ratios (CNR) were calculated. Differences between CNR of monoenergetic series and mixed images were assessed with a paired t-test.

RESULTS
Liver laceration was identified in 17 patients, and splenic laceration in 10 patients. Background noise was lower at higher monoenergetic levels, with the lowest noise seen at 90 keV, equivalent to that of mixed images (8.26 for 90 keV and 8.66 for mixed, p=0.035). For liver and splenic lacerations, CNR at 40-60 keV was higher than that of mixed images. Injury-to-parenchyma CNR was highest at 40 keV, significantly higher than mixed images (mean CNR 6.14 for 40 keV, 5.48 for mixed, p=0.024). Subgroup analysis of liver and splenic lacerations demonstrated a significant improvement in CNR at 40 keV compared with mixed images for splenic lacerations (5.89 vs. 4.98, p=0.036); for liver lacerations, the increased CNR at 40 keV compared with mixed images was not statistically significant (6.29 vs. 5.77, p=0.02).

CONCLUSION
With DECT virtual monoenergetic imaging, the optimal energy level for assessing liver and splenic lacerations was 40 keV, which showed improved injury-to-parenchyma CNR compared with traditional polyenergetic reconstructions.

CLINICAL RELEVANCE/APPLICATION
Virtual monoenergetic imaging at low keV can improve contrast to noise ratio of hepatic and splenic lacerations, which may improve
SSA06-06 Emergency Department Would Become the New Diagnostic Center if the Trend in National Imaging Utilization Continues

Sunday, Nov. 25 11:35AM - 11:45AM Room: S405AB

Participants
Santosh K. Selvarajan, MD, Philadelphia, PA (Presenter) Nothing to Disclose

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PURPOSE
Policymakers and payers have been concerned with the rapid growth in imaging utilization particularly in the Emergency Departments. Our purpose is to study the trends in utilization of imaging in EDs in recent years, by modality. Secondly, to determine the specialty of the interpreting physicians.

METHOD AND MATERIALS
The nationwide Medicare Part B Physician/Supplier Procedure Summary Master Files for 2004-2016 were the data source. CPT codes for plain radiography (XR), non-cardiac ultrasound (US), CT, MRI, and nuclear medicine (NM) were aggregated by modality. Medicare's place-of-service codes were used to identify those exams done during ED visits, and its specialty codes were used to determine which specialties did the interpretations. Trends from 2004 to 2016 were assessed.

RESULTS
Between 2004 and 2016 in the ED, the utilization of CT increased from 2,842,446 in 2004 to 7,705,340 in 2016 (+103%). MRI studies increased from 69,000 to 286,000 (+204%). The number of non-cardiac ultrasounds grew from 408,000 to 1,024,809 (+151%). The radiographs performed grew from 9,471,777 in 2004 to 13,177,023 in 2016 (+31%). The Nuclear Medicine studies showed a slight numerical decline, from 106,792 in 2004 to 65,985 in 2010 (-25%), but this was largely due to code bundling that occurred in myocardial perfusion imaging in 2010. Nuclear Medicine studies slightly increased from 65,985 in 2010 to 78,000 in 2016 (+11%). In each of the first 4 modalities, growth was steady and progressive with no evidence of slowing even after code bundling for CT abdomen and pelvis. Radiologists' share of the interpretations in 2016 were: CT 99%, MRI 99%, XR 98%, US 87.5%, NM 95%

CONCLUSION
The utilization of imaging in EDs grew substantially from 2004 to 2016 in comparison to the utilization in other places where imaging is performed. The largest numerical increases were seen in CT and XR. Radiologists strongly predominate in interpreting in all modalities.

CLINICAL RELEVANCE/APPLICATION
The progressive growth of utilization is of concern and suggests that more interdepartmental cooperation is needed for appropriate use of imaging in EDs.

SSA06-07 The Value of the Radiologist as Consultant to Improve Patient Care in the Emergency Department

Sunday, Nov. 25 11:45AM - 11:55AM Room: S405AB

Participants
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PURPOSE
In the emergency department (ED), imaging studies are requested by a wide spectrum of healthcare providers, many of whom are not educated in the finer details of imaging protocols. This lack of expertise leads to suboptimal diagnostic imaging; this results in decreased diagnostic accuracy, unnecessary cost and added radiation, among other potential inefficiencies. While order entry algorithms been implemented, they are not a comprehensive solution. This study demonstrates the value of radiologists’ input on diagnostic imaging at the time of order entry.

METHOD AND MATERIALS
Contrast enhanced CT/CT Angiogram (CTA) exams ordered in our ED are subject to validation by radiologist/radiology physician assistant. If the ordered study is deemed to be suboptimal, the provider is contacted and better options are discussed. Subsequently, the optimal study is protocoted. Per IRB, this quality improvement study was not subject to review. Ordered CT/CTA exams of the chest, abdomen or pelvis were reviewed over the course of 90 ED shifts (10pm-7am) spanning from 9/2017-3/2018. Total CT exam orders placed and the number of exams that were ultimately modified were recorded.
RESULTS
During the study, 631 eligible exam orders were reviewed. 14% (88/631) of the requests were modified. Of these modifications, 15% (13/88) were cancellations. In 84% (63/75) of alterations, contrast was improperly used. Suggested order alterations were more often related to oral contrast (52%, 38/75) than intravenous contrast (31%, 23/75). The anatomic area scanned was changed in 15% (11/75) of modified exams. In 13% (10/75) of modified exams, the type of study was changed entirely (Fig. 1).

CONCLUSION
In the era of value-based health care, it is essential to tailor patients' imaging to address specific clinical questions. Our results demonstrate that approximately 14% of diagnostic CT orders requested in the ED are not optimized. Most commonly, mistakes are related to contrast. Having radiology staff available to identify suboptimal diagnostic CT orders can add value to patient care by optimizing contrast protocols, ensuring the clinical question will be addressed and avoiding redundant examinations.

CLINICAL RELEVANCE/APPLICATION
In the ED, active monitoring of CT scan requests by a radiologist/trained radiology staff can further optimize diagnostic imaging, despite the availability of clinical decision support.

SSA06-08 National Trends of Non-Cardiac Ultrasound in the Emergency Department: What's the Contribution of Non-Radiologists?

Sunday, Nov. 25 11:55AM - 12:05PM Room: S405AB

Participants
Santosh K. Selvarajan, MD, Philadelphia, PA (Presenter) Nothing to Disclose

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PURPOSE
The Accreditation council for Graduate Medical Education (ACGME) requires Point of Care Ultrasound (POCUS) training to be part of Emergency Medicine. Our purpose was to determine recent trends in Non-cardiac ultrasound utilization in Emergency Departments. Secondly, assess the contribution of Non-Radiologists interpretations from 2004 to 2016.

METHOD AND MATERIALS
The Medicare Physician/Supplier Procedure Summary Master Files for 2004-2016 were used. The codes for ED Ultrasound were selected for 2004 and 2016. The procedure volumes in ED settings were calculated. Then Medicare provider specialty codes were used to identify those exams interpreted by Radiologists and other specialties.

RESULTS
The number of non-cardiac ultrasounds grew from 408,000 in 2004 to 1,024,809 in 2016 (+151%). Radiologists interpreted 87.5% of all ED non-cardiac ultrasounds. The vascular surgeons and emergency physicians interpreted 4% each, cardiologists and other surgical subspecialties interpreted the remaining 4.5%. There is 181% increase in the studies interpreted by vascular surgeons (15820 in 2004 to 44,369 in 2016), 1117% increase in the studies interpreted by emergency physicians (3459 in 2004 to 41400 in 2016), 26% increase by surgical specialties (14502 in 2004 to 18351 in 2016), and 140% increase by cardiologists (5270 in 2004 to 12470 in 2016).

CONCLUSION
The utilization of non-cardiac ultrasound grew substantially from 2004 to 2016. Radiologists continue to predominate in interpreting ED ultrasounds. There is small but substantial growth of emergency physicians and vascular surgeons' interpretations. Although much small in number the interpretations by cardiologists and other surgical specialties have also slowly increased.

CLINICAL RELEVANCE/APPLICATION
Although Non-Radiologists interpreting non-cardiac Emergency ultrasound has slowly grown, future studies are needed to assess the complexity of studies interpreted by them.

SSA06-09 Tiered Response Algorithm for Endovascular Management of Traumatic Hemorrhage

Sunday, Nov. 25 12:05PM - 12:15PM Room: S405AB

Participants
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PURPOSE
Hemorrhagic shock represents the second-leading cause of early death in traumatic injury with endovascular therapy as an integral part of the therapeutic armamentarium. The emphasis on a rapid response is balanced with the judicious utilization of resources that led to the creation of a tiered algorithm. The purpose of this study is to assess the efficacy of such a response for the
management of non-operative traumatic hemorrhage.

METHOD AND MATERIALS

A retrospective review of after-hour trauma activations was performed at a level 1 trauma center from July 2015 to July 2017. Activation of the interventional team was initiated either immediately ("EmboNow"), prior to imaging review and attending interventional radiologist (IR) approval, or after review and discussion with IR ("EmboSoon"). The need for transfusion and overall technical clinical success (defined as lack of re-intervention) were collected. Length of stay (LOS) and overall mortality, as well as overall morbidity, was evaluated. Pearson chi-square and Wilcoxon Rank-Sum (WRS) analyses were performed on various parameters to determine the significant clinical efficacy of a tiered response system.

RESULTS

A total of 73 trauma activations with EmboNow (n=27) and EmboSoon (n=46) occurred in the study time frame. Of the EmboSoon activations, 28 instances did not require the mobilization of the team and 3 instances required the mobilization of the team but did not progress to intervention. No significant difference was determined when assessing the necessity of hemostatic intervention within the groups. Of the cases requiring embolization (n=31), no difference in the clinical success rate was noted. Overall mortality for the EmboNow and EmboSoon groups was not significantly different, 3.7% and 6.7%, respectively. Also, no significant difference observed between the response groups for average LOS, EmboNow = 10.1 days and EmboSoon = 13.3 days.

CONCLUSION

A tiered response algorithm did not increase overall mortality nor length of stay in patients who ultimately underwent embolization but prevented unnecessary mobilization in 28 cases.

CLINICAL RELEVANCE/APPLICATION

Efficient use of IR resources as well as cooperation and communication among a multidisciplinary trauma team is essential to improve and maintain high-quality clinical services, and to get the best clinical outcomes in management of traumatic hemorrhage.
Gastrointestinal Keynote Speaker

Sunday, Nov. 25 10:45AM - 10:55AM Room: N226

SSA07-01  Gastrointestinal Keynote Speaker

Participants
Alexander R. Guimaraes, MD, PhD, Portland, OR (Moderator) Consultant, Agfa-Gevaert Group
Aiyia Qayyum, MD,MBBS, Houston, TX (Moderator) Spouse, Founder, In Context Reporting

SSA07-02  Added Value of Radiomic Analysis in Gadoxetic Acid-Enhanced MRI for Prediction of Postoperative Early and Late Recurrence of Single Hepatocellular Carcinoma

Participants
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PURPOSE
To evaluate the added value of the radiomic model in predicting early and late recurrence after resection in a single HCC of less than 5 cm using preoperative gadoxetic acid-enhanced MRI, compared to clinical-only model.

METHOD AND MATERIALS
This retrospective study included 214 patients with surgically resected and pathologically confirmed single HCC (<5cm; 1-2cm [n = 47]; 2-5cm [n = 167]) between January 2010 and December 2015 who underwent preoperative gadoxetic acid-enhanced MR imaging. All prediction models were made with training set and performance was evaluated with temporally independent validation set (training set vs. validation set; 1-5cm, 162 vs 52; 2-5cm, 128 vs. 39). Independent predictors for early and late disease-free survival (DFS) in clinicopathologic information were identified using the Cox regression model, respectively. Three dimensional radiomic features for predicting DFS were selected in each early (<2 years) and late period (2-5 years). A combined radiomic-clinical model (CMB) and a clinical-only model (CLN) were created using a random survival forest and additional values of radiomic features were evaluated using bootstrapping method (n = 1000) in each of the following conditions: early DFS vs. late DFS; tumor size 1-2cm vs. 2-5cm; all combinations of the three dynamic phases (arterial, portal, hepatobiliary phase); the peritumoral border extension included in the radiomic feature extraction (0mm vs. 3mm vs. 5mm).

RESULTS
The combined radiomic-clinical model showed a higher C-index than the clinical-only model in the prediction of early DFS but showed a lower C-index than the clinical-only model in the prediction of late DFS. The combined model using the radiomic features from 2-5cm size tumors, all three phases, 3mm peritumoral border extension showed the highest C-index value (CMB, C-index 0.716 [0.627-0.799]; CLN, C-index 0.696 [0.557-0.799]).

CONCLUSION
Radiomic features combined with clinical factors may improve the prediction of postoperative early recurrence of HCC, but they do not affect the prediction of late recurrence.

CLINICAL RELEVANCE/APPLICATION
Combined analysis of radiomic and clinicopathologic features may influence the postoperative management of patients by increasing the predictive power of postoperative early recurrence of HCC.

**SSA07-03** Auto-Encoder and Multilayer Perceptron Assisted Radiomics Approach for Prediction of Early Intrahepatic Recurrence After Radiofrequency Ablation in Hepatocellular Carcinoma

**Sunday, Nov. 25 11:05AM - 11:15AM Room: N226**

**Participants**
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**PURPOSE**
After radiofrequency ablation (RFA), > 50% of early stage hepatocellular carcinoma (HCC) patients undergo intrahepatic recurrence (IHR) within 2-3 years. To optimize the selection of most profitable patients to receive RFA, better prediction algorithms are needed to identify early IHR after RFA. Radiomics allows noninvasively extracting three-dimensional and quantitative features of tumor phenotypes from radiographic images. Recent advances in deep neural network also provide powerful tools for features selection and classification. The present study aims to combine those approaches to establish prediction model to identify patients with a low predicted IHR and suitable for RFA as first-line treatment.

**METHOD AND MATERIALS**
Patients who initially underwent RFA for single nodular HCC ≤ 5 cm with Child-Pugh grade A or B were included. A total of 6568 triphasic CT-based features of pretreatment tumors were obtained from 176 patients in the experimental cohort (EC). A Radiomic based prediction model (RPM), trained with variational autoencoder (VAE) and multilayer perceptron (MLP), was developed to predict the 2-year IHR, and validated in an independent validation cohort (VC) of 57 HCC patients. Imaging traits including tumor encapsulation, tumor necrosis, lack of fast wash-in or wash-out, multi-segment involvement were analyzed and correlated to the neurons of the encoder layers as an approach to explain the black box of hidden layers.

**RESULTS**
The VAE, with 16 neurons in encoder layers, held the task of noise reduction for high dimensional radiomic features, and MLP, with 4 hidden layers, was used to train the model. The RPM, trained with 1,711,457 parameters, outperformed the traditional volumetric predictors of maximal tumor diameter in the prediction of 2-year IHR, with a C-index of 0.757 / 0.707 (EC / VC), compared to 0.540 / 0.510. Imaging traits of tumor necrosis and lack of fast wash-in were associated with neuron_A and neuron_B in the encoder layers. Multivariate analysis showed only RPM and pre-RFA AFP level were significantly associated with 2-year IHR.

**CONCLUSION**
The radiomics approach provides a novel and convenient way to predict 2-year IHR in patients with early stage HCC who received RFA. The VAE and MLP help denoise high dimensional data and shed the light on the explanation of deep neural network.

**CLINICAL RELEVANCE/APPLICATION**
The RPM will select most profitable patients to receive RFA

**SSA07-04** Development of a Liver Tumor Diagnosis Tool with Deep Neural Networks: Radiologist-Level Performance with Artificial Intelligence

**Sunday, Nov. 25 11:15AM - 11:25AM Room: N226**

**Participants**
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**PURPOSE**
To develop and evaluate the performance of a 3D deep convolutional neural network (CNN) system compared to board-certified radiologists in automatically classifying hepatic lesions on contrast-enhanced multi-phasic magnetic resonance images (MRI).

**METHOD AND MATERIALS**
This IRB-approved, HIPAA-compliant analysis included 296 patients with a total of 494 focal hepatic lesions of different entities
(simple cyst, hemangioma, focal nodular hyperplasia, hepatocellular carcinoma [HCC], intrahepatic cholangiocarcinoma, and colorectal carcinoma metastasis). Lesions were defined on T1-weighted MRI scans (arterial, portal venous, delayed phase) and divided into training (n=434) and test sets (n=60). The training set was provided to a 3D CNN to learn how to classify each lesion type. The system's performance on the test set was compared with that of two board-certified radiologists.

RESULTS
Over 20 iterations, the CNN model achieved an overall average accuracy of 92%, a sensitivity (Sn) of 92%, and a specificity (Sp) of 98%. The model showed the lowest performance for colorectal carcinoma metastasis (89% Sn, 98% Sp) while the highest performance was achieved in classifying simple cysts (99% Sn, 100% Sp). The model's performance in a single run on the test set showed an average Sn of 90% and Sp of 98% across the six lesion types, compared to an average Sn of 82.5% and Sp of 96.5% for the radiologists. Specifically, the model achieved a 90% Sn for classifying HCC compared to 65% for radiologists. The model showed a true positive rate of 93.5% and false positive rate of 1.6% for HCC classification, with a receiver operating characteristic area under the curve (AUC) of 0.992. The model computation time per lesion was 1 millisecond.

CONCLUSION
This novel 3D CNN system demonstrates the feasibility of AI decision-support to accurately classify several classes of liver lesions on multi-phase MRI, providing a tool to potentially augment radiologists' performance and efficiency.

CLINICAL RELEVANCE/APPLICATION
As the volume demands of radiology increase, a synergistic workflow that combines a radiologist's experience and intuition with the computational power of AI may enhance efficiency and quality.

HONORED EDUCATORS

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PURPOSE
To develop and validate a radiomics-based index for staging liver fibrosis using gadoxetic acid-enhanced hepatobiliary phase (HBP) MR images.

METHOD AND MATERIALS
The institutional review board approved the study, and informed consent was waived. A total of 436 patients with pathologically proven liver fibrosis and gadoxetic acid-enhanced liver MR imaging preceding less than 3 months of histopathologic analysis were included (132, 22, 53, 77, 153 for fibrosis grade 0, 1, 2, 3, 4, respectively). The subjects were randomly divided into the development and test cohorts at a ratio of 3:1. Feature extraction was performed from HBP images, and extracted features included 8 histogram features and 35 high-order textural features. For feature selection and modeling for binary decision to discriminate F0-2 vs. F3-4, we used a logistic regression with elastic net regularization. Performance of the selected model in diagnosing significant fibrosis (>= F2), advanced fibrosis (>= F3), and cirrhosis (F4) was evaluated using the AUROC in the test cohort, and was compared with serum markers (APRI and FIB-4).

RESULTS
Radiomic fibrosis index had significant positive correlation with the pathologic fibrosis stage (p=0.735, P<.001). In the test cohort, AUROCs of the model were 0.9, 0.89, and 0.91 for diagnosing significant fibrosis, advanced fibrosis and cirrhosis, respectively. The Obuchowski index, a weighted average of the AUROC values obtained for all pairs of fibrosis stages, was 0.864 (62% CI, 0.819-0.909) in radiomics model, significantly higher than those of APRI (0.604, P<.001) and FIB-4 (0.621, P<.001). Using the threshold values for radiomic fibrosis index determined in the development cohort, the sensitivities of 78.9% - 92.1%, specificities of 75.4% - 82.0%, and accuracies of 80.3% - 81.3% were achieved for diagnosing significant fibrosis, advanced fibrosis, and cirrhosis in the test cohort.

CONCLUSION
Radiomics analysis of HBP images of gadoxetic acid-enhanced MRI can provide accurate diagnosis and staging of liver fibrosis.

CLINICAL RELEVANCE/APPLICATION
Radiomics analysis of HBP images has a potential usefulness for the noninvasive and accurate diagnosis and staging of hepatic fibrosis.
**SSA07-06**  
**Application Value of Radiomics Features Based on Monochromatic Images of Spectrum CT in the Pathological Grading of Gastric Adenocarcinoma**  
Sunday, Nov. 25 11:35AM - 11:45AM Room: N226

**Participants**  
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**PURPOSE**  
To evaluate the clinical value of radiomics features based on monochromatic images of spectrum CT in the pathological grading of gastric adenocarcinoma.

**METHOD AND MATERIALS**  
Retrospectively 196 patients with gastric adenocarcinoma who underwent upper or total abdominal GSI scanning using the Discovery 750 CT machine were collected, who were divided into poorly differentiated group (Group A) and moderately-well differentiated group (Group B) according to pathological results. High-quality, standardized venous phase single-energy images of 70 keV were obtained from the AW4.6 workstation, and then radiomics features based on the monochromatic images were extracted and a Logistic regression model was established by the dimensionality-reduced features. The efficacy of the Logistic regression model was evaluated by the receiver operating characteristic curve (ROC) and its accuracy was verified. At the same time, the grading results and performance of conventional energy spectrum parameters were compared and analyzed.

**RESULTS**  
The grading efficacy of the normalized iodine (water) concentration of conventional spectral parameters was 0.668. The area under the ROC curve (AUC) of the Logistic regression model was 0.872 (sensitivity was 73.3% and specificity was 83.3%) and the diagnostic accuracy was 78.3%.

**CONCLUSION**  
Radiomics features based on the single-source dual-energy CT monochromatic images can non-invasively differentiate gastric adenocarcinoma from poorly differentiated and moderately-well differentiated tumors. Its efficacy is better than that of conventional spectral CT.

**CLINICAL RELEVANCE/APPLICATION**  
Radiomics features based on the single-source dual-energy CT monochromatic images can provide more quantitative and repeatable information for clinical treatment options and preoperative evaluations.

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**SSA07-07**  
**Multi-Feature Based CT Radiomic Signature Peroperatively Predicts Lymph Node Metastasis in Advanced Gastric Cancer**  
Sunday, Nov. 25 11:45AM - 11:55AM Room: N226

**Participants**  
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**PURPOSE**  
To investigate whether the method of deep learning could improve the performance of radiomic features, and to build a radiomic signature for preoperative prediction of lymph node metastasis (LNM) in patients with advanced gastric cancer (AGC).

**METHOD AND MATERIALS**  
In this ethical-approved retrospective study, we collected a primary cohort consisting of 110 patients from Center 1 and a validation cohort consisting of 121 patients from Center 2. A total of 521 features were extracted from venous-phase CT images. The features could be divided into two groups: deep learning features and conventional hand-crafted features. Based on the whole feature set and the hand-crafted-only feature set respectively, RELIEFF and support vector machine model were implemented to select key features and build two radiomic signatures to yield quantitative risk for LNM. The predictive performances of the signatures were evaluated by receiver operator characteristics analysis and accuracy analysis in the external validation cohort.

**RESULTS**  
Combining the deep learning features and conventional features, the multi-feature based CT radiomic signature outperformed the conventional signature (area under the curve: 0.799 vs. 0.735 in the external validation cohort). It showed powerful predictive ability of discriminate non-N0 patients from N0 patients with accuracies of 0.764 (95% confidence interval [CI]: 0.673-0.839) and...
0.736 (95% CI: 0.648-0.812) in the primary and validation cohorts respectively.

CONCLUSION
Taking advantages of the novel deep learning method and the conventional machine learning method, radiomic signature could serve as a useful tool for preoperative LNMI status prediction in patients with AGC.

CLINICAL RELEVANCE/APPLICATION
Multi-feature based CT radiomic signature has potential in the preoperative non-invasive prediction of lymph node metastasis and facilitate the clinical strategy.

SSA07-08  Correlation Analysis of Spectral CT Parameters and K-ras Gene Mutation in Colorectal Cancer

Sunday, Nov. 25 11:55AM - 12:05PM Room: N226

Participants
Dan Wang, Lanzhou, China (Presenter) Nothing to Disclose
Junlin Zhou, Lanzhou, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
To evaluate the relationship between K-ras mutation of colorectal cancer and the quantitative parameters and qualitative parameters with spectral CT.

METHOD AND MATERIALS
A retrospective analysis of 66 cases of colorectal adenocarcinoma with K-ras mutation confirmed by surgical or endoscopic biopsy was performed by spectral CT dual-phase enhanced scans. The relationship between K-ras mutation and the qualitative and quantitative parameters of CT was statistically analyzed. The CT qualitative evaluation included the location of the tumor, the thickening of the intestinal wall, the infiltration of perienteral fat, and the enlargement of the lymph nodes; the parameters of the CT quantitative assessment include the 40~140keV single energy CT, the iodine (water) concentration, the water(iodine) concentration, the normalized iodine concentration(NIC) and the spectrum curve slope in the arterial and venous phase. The slope is calculated according to the following formula: slope = (CT40keV-CT100keV) /60. Chi-square test was used to statistically analyze the correlation between CT qualitative signs and K-ras mutation status. Independent sample t-test was used for statistical analysis to evaluate the correlation between spectral CT features and K-ras mutations.

RESULTS
K-ras mutations were positive in 32 (48%) of the 66 patients. The colorectal cancer patients with K-ras mutation were multiple in the right hemicolon($x^2=8.09$, $P=0.007$), eccentric thickening($x^2=12.17$, $P=0.001$), and more perienteric lymph nodes($x^2=12.17$, $P=0.001$), which were not related to the degree of fat infiltration around the lesions, and the extent of perianal invasion($P>0.05$). The iodine concentration($t=-3.47$, $P=0.002$), NIC($t=-3.18$, $P=0.004$), the slope of the spectrum curve($t=-3.58$, $P=0.001$) and the CT value of the low energy level (40~70 keV) ($P<0.05$) in arterial phase were increased in the K-ras mutation-type colorectal cancer patients than the wild-type ones.

CONCLUSION
K-ras mutations in colorectal cancer correlated with a part of spectral CT quantitative parameters and qualitative parameters.

CLINICAL RELEVANCE/APPLICATION
K-ras mutations could be initially judged by qualitative and quantitative parameters of spectral CT.

SSA07-09  MRI-Based Radiomics Analysis for Predicting KRAS Mutation in Patients with Rectal Cancer

Sunday, Nov. 25 12:05PM - 12:15PM Room: N226

Participants
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PURPOSE
Genetic profiling of tumors is important for personalized treatment through the development of targeted therapies. For patients with suspected or proven metastatic rectal cancer, the identification of KRAS/NRAS/BRAF mutations is of great significance. Either of the mutations predicts a lack of response to cetuximab and panitumumab, which is important for the individual treatment strategy. Therefore, our study was to investigate the value of radiomics analysis for predicting KRAS mutation in patients with rectal cancer.

METHOD AND MATERIALS
A total of 128 patients with histopathologically confirmed rectal cancer who underwent preoperative MR imaging and postoperative KRAS mutation test without any preoperative chemoradiotherapy were divided into the primary cohort (n=89) and the validation cohort (n=39). MRI-based radiomics features were extracted from oblique axial T2-weighted images. The independent two-sample t test, Kruskal-Wallis test, and Pearson correlation analysis were used for features selection. A radiomics signature was built and multivariable logistic regression analysis was used to develop the radiomics model including radiomics features and independent clinicoradiologic risk factors. The performance of the radiomics model was assessed by the receiver operating characteristic curve (ROC) and decision curve analysis.

RESULTS
A total of 385 radiomic features were extracted from each patient, and 12 radiomics features were selected for the radiomics signature. The radiomics signature was significantly associated with KRAS mutation (P<0.001). The areas under the ROCs were 0.845 in the primary cohort and 0.767 in the validation cohort. Decision curve analysis confirmed the clinical utility of the radiomics model. The clinical background and tumor MRI-staging showed no significant correlation with KRAS mutation.

**CONCLUSION**

The MRI-based radiomics model could be used to predict the KRAS mutation in patients with rectal cancer, which could be helpful for individual treatment strategy.

**CLINICAL RELEVANCE/APPLICATION**

(dealing with MRI-based radiomics ) "The MRI-based radiomics model could be used to predict the KRAS mutation in patients with rectal cancer, which could be helpful for individual treatment strategy"
MRI-Based 3D Models of the Pelvis Can Replace CT-Based 3D Models for Range of Motion Analysis in Femoroacetabular Impingement

Sunday, Nov. 25 10:45AM - 10:55AM Room: E353B

Purposes

Although femoroacetabular impingement (FAI) describes a dynamic osseous abutment of the femur against the acetabulum, current standard imaging assessment is static. Recently CT-based impingement analysis was introduced whereas MRI would offer a radiation-free alternative. Thus we asked (1) what is the mean distance between surface points of 3D pelvis models derived from CT/MRI; (2) whether impingement-free range of motion correlates between CT and MRI; (3) and whether zones of impingement match for 3D models based on CT and MRI?

Methods and Materials

IRB-approved comparative, retrospective study of 20 symptomatic hips with FAI. 3D CT scans (isovoxel: 1mm³) of the entire pelvis and the distal femoral condyles were obtained. Preoperative MR arthrograms of the hip were obtained including 0.8mm³ isovoxel T1 3D VIBE- and 1mm³ isovoxel T1 VIBE DIXON sequences of the entire pelvis and the distal femoral condyles. Threshold-based manual segmentation was performed using commercial software (AMIRA). Both 3D models were compared with inhouse developed software which includes two specific algorithms for detection of the acetabular rim and for detection of the center of rotation. We calculated (1) percentage of the surface points with < 1mm difference between the CT-based and MRI-based 3D models; (2) assessed correlation of impingement-free range of motion (in: flexion; extension; internal rotation 90° of flexion; external rotation in 90° of flexion; abduction; adduction) between CT and MRI and (3) compared location of impingement zones between CT and MRI using the clock-face system which divides the femur and acetabulum into 12 ‘hour’ positions.

Results

(1) 83% and 79% of the surface points of the proximal femur respectively of the acetabulum differed <1mm between the CT-based and MRI-based 3D models. (2) Correlation for the range of motion values was excellent (spearman rho=0.993, p<0.05) between CT and MRI. (3) Location of impingement did not differ between CT-based and MRI-based range of motion analysis in 12/12 acetabular and 11/12 femoral clock-face positions.

Conclusion

MRI-based 3D models of the pelvis can replace CT-based 3D models for range of motion analysis in femoroacetabular impingement

Clinical Relevance/Application

3D-MRI based impingement analysis of the hip is a further step towards non-invasive, personalized surgical planning of FAI especially for complex deformities such as abnormal femoral torsion.

Awards

Student Travel Stipend Award

Participants

Karen C. Chen, MD, Providence, RI (Moderator) Nothing to Disclose
Matthew D. Bucknor, MD, San Francisco, CA (Moderator) Nothing to Disclose

104th Scientific Assembly and Annual Meeting
November 25-30 | McCormick Place, Chicago

SSA15-02 Does 3DMR Provide Equivalent Information as 3DCT for the Pre-Operative Evaluation of Adult Hip Pain Conditions of Femoroacetabular Impingement and Hip Dysplasia?

Sunday, Nov. 25 10:55AM - 11:05AM Room: E353B

Awards

Student Travel Stipend Award

Participants
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PURPOSE
Femoroacetabular impingement (FAI) and hip dysplasia (HD) are frequently evaluated by isotropic CT (3DCT) for preoperative planning at the expense of radiation. The aim was to determine if isotropic MRI (3DMR) imaging can provide similar quantitative and qualitative morphological information as 3DCT.

METHOD AND MATERIALS
25 consecutive patients with a final diagnosis of FAI or HD were retrospectively selected from December 2016 - December 2017. Two readers (R1, R2) performed quantitative angular measurements on 3DCT and 3DMR, blinded to the diagnosis and each other’s measurements. 3DMR and 3DCT of the hips were qualitatively and independently evaluated by a radiologist (R3), surgeon (R4), and fellow (R5). Interobserver and intermodality comparisons were performed.

RESULTS
Quality was good to excellent on all 3DCT and 3DMR reconstructions. The ICC was good to excellent for all measurements between R1 and R2 (ICC: 0.60-0.98) and the majority of intermodality measurements for R1 and R2. Average inter-reader and inter-modality PABAK showed good to excellent agreement for qualitative reads. On CT, all alpha angles (AA) were significantly lower in dysplasia patients than in cam patients (p<0.05). Lateral center-edge angle (LCEA) at the anterior, center, and posterior acetabulum were significantly lower in dysplasia than in cam patients (p<0.05). On MR, AA at 12, 1, and 2 o’clock, and LCEA at center were significantly lower in dysplasia patients than in cam patients (p<0.05).

CONCLUSION
Strong interobserver and intermodality correlations of hip morphology suggest that 3DMR has good potential to replace 3DCT and serve as a one-stop modality for bone and soft tissue characterizations in the pre-operative evaluation of FAI and HD.

CLINICAL RELEVANCE/APPLICATION
In patients with symptomatic FAI and HD, 3DMR can replace 3DCT in the pre-operative evaluation, thereby reducing radiation, time, cost, and discomfort for the patients.

SSA15-03 MR Texture Analysis of Acetabular Subchondral Bone Can Discriminate Between Normal and Cam Positive Hips

Sunday, Nov. 25 11:05AM - 11:15AM Room: E353B

Participants
Taryn Hodgdon, MD, Ottawa, ON (Presenter) Nothing to Disclose  
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Kawan S. Rakhra, MD, Ottawa, ON (Abstract Co-Author) Nothing to Disclose

PURPOSE
To assess whether texture analysis of acetabular subchondral bone on MRI can differentiate between normal and cam positive hips.

METHOD AND MATERIALS
IRB-approved, retrospective case-control study analyzing MR images in subjects with and without cam morphology of the proximal femur (n=68: 19 controls, 25 asymptomatic cam and 24 symptomatic cam-FAI). All subjects underwent unilateral 1.5T hip MRI. The acetabular subchondral bone was contoured manually as a volume of interest (VOI) on sagittal PD images. 3D histogram and second order texture features were evaluated for the global acetabular VOI for each subject using MaZda (v4.6). Differences between controls and asymptomatic or symptomatic cam hips were explored using Mann-Whitney U tests with post-hoc Bonferroni correction. Intra-acetabular variations in texture were assessed by subdividing each VOI into anterior and posterior segments in the sagittal plane and into medial, middle, and lateral segments in the coronal plane, generating 6 ROIs. Between groups and within-subjects differences in texture features were assessed using mixed model ANOVAs. Features were used to train a series of gradient boosted tree models using the R package “xgboost”.

RESULTS
Both asymptomatic and symptomatic cam-FAI hips demonstrated higher gray-level variance and lower kurtosis compared to controls (p<0.003 for each). Gray-level co-occurrence features f3, f4, and f7 were significantly higher in cam positive hips compared to controls (p<=0.003 for each). Sub-region analysis revealed no significant interactions between subject group and ROI. The post-validation classification accuracy achieved by each gradient boosted tree model was 72% (control vs asymptomatic) and 79% (control vs symptomatic cam-FAI).

CONCLUSION
Texture features extracted from MRI can detect subtle differences in subchondral bone architecture between controls and cam positive hips, regardless of patient symptom status.
Postoperative, Traction MR Arthrography in Patients with Persisting Pain After Hip Arthroscopy for FAI Reveals Unexpected High Prevalence of Osseous Deformities and Intra-Articular Lesions Due to Under-/ or Overcorrection

Sunday, Nov. 25 11:15AM - 11:25AM Room: E353B

Participants
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Ehrenfried Schmaranzer, St. Johann in Tirol, Austria (Abstract Co-Author) Nothing to Disclose

PURPOSE

Numbers of hip arthroscopies for FAI correction have risen exponentially, leading to an increase of patients with persistent pain who undergo postoperative MR imaging. To assess prevalence of new/residual (1) osseous deformities, (2) intra-articular lesions and (3) progression of osteoarthritis in symptomatic patients undergoing pre- and postoperative MR imaging after hip arthroscopy.

METHOD AND MATERIALS

IRB-approved, retrospective study. Between 2010-17, 806 patients underwent arthroscopic FAI correction and/or labrum surgery. Database was reviewed for symptomatic patients with complete radiographs and traction MR arthrography (MRA) of the hip (1.5 T) obtained before and after hip arthroscopy according to the routine protocol. 49 patients were included: mean age 29 ± 10 years, 67% female. Traction was applied using a MR-compatible traction device with weight-adaption. One reader assessed pre- and postoperative images. (1) Acetabular coverage (LCE<25° = dysplasia, LCE>39° = pincer deformity) and Tönnis osteoarthritis (OA) grade were assessed on AP pelvic views. Cam deformity was defined (a>60°) on radial MR images. Femoral torsion measurements were only available for postoperative MRI (low/high torsion: <5°/>30°). (2) Presence of residual tears-, retears of the labrum, capsular adhesions/defects was assessed on traction MRA. (3) OA progression on traction MRA was defined as new acetabular/femoral cartilage lesions and osteophytes formation.

RESULTS

(1) Preoperatively 42 (86%) hips showed deformities: 2 (4%) dysplastic-, 11 (22%) pincer- and 39 (80%) cam deformities. Postoperatively 39 (80%) hips showed deformities; 9 (18%) dysplastic-, 8 (16%) pincer-, 20 (41%) cam deformity, 4 (8%) hips with torsion <5°, 10 (20%) hips with torsion >30°. (2) Postoperatively 14 (29%) cases with residual-, 12 (24%) cases with labrum retears were observed. 6 (12%) hips had capsular adhesions, 22 (45%) had capsular defects. (3) Radiographic OA progression was observed in 5 (10%) hips, in 14 (30%) hips on traction MRA.

CONCLUSION

Prevalence of osseous deformities due to over- or undercorrection and intra-articular lesions is high after failed hip arthroscopy. Traction MRA was useful for detection of OA progression.

CLINICAL RELEVANCE/APPLICATION

Identification of osseous over-/undercorrection after failed hip arthroscopy is essential because open surgical approaches must be considered for correction of dysplasia and abnormal femoral torsion.

Comparison of Lateral Centre Edge Angle and Sourcil Angle Measurements on "Ghost" 3D Volume Rendered CTs and Plain Radiographs

Sunday, Nov. 25 11:25AM - 11:35AM Room: E353B

Participants
Madhvi Patel, BSC,MBBS, London, United Kingdom (Presenter) Nothing to Disclose
Martin Siebachmeyer, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
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Jonathan Hutt, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Nikolaos Papadakos, Tooting, United Kingdom (Abstract Co-Author) Nothing to Disclose

PURPOSE

Comparison of lateral centre edge angle and sourcil angle measurements on "Ghost" 3D volume rendered CTs and plain radiographs.

METHOD AND MATERIALS

A retrospective single-centre observational study evaluating the degree of agreement between measurements of lateral centre edge angle on CT and plain radiographs in 50 hips. Measurements of LCEA and sourcil angle were made on AP radiographs and ‘Ghost’ CT. All patients who were under orthopaedic investigation for femoro-acetabular impingement, had both a pelvic radiograph
and CT of at least one hip were included. Patients with severe anatomic deformity or those who were post-operative were excluded from the study. A paired sample t-test was performed to determine if there was a significant difference between measurements on plain radiograph and 'Ghost' CT, with the null hypothesis stating no significant difference.

RESULTS

On plain film the mean of the LCEA was 31.60, standard deviation = 8.254; and on CT "Ghost" images the mean LCEA was 30.96, standard deviation = 8.315 (paired t-test: p < .002). The confidence interval is 0.25 to 1.03. On plain film the mean of the Sourcil angle was 6.20, standard deviation = 4.848; and on CT "Ghost" images the mean of LCEA was 6.76, standard deviation = 4.841 (paired t-test: p < .016). The confidence interval is -1.19 to -1.17. The results show that there is a statistical difference between measurements of LCE and sourcil angles made on plain radiographs and CT, but the confidence interval is small. We can be 95% sure that the true mean angle lies within a range of 1.28 degrees for lateral centre edge angle and a range of 0.02 degrees for the sourcil angle.

CONCLUSION

Although there is a statistical difference between measurements of LCE and sourcil angles made on plain radiographs and "Ghost" CT the narrow confidence interval infers that the difference is actually quite small and in clinical practice this would be clinically insignificant. This would preclude the need for plain radiographs and reduce the radiation dose in young patients who ultimately require CT imaging as part of their femoro-acetabular impingement workup.

CLINICAL RELEVANCE/APPLICATION

Measurements of LCEA and sourcil angles on 'Ghost CT' are clinically indifferent and can be used to preclude the need for plain radiographs in the work up of FAI in young patients with hip pain.

SSA15-06  The Puck Stops Here: An Adaptive Response of the Hip Observed with MRI and Unique to Super External Rotators

Participants
Matthew Bober, MD, Philadelphia, PA (Presenter) Nothing to Disclose
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PURPOSE

Overhead athletes rely on extreme ranges of motion to excel in their respective fields, leading to structural changes including capsular and osseous overgrowth, which in turn contribute to overuse lesions including SLAP and unique impingement syndromes. Super external hip rotators, in particular hockey goalies, similarly rely on tremendous ranges of motion to excel at their avocation. We sought to compare hip capsule thickness in hockey goalies with age and gender matched controls in order to describe MRI findings of adaptive response of the hip.

METHOD AND MATERIALS

Retrospective cohort study examining the hip capsule thickness of hockey goalies with other male athletes aged matched at 20-30 years. Capsule thickness was used as a marker for adaptive response at the hip as this was described previously with adaptive response in the shoulder. Power analysis was performed and determined that a sample size of 17 was selected for each group. Measurements were performed at the anterior, middle, and posterior capsule regions on coronal non-fat saturated T1 MRI images at the level of the femoral head and neck. A two tailed t-test was then conducted to analyze the two groups.

RESULTS

The hip capsule was statistically thicker in super external rotators at each region when compared with other age matches athletic males. The average capsule thickness at the femoral head in the control group ranged from 8 - 9 mm and in the goalies group from 10 - 12 mm (p values ranged from 0.001 and 0.007). At the femoral neck, the control group capsule thickness was between 11 - 13 mm compared to 16 - 18 mm for the super external rotators (p-values between 0.002 and 0.01).

CONCLUSION

Hip super external rotating hockey goalies have a thicker hip capsule than their age and gender matched controls at both the level of the femoral head and neck.

CLINICAL RELEVANCE/APPLICATION

Hip super external rotators adapt with capsular thickening, which may predispose to hip pathology known to be prevalent in such athletes such as femoroacetabular impingement, labral tears, and early osteoarthritis. This adaptive hip capsular thickening should be observed at MRI, and should be correlated with other pathologies on a larger scale with a goal of prevention and early intervention.

SSA15-07  Diagnostic Performance of Magnetic Resonance Imaging in Detecting Syndesmotic Injuries: A Meta-Analysis

Participants
Delaram Shakoor, MD, Baltimore, MD (Presenter) Nothing to Disclose
Lew Schon, MD, Baltimore, MD (Abstract Co-Author) Royalties, DJO, LLC; Royalties, Arthrex, Inc; Royalties, DARCO International, Inc; Royalties, Gerson Lehman Group, Inc; Royalties, Zimmer Biomet Holdings, Inc; Royalties, Reed Elsevier; Speakers Bureau, Tornier, Inc; Speakers Bureau, Zimmer Biomet Holdings, Inc; Speakers Bureau, BioMimetic Therapeutics, Inc; Consultant, Zimmer Biomet Holdings, Inc; Consultant, BioMimetic Therapeutics, Inc; Consultant, Guidepoint Global, LLC; Consultant, Gerson Lehman Group, Inc; Consultant, Tornier, Inc; Consultant, Wright Medical Technology, Inc; Consultant, Royer Medical, Inc; Consultant,
PURPOSE

Distal tibiofibular syndesmotic injuries are common and occur in association with ankle sprains and ankle fractures. There are conflicting reports in the literature regarding the diagnostic performance of magnetic resonance (MR) imaging in detecting these injuries. Therefore, in this meta-analysis we intend to determine diagnostic performance of MR-imaging in detecting syndesmotic injuries, using open or arthroscopic surgery as the standard of reference.

METHOD AND MATERIALS

A comprehensive literature search (until March 2018) was performed and original research studies reporting diagnostic performance of MRI and MR arthrography (MRA) in detecting syndesmotic injuries were included. Pooled values of sensitivity and specificity were calculated using fixed or random effect models based on the level of heterogeneity.

RESULTS

Out of 421 identified records, seven studies (309 MRI examinations) were included. Two studies (65 ankles) also reported the results of indirect MRA (iMRA) while other two studies (53 ankles) reported the results of direct MRA. There was no publication bias according to Deeks funnel plot asymmetry test (P=0.2) and meta-funnel. Pooled values of sensitivity were 89% [95% confidence interval (CI): 84%-94%] for non-enhanced MRI, 91% (CI: 79%-98%) for iMRA and 92% (CI: 73%-99%) for MRA. Pooled values of specificity of MRI, iMRA and MRA were 88% (CI: 82%-93%), 91% (CI: 82%-96%) and 67% (CI: 35%-90%), respectively. High degree of heterogeneity was observed in all modalities (I² >50%). Comparing diagnostic odds ratios (DOR) of MRI with iMRA yielded no significant result (relative DOR (rDOR):0.41, P=0.5). No significant difference was observed between DORs of MRI and MRA (rDOR: 1.76, P=0.4). There was no significant difference between DORs of IMRA and MRA (rDOR: 7.69, P=0.2).

CONCLUSION

MRI, iMRA and MRA can accurately detect syndesmotic injuries. The specificity of MRA appeared to be lower when compared to MRI and iMRA.

CLINICAL RELEVANCE/APPLICATION

With high diagnostic performance of conventional non-enhanced MRI, using intravenous or intraarticular gadolinium may not improve the diagnostic performance of MRI examinations.
performance, three readers with different levels of experience independently read the scanned images once and the fused images twice. We analyzed sensitivity, specificity, negative and positive predictive values, accuracy and agreement.

RESULTS
The experienced reader misinterpreted one OFR as false negative, demonstrating a sensitivity of 0.97 and specificity of 1.00. The intermediate reader had perfect accuracy. The inexperienced reader diagnosed two false positive ruptures (specificity: 0.92) in his first, and missed three ruptures (sensitivity: 0.81) in his second read. No differences were significant. Intrareader agreement was 0.95, 1.00 and 0.74 and interreader agreement was 0.90.

CONCLUSION
The proposed OFR enables reliable detection of anterior inferior tibiofibular ligament rupture with excellent inter- and intrareader agreement, making conventional scanning of oblique images redundant.

CLINICAL RELEVANCE/APPLICATION
Presented method enables the creation of additional MRI sequences in a totally different orientation from routine 2D images. Thereby scanning of e.g. oblique images is redundant and MRI scanning time - in our case 28% can be saved.

PURPOSE
The accessory anterolateral talar facet (AALTF) is an anatomic variant that can cause peroneal spastic flatfoot in adolescents and accessory talar facet impingement (ATFI) in adults. The purpose of this study was to assess the relationship between AALTF and tarsal coalitions.

METHOD AND MATERIALS
Retrospective analysis of consecutive patients undergoing MRI ankle over a 2-year period (01/2014 to 12/2015) at our institution was performed. This study received IRB approval and complied with HIPAA guidelines. We reviewed MRIs for presence of AALTF and tarsal coalition. The criteria for identifying AALTF on MRI was facet articulation spreading contiguously from the posterior facet of the talus anterior to the lateral process of the talus. Presence of a tarsal coalition was assessed using MRI, allowing differentiation between types of coalition (cartilaginous, fibrous and osseous). Exclusion criteria were prior surgery, recent trauma, or abnormalities preventing visualization of the talocalcaneal joint.

RESULTS
Of the 391 patients (137 men, 254 women; mean age 45 years) included in this study, 3.6% (14/391) had an AALTF. Of these patients, 29% (4/14) had a tarsal coalition, of which 3 were talocalcaneal (1 osseous, 1 fibrous and 1 cartilaginous) and 1 was calcaneonavicular (fibrous). Of the patients without an AALTF, 2% (9/377) had a tarsal coalition, of which 7 were calcaneonavicular (4 fibrous and 3 cartilaginous), 2 were talocalcaneal (1 osseous, 1 fibrous). One-tailed chi-square tests of independence with Yates correction and odds ratio (OR) calculations were performed to examine the relation between the AALTF and the presence of a tarsal coalition. For the relationship between AALTF and tarsal coalition, χ² = 21.2 (df, 1; n = 391; p < 0.0001; OR 16.3; 95% CI, 4.3-62.1).

CONCLUSION
Our study showed a significant relationship between the presence of an AALTF and tarsal coalition. Our findings indicate that MRI is a valuable test for identifying comorbid findings of AALTF in patients.

CLINICAL RELEVANCE/APPLICATION
The accessory anterolateral talar facet (AALTF) is an anatomic variant that can cause peroneal spastic flatfoot and accessory talar facet impingement (ATFI). Our study showed a significant relationship between the presence of an AALTF and tarsal coalition. Patients undergoing resection for tarsal coalition should be evaluated for AALTF, in order to improve pre-operative planning and postsurgical outcome.
Nuclear Medicine (Chest and Cardiovascular Nuclear Imaging)

Sunday, Nov. 25 10:45AM - 12:15PM Room: S505AB

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Ukihide Tateishi, MD, PhD, Tokyo, Japan (Moderator) Nothing to Disclose
Phillip J. Koo, MD, Phoenix, AZ (Moderator) Advisory Board, Bayer AG; Advisory Board, Johnson & Johnson; ; ;

Sub-Events

SSA16-01  Association Between Asynchrony and Stenoses in Apparently Normal Coronary Arteries

Participants
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PURPOSE

Left ventricular (LV) arteries are considered abnormal if stenosis > 70%, but lesser stenoses may be concerning. Our study was undertaken to determine the % of cases in which stenoses are < 70% & perfusion images suggest apparently normal (ApNl) arteries, yet myocardial flow reserve (MFR) is abnormally low, & whether PET parameters predict magnitude of stenosis.

METHOD AND MATERIALS

Data were analyzed of 105 pts evaluated by Rb-82 rest/regadenoson-stress PET/CT & arteriography, which measured % stenoses. Global ejection fractions (EFs) & regional summed stress score (SSS) & summed rest score (SRS) of relative myocardial perfusion were assessed. Rest & stress systolic & diastolic asynchrony (Asynch) was assessed by a medical imaging physicist who visually scored phase histograms & phase polar maps within a coronary territory using a 5-point scale (0 = normal to 4 = markedly asynchronous extensive territory), based on phase polar maps being out of phase from expected contraction patterns of normal pts. Absolute myocardial blood flow (MBF) was quantified from rebinned first pass dynamic transit images of the Rb-82 bolus injection through the heart chambers, with myocardial flow reserve (MFR) computed as stress-MBF/rest-MBF. ApNl arteries were defined as those with SRS < 4 & SSS < 4 & stenosis < 70%. Following convention, abnormal regional MFR was defined as < 2.0.

RESULTS

Among 315 arteries, 174 had undetectable stenosis, 72 ranged from 25-69% & 69 ranged from 70-100%. Among all arteries, 162 were ApNl with higher MFR than the other 153 arteries (2.65±1.34 versus 1.96±1.26, p < 0.0001). Nonetheless, 35% (56/162) of ApNl arteries had abnormally low MFR < 2.0 (mean = 1.50±0.31). For all arteries, magnitude of % stenosis was most strongly associated with magnitude of Asynch (r = 0.50, p < 0.0001), & significantly associated with stress MBF (r = -0.25, p < 0.0001), SSS (r = 0.24, p < 0.0001), SRS (r = 0.17, p = 0.002), & MFR (r = -0.18, p = 0.002). For ApNl arteries, % stenosis was associated with magnitude of Asynch (r = 0.34, p < 0.0001).

CONCLUSION

In arteries that are apparently normal by relative perfusion assessment & by conventional arteriographic criteria, MFR can nonetheless be abnormally low, with stenoses < 70% associated with regional asynchrony.

CLINICAL RELEVANCE/APPLICATION

It is advisable to measure regional MFR & regional asynchrony for pts with suspected CAD.

SSA16-02  Evaluation of Role of F-18 FDG Cardiac PET and Tc-99m Septanibmy Myocardial Perfusion Imaging in Assessing the Therapeutic Benefit in Patients with Coronary Artery Disease and Left Ventricular Systolic Dysfunction

Participants
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Purposeto evaluate the therapeutic benefit with revascularization and optimal medical treatment (OMT) in patients diagnosed with hibernating myocardium on myocardial perfusion imaging (MPI) using F-18 FDG cardiac PET.

Method and Materials
59 consecutive patients (43 males, 16 females, Mean Age 60.7 ± 9.4 years) with CAD and LV systolic dysfunction who underwent myocardial viability imaging for revascularization work-up and were diagnosed with hibernating myocardium were enrolled in this study. Patients were later treated with either revascularization or OMT and were followed for a median duration of 7.7 months for assessing the therapeutic benefit. Therapeutic benefit was assessed under 3 categories (a) Improvement in functional class (b) Adverse cardiac-events and (c) Improvement in LV function and myocardial perfusion on follow-up resting 99mTc-sestamibi myocardial perfusion imaging.

Results
29 patients underwent revascularization (49%) and 25 patients received OMT (42%). Five patients were lost to follow-up. Patients were matched for baseline characteristics in both treatment arms. On follow-up, significant improvement was noted in NYHA functional class and CCS angina class post-revascularization. No such improvement was noted in the OMT group. The cardiac-event rate of patients in OMT group was significantly higher than that of patients in revascularization group (36% vs. 10.3%; p = 0.046). At 1 year of follow-up, event-free survival in revascularization group was significantly superior compared to OMT group (83.8% vs. 50.8%; p = 0.039). On follow-up resting MPI scan, mean improvement in LVEF in revascularization group was significantly higher than in OMT group (6.0% vs. 1.4%; p = 0.04).

Conclusion
Myocardial viability imaging is a sensitive modality to identify hibernating myocardium in patients with CAD and LV dysfunction and predicting its recovery following revascularization, thereby guiding the optimal treatment strategy for these patients.

Clinical Relevance/Application
Myocardial viability imaging should be performed prior to revascularization in patients with coronary artery disease with left-ventricular dysfunction to help predict recovery post-treatment.

A Comparative Analysis of Myocardial Perfusion on Gated SPECT versus Coronary Atherosclerosis and Calcium Score on 64-Slice CT

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Purpose
The aim of the current study was to compare the results of 64-slice CT and gated SPECT on a regional basis (per vessel distribution territory) in patients with known or suspected CAD.

Method and Materials
Three hundred and seventy five patients underwent both gated SPECT for myocardial perfusion imaging and 64-slice CT for coronary calcium scoring and coronary angiography. The coronary calcium score was determined for each coronary artery. Coronary arteries on multislice CT angiography were classified as having no CAD, insignificant stenosis (<50% luminal narrowing), significant stenosis, or total or subtotal occlusion (>90% luminal narrowing). Gated SPECT findings were classified as normal or abnormal (reversible or fixed defects) and were allocated to the territory of one of the various coronary arteries.

Results
In coronary arteries with a calcium score of 10 or less, the corresponding myocardial perfusion was normal in 96%. In coronary arteries with extensive calcifications (score > 400), the percentage of vascular territories with normal myocardial perfusion was lower, 48%. Similarly, in most of the normal coronary arteries on 64-slice CT angiography, the corresponding myocardial perfusion was normal on SPECT in >94%. In contrast, the percentage of normal SPECT findings was significantly lower in coronary arteries with obstructive lesions (>57%) or with total or subtotal occlusions (<10%) (P < 0.01). Nonetheless, only 42% of vascular territories with normal perfusion corresponded to normal coronary arteries on multislice CTAngiography, whereas insignificant and significant stenosis were present in, respectively, 40% and 18% of corresponding coronary arteries.

Conclusion
Although a relationship exists between the severity of CAD on multislice CT and myocardial perfusion abnormalities on SPECT, analysis on a regional basis showed only moderate agreement between observed atherosclerosis and abnormal perfusion. Accordingly, 64-slice CT and gated SPECT provide complementary rather than competitive information, and further studies should address how these two modalities can be integrated to optimize patient management.

Clinical Relevance/Application
Accordingly, 64-slice CT and gated SPECT provide complementary rather than competitive information.

**SSA16-04 The Association of Carotid Plaque 18F-FDG and 18F-NaF Uptake on PET Scan with Symptomatic Carotid Artery Disease: A Systematic Review and Meta-Analysis**

**Sunday, Nov. 25 11:15AM - 11:25AM Room: S505AB**

**Participants**
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**PURPOSE**
We sought to investigate the ability of 18F-FDG and 18F-NaF PET imaging to identify vulnerable carotid plaques and predict stroke recurrence in the setting of recent cerebrovascular accidents by performing a systematic review.

**METHOD AND MATERIALS**
We performed this study according to the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) group and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines. We performed a systematic review of Ovid MEDLINE, Ovid EMBASE, and the Cochrane Library Databases yielding a total of 4,144 unique articles for screening after de-duplication. These were screened for peer-reviewed journal articles that examined the association between carotid plaque tracer uptake and recent or future ischemic events such as strokes, transient ischemic attacks and retinal artery embolisms. Screened articles were then adjudicated as meeting inclusion criteria by two independent readers.

**RESULTS**
Fourteen articles were included for subsequent analysis. Of those, 11 articles analyzed 18F-FDG uptake in recently symptomatic carotid arteries as compared to asymptomatic carotid arteries. Two of these studies analyzed 18F-NaF uptake as well. The remaining 3 articles investigated the risk of stroke recurrence associated with 18F-FDG uptake. The existing literature demonstrates significant heterogeneity in the PET protocols, reported tracer uptake metrics, and thresholds for positive uptake.

**CONCLUSION**
Our systematic review revealed a growing body of literature supporting 18F-FDG's utility in predicting future stroke recurrence and its modest ability in discerning symptomatic from asymptomatic carotid plaques. Additional studies are needed to elucidate the role of 18F-NaF as compared to 18F-FDG imaging. Further work is needed to define more standardized approaches for PET imaging acquisition and imaging analysis in order to improve the generalizability of this technique to detect high-risk carotid plaques.

**CLINICAL RELEVANCE/APPLICATION**
Carotid atherosclerosis is responsible for 15% of ischemic strokes. Further work is needed to investigate the utility of 18F-FDG and 18F-NaF PET imaging in detecting high-risk carotid plaques.

**SSA16-05 Provider Utilization Trends for Elective Myocardial Perfusion Imaging**

**Sunday, Nov. 25 11:25AM - 11:35AM Room: S505AB**

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**PURPOSE**
To analyze trends in performance of elective stress nuclear myocardial perfusion imaging (MPI) modalities in the Medicare population.

**METHOD AND MATERIALS**
The nationwide Medicare Part B fee-for-service databases for 2004-2016 were reviewed. CPT codes relevant to stress MPI were selected: planar and single photon emission computed tomography (SPECT), and positron emission computed tomography (PET). The databases indicate procedure volume for each code, and these were used to calculate utilization rates per 1,000 Medicare beneficiaries. Elective MPI exams were identified by using place-of-service codes for private offices and hospital outpatient departments (HOPDs). The specialty of the performing physician was determined using Medicare physician specialty codes. Because the Medicare Part B databases are complete population counts, sample statistics are not required.

**RESULTS**
Elective standard (STD) MPI (both planar imaging and SPECT) utilization peaked in 2006 at 74 studies per 1,000 beneficiaries and then progressively decreased to 45 by 2016 (-36%). In 2004, cardiologists' share of elective STD MPI had been 79%, and this steadily increased in subsequent years to 87% in 2016. Cardiologists perform elective STD MPI mostly in private offices where
utilization peaked in 2008 at 50 studies per 1,000 and then declined to 22 in 2016 (-56%). In HOPDs, utilization by cardiologists has increased over the period of the study from 7 studies to 15 (+120%). Utilization in private offices and HOPDs by radiologists has declined from 13 in 2004 to 6 in 2016 (-58%). Elective PET MPI, less frequently used at 3 studies per 1,000 in 2016, maintained an overall net upward trend since 2005, and most of this growth reflected increasing use by cardiologists (90% share in 2016).

CONCLUSION
In the Medicare population, the overall use of elective STD MPI is declining, however cardiologists are performing an increasing market share in the outpatient setting. A shift in place-of-service has been noted with fewer studies performed in private offices and increasing numbers performed in HOPDs. PET MPI utilization, while still not widespread, has grown over the period of the study, reflecting an increasing use by cardiologists.

CLINICAL RELEVANCE/APPLICATION
Cardiologists maintain an increasing share in utilization of elective standard and PET MPI.

SSA16-06 Medium and Large Vessel Vasculitis: Recognizing Patterns on FDG PET-CT

Sunday, Nov. 25 11:35AM - 11:45AM Room: S505AB

Participants
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PURPOSE
The diagnosis of medium to large-vessel vasculitis and the assessment of its activity and extent remain challenging. We assess the clinical utility of FDG PET CT in patients with suspected medium and large vessel vasculitis to evaluate the pattern and extent of vessel involvement.

METHOD AND MATERIALS
100 consecutive patients (64 males and 36 females) with suspected medium and large-vessel vasculitis were evaluated with FDG PET/CT. FDG uptake in the major vessels was visually graded using a four-point scale and quantified with standardised uptake values (SUV max). Patients were further sub-divided into three groups: (a) steroid-naive medium to large-vessel vasculitis (N=34, 69% of total positive patients), (b) vasculitis on steroid treatment (N=15, 30.6% of total positive patients) and (c) no evidence of vasculitis (N=51). Analysis of variance and linear regression were used to investigate the association of FDG uptake with clinical parameters.

RESULTS
FDG-PET revealed pathological findings in 49 of 100 patients. FDG PET/CT was positive (visual uptake >2; equal to or greater than liver) in all patients with steroid-naive medium to large-vessel vasculitis. The thoracic aorta, the carotid and the subclavian arteries were most frequently involved. In these patients, SUVmax values were significantly higher than in the other groups.

CONCLUSION
FDG PET is a sensitive and specific imaging tool for medium and large vessel vasculitis, especially when performed in steroid naive patients. It increases the overall diagnostic accuracy and has an impact on the clinical management in a significant proportion of patients.

CLINICAL RELEVANCE/APPLICATION
FDG-PET should be used in diagnosis and characterisation of medium and large vessel vasculitis to determine optimal treatment methodologies.

SSA16-07 Assessing the Feasibility of 18F-Naf PET/CT to Detect the Atherosclerotic Calcification of Aortic Wall in Rheumatoid Arthritis Patients

Sunday, Nov. 25 11:45AM - 11:55AM Room: S505AB

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PURPOSE
The diagnosis of medium to large-vessel vasculitis and the assessment of its activity and extent remain challenging. We assess the clinical utility of FDG PET CT in patients with suspected medium and large vessel vasculitis to evaluate the pattern and extent of vessel involvement.
Rheumatoid arthritis (RA) has long been associated with increased risk for atherosclerosis. \(^{18}\)F-sodium fluoride (NaF) is a PET tracer that detects calcium deposition in the early stages of atherosclerotic plaque formation. We aimed to assess whether NaF-PET/CT can sensitively discriminate aorta calcification between RA patients and normal subjects.

**METHOD AND MATERIALS**

Fifteen RA patients (11 men, 4 women; mean age 53.8±10.8 y, range 25-64) and fifteen healthy controls (11 men, 4 women; mean age 53.5±11.2 y, range 25-64) were included in this study. Controls were matched to patients by sex and age (±5 years). All subjects in this study underwent NaF-PET/CT scanning 90 minutes after NaF tracer administration. Using OsiriX software, regions of interest were manually drawn around the abdominal aorta wall starting superiorly with the first axial slice containing the left kidney, ending with the last slice before the aortic bifurcation. The global mean standardized uptake value (global SUVmean) was obtained and compared between RA patients and healthy subjects. An unpaired t-test assessed the difference in means of RA group and controls, and a ROC analysis assessed discrimination.

**RESULTS**

The global SUVmean of RA patients ranged from 0.88 to 2.35, and from 0.79 to 1.47 in healthy controls. Furthermore, average global SUVmean scores among RA patients was significantly greater than that of healthy controls. (1.62±0.49 and 1.04±0.16, respectively, P<0.01). ROC analysis revealed fair discrimination between the two groups (AUC = 0.77).

**CONCLUSION**

Our findings indicate that global assessment with NaF-PET/CT is a feasible technique to detect active vascular calcification in the abdominal aorta. Discriminant validity was observed by assessing a known co-morbidity of RA and comparing RA to non-RA. Further studies are needed to validate this technique to diagnose and monitor patients at high risk for atherosclerosis.

**CLINICAL RELEVANCE/APPLICATION**

Global assessment with NaF-PET/CT can determine the degree of active vascular calcification, which can help diagnose, monitor, and assess treatment response in atherosclerosis.

**SSA16-08 F-18 FLT PET/CT for Therapeutic Monitoring in Patients with Cardiac Sarcoidosis: Comparison with F-18 FDG PET/CT**

**Presenters**

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**PURPOSE**

F-18 fluorodeoxyglucose (FDG) PET has been used in sarcoidosis including cardiac involvement for therapeutic monitoring. However, it can be challenging because it accumulates physiologically in normal myocardium. The purpose of this study was to evaluate the ability of F-18 fluorothymidine (FLT) PET for therapeutic monitoring in patients with cardiac sarcoidosis, in comparison with FDG.

**METHOD AND MATERIALS**

FLT and FDG PET/CT studies were performed before and after immunosuppressive therapy in 6 patients with newly diagnosed cardiac sarcoidosis. The patients had fasted for at least 18 h before FDG PET/CT, but were given no special dietary instructions before FLT PET/CT. Uptake of FLT and FDG was examined visually and semiquantitatively using maximal standardized uptake value (SUV).

**RESULTS**

Before therapy, all patients had both cardiac and extra-cardiac thoracic sarcoidosis. Fifteen lesions in cardiac region and 22 lesions in extra-cardiac region were visually detected on both FLT and FDG PET/CT. After therapy, 10 and 8 lesions in cardiac region and 15 and 11 lesions in extra-cardiac region showed no increased uptake on FLT and FDG PET/CT, respectively. On after therapy FLT scan, all SUV for each lesion were lower than those on before therapy FLT scan, and the mean SUVs in cardiac and extra-cardiac lesions decreased significantly (p<0.001 and p<0.001, respectively). On after therapy FDG scan, all SUV for each lesion were also lower than those on before therapy FDG scan, and the mean SUVs in cardiac and extra-cardiac lesions also decreased significantly (p<0.001 and p<0.001, respectively). The mean SUV reductions in cardiac and extra-cardiac lesions on FLT scan were 53% and 57%, respectively. The mean SUV reductions in cardiac and extra-cardiac lesions on FDG scan were 57% and 55%, respectively. No significant difference in SUV reduction was found between FLT and FDG scans.

**CONCLUSION**

This preliminary study indicates that FLT PET/CT, even without the usually necessary fasting, may have the potential to identify the therapeutic response in patients with cardiac sarcoidosis as well as FDG PET/CT.

**CLINICAL RELEVANCE/APPLICATION**

FLT PET/CT, even without the usually necessary fasting, may have the potential to identify the therapeutic response in patients with cardiac sarcoidosis.

**SSA16-09 Feasibility of Using Global Lung FDG Uptake in COPD Patients on PET/CT to Assess the Correlation Between Pulmonary Parenchymal Inflammation and Pulmonary Function Test Indices as well as Emphysema Severity**

**Presenters**

Pegah Jahangiri, MD, Philadelphia, PA (Abstract Co-Author) Nothing to Disclose
PURPOSE

The purpose of this study was to determine the relationship between the degree of pulmonary parenchymal inflammation measured from FDG-PET/CT with the degree of emphysema and also with PFT indices in chronic obstructive pulmonary disease (COPD) patients based on image segmentation and partial volume correction.

METHOD AND MATERIALS

56 COPD patients (51 men; median age 64) who underwent 18F-fluorodeoxyglucose-positron emission tomography/computed tomography (FDG-PET/CT) were studied. Lung parenchymal volume (L), macroscopic emphysema volume (E) and non-emphysematous lung parenchyma mean attenuation (A) were measured from CT images. Uncorrected maximum standardized uptake value of lung (USUVmax) was measured from PET/CT images. A first level of partial volume correction was then applied to account for varying amounts of macroscopic emphysema (CSUVmax) followed by a second level of correction to account for the mixture of air and lung parenchyma at the microscopic level (CCSUVMax). Correlation of fraction of emphysema (F=E/L) with USUVmax, CSUVmax, CCSUVmax were tested using Pearson correlation and linear regression statistical tests. Pearson correlation and linear regression statistical tests were applied to test the correlations of USUVmax, CSUVmax, and CCSUVmax with FEV1/FVC ratio.

RESULTS

Lung USUVmax and CSUVmax were not significantly correlated with fraction of emphysema (r=0.03, p=0.831 and r=0.18, p=0.292, respectively). However, CCSUVmax was significantly positively correlated with fraction of emphysema (r=0.47, p=0.013). Lung CSUVmax and CCSUVmax were significantly negatively correlated with FEV1/FVC ratio (r=-0.49, p=0.026 and r=-0.71, p<0.001, respectively), whereas there was no significant correlation between lung USUVmax and FEV1/FVC ratio (r=-0.25, p=0.073).

CONCLUSION

These data demonstrate that the degree of pulmonary inflammation increases with the degree of emphysema severity and that patients with lower FEV1/FVC ratios have greater degrees of pulmonary parenchymal inflammation based on FDG-PET/CT quantitative assessment. These correlations are more statistically significant when pulmonary FDG uptake is corrected for the partial volume effect, which shows the importance of partial volume correction for accurate quantification of lung disease severity.

CLINICAL RELEVANCE/APPLICATION

Measurement of pulmonary FDG uptake on PET/CT may therefore be useful in the diagnostic and response assessment of patients with COPD.
**SSA21**

**Physics (Dual-Energy/Spectral CT)**

Sunday, Nov. 25 10:45AM - 12:15PM Room: S103AB

AMx PH

AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

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Sub-Events

SSA21-01  **DXA-like Quantification of Bone Mineral Density using Dual-Layer Spectral CT Scout Scans**

Sunday, Nov. 25 10:45AM - 10:55AM Room: S103AB

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**PURPOSE**

Scout scans are a mandatory part of CT examinations, but do not -yet- provide quantitative information. Purpose of this study was to develop and evaluate a method for areal bone mineral density (aBMD) measurement based on dual-layer spectral CT scout scans.

**METHOD AND MATERIALS**

A post-processing algorithm using a pair of 2D virtual mono-energetic scout images (VMSIs) was established in order to semi-automatically compute aBMD at the spine. The method was assessed based on repetitive measurements of the standardized European spine phantom (ESP) at the standard scout scan tube current (30 mA), at other tube currents (10 to 200 mA), as well as with fat-equivalent extension rings simulating different patient habitus, and was compared to dual-energy X-ray absorptiometry (DXA). In two female patients, the feasibility of the method was assessed in-vivo for vertebrae L1 to L4 and the results were compared to age-matched reference values. Finally, BMD was determined in a female patient population (n=31, age range 22-87 years old) with the proposed method, and T-scores were derived from the measurements, taking a young subset of the population as the reference.

**RESULTS**

Derived from standard scout scans, aBMD values measured with the proposed method highly correlated with DXA measurements (r=0.9925), and mean accuracy (DXA: 4.12%, Scout: 1.60%) and precision (DXA: 2.64%, Scout: 2.03%) were comparable. In particular, the scout scan-based method performed better than DXA at low BMD values (accuracy DXA: 8.3%, Scout:4.79%). Moreover, when assessed at different tube currents, aBMD values did not differ significantly (p>=0.20 for all), suggesting that the presented method could be applied to scout scans with different settings. Finally, data derived from sample patients as well as first T-score representations agreed well with BMD values and T-score trend from a reference age-matched population.

**CONCLUSION**

Based on dual-layer spectral CT scout scans, aBMD measurements were fast and reliable and highly correlated with DXA measurements. First measurements on patients were promising. Considering the number of CT acquisitions performed worldwide, this method could allow truly opportunistic osteoporosis screening at a larger scale.
Dual-layer spectral CT frontal scout scans could provide fast and quantitative DXA-like BMD assessment at the spine and allow large-scale, opportunistic osteoporosis screening.

**SSA21-02 Spectral CT Metal Artifact Reduction**

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**PURPOSE**
To evaluate a novel Spectral CT metal artifact reduction method through simulations and phantom experiments using a photon-counting detector.

**METHOD AND MATERIALS**
The proposed constrained 'one-step' Spectral CT Image Reconstruction (cOSSCIR) method addresses beam hardening due to metal by directly estimating basis material maps using a polyenergetic x-ray transmission model. The proposed method enables masking energy windows corrupted by metal on a ray-by-ray basis, for example masking only the lowest energy window in some rays while using information from higher energy windows. The cOSSCIR algorithm includes constraints that mitigate undersampling artifacts that occur when unreliable measurements through metal are masked. A Spectral CT acquisition of a pelvic phantom with Co-Cr-Mo hip prostheses was simulated with four energy windows. An experimental Spectral CT acquisition was performed with a CdTe photon-counting detector, three energy windows, and a phantom with and without metal. For both simulations and experiments, a weighted mask was applied to remove projection data corrupted by metal. cOSSCIR reconstruction was performed by decomposing into bone, water, and copper material maps and then combining the maps to form an effective monoenergetic image. Images were also reconstructed using filtered backprojection (FBP) with and without the Normalized Metal Artifact Reduction (NMAR) technique. CT number error in the region between the metal implants was compared.

**RESULTS**
In the simulation study, the cOSSCIR algorithm reduced the CT number error in the metal artifact streaking region to less than 1 HU error. In the experimental study, the CT number error was 7 HU for cOSSCIR reconstruction with weighted mask, 60 HU for cOSSCIR without masking, 40 HU for FBP +NMAR, and 212 HU error for FBP. The cOSSCIR images did not contain streak artifacts seen in the NMAR images.

**CONCLUSION**
The proposed Spectral CT metal artifact reduction method reduced shading artifacts to <1 HU error in simulations and 7 HU error in experiments, without introducing residual streak artifacts.

**CLINICAL RELEVANCE/APPLICATION**
Metal artifacts in CT images obscure structures, alter CT numbers, challenge diagnosis, and impede radiation therapy planning. The proposed method, which could also be applied to dual-KV systems, corrects metal artifacts without knowledge of the implant material.

**SSA21-03 Areal Bone Mineral Density Estimation Using Dual-Energy Computed Tomography Topograms**

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**PURPOSE**
Dual-Energy X-ray absorptiometry (DXA) is in wide clinical use for the diagnosis and monitoring of osteoporosis. Using DXA, a good estimation of areal bone mineral density (aBMD) can be extracted from two images acquired with different X-ray spectra by subtracting the influence of soft tissue on the total X-ray absorption and isolating the absorption of carbonated hydroxyapatite (HA). Since most clinically performed CT scans include a topogram as a 2D overview image, it would be beneficial to also employ these images for the diagnostic purpose of an aBMD estimation. A prerequisite for this approach is the acquisition of dual-energy topograms, either sequentially, or ideally, using a single scan. In this work, we compared quality and dose of aBMD measurements from a standard DXA (bone densitometry) scan with sequentially acquired dual-energy topograms.

**METHOD AND MATERIALS**
Two anterior-posterior (AP) topograms of a BMD calibration spine phantom (European Spine Phantom, QRM GmbH, Möhrendorf, Germany) were sequentially acquired using a dual source SOMATOM Force CT System (Siemens Healthcare GmbH, Forchheim Germany). In order to maximize spectral separation, tube voltages of 70 kV without and 150 kV with added tin filtration were chosen at tube current time products of 70 and 75 mAs, respectively. The phantom consists of water-equivalent plastic with diameters of 260 mm (lateral) and 180 mm (AP) and holds three anthropomorphic vertebrae, L1-L3, of varying HA content (50, 100 and 200 mg/cm²) in the spongious part of the bone. A custom tool was developed to subtract soft tissue and create aBMD density maps from the input topograms. Deviations from the known aBMD values of 0.5, 1.0 and 1.5 g/cm² of the AP projections of vertebrae L1-L3 were evaluated.
RESULTS
The extracted values for vertebrae L1-L3 from the generated aBMD maps were in good agreement with the ground truth. The mean areal densities and standard deviations for L1, L2 and L3 were 0.493 ± 0.05, 1.01 ± 0.04 and 1.52 g/cm² ± 0.03, respectively.

CONCLUSION
Especially with regard to the advent of energy-discriminating, photon-counting detectors, the work presented here shows a promising new domain for spectrally acquired topograms. This technique might serve as an alternative to using dedicated DXA scanners.

CLINICAL RELEVANCE/APPLICATION
Areal bone mineral density measurement is feasible via topograms with sufficient energy separation acquired via dual-energy CT.

SSA21-04  Monochromatic CT Image Reconstruction via Deep Learning
Sunday, Nov. 25 11:15AM - 11:25AM Room: S103AB

Participants
Wenxiang Cong, Albany, NY (Abstract Co-Author) Nothing to Disclose
Ge Wang, PhD, troy, NY (Abstract Co-Author) Nothing to Disclose
Hongming Shan, Troy, NY (Presenter) Research Grant, General Electric Company

PURPOSE
Develop a deep-learning-based algorithm to achieve monochromatic CT image reconstruction from current-integrating raw data.

METHOD AND MATERIALS
In clinical CT, with a polychromatic x-ray source, raw data are collected in the current-integrating mode. This physical process is accurately described by an energy-dependent non-linear integral model. However, the non-linear model is too complicated to be directly solved for the image reconstruction, and often approximated as a linear integral model known as the Radon/X-ray transform, which basically ignores energy-dependent information. This model mismatch leads to inaccurate quantification of an attenuation image and significant beam-hardening artifacts. Here, we develop a deep-learning-based approach to address the mismatch between the computational process and the physical model. Our method learns a nonlinear transformation from big data to correct measured raw data in accordance with line integrals at a pre-specified monochromatic energy. A multi-layer perceptron (MLP) neural network is designed for this purpose, consisting of four layers, one input layer, two hidden layers, and one output layer. The sigmoid function is used for non-linear activation. The neural network is trained with the ADAM optimization. The training procedure is programmed in Python and the TensorFlow framework on a computer with a NVIDIA Titan XP GPU of 12 GB memory. A set of clinical dual-energy CT datasets of the human abdomen, collected on a GE Discovery CT750 scanner, are used in the training and testing stages to demonstrate the feasibility of the proposed methodology.

RESULTS
The optimization of the neural network has an excellent converging performance, achieving a high accuracy in the monochromatic projection estimation with a relative error of less than 0.2%, overcoming beam hardening effectively.

CONCLUSION
Our approach is capable of learning a nonlinear transformation from big data, making a step forward towards monochromatic imaging directly from single-spectrum energy-integrating data. This is a potential cost-effective alternative to dual-energy CT.

CLINICAL RELEVANCE/APPLICATION
The deep-learning-based reconstruction method may perform monochromatic CT imaging, allowing for applications in lesion detection and tissue characterization, and proton therapy.

SSA21-05  Evaluation of a Spectral Imaging Metal Artifact Reduction Algorithm Using a Novel Image Quality Phantom
Sunday, Nov. 25 11:25AM - 11:35AM Room: S103AB

Participants
Hilde K. Andersen, MSc, Oslo, Norway (Presenter) Nothing to Disclose
Anette Aarsnes, Oslo, Norway (Abstract Co-Author) Nothing to Disclose
Hildur Olafsdottir, Salem, NY (Abstract Co-Author) Research funded, Image Owl, Inc
David J. Goodenough, PhD, Myersville, MD (Abstract Co-Author) Consultant, The Phantom Laboratory
Anne C. Martinsen, Oslo, Norway (Abstract Co-Author) Nothing to Disclose

PURPOSE
To evaluate the performance of a spectral imaging metal artifact reduction algorithm (GSI-MAR) using a novel phantom.

METHOD AND MATERIALS
A Catphan phantom with a CTP682 module (The Phantom Laboratory, Salem, NY, USA) was scanned on a GE Revolution 16 CT scanner (GE Healthcare, Milwaukee, WI, USA) with and without body annulus and with inserts of stainless steel, titanium and PMMA (control). Metal inserts had diameters of 0.5' and 0.25'. Spectral imaging scans were reconstructed in mono-energetic levels of 55 keV, 68 keV and 90 keV, with filtered back-projection (FBP), FBP with metal artifact reduction (MAR), 50% iterative reconstruction (ASIR-V) and 50% ASIR-V with MAR. Standard deviation (SD) as measures of streaking was derived from ROIs surrounding the inserts and in the outer part of the phantom. Low contrast detectability (LCD) close to the inserts was evaluated by two human observers. MTF and NPS were measured for all series.

RESULTS
Titanium did only introduce streaking close to the large insert. Stainless steel introduced large streaking artifacts. For the large titanium insert, MAR reduced SD from 23HU to 11HU without ring, and from 159HU to 14HU with ring. For the large stainless steel insert, MAR reduced SD from 61HU to 10HU without ring, and from 436HU to 23HU with ring. For the control, SD was 4HU without ring and 10HU with ring (all at 68 keV, same trend for 55 and 90 keV). Without the ring, LCD was close to the level of the control for the small inserts and the large titanium insert. For the large stainless steel insert, LCD decreased for 55 and 90 keV, and MAR improved LCD but not to the level of 68 keV and the control. With the ring, LCD decreased for all energies and inserts. For stainless steel, 90 keV had the best LCD, MAR improved LCD for 55 and 68 keV, but only to the level of 90 keV. For titanium, 68 keV had the best LCD, and MAR improved LCD for the small insert. Analyses of NPS and MTF are work in progress.

CONCLUSION

GSi-MAR reduced streaks from titanium and stainless steel and improved LCD close to metal. Optimal energy level and effect of MAR depends on metal type and size, as well as patient size.

CLINICAL RELEVANCE/APPLICATION

The performance of new metal artifact reduction algorithms in CT for different metals is not known. Catphan CTP682 module with metal inserts proved useful in evaluation of one such algorithm, GSI-MAR.

SSA21-06  Limits for Detecting Low Concentrations of Iodine with Dual-Energy Computed Tomography

Participants
Megan C. Jacobsen, BA, Houston, TX (Presenter) Nothing to Disclose
Erk N. Cressman, MD, Houston, TX (Abstract Co-Author) Nothing to Disclose
Xinhui Duan, PhD, Dallas, TX (Abstract Co-Author) Nothing to Disclose
Dianna D. Cody, PhD, Houston, TX (Abstract Co-Author) In-kind support, General Electric Company; Reviewer, ACR CT accreditation program; Researcher, Gammex, Inc
Dawid Schellingerhout, MD, Houston, TX (Abstract Co-Author) Nothing to Disclose
Rick R. Layman, PhD, Houston, TX (Abstract Co-Author) Researcher, Siemens AG

PURPOSE

Multiple studies in the literature have proposed diagnostic thresholds based on Dual-Energy Computed Tomography (DECT) iodine maps. However, it is critical to determine the minimum detectable iodine concentration for DECT systems to establish the clinical significance of various measured quantities for these image types.

METHOD AND MATERIALS

Seven serial dilutions of iohexol were made with concentrations from 0.03 to 2.0 mg iodine/mL in 50 mL centrifuge tubes. The dilutions and one blank with distilled water were scanned five times each in two scatter conditions: a 20.0 cm diameter (Head) phantom and a 30.0 cm x 40.0 cm elliptical (Body) phantom. We utilized six scanners from three vendors, including fast-kVp switching, dual-source, dual-layer detector, and split-filter DECT. Scan parameters and dose were matched as closely as possible across systems, and iodine maps were reconstructed using each vendor's software. Regions-of-Interest were placed centrally within each vial on the iodine map. Mean and standard deviation were calculated across the five scan acquisitions, and linear calibration curves were calculated for each scanner. Using standard analytical methods, the signal region corresponding to a 95% confidence limit was defined as the LOB plus 1.645 times the standard deviation of the 0.5 mg/mL vial and was converted to a likelihood of measuring only water. Subsequently, the Limit of Detection (LOD) in the signal domain was defined as the LOB plus 1.645 times the standard deviation of the 0.5 mg/mL vial and was converted to a concentration using the calibration curves.

RESULTS

We found that the range of LOD was 0.021 - 0.257 mg iodine/mL in the head phantom and 0.113 - 0.547 mg iodine/mL in the body phantom. Higher kVp levels on a given system generally performed better than lower kVp settings in the body phantom.

CONCLUSION

DECT systems available in today's marketplace can detect iodine concentrations as low as 0.113 mg I/mL in an anthropomorphic body phantom, which corresponds to an enhancement of approximately 2.8 HU at 120-kVp.

CLINICAL RELEVANCE/APPLICATION

DECT iodine quantification is a potential imaging biomarker, and we define detection limits for iodine measurements across multiple DECT systems, under which iodine cannot be reliably detected.

SSA21-07  Radiation Dose Efficiency of Multi-Energy CT for Simultaneous Imaging of Multiple Contrast Agents

Participants
Liqiang Ren, PhD, Rochester, MN (Presenter) Nothing to Disclose
Kishore Rajendran, PhD, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Michael R. Bruesewitz, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Joel G. Fletcher, MD, Rochester, MN (Abstract Co-Author) Grant, Siemens AG; Consultant, Medtronic plc; ;
Shuai Leng, PhD, Rochester, MN (Abstract Co-Author) License agreement, Bayer AG
Cynthia H. McCollough, PhD, Rochester, MN (Abstract Co-Author) Research Grant, Siemens AG
Lifeng Yu, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

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PURPOSE

Multi-energy CT (MECT) has been proposed for imaging multiple contrast agents simultaneously, which may allow multi-phase data...
to be acquired in one single scan, potentially reducing radiation dose. This work aims to evaluate the dose efficiency of MECT in two potential applications: iodine/gadolinium (I/Gd) for liver imaging and iodine/bismuth (I/Bi) for small bowel imaging.

**METHOD AND MATERIALS**

Dose efficiency was experimentally evaluated for I/Gd and for I/Bi by comparing a single-scan MECT (MECT_1s) protocol and a traditional two-scan single-energy CT (SECT_2s) protocol. For SECT_2s, an abdominal phantom containing two sets of I samples was designed to mimic enhancement at late arterial and portal-venous phases. For MECT_1s, I/Gd samples were used, with I enhancement corresponding to the late arterial phase and Gd enhancement to the portal-venous phase. Data were acquired on a SECT (120kV) for SECT_2s, and on a dual-energy CT (DECT: 80/Sn150kV or 90/Sn150kV) or a photon-counting-detector (PCD) CT (140kV [25 50 75 90keV]) for MECT_1s, with the total radiation dose from the two scan protocols matched. A generic image-based material decomposition method was used to determine the densities of I/Gd/water, based on which CT biphasic images were synthesized. The noise levels on the original images acquired with the SECT_2s protocol and the synthesized images generated with the MECT_1s protocol were compared. The dose efficiency for I/Bi was evaluated in a similar way except for the phantom design. For SECT_2s, a different abdominal phantom was used, containing one set of I samples and one set of Bi samples mimicking the arterial and enteric enhancement, respectively. For MECT_1s, I/Bi samples was used.

**RESULTS**

For I/Gd, the noise level with the MECT_1s protocol was 500-1600% higher than that with the SECT_2s protocol, given the same total dose. For I/Bi, the noise level with the MECT_1s protocol was 110-230% higher.

**CONCLUSION**

Single-scan MECT imaging using two contrast agents (I/Gd and I/Bi) is intrinsically dose inefficient compared with traditional multiple SECT scans, particularly for I/Gd. The dose efficiency of MECT is highly dependent on the contrast materials used for a particular application.

**CLINICAL RELEVANCE/APPLICATION**

Use of a single-scan MECT protocol for multi-phase liver and small bowel CT imaging is very dose inefficient compared with a traditional dual-scan SECT protocol.

**SSA21-08 Liver Lesion Localization and Classification with Convolutional Neural Networks Comparing Conventional and Spectral Computed Tomography**

Sunday, Nov. 25 11:55AM - 12:05PM Room: S103AB

Participants

Julia Fokuhi, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Shadi Albarqouni, Garching, Germany (Abstract Co-Author) Nothing to Disclose
Manuel Schultheiss, Munich, Germany (Abstract Co-Author) Nothing to Disclose
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Julia Dangelmaier, MD, Munich, Germany (Abstract Co-Author) Nothing to Disclose
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Peter B. Noel, PhD, Munich, Germany (Presenter) Nothing to Disclose

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**PURPOSE**

To localize and classify hepatic lesions with convolutional neural networks (CNNs) and evaluate the performance for different conventional and spectral computed tomography (CT) data.

**METHOD AND MATERIALS**

Contrast-enhanced liver CTs of 172 patients (33 with cysts, 57 with hypodense metastases and 82 healthy) were collected from a dual-layer spectral CT. Automatic liver segmentation was used. The localization and classification tasks were split into two stages: The first CNN was trained to localize hepatic lesions and produce heatmaps showing the location. Only the disease type and no segmentation ground truth was needed for the training. The heatmaps were used to automatically cut a region of interest (ROI) around the predicted lesion. In the second stage, the ROIs were used to train an additional CNN for the classification between healthy, cyst and metastasis. The final evaluation was performed on previously unseen patient data. All experiments were compared for conventional CT data, reconstructed virtual monoenergetic images (VMIs) and iodine concentration maps. The classification performance was evaluated with precision, recall, accuracy and F1-score. The localization results on the test set were compared to the segmentation ground truth. The distance between lesion predictions and true lesions and the localization accuracy were evaluated.

**RESULTS**

The classification of the first CNN for healthy vs. lesion achieved a recall of 0.890, 0.855, 0.798, 0.874, 0.822 for 40 keV, 70 keV and 100 keV VMIs, iodine maps and conventional images, respectively. The localization accuracy and distance between true and predicted lesions presented the best results for low energy VMIs (40 - 70 keV) and iodine maps, outperforming the conventional data. The classification of ROIs into three classes reached the highest accuracy with 70 keV VMIs (84.5 %) compared to conventional data (83.5 %).

**CONCLUSION**

Using CNNs to localize lesions, cut ROIs and perform lesion classification offers a robust automatic workflow. Low energy VMIs show...
Using CNNs to localize lesions, cut ROIs and perform lesion classification offers a robust automatic workflow. Low energy X-rays show several benefits compared to conventional CT: Small lesions were detected with higher accuracies, heatmap results were more reliable and metastases and cysts were classified better.

**CLINICAL RELEVANCE/APPLICATION**

Using convolutional neural networks and spectral CT data for the automatic localization and classification of hepatic lesions has the potential to significantly aid the diagnostic decision process.

**SSA21-09  Realistic Liver Tissue Surrogates for CT Phantom Studies Can Accurately Quantify the Benefits and Limitations of Reduced kV Imaging in CT**

Sunday, Nov. 25 12:05PM - 12:15PM Room: S103AB

Participants
Andre Euler, MD, Durham, NC (Presenter) Fellowship funded, General Electric Company
Justin B. Solomon, PhD, Durham, NC (Abstract Co-Author) License agreement, Sun Nuclear Corporation; License agreement, 12 Sigma Technologies
Paul Fitzgerald, Niskayuna, NY (Abstract Co-Author) Employee, General Electric Company
Ehsan Samei, PhD, Durham, NC (Abstract Co-Author) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammaex, Inc
Rendon C. Nelson, MD, Durham, NC (Abstract Co-Author) Research Consultant, General Electric Company; Research Consultant, Nemoto Kyorindo Co, Ltd; Consultant, VoxelMetrix, LLC; Co-owner, VoxelMetrix, LLC; Advisory Board, Bracco Group; Advisory Board, Guerbet SA; Research Grant, Nemoto Kyorindo Co, Ltd; Speakers Bureau, Bracco Group; Royalties, Wolters Kluwer nv

**PURPOSE**

To assess the utility of a liquid tissue surrogate for the liver (LTSL) to emulate the CT attenuation characteristics of contrast-enhanced liver parenchyma and lesions as a function of tube potential, lesion contrast, phase of enhancement, and phantom size.

**METHOD AND MATERIALS**

A 3D-printed, fillable phantom was used to emulate liver parenchyma and focal lesions. First, we compared the CT attenuation of LTSL-iodine and water-iodine solutions at 80, 100, 120, 140 kV to published patient data. Based on these results, we emulated liver parenchyma in late arterial phase (LA: +92HU at 120kV) and portal venous phase (PV: +112HU at 120kV) using LTSL-iodine. Additional LTSL-iodine solutions emulated hyperattenuating lesions during the LA-phase (lesion-to-parenchyma contrast (CLP) = +5 to +50HU) and hypoattenuating lesions during the PV-phase (CLP = -5 to -50HU). Fat-equivalent plastic rings emulated medium and large patients. Each combination of CLP, phase of enhancement, and phantom size was imaged at 80, 100, 120, 140 kV at constant radiation dose. CT attenuation, CLP, and CNRLP were assessed. A theoretical model estimated CT attenuation, CLP, and CNRLP as a function of tube potential and lesion contrast which was compared to the measured data.

**RESULTS**

LTSL-iodine more accurately emulated the CT attenuation of contrast-enhanced liver parenchyma compared to water-iodine solutions. The theoretical model was confirmed by the empirical measurements using LTSL-iodine solutions: CT attenuation, CLP, and CNRLP increased when the tube potential decreased (P<0.001). This trend was independent of lesion contrast, phase of enhancement, and phantom size. The absolute improvement in CLP and CNRLP at reduced tube potentials, however, was inversely related to the magnitude of CLP at 140kV.

**CONCLUSION**

LTSL accurately emulated the CT attenuation characteristics of contrast-enhanced liver parenchyma and lesions at different tube potentials, lesion contrast, and phase of parenchymal enhancement. The relative improvement in CLP and CNRLP at reduced tube potentials was independent of lesion contrast, phase, and phantom size while the absolute improvement decreased for low-contrast lesions.

**CLINICAL RELEVANCE/APPLICATION**

Liquid tissue surrogates offer a promising tool for liver emulation in multi-energy CT phantom studies. Low contrast lesions, which are most difficult to detect in clinical routine, benefit less from low kV-imaging than high contrast lesions.
RC101

Interstitial Lung Disease: Update 2018

Sunday, Nov. 25 2:00PM - 3:30PM Room: S406A

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
David A. Lynch, MBBCh, Denver, CO (Moderator) Research support, Siemens AG; Research Consultant, PAREXEL International Corporation; Research Consultant, Boehringer Ingelheim GmbH; Research Consultant, F. Hoffmann-La Roche Ltd; Research Consultant, Veracyte, Inc;

Sub-Events

RC101A  Pulmonary Fibrosis

Participants
David A. Lynch, MBBCh, Denver, CO (Presenter) Research support, Siemens AG; Research Consultant, PAREXEL International Corporation; Research Consultant, Boehringer Ingelheim GmbH; Research Consultant, F. Hoffmann-La Roche Ltd; Research Consultant, Veracyte, Inc;

LEARNING OBJECTIVES
1) Understand the radiologic differential diagnosis of fibrotic lung disease. 2) Become familiar with the most recent diagnostic criteria for usual interstitial pneumonia (UIP) on CT. 3) Understand the significance of 'early interstitial abnormality' on CT.

RC101B  Hypersensitivity Pneumonitis

Participants
Santiago E. Rossi, MD, Buenos Aires City, Argentina (Presenter) Advisory Board, Boehringer Ingelheim GmbH; Speaker, Boehringer Ingelheim GmbH; Royalties, Springer Nature

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LEARNING OBJECTIVES
1) Review the most common imaging findings of hypersensitivity pneumonitis (HP) (case-based). 2) Describe clinical manifestations of HP. 3) Identify proposed classification of HP.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Santiago E. Rossi, MD - 2015 Honored Educator

RC101C  Smoking-Related Interstitial Lung Diseases

Participants
Carolina A. Souza, MD, Ottawa, ON (Presenter) Consultant, Pfizer Inc; Consultant, Boehringer Ingelheim GmbH; Consultant, AstraZeneca PLC; Speaker, Pfizer Inc; Speaker, Boehringer Ingelheim GmbH; Speaker, F. Hoffmann-La Roche Ltd; Speaker, AstraZeneca PLC; Advisory Board, AstraZeneca PLC

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LEARNING OBJECTIVES
1) Describe the spectrum of smoking-related interstitial lung diseases and their clinical manifestations. 2) Recognize the high-resolution CT appearances of smoking-related lung diseases. 3) Identify the most common imaging differential diagnoses of smoking-related interstitial lung diseases.

RC101D  Sarcoidosis

Participants
Lacey Washington, MD, Durham, NC (Presenter) Consultant, Novartis AG

LEARNING OBJECTIVES
1) Review the classic clinical and imaging manifestations and common complications of thoracic sarcoidosis. 2) Review less well known clinical features and imaging findings.
Participants
Joseph Jacob, MBBS, MRCP, London, United Kingdom (Presenter) Consultant, Boehringer Ingelheim GmbH; Consultant, F. Hoffmann-La Roche Ltd

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LEARNING OBJECTIVES
1) Understand why computer analysis of CT imaging has relevance in interstitial lung diseases. 2) Understand the limitations of visual CT scoring. 3) Understand the various quantitative analytic techniques/tools. 4) Become aware of the latest results achieved by quantitative tools in predicting outcome across the various interstitial lung diseases.
Opportunistic CT Screening for Osteoporosis, Sarcopenia, and Adiposity

Participants
Robert D. Boutin, MD, Davis, CA (Director) Nothing to Disclose

For information about this presentation, contact:
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LEARNING OBJECTIVES
1) Discuss proposed CT-based definitions of osteoporosis, sarcopenia, and adiposity. 2) Review the potential for clinical impact when using routine CT to screen for osteoporosis, sarcopenia, and adiposity. 3) Highlight practical pearls and pitfalls for diagnostic imagers using opportunistic CT.

ABSTRACT
Non-communicable diseases are now "the world's main killer" [WHO, 2011]. The pandemics of osteoporosis, sarcopenia, and adiposity continue to grow globally as populations age. With more than 100 million CT exams performed annually worldwide, how might CT be used to screen patients efficiently for body composition derangements? This course focuses on the rapidly evolving field of "opportunistic" CT screening for the value-added diagnosis of osteoporosis, sarcopenia, and adiposity, with an emphasis on the clinical consequences of diagnostic imaging, as well as practical pearls and pitfalls.

Sub-Events

OPPORTUNISTIC CT: BOOM OR BUST

Participants
Leon Lenchik, MD, Winston-Salem, NC (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Define opportunistic CT screening.

MUSCLE CT: VALUE-ADDED ASSESSMENT FOR SARCOPENIA

Participants
Robert D. Boutin, MD, Davis, CA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Discuss clinical and CT-based definitions of sarcopenia. 2) Review the potential clinical impact of screening for sarcopenia at the point of imaging care. 3) Highlight practical pearls and pitfalls for diagnostic imagers using opportunistic CT to screen for sarcopenia.

ABSTRACT
This session will focus on the state-of-art imaging of sarcopenia and provide a clinical context by discussing the epidemiology, pathophysiology, consequences, and future directions in the field of sarcopenia. Our goal is to provide radiologists with the foundation needed to help evaluate patients affected by this clinically relevant and increasingly common diagnosis.

BONE CT: OPPORTUNITIES FOR OSTEOPOROSIS

Participants
Robert J. Ward, MD, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To apply currently available CT technologies, both retrospective and prospective, for the identification of patients at risk for osteoporosis in their daily practice.
RC104D  Fat CT: From Research to Patient Care

Participants
Miriam A. Bredella, MD, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Be familiar with assessment of abdominal and intermuscular fat compartments and fat depots in the head and neck using CT. 2) Understand the effects of different fat compartments on cardiometabolic risk. 3) Be familiar with the bone-fat connection.

RC104E  Machine Learning for Body Composition

Participants
Martin Torriani, MD, Lincoln, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Understand basic concepts of artificial intelligence and machine learning. 2) Understand how such techniques can extract body composition data from images. 3) Discuss other applications of machine learning in body composition.

RC104F  Osteosarcopenic Obesity: Why Bother

Participants
Leon Lenchik, MD, Winston-Salem, NC (Presenter) Nothing to Disclose

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llenchik@wakehealth.edu

LEARNING OBJECTIVES
1) Define osteosarcopenic obesity.
RC112

CTA for TAVR and Other Aortic Valve Replacements

Sunday, Nov. 25 2:00PM - 3:30PM Room: N230B

Participants

Jonathon A. Leipsic, MD, Vancouver, BC (Moderator) Speakers Bureau, General Electric Company; Speakers Bureau, Edwards Lifesciences Corporation; Consultant, Heartflow, Inc; Consultant, Circle Cardiovascular Imaging Inc; Consultant, Edwards Lifesciences Corporation; Consultant, Neovasc Inc; Consultant, Sareung Electronics Co, Ltd; Consultant, Koninklijke Philips NV; Consultant, Arineta Ltd; Consultant, Pi-Cardia Ltd; Jean Jeudy JR, MD, Baltimore, MD (Moderator) Nothing to Disclose

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LEARNING OBJECTIVES

1) To review CT imaging requirements for TAVR planning. 2) To provide an overview of default acquisition protocols to ensure robust CT image quality with various CT systems. 3) To provide tips and tricks of how to image challenging patients with renal failure or atrial fibrillation.

Honored Educators

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RC112A Pre-TAVR CT Imaging Protocols

Participants

Stefan L. Zimmerman, MD, Ellicott City, MD (Presenter) Project consultant, Siemens Healthcare; Research grant, American Heart Association;

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LEARNING OBJECTIVES

1) To review CT imaging requirements for TAVR planning. 2) To provide an overview of default acquisition protocols to ensure robust CT image quality with various CT systems. 3) To provide tips and tricks of how to image challenging patients with renal failure or atrial fibrillation.

Honored Educators

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RC112B CTA for Sizing Transcather Heart Valves

Participants

Jonathon A. Leipsic, MD, Vancouver, BC (Presenter) Speakers Bureau, General Electric Company; Speakers Bureau, Edwards Lifesciences Corporation; Consultant, Heartflow, Inc; Consultant, Circle Cardiovascular Imaging Inc; Consultant, Edwards Lifesciences Corporation; Consultant, Neovasc Inc; Consultant, Sareung Electronics Co, Ltd; Consultant, Koninklijke Philips NV; Consultant, Arineta Ltd; Consultant, Pi-Cardia Ltd;

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LEARNING OBJECTIVES

1) Discuss the importance of reproducible and accurate annular anatomical definition. 2) Define the meaning of oversizing in device selection and the role that capture and sealing have to optimize clinical outcomes. 3) Discuss the importance of appropriate sizing to optimize clinical outcomes.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Jonathon A. Leipsic, MD - 2015 Honored Educator

RC112C Aortic Valve Assessment in the Post-TAVR Patient

Participants

Jean Jeudy JR, MD, Baltimore, MD (Presenter) Nothing to Disclose

For information about this presentation, contact:

jjeudy@som.umaryland.edu
Participants
Dominika Sucha, MD,PhD, Utrecht, Netherlands (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand differences in surgical bioprostheses and learn to appreciate normal CT findings after surgical implantation. 2) To review the underlying pathology in biovalve dysfunction and the role of CT. 3) To learn what the surgeon and cardiologist want to know for clinical decision-making. 4) To discuss latest literature and developments.
Advances in CT: Technologies, Applications, Operations-Quantitative CT (QIBA)

Sunday, Nov. 25 2:00PM - 3:30PM Room: E351

LEARNING OBJECTIVES

1) Understand the role of lesion volumetry in CT, especially in the setting of oncologic imaging.
2) Understand the basic methods in lesion volumetry.
3) Understand the factors that influence the measurement of lesion volume in CT.

LEARNING OBJECTIVES

1) Review different dual-energy CT imaging techniques for material identification.
2) Provide an overview of clinically available applications of material identification using dual-energy CT.
3) Identify factors that can affect the reproducibility of quantitative measurements of material composition using dual-energy CT.

LEARNING OBJECTIVES

1) Understand the concept of texture-based image characterization.
2) Identify radiologic tasks in CT that could benefit from image texture analysis.
3) Describe the limitations of these techniques.
Participants
Christopher Lee, MD, Los Angeles, CA (Moderator) Nothing to Disclose

For information about this presentation, contact:
christopher.lee.1@med.usc.edu

LEARNING OBJECTIVES
1) Describe techniques for CTA of the neck, upper and lower extremities. 2) Distinguish common artifacts on CTA of these anatomic regions. 3) Evaluate protocol/scanner modifications for optimal CTA imaging. 4) Formulate a CTA protocol to optimally image acute aortic syndrome. 5) Distinguish the imaging appearances and pitfalls of acute aortic syndrome. 6) Summarize the important measurements that help guide therapy. 7) Describe pre-procedural patient preparation including appropriate patient selection, contraindications, and beta-blockade. 8) Evaluate peri-procedural issues including vasodilation, continued heart rate control, and breathholding. 9) Evaluate Image acquisition including radiation dose reduction techniques and technique choice. 10) Describe postprocedural complications including contrast reactions and their management.

Sub-Events

RC131A Head and Neck CTA
Participants
Alexander Lerner, MD, Los Angeles, CA (Presenter) Research Grant, Koninklijke Philips NV; Research Grant, Bracco Group

LEARNING OBJECTIVES
1) Describe techniques for CTA of the neck, upper and lower extremities. 2) Distinguish common artifacts on CTA of these anatomic regions. 3) Evaluate protocol/scanner modifications for optimal CTA imaging.

RC131B Aortic CTA
Participants
Christopher Lee, MD, Los Angeles, CA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Formulate a CTA protocol to optimally image acute aortic syndrome. 2) Distinguish the imaging appearances and pitfalls of acute aortic syndrome. 3) Summarize the important measurements that help guide therapy.

ABSTRACT
Acute aortic syndrome (AAS) represents the triad of aortic dissection, intramural hematoma, and penetrating atherosclerotic ulcer. Imaging with CTA is essential for the accurate diagnosis of AAS. CTA protocols should optimally image the aorta while minimizing radiation exposure and intravenous contrast administration. Newer CT technology can reduce radiation dose and contrast delivery while preserving image quality. Minimally invasive treatment of acute aortic syndrome with thoracic endovascular aortic repair (TEVAR) has become increasingly popular.

RC131C Cardiac CTA
Participants
Cameron Hassani, MD, Los Angeles, CA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Describe pre-procedural patient preparation including appropriate patient selection, contraindications, and beta-blockade. 2) Evaluate peri-procedural issues including vasodilation, continued heart rate control, and breathholding. 3) Evaluate Image acquisition including radiation dose reduction techniques and technique choice. 4) Describe postprocedural complications including contrast reactions and their management.

Honored Educators
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MSMC21

Cardiac CT Mentored Case Review: Part I (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Nov. 26 8:30AM - 10:00AM Room: S406A

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Jill E. Jacobs, MD, New York, NY (Moderator) Nothing to Disclose

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LEARNING OBJECTIVES
1) To be able to identify and understand normal cardiac anatomy. 2) To be able to identify and understand some of the common coronary anomalies.

Sub-Events

MSMC21A Normal Coronary Anatomy

Participants
Brian B. Ghoshhajra, MD, Waban, MA (Presenter) Research Grant, Siemens Healthcare USA;

MSMC21B Anomalous Coronary Arteries

Participants
Prachi P. Agarwal, MD, Canton, MI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) List the various coronary artery anomalies. 2) Identify the CT imaging features and hemodynamics of clinically significant coronary artery anomalies. 3) Apply the knowledge of treatment options to understand normal postoperative appearance and postoperative complications.
The Many Facets of Organizing Pneumonia: A Rad-Path Guide to Understanding and Diagnosis

Monday, Nov. 26 8:30AM - 10:00AM Room: E351

CH CT

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Jeffrey R. Galvin, MD, Baltimore, MD (Moderator) Nothing to Disclose

LEARNING OBJECTIVES
1) Understand the microscopic anatomy of the lung that explains the high resolution CT findings associated with organizing pneumonia. 2) Improve their diagnostic skills related to the imaging recognition of organizing pneumonia. 3) Recognize the range of injuries and inhaled insults that lead to organizing pneumonia. 4) Apply a new knowledge of the pathways to fibrosis that allows for the differentiation of organizing pneumonia, IPF and diffuse alveolar damage. 5) Appreciate the importance of communication between the clinician, radiologist, and pathologist to improve diagnosis.

ABSTRACT
This presentation will review the histologic and radiologic findings of organization in lung injury due to diffuse alveolar damage, organizing pneumonia and acute fibrinous and organizing pneumonia. It will clarify the role of organizing pneumonia in the pathway to fibrosis that will sharpen the radiologist’s ability to separate the various forms of fibrosis including: idiopathic pulmonary fibrosis, non-specific interstitial pneumonia and diffuse alveolar damage. Finally it will describe the multidisciplinary diagnostic process of which the radiologist is a key member.

Active Handout: Jeffrey R. Galvin

Sub-Events

RC201A Introduction
Participants
Jeffrey R. Galvin, MD, Baltimore, MD (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

RC201B Pathology of Organizing Pneumonia
Participants
Teri J. Franks, MD, Silver Spring, MD (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

Active Handout: Teri J. Franks

RC201C Imaging of Organizing Pneumonia
Participants
Seth J. Kligerman, MD, Denver, CO (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
View learning objectives under main course title.

Active Handout: Seth Jay Kligerman

RC201D Pathways to Fibrosis and Summary
Participants
Jeffrey R. Galvin, MD, Baltimore, MD (Presenter) Nothing to Disclose
LEARNING OBJECTIVES

View learning objectives under main course title.
**RC203**

**Coronary CTA and Calcium Scoring**

Monday, Nov. 26 8:30AM - 10:00AM Room: E263

**LEARNING OBJECTIVES**

1) Discuss the current evidence for using CT-based fractional flow reserve. 2) Describe a potential role for FFRct in the clinical practice of cardiac CT.

**Participants**

Gregory Kicska, MD, PhD, Seattle, WA (Moderator) Nothing to Disclose

**Sub-Events**

**RC203A**  
**CT Derived Fractional Flow Reserve (FFR CT): A Sine Qua Non?**

**Participants**

Eric E. Williamson, MD, Rochester, MN (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Discuss the current evidence for using CT-based fractional flow reserve. 2) Describe a potential role for FFRct in the clinical practice of cardiac CT.

**RC203B**  
**Interpreting and Reporting Cardiac CT - CAD-RADS**

**Participants**

Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Consultant, HeartFlow, Inc; Consultant, General Electric Company;

**LEARNING OBJECTIVES**

1) To review the CAD-RADS lexicon, including assessment categories and modifiers, for coronary CT angiography in the evaluation of acute and stable chest pain. 2) To understand how CAD-RADS can improve patient care through standardized reporting and linking management recommendations to actionable information in the radiology report. 3) To apply appropriate CAD-RADS coding for difficult coronary CT angiography cases.

**RC203C**  
**Added Value of Myocardial Perfusion Imaging in Cardiac CT**

**Participants**

Ricardo C. Cury, MD, Miami, FL (Presenter) Research Grant, General Electric Company; Research Consultant, General Electric Company

**LEARNING OBJECTIVES**

1) To review the literature and available evidence of Myocardial CT perfusion. 2) To evaluate the emerging role of Myocardial CTP in the work-up of patients with suspected or known CAD. 3) To describe the incremental value of Myocardial CTP over CT angiography.

**RC203D**  
**Cardiac CT in Acute Chest Pain: Critical Review of the Evidence**

**Participants**

Marc Dewey, MD, Berlin, Germany (Presenter) Research Grant, General Electric Company; Research Grant, Bracco Group; Research Grant, Guerbet SA; Research Grant, Canon Medical Systems Corporation; Research Grant, European Commission; Research Grant, BiH Digital Health Accelerator; Speakers Bureau, Canon Medical Systems Corporation; Speakers Bureau, Guerbet SA; Speakers Bureau, Bayer AG; Consultant, Guerbet SA; Author, Springer Nature; Editor, Springer Nature; Institutional research agreement, Siemens AG; Institutional research agreement, Koninklijke Philips NV; Institutional research agreement, Canon Medical Systems Corporation; ; ; ; ; ; ;

For information about this presentation, contact:
dewey@charite.de

**LEARNING OBJECTIVES**

1) Get to know the evidence for using CT in patients with acute chest pain. 2) Learn about important details from these studies that will show in which patients CT might have greatest clinical value.

**ABSTRACT**

Several clinical trials and smaller studies looked at the advantages and disadvantages of using CT in patients with acute chest pain. This practical talk about the pivotal facts from these clinical studies will provide the information required for informed decision making with referring physicians.
PURPOSE
To validate the use of image-derived input function of the common iliac artery as an alternative to arterial blood sampling in pharmacokinetic modeling of Ga-68 PSMA-11 uptake using hybrid positron emission tomography and magnetic resonance (PET/MR) imaging in primary prostate cancer.

METHOD AND MATERIALS
This observational prospective study was approved by our Institution's Ethics Committee. Eleven patients with clinically significant prostate cancer underwent a 60-minute dynamic PET/MR scan of the pelvis with an injected dose of Ga-68 HBED-CC-PSMA (Ga-68 PSMA-11). Arterial blood activity was measured by an automatic arterial blood sampling device during the first 10 min and manual blood samples were collected for metabolite analysis and for blood to plasma transformation to derive an arterial input function (AIF). One lesion per patient (with the highest uptake) and the common iliac artery were outlined using isocontour volumes on the PET images. Two image-derived input functions (IDIF) were calculated: whole blood curve (IDIF_bl) and plasma curve (IDIF_pl) corrected by the average plasma-to-blood ratio. An irreversible two-tissue compartment model, with rate constants K1, k2 and k3, were fitted to the data using AIF, IDIF_pl and IDIF_bl and the net influx rate Ki=K1k3/(k2+k3) was calculated. The agreement between K1 and Ki from AIF and IDIF_bl and IDIF_pl were reported by intraclass correlation coefficients (ICC) with 95% confidence intervals.

RESULTS
Ga-68 PSMA-11 was stable in-vivo, not necessitating metabolite correction. The mean plasma-to-blood ratio was 1.63. IDIF underestimated the arterial input function by 50% at the bolus peak and by 20% at late times. For K1, ICC between AIF and IDIF_bl was 0.40 (-0.22, 0.80) and between AIF and IDIF_pl 0.60 (0.04, 0.87). For Ki, ICC between AIF and IDIF_bl was 0.77 (0.34, 0.93) and between AIF and IDIF_pl 0.94 (0.78, 0.98).

CONCLUSION
IDIF plasma curve can be used in clinical practice as an alternative to arterial blood sampling to calculate the uptake of Ga-68 PSMA-11 in prostate cancer patients using hybrid PET/MR imaging.
PSMA-11, but the method requires a known mean plasma-to-blood ratio. Agreement between IDIF whole blood curve and arterial input function was poor to moderate. Underestimation of the IDIF should be explained by partial volume effects.

**CLINICAL RELEVANCE/APPLICATION**

Image-derived plasma curves can be used in clinical practice as an alternative to arterial blood sampling to quantify uptake of Ga-68 PSMA-11 in prostate cancer.

**RC211-03 Dual-Time 68Ga-PSMA-11 Imaging for Biochemically Recurrent Prostate Cancer Using LYSO and SiPM-Based Detectors PET/CT**

Monday, Nov. 26 8:55AM - 9:05AM Room: S505AB

Participants
Heying Duan, Stanford, CA (Presenter) Nothing to Disclose
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Thomas Yohannan, MD, Chicago, IL (Abstract Co-Author) Nothing to Disclose
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Andrei Iagaru, MD, Emerald Hills, CA (Abstract Co-Author) Research Grant, General Electric Company

For information about this presentation, contact: heying@stanford.edu

**PURPOSE**

68Ga-labeled prostate-specific membrane antigen (PSMA-11) is a highly specific tracer for biochemically recurrent prostate cancer at low PSA levels. In this study we aim to compare the diagnostic performance of a new PET/CT scanner (Discovery Molecular Insights - DMI) using silicon photomultipliers (SiPM) detectors vs standard LYSO detectors PET/CT (Discovery 690 - D690) in patients with biochemical relapse following a single injection of radiopharmaceutical.

**METHOD AND MATERIALS**

Forty-four patients were prospectively recruited to undergo imaging on the D690 and DMI scanners, in randomized order. Images from the DMI PET/CT were reconstructed using ToF and a Bayesian penalized likelihood algorithm (Q.Clear®) whereas images from the D690 PET/CT were reconstructed using time-of-flight (ToF) and an ordered subset expectation maximization (OSEM) protocol. Two experienced nuclear medicine physicians reviewed both scans for each patient in random order, recorded the number and location of each lesion, and acquired standardized uptake value (SUV) measurements.

**RESULTS**

Twenty-three patients underwent imaging on the D690 PET/CT first followed by the DMI scanner, and twenty-one underwent scanning in the reverse order. The median PSA was 4.33 ng/mL with one outlier of 1170 ng/mL. PSMA PET detected sites of recurrence in 32/44 (73 %) patients, including 6/12 (50 %) patients with PSA below 1 ng/mL with the lowest PSA and a positive scan at 0.05 ng/mL. The mean lesion SUVmax measurements were higher on DMI than D690 regardless of the timely order of the scan (6.5 vs. 5.7 in D690 scan first and 4.6 vs. 4.2 for DMI performed first). However, the difference in mean lesion SUVmax was only significant for patients scanned on the D690 first (p<0.018).

**CONCLUSION**

These preliminary results suggest that the SiPM-based DMI PET/CT system offers better performance and superior detector technology and image quality compared to conventional LYSO-based D690 PET/CT. These results need to be confirmed in larger studies.

**CLINICAL RELEVANCE/APPLICATION**

SiPM-based DMI PET/CT system seems to offer better performance and superior detector technology and image quality compared to conventional LYSO-based D690 PET/CT.

**RC211-04 Same Day PET/CT and PET/MRI with 68Ga-PSMA in the Evaluation of Biochemical Recurrence of Prostate Cancer**

Monday, Nov. 26 9:05AM - 9:15AM Room: S505AB

Participants
Marcelo L. Cunha, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Akemi Osawa, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Guilherme Campos, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Lilian Y. Yamaga, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Julio Cesar Oliveira, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Ricardo C. Fonseca, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Taise Vitor, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Fernando I. Yamauchi, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Thais Mussi, MD,PhD, Sao Paulo, Brazil (Presenter) Nothing to Disclose
Ronaldo H. Baroni, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose

**PURPOSE**

To compare PET/CT and PET/MRI with 68Ga-PSMA in patients with radical prostatectomy and biochemical recurrence (BCR).

**METHOD AND MATERIALS**

This is a prospective, IRB approved study. 29 patients with prostate cancer were referred to our department to investigate BCR
The purpose of our study was to assess whole-body MRI (wb-MRI) for lesion detection of biochemical relapse in prostate cancer (PCa) patients after curative treatment in comparison to 68Ga-PSMA PET/CT.

**METHOD AND MATERIALS**

This is a prospective, IRB-approved study of 30 patients (age: 65.5 ± 9.6 years) with newly documented biochemical relapse of PCa (mean prostate-specific antigen (PSA) 2.11 ± 1.97 ng/ml) after curative therapy. All patients underwent both wb-MRI including a dedicated pelvic imaging protocol and PET/CT with 167 ± 35 MBq 68Ga-PSMA within a time window of 10.5 ± 9.5 days. PET/CT and MRI datasets were separately evaluated regarding PCa lesion count, lesion type, localization, and diagnostic confidence (3-point scale; 1-3) by two physicians. The reference standard was based on histopathology results, changes of PSA after targeted irradiation, follow-up imaging, and clinical data. Lesion-based and patient-based detection rates were compared using chi2 test. Differences in diagnostic confidence were assessed by Welch test.

**RESULTS**

A total of 58 PCa lesions were found in 22/30 patients in the study cohort. 68Ga-PSMA PET/CT detected 57/58 (98.3 %) lesions in 21/30 (70 %) patients, and 15/58 (25.9 %) lesions were detected in 13/30 (43.3 %) patients using wb-MRI. The higher detection rate of 68Ga-PSMA PET/CT was statistically significant both on a per-lesion (p = 0.001) and per-patient (p = 0.039) basis. In 8/30 patients none of the two modalities actually localized the PCa relapse. Except for one local recurrence in the former prostate fossa that was exclusively detected by wb-MRI, all lesions detected by wb-MRI were also detectable on 68Ga-PSMA PET/CT. 68Ga-PSMA PET/CT offered a superior diagnostic confidence in categorization of PCa lesions compared to wb-MRI (2.7 ± 0.6 vs. 2.3 ± 0.6, p = 0.011).

**CONCLUSION**

68Ga-PSMA PET/CT significantly outperforms wb-MRI for detection of biochemical relapse in PCa patients after curative treatment.

**CLINICAL RELEVANCE/APPLICATION**

Wb-MRI is inferior to 68Ga-PSMA PET/CT for the detection of recurrent PCa. Nevertheless, as one local recurrence in one patient was only detectable with MRI, it might be useful in selected cases.
The block sequential regularized expectation maximization (BSREM) algorithm is a new image reconstruction method that controls noise at higher iterations by applying a relative difference penalty built into the objective function. This enables one to employ more iterations for convergence and better contrast recovery, while mitigating noise amplification. BSREM was recently introduced on the GE SIGNA PET/MRI platform. Here we evaluated how different values influence image quality and SUVmax in a cohort of prostate cancer patients who underwent 68Ga-RM2 or 68Ga-PSMA-11 scans.

METHOD AND MATERIALS

We analyzed 36 prostate cancer patients who underwent either 68Ga-RM2 (15) or 68Ga-PSMA-11 (21) PET/MRI. The raw PET data were retrospectively reconstructed using values of 250, 350, 500, 750 and 1000. Each reconstruction was reviewed independently by 3 nuclear medicine physicians and scored using a Likert scale (1 - poor, 5 - excellent quality). SUVmax values were measured from 68Ga-RM2/PSMA PET/MRI for all the lesions identified as compatible with prostate cancer.

RESULTS

The mean±SD scores for 68Ga-RM2 PET images were 2.5±0.5 for =250 reconstructions, 3.2±0.6 for =350, 4.1±0.6 for =500, 4.7±0.5 for =750 and 4.8±0.5 for =1000. The mean±SD scores for 68Ga-PSMA-11 PET images were 3.3±0.9 for =250 reconstructions, 4.2±0.9 for =350, 4.7±0.6 for =500, 4.9±0.3 for =750 and 4.9±0.4 for =1000. The relative observed agreement among readers for the values of 250, 350, 500, 750, 1000 were 49%, 50%, 60%, 70% and 74%, respectively. A total of 24 lesions (6 on RM2 and 18 on PSMA-11) were detected and the mean SUVmax measurements were: 13.1, 12.5, 10.4, 9.3 and 8 for the 68Ga-RM2 values of 250, 350, 500, 750 and 1000, respectively; 22.6, 21.2, 19.7, 18.9 and 16.8 for the 68Ga-PSMA-11 values of 250, 350, 500 and 1000, respectively.

CONCLUSION

Different values should be used for different 68Ga-labeled radiopharmaceuticals such as those targeting GRPR and PSMA receptors in prostate cancer. Once selected, the same value should be consistently used since SUVmax measurements differ with different values.

CLINICAL RELEVANCE/APPLICATION

BSREM algorithm improves image quality. Different beta values make different image quality and different SUVmax measurements on different 68Ga-labeled radiopharmaceuticals.

RC211-07 Fluciclovine PET/CT: Practical Approach to Interpretation

Monday, Nov. 26 9:35AM - 9:50AM Room: S505AB

Participants
Ephraim E. Parent, MD,PhD, Ponta Vedra Beach, FL (Presenter) Research support, Blue Earth Diagnostics Ltd; Research support, Advanced Accelerator Applications SA

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LEARNING OBJECTIVES

1) Assess the appropriate clinical indications for 18F-fluciclovine PET and understand the diagnostic accuracy of 18F-fluciclovine PET for local and metastatic prostate cancer. 2) Develop 18F-fluciclovine PET protocols for image optimization. 3) Apply the correct 18F-fluciclovine PET interpretation for local and metastatic prostate cancer and benign physiologic variants.

ABSTRACT

Anti-1-amino-3-[18F]-fluorocyclobutane-1-carboxylic acid (18F-fluciclovine) is a non-naturally occurring amino acid PET radiotracer that is recently United States Food and Drug Administration approved for detection of suspected recurrent prostate cancer. The tumor imaging features of this radiotracer mirror the upregulation of transmembrane amino acid transport that occurs in prostate cancer due to increased amino acid metabolism for energy and protein synthesis. This refresher course provides an overview of 18F-fluciclovine PET diagnostic accuracy for identifying primary and metastatic disease, as well as proper 18F-fluciclovine PET imaging protocols. Correct interpretation criteria will be explored in detail to identify physiologic and pathologic 18F-fluciclovine uptake patterns and potential pitfalls.

RC211-08 Quantitative Comparison of Standardized Uptake Values of Same-Day Randomized Ga-68 PSMA-11 PET/CT and PET/MR Scans in Recurrent Prostate Cancer Patients

Monday, Nov. 26 9:50AM - 10:00AM Room: S505AB

Participants
Anna Maria Ringheim, MSc,BEng, Sao Paulo, Brazil (Presenter) Nothing to Disclose
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Karine M. Martins, MS, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
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Marcelo L. Cunha, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose
Ronaldo H. Baroni, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To determine the reproducibility and agreement of standardized uptake values from same-day Ga-68 PSMA-11 PET/CT and PET/MR scans, randomized in order to eliminate the influence of Ga-68 PSMA-11 accumulation as a function of time, in patients with recurrent prostate cancer.

METHOD AND MATERIALS
Eighteen patients with recurrent prostate cancer after radical prostatectomy, all with visible lesions on the PET scan, were included in this retrospective study, approved by the Institution's Ethics Committee. All patients underwent PET/CT and PET/MR scans in randomized order after intravenous injection of a single dose of Ga-68 HBED-CC-PSMA (Ga-68 PSMA-11). Volumes of interest on tumor lesions were outlined and maximum standardized uptake value (SUVmax) corrected for lean body mass was calculated. Correlation and agreement between scans were assessed by generalized linear mixed-effects models and Bland Altman analysis. A predictive model of PET/CT SUVmax was developed based on PET/MR SUVmax, patient characteristics, and imaging parameters.

RESULTS
In total, there were 34 visible lesions on the PET scans: 5 local recurrences, 22 lymph node, and 7 bone metastases. SUVmax from PET/CT and PET/MR were significantly correlated, described by the following regression model equation: (PET/CT SUVmax) = 0.75 + 1.00* (PET/MR SUVmax), with a coefficient of determination R² of 0.77. Bland Altman analysis showed that SUVmax were on average 20% higher on PET/CT than on PET/MR, with the largest percentage differences for small SUV's. The full predictive model of PET/CT SUVmax showed significant association with PET/MR SUVmax (effect 1.15, p<0.001), serum prostate specific antigen (effect 0.99, p=0.053), scan time post-injection (effect 0.98, p=0.003), and acquisition time per bed position (effect 1.49, p=0.021) with a coefficient of determination R² of 0.85.

CONCLUSION
SUVmax from PET/CT and PET/MR are comparable and well correlated, but should not be used interchangeably without applying a correction factor.

CLINICAL RELEVANCE/APPLICATION
Since both Ga-68 PSMA-11 PET/CT and PET/MR are increasingly used in clinical practice, the reproducibility of SUVmax measurements is essential in monitoring of disease progression and response to treatment.
PURPOSE

Ga-68 Prostate-Specific Membrane Antigen (PSMA) PET/CT is a new tool for the detection of new and recurrent prostate cancer. Standard imaging time is 60 minutes post injection of radiotracer but some lesions may be obscured by physiologic accumulation of radiotracer in bladder. The aim of the study is to determine if the addition of early imaging at 3 and 6 minutes to standard imaging at 60 minutes can improve the detection of new and recurrent prostate cancer at Ga-68 PSMA PET/CT.

METHOD AND MATERIALS

After obtaining IRB approval, retrospective review of 257 consecutive patients who underwent Ga-68 PSMA PET/CT between December 2016 and July 2017 was conducted. 167 patients underwent early (3 and 6 minute) and late (60 minute) imaging. Two readers blinded to the patient’s clinical information, independently reviewed the early and late images and qualitatively and quantitatively scored the visibility of prostate lesions on a scale of 1-2 (1: lesion seen, 2: lesion not seen). Qualitatively, focal uptake higher than background that did not correspond to physiologic tracer accumulation was considered cancer. Quantitatively, a cut off maximum standardized uptake value (SUVmax) of 2 was indicative of prostate cancer. Detection of prostate cancer was compared between early and late imaging using McNemar test.

RESULTS

A total 115 patients (68.9%) had prostate cancer on imaging as seen on early (median SUVmax= 6.4) and late (median SUVmax= 8) PET/CT images. In 106/115 (64%), the cancers were seen on early and delayed imaging, in 8/115 (6.9%) the cancer was only seen on early imaging and masked by bladder activity on delayed imaging, and in 1/115 (0.6%) only seen on delayed imaging. The addition of early imaging significantly improved the detection rate of prostate cancer (p=0.039).

CONCLUSION

The addition of early imaging at 3 and 6 minutes to the standard 60 minute imaging at Ga-68 PSMA PET/CT improves the detection of prostate cancer.

CLINICAL RELEVANCE/APPLICATION

Early imaging at Ga-68 PSMA PET/CT can help in the detection of prostate cancer that is obscured by the bladder activity at 60 minutes.

Monday, Nov. 26 10:20AM - 10:30AM Room: S505AB

Awards

Student Travel Stipend Award

Participants

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Mark M. Goodman, PhD, Atlanta, GA (Abstract Co-Author) Royalties, Nihon Medi-Physics Co, Ltd
David M. Schuster, MD, Decatur, GA (Abstract Co-Author) Institutional Research Grant, Nihon Medi-Physics Co, Ltd; Institutional Research Grant, Blue Earth Diagnostics Ltd; Institutional Research Grant, Advanced Accelerator Applications SA; Consultant, Syncona Ltd; ;

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PURPOSE

We previously reported a 40.5% post-prostatectomy salvage radiotherapy management decision change based on guidance with fluciclovine PET/CT in a trial with 87/162 accrual (Clin Nucl Med. 2017 Jan;42(1):e22-e28). We set out to determine if this finding continued at the current accrual of 145/162 patients.

METHOD AND MATERIALS

145 patients with post-prostatectomy biochemical recurrence of prostate cancer and negative bone scan were randomized to undergo treatment planning based on conventional imaging (CT, MRI) or fluciclovine PET/CT in a provider-determined intention-to-treat protocol. Radiotherapy decisions before and after fluciclovine PET/CT were compared and changes in treatment decision and field were noted. Statistical significance of decision changes was determined using Clopper-Pearson (exact) binomial method with significance set at p <0.05.
RESULTS
70/145 patients underwent fluciclovine PET. Mean PSA (±SD) at scan was 1.89 (±4.32) ng/ml. 54/70 (77.1%) patients had a positive fluciclovine PET. Radiotherapy decision was changed in 27/70 (38.6%). Four (5.7%) had the decision for radiotherapy withdrawn after the fluciclovine PET findings of extrapelvic uptake. Radiotherapy field decision was changed in 23/66 (34.9%) remaining patients: 13/23 prostate bed only to prostate bed and pelvis; 10/23 prostate bed and pelvis to prostate bed only. There was no significant difference in mean age (62.0 vs. 61.6 years) and treatment-recurrence time interval (991.4 vs. 1403.6 days) between those with change in radiotherapy decision and those without. However, the pre-treatment PSA mean was significantly higher in those with treatment change (2.76ng/ml vs. 1.35ng/ml, p < 0.05). Changes in overall radiotherapy decision (p = 0.01) and field (p < 0.05) were statistically significant.

CONCLUSION
Fluciclovine PET/CT had a significant effect on radiotherapy planning in post-prostatectomy patients with biochemical recurrent prostate cancer. Radiotherapy planning decision and field changes in the updated analysis is similar to the prior report. Further studies are required to determine if this change in treatment plan has an effect on clinical outcomes. Research support: NIH (R01CA169188), NCT 01666808.

CLINICAL RELEVANCE/APPLICATION
Use of fluciclovine PET/CT resulted in significant change in management (38.6%) in salvage radiotherapy planning in post-prostatectomy patients with recurrent prostate cancer.

PURPOSE
68Gallium prostate-specific membrane antigen positron emission tomography (68Ga-PSMA PET) is a relatively novel imaging modality for assessment of patients with prostate cancer. Recent studies have shown promising results, with their ability to detect recurrent/metastatic prostate cancer foci with superior performance than that of conventional imaging modalities (computed tomography, bone scintigraphy, and choline PET). However, the actual impact that 68Ga-PSMA PET has on management of prostate cancer patients has not been well-established. Therefore, we aimed to systematically review the literature and to perform a meta-analysis on the impact of 68Ga-PSMA PET on management of patients with prostate cancer.

METHOD AND MATERIALS
Pubmed and EMBASE databases were systematically searched up to January 20, 2018. Studies reporting the proportion of patients with prostate cancer that experienced change in management after 68Ga-PSMA PET were included. Quality of the included studies was evaluated using the GRADE system. The proportion of management changes were pooled using a random-effects model. Subgroup analyses and meta-regression analyses were done to explore potential causes of heterogeneity.

RESULTS
15 studies (1163 patients) were included. The pooled proportion of management changes was 54% (95% CI 47%-60%). Meta-regression analyses revealed that PET-positivity was a significant factor of heterogeneity (p=0.0486). Other variables, including clinical setting, change type (intended vs implemented), responding entity (referring doctor or multidisciplinary committee), D'Amico risk, Gleason score, use of androgen deprivation therapy, PSA at initial diagnosis, pre-PET PSA, and PSA-doubling time, were not significant (p=0.2802-0.9574). In patients with biochemical failure, proportions of radiotherapy, surgery, focal therapy, and multimodal treatment increased, while those of systemic treatment and no treatment decreased after performing 68Ga-PSMA PET.

CONCLUSION
This meta-analysis showed that 68Ga-PSMA PET had a large impact on the management of prostate cancer patients. PET-positivity affected the proportion of management changes.

LEARNING OBJECTIVES
1) Review current and emerging PET radiotracers for prostate cancer. 2) Assess how PET imaging can address unmet clinical needs in prostate cancer. 3) Address remaining and new clinical and research questions arising from these new PET radiotracers.
**PURPOSE**

Fluciclovine is FDA approved for detection of recurrent prostate cancer. We set out to evaluate fluciclovine uptake parameters that correlate with true positivity for local recurrence in non-prostatectomy treated patients.

**METHOD AND MATERIALS**

21 patients (PSA 7.4±4.6 ng/ml) with nadir PSA+2 after non-prostatectomy local therapy underwent dual time-point fluciclovine (364.1±37.7 MBq) PET/CT (4-15 minutes; 16-25 minutes) from pelvis to diaphragm. Uptake in the prostate over background was delineated and co-registered to a previously obtained planning 3-D ultrasound. Fluciclovine uptake (SUVmax) and target-to-background ratios (TBR) (SUVmax/SUVmean) of blood pool (aorta), prostate, and marrow (L3) were recorded. Uptake pattern (focal vs non-focal), subjective suspicion level [3 (equivocal), 4 (moderate), 5 (high)], and lesion location were noted. Targeted biopsies of the identified lesions with histologic analysis were completed. Statistical significance was determined using univariate regression analysis.

**RESULTS**

17/50 (34.0%) targeted lesions were positive for recurrent cancer. Compared to negative lesions, targeted positive lesions had significantly (p<0.01) higher mean SUVmax of lesion (6.62±1.70 vs 4.92±1.27), TBR (marrow) (2.57±0.81 vs 1.69±0.51), and TBR (blood pool) (4.10±1.17 vs 3.00±1.01) at the first time-point, and remained significant at the later time-point except TBR (blood pool). Focal uptake (OR 12.07, [95% CI 2.98-48.80], p<0.01) and subjective high (5) suspicion level (OR 10.91, [95% CI 1.19-99.69], p=0.03) correlated with true positivity. All other parameters did not significantly correlate with true positivity. Of the 17 targeted lesions with focal uptake and subjective high suspicion, 11/17 (64.7%) were true positive. 16/33 (48.5%) false positive targeted lesions had evidence of prostatitis or radiation changes.

**CONCLUSION**

True positivity of fluciclovine targeted prostate biopsy in non-prostatectomy treated patients correlates with focal uptake, higher SUV, target-to-background ratios and subjective high suspicion level. These parameters may be utilized for future modification of interpretative criteria. Research Support: NIH (CA156775, CA204254 and CA176684)

**CLINICAL RELEVANCE/APPLICATION**

Targeted biopsy of lesions with focal uptake and subjective high suspicion on fluciclovine PET-CT increases the true positivity rate from 34.0% to 64.7% in non-prostatectomy treated patients.

**RC211-15** Evaluation of 18F-DCFPyL PSMA-Based PET/CT and mpMRI in Patients with Localized Prostate Cancer

**Participants**

Oluyinka A. Abiodun-Ojo, MD, MPH, Atlanta, GA (Presenter) Nothing to Disclose

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Mark M. Goodman, PhD, Atlanta, GA (Abstract Co-Author) Research funded, NCI

David M. Schuster, MD, Decatur, GA (Abstract Co-Author) Institutional Research Grant, Nihon Medi-Physics Co, Ltd

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**For information about this presentation, contact:**
To assess the ability of 18F-DCFPyL PET/CT to predict prostate cancer Gleason grade and its role as a potential adjunct to multiparametric prostate MRI.

**METHOD AND MATERIALS**

Patients with prostate cancer (PCa) underwent multi-parametric MRI (mpMRI) and 18F-DCFPyL PET/CT imaging. MpMRI lesion characteristics (PIRADS, ADCmean, ADCmin, ADC10, MRvol) were derived manually and 18F-DCFPyL PET/CT metrics SUVmax, SUVmean, MTV and TLG (SUVmean*MTV) were extracted from tracer-specific regions of interest (ROI). Lesion metrics were correlated with each other using the Spearman rank test, and their ability to differentiate tumor pathology Gleason grade (GG) <3 vs. GG 3-5 was performed using the Wilcoxon rank sum test.

**RESULTS**

Thirteen patients with high-risk PCa were included in the study, with 25 (12 GG<3, 12 GG 3-5) lesions found across the two modalities (median age 70.6, MRI volume 62mL, and PSA 18.87ng/mL). Seven patients did not have findings suspicious for metastatic disease on 18F-DCFPyL-PET/CT. MpMRI and 18F-DCFPyL PET/CT both detected 22/25 lesions, while 3 were not detected by any of the two modalities. 18F-DCFPyL PET/CT (SUVmax, SUVmean and TLG) as well as mpMRI metrics (ADCmin and MRI size) were significantly associated with GG 3-5 pathology (p=0.017, 0.020, 0.004, 0.026, 0.008, respectively). Additionally, MRI size correlated significantly with SUVmax, MTV and TLG (p=0.01, 0.02, 0.02, respectively) and SUVmax, SUVmean correlated significantly to ADCmin. All SUV metrics correlated positively with PIRADS 5 lesions vs. the remaining categories. In some cases, MRI findings did not entirely colocalize with PET avidity indicating MRI underestimation of functional burden.

**CONCLUSION**

18F-DCFPyL PET-identified prostatic lesions and mpMRI findings correlate with each other, Gleason grades and PIRADS. MpMRI may underestimate the tumor burden seen on 18F-DCFPyL PET/CT imaging, which may aid focal therapy decisions.

**CLINICAL RELEVANCE/APPLICATION**

Quantitative metrics of 18F-DCFPyL PET/CT and mpMRI correlate well with each other and with PCa Gleason grade and PIRADS. 18F-DCFPyL PET/CT adds additional functional metrics which may be meaningful in determining tumour heterogeneity and burden.

**RC211-16 Quantification of the Pharmacokinetics of Ga-68 PSMA-11 in Prostate Cancer Patients using Hybrid Positron Emission Tomography and Magnetic Resonance Imaging**

Participants

Anna Maria Ringheim, MsC,BEng, Sao Paulo, Brazil (Presenter) Nothing to Disclose  
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Ronaldo H. Baroni, MD, Sao Paulo, Brazil (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To quantify Ga-68 PSMA-11 uptake by pharmacokinetic modeling using arterial blood sampling and hybrid positron emission tomography and magnetic resonance (PET/MR) imaging in primary prostate cancer.

**METHOD AND MATERIALS**

This observational prospective study was approved by our Institution’s Ethics Committee. Eleven patients with clinically significant prostate cancer underwent a 60-minute dynamic PET/MR scan of the pelvis with an injected dose of Ga-68 HBED-CC-PSMA (Ga-68 PSMA-11). Simultaneously, axial T1 Dixon, T2 and diffusion-weighted MR images were acquired. Arterial blood activity was measured by an automatic arterial blood sampling device during the first 10 min. Manual blood samples at time points 3, 7, 15, 25, 40 and 60 min were collected for metabolite analysis and for blood to plasma transformation to derive an arterial input function. Activity-time curves of lesions, prostate and muscle were generated and mean standardized uptake values (SUVmean) calculated. An irreversible two-tissue compartment model, with rate constants K1, k2 and k3, were fitted to the data and the net influx rate Ki=K1k3/(k2+k3) was calculated. Ki showed strong correlation with SUVmean (Spearman rho 0.92, p<0.001).

**RESULTS**

In total 13 lesions located in the prostate were identified. Ga-68 PSMA-11 was stable in-vivo, not necessitating metabolite correction. The mean plasma-to-blood ratio was 1.63, stable over time. The kinetics could be described by an irreversible two-tissue compartment model. K1, k3 and Ki were all significantly higher in lesion compared to normal tissue (p<0.05): mean K1 in lesion, prostate and muscle 0.086, 0.063 and 0.018 mL/min/mL, mean k3 in lesion, prostate and muscle 0.075, 0.033 and 0.034 min-1 and mean Ki in lesion, prostate and muscle 0.031, 0.011 and 0.003 min-1. Ki showed strong correlation with SUVmean (Spearman rho 0.92, p<0.001). There was no significant correlation between Ki and patient data and MR parameters (p>0.060).
CONCLUSION
The kinetics of Ga-68 PSMA-11 can be described by an irreversible two-tissue compartment model. SUVmean showed strong correlation with Ki and can be used in clinical practice to quantify Ga-68 PSMA-11 uptake.

CLINICAL RELEVANCE/APPLICATION
Pharmacokinetic modeling is the gold standard for PET quantification. SUV strongly correlates with net influx rate Ki and can therefore be used in clinical practice to quantify Ga-68 PSMA-11 uptake.

RC211-17 Localization and Restaging of Carcinoma Prostate by 68Ga PSMA PET/CT in Patients with Biochemical Recurrence: A Descriptive Study
Monday, Nov. 26 11:25AM - 11:35AM Room: S505AB

Participants
Nikhil Seniaray, New Delhi, India (Abstract Co-Author) Nothing to Disclose
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Vidur Mahajan, MBBS, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Sudhir Khanna, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Ethel S. Belho, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Vanshika Gupta, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Ankur Pruthi, New Delhi, India (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Prostate cancer is the most common solid cancer in men. Following definitive treatment of prostate cancer by radical prostatectomy (RP) or radiotherapy, cancer recurrence is heralded by an increase in serum prostate-specific antigen (PSA) which is called biochemical recurrence. We investigate the relationship between prostate specific antigen (PSA) level and detection of suspected cancer recurrence using 68 Ga-PSMA PET/CT in patients with biochemical recurrence after radical prostatectomy (RP) or radiotherapy.

METHOD AND MATERIALS
We analyzed retrospective data of 150 men with carcinoma prostate post RP and post radiotherapy with biochemical recurrence from May 2014 to Jan 2018 by 68 Ga-PSMA PET/CT. We included men with suspected recurrent prostate cancer based on an elevated post treatment PSA level. The data collected analyzed the relationship of the pre-scan PSA level to the probability of a positive scan finding for recurrent prostate cancer.

RESULTS
Our cohort included 150 men, all had adenocarcinoma of prostate, 126/150 had a previous RP and 24/150 had prior radiotherapy. The mean PSA of the RP group was 4.8 ng/mL and 22.8 ng/mL in the radiotherapy group. In the post RP cohort, the detection rate of 68 Ga-PSMA PET/CT was 39.3% for PSA 0.2 to <0.5 ng/mL, 45.3% for PSA 0.5 to <1 ng/mL, 88.2% for PSA 1 to <2 ng/mL and 95.5% for PSA >=2. Lymph node metastasis post RP was identified in 52% of men with suspected disease recurrence. In the post radiotherapy cohort the detection rate was 96.1% for PSA 2 to 4 ng/mL, 99.2% for PSA 4 to 6 ng/mL and 100% for PSA >=6. Local recurrence after radiotherapy was present in 62% of the cohort and 58% had lymph node metastasis.

CONCLUSION
68Ga-PSMA PET/CT provides a novel imaging modality for the detection of prostate cancer recurrence and metastasis. Suspected PSMA avid metastatic lesions are common and are identified at low post treatment PSA levels, which if detected will help direct appropriate salvage treatments.

 CLINICAL RELEVANCE/APPLICATION
PSMA PET/CT should be considered a routine part of follow-up of treated prostate cancer patients since metastasis may present with low PSA levels leading to delay in addressing relapses.

RC211-18 68Ga-PSMA PET/PSMA for Prostate Cancer Staging Correlated to Prostatectomy Specimen
Monday, Nov. 26 11:35AM - 11:45AM Room: S505AB

Participants
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PURPOSE
To evaluate the accuracy of 68Ga-PSMA PET/PSMA for prostate cancer staging using prostatectomy specimen as gold standard for local staging.

METHOD AND MATERIALS
IRB approved retrospective study. We reviewed our database from February 2016 to February 2018 and found 214 patients who had submitted to a 68Ga-PSMA PET/PSMA and had no prior prostatectomy. 162 patients were excluded because had no prostatectomy in our hospital and eight had not performed lymphadenectomy. A total of 44 patients were included in the study.
RESULTS
Histology in 16, 17, 5 and 6 patients were ISUP 2, 3, 4 and 5, respectively. From the 44 patients, six had lymph node uptake and ten had uptake in bone lesions suggestive of benignity/fibrous dysplasia. On pathology, three patient had lymph nodes metastasis, not seen on PET/PSMA. Sensitivity for lymph node was 62% and specificity was 95%.

CONCLUSION
68Ga-PSMA PET/PSMA showed high specificity for lymph node metastasis and low specificity for bone lesions.

CLINICAL RELEVANCE/APPLICATION
68Ga-PSMA PET/PSMA is an advance in a new imaging method for prostate cancer staging, with high level of specificity for lymph node metastasis.

RC211-19  Panel Discussion
Monday, Nov. 26 11:45AM - 12:00PM Room: S505AB

Participants
Nancy M. Swanston, RT, Houston, TX (Presenter) Nothing to Disclose
Ephraim E. Parent, MD,PhD, Ponta Vedra Beach, FL (Presenter) Research support, Blue Earth Diagnostics Ltd; Research support, Advanced Accelerator Applications SA
Steve Cho, MD, Madison, WI (Presenter) Imaging Endpoints; General Electric Company

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LEARNING OBJECTIVES
1) Assess the appropriate clinical indications for 18F-fluciclovine PET and understand the diagnostic accuracy of 18F-fluciclovine PET for local and metastatic prostate cancer. 2) Develop 18F-fluciclovine PET protocols for image optimization. 3) Apply the correct 18F-fluciclovine PET interpretation for local and metastatic prostate cancer and benign physiologic variants.

ABSTRACT
Anti-1-amino-3-[18F]-fluorocyclobutane-1-carboxylic acid (18F-fluciclovine) is a non-naturally occurring amino acid PET radiotracer that is recently United States Food and Drug Administration approved for detection of suspected recurrent prostate cancer. The tumor imaging features of this radiotracer mirror the upregulation of transmembrane amino acid transport that occurs in prostate cancer due to increased amino acid metabolism for energy and protein synthesis. This refresher course provides an overview of 18F-fluciclovine PET diagnostic accuracy for identifying primary and metastatic disease, as well as proper 18F-fluciclovine PET imaging protocols. Correct interpretation criteria will be explored in detail to identify physiologic and pathologic 18F-fluciclovine uptake patterns and potential pitfalls.
**Advances in CT: Technologies, Applications, Operations—Special Purpose CT**

**Monday, Nov. 26 8:30AM - 10:00AM Room: S102CD**

**Participants**

Ehsan Samei, PhD, Durham, NC (Coordinator) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc

Lifeng Yu, PhD, Chicago, IL (Coordinator) Nothing to Disclose

**ABSTRACT**

CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

**Sub-Events**

**RC221A  Breast CT Applications**

**Participants**

John M. Boone, PhD, Sacramento, CA (Presenter) Patent agreement, Isotropic Imaging Corporation Consultant, RadSite

**LEARNING OBJECTIVES**

1) Introduce the technology of cone beam breast CT to audience. 2) Show both qualitative parameters describing image quality and qualitative images. 3) Demonstrate breast CT performance using metrics such as anatomical noise metrics, computer and human observer studies. 4) Illustrate the future potential of breast CT in diagnostic and screening breast imaging.

**RC221B  MSK CT Applications**

**Participants**

Wojciech Zbijewski, PhD, Baltimore, MD (Presenter) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG

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**LEARNING OBJECTIVES**

1) Explain the technology of musculoskeletal (MSK) cone-beam CT (CBCT). 2) Identify key differences between MSK CBCT and other orthopedic imaging modalities. 3) Discuss emerging clinical applications of MSK CBCT.

**RC221C  Interventional CT Applications**

**Participants**

Christopher P. Favazza, PhD, Rochester, MN (Presenter) Nothing to Disclose
Participants
Donald P. Frush, MD, Durham, NC (Moderator) Nothing to Disclose
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LEARNING OBJECTIVES
1) To learn fundamental elements of a CT dose monitoring program. 2) To review current programs (products) and resources available. 3) To understand current status, including challenges of dose monitoring in adults. 4) To be able to describe current status, including challenges of dose monitoring in children. 5) To be able to discuss potential advances in dose monitoring.

Sub-Events

RC224A Fundamentals (Nuts and Bolts) and Current Products (Tools)
Participants
Sarah E. McKenney, PhD, Sacramento, CA (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Evaluate clinical needs for radiation dose monitoring within their institution. 2) Identify resources necessary to ensure a successful monitoring program. 3) Classify the different features of dose monitoring software.

Active Handout: Sarah Eva McKenney

RC224B CT Dose Monitoring Status in Adults (Including Diagnostic Reference Levels)
Participants
Kalpana M. Kanal, PhD, Seattle, WA (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) To discuss CT dose monitoring for adults. 2) To learn about diagnostic reference levels in CT. 3) To understand how to implement dose monitoring and diagnostic reference levels in practice.

RC224C CT Dose Monitoring Status in Children (Including Diagnostic Reference Levels)
Participants
Donald P. Frush, MD, Durham, NC (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) To understand the unique considerations in CT dose monitoring program for children. 2) To learn challenges and obstacles in CT dose monitoring programs in children. 3) To be able to discuss future opportunities for CT dose monitoring program in children.

RC224D Designing the Program of the Future
Participants
Ehsan Samei, PhD, Durham, NC (Presenter) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc

LEARNING OBJECTIVES
1) To understand the importance of analytics in extracting meaningful and actionable knowledge from performance data. 2) To
1) To understand the importance of analytics in extracting meaningful and actionable knowledge from performance data. 2) To understand the role and components of image quality characterization based on patient images. 3) To understand performance monitoring as the overarching objective of dose monitoring.
MSMC22

Cardiac CT Mentored Case Review: Part II (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Nov. 26 10:30AM - 12:15PM Room: S406A

CA  CT

AMA PRA Category 1 Credits ™: 1.75
ARRT Category A+ Credits: 2.00

Participants
Jill E. Jacobs, MD, New York, NY (Director) Nothing to Disclose
Charles S. White, MD, Baltimore, MD (Moderator) Consultant, Koninklijke Philips NV

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LEARNING OBJECTIVES
1) Identify cardiac and coronary artery anatomy. 2) Recognize cardiac disease processes, including coronary atherosclerosis, as diagnosed on CT. 3) Understand methods of cardiac CT and coronary CT angiography post-processing.

Sub-Events

MSMC22A  Coronary Atherosclerosis I

Participants
Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Consultant, HeartFlow, Inc; Consultant, General Electric Company;

LEARNING OBJECTIVES
View learning objectives under main course title.

MSMC22B  Coronary Atherosclerosis II

Participants
Karin E. Dill, MD, Worcester, MA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

MSMC22C  Valves and Cardiac Function

Participants
Suhny Abbara, MD, Dallas, TX (Presenter) Royalties, Reed Elsevier; Institutional research agreement, Koninklijke Philips NV; Institutional research agreement, Siemens AG

LEARNING OBJECTIVES
View learning objectives under main course title.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Suhny Abbara, MD - 2014 Honored EducatorSuhny Abbara, MD - 2017 Honored Educator
SSC01
Science Session with Keynote: Cardiac (Coronary Artery Disease: Practice and Prognosis)
Monday, Nov. 26 10:30AM - 12:00PM Room: S504CD

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Yeon Hyeon Choe, MD, PhD, Seoul, Korea, Republic Of (Moderator) Nothing to Disclose
Gregory Kicska, MD, PhD, Seattle, WA (Moderator) Nothing to Disclose

Sub-Events
SSC01-01 Cardiac Keynote Speaker: Prognostic Role of Coronary CT Angiography

Participants
Gregory Kicska, MD, PhD, Seattle, WA (Presenter) Nothing to Disclose

SSC01-03 The Intermediate-Term Impact of Coronary CT Compared to Stress Echocardiography During Risk Assessment in Patients Undergoing Liver Transplantation: A Prospective Follow-Up Study in a Consecutive Patient Population

Participants
Patricia Tischendorf, Frankfurt, Germany (Presenter) Nothing to Disclose
Claudia Frellesen, Frankfurt, Germany (Abstract Co-Author) Nothing to Disclose
Christophe Arendt, MD, Frankfurt am Main, Germany (Abstract Co-Author) Nothing to Disclose
Thomas J. Vogl, MD, Frankfurt, Germany (Abstract Co-Author) Nothing to Disclose
Ralf W. Bauer, MD, Frankfurt, Germany (Abstract Co-Author) Speakers Bureau, Siemens AG; Speakers Bureau, Bayer AG; Speakers Bureau, General Electric Company

PURPOSE
Aim of this study was to evaluate the intermediate-term impact of coronary Computed Tomography (cCT) versus Stress Echocardiography (STE) as a cardiac risk stratification prior to liver transplantation in a consecutive patient population with unknown coronary artery disease (CAD).

METHOD AND MATERIALS
From 2014 to 2017, 139 consecutive patients, who underwent cCT or STE as a part of the institutional liver transplantation evaluation procedure, were enrolled unless they met the predefined exclusion criteria. 67 patients underwent non-enhanced CaSc followed by prospectively ECG-triggered sequential coronary CTA, in addition to the Agatston-Score, we used the CAD-RADS classification for risk assessment. 72 patients were examined by STE. Follow-up information concerning the primary endpoint, consist of cardiac or non-cardiac death and the combined endpoint of cardiac death, myocardial infarction, revascularisation and stroke was obtained from general practitioners, or treating hospitals, respectively.

RESULTS
The mean follow-up period was 569±442 days. During this time, 40 primary endpoints and 7 combined endpoints occurred. There was no significant difference in the incidence of primary endpoints in patients with pos. cCT or STE compared to patients without a pathological finding. In patients with pos. cCT, significantly more combined endpoint were observed than in the control group (p=0.0004). Moreover, the absence of a pathological finding in cCT or STE was shown to exhibit high negative predictive value. On multivariate analysis, Child-Pugh C liver status was the strongest independent predictor for an primary endpoint, with a 5-fold increased risk. While pos. cCT was the strongest independent predictor for an combined entpoint.

CONCLUSION
cCT and STE both provide excellent risk stratification and intermediate-term prognostic value in patients with unknown CAD. cCTA shows promising results in the initial work-up of unselected liver transplantation candidates with perviously unknown CAD. Patients with positive findings in cCT were successfully routed towards revascularization leading to a non-significant difference concerning the primary endpoint compared to patients with neg. cCT (p=0.47).

CLINICAL RELEVANCE/APPLICATION
Different cardiac imaging methods need to be investigated to avoid cardiac complications in patients undergoing liver transplantation, because the prevalence of asymptomatic CAD is relatively high in this population.

SSC01-04 Utilization of Coronary CT Angiography in Private Offices and Hospitals: Reversal of Earlier Trends and Implications for Radiologists

Monday, Nov. 26 11:00AM - 11:10AM Room: S504CD
To assess recent trends in utilization of coronary CT angiography (CCTA), based upon place-of-service and provider specialty.

**METHOD AND MATERIALS**

The nationwide Medicare Part B Physician/Supplier Procedure Procedure Summary Master Files for 2006-2016 were the data source. CPT-4 codes for CCTA were selected. The files provided procedure volume for each code. Utilization rates per 100,000 Medicare fee-for-service enrollees were then calculated. Medicare's place-of-service codes were used to identify CCTAs performed in private offices, hospital outpatient departments (HOPDs), emergency departments (EDs), and inpatient settings. Physician specialty codes were used to identify CCTAs interpreted by radiologists, cardiologists, and all other physicians as a group. Because these files represent an entire population count, sample statistics are not required.

**RESULTS**

The overall CCTA utilization rate per 100,000 Medicare enrollees rose abruptly from 99.1 in 2006 to 210.3 in 2007, but then progressively dropped to 107.1 by 2013. However, thereafter it rose each year, reaching 131.0 in 2016. The private office CCTA utilization rate increased abruptly from 70.3 in 2006 to a peak of 150.1 in 2007, but thereafter dropped rapidly to 39.5 in 2016. The HOPD rate rose from 22.9 in 2006 to 46.1 in 2007, then declined to 36.1 by 2010. However, it thereafter increased progressively to 69.8 in 2016. The ED rate increased continually from 0.4 in 2006 to 5.3 in 2016. Among inpatients, the rate was 11.0 in 2007 and remained relatively unchanged through 2013. But in the 3 subsequent years, it increased to 16.4 by 2016. Radiologists' CCTA market share in the 4 venues in 2016 were: offices 44%, HOPDs 62%, EDs 85%, inpatients 66%. Radiologists' overall share had been 32% in 2007 (the peak year), compared with 60% for cardiologists. However, by 2016, radiologists' overall share was 58%, compared with 38% for cardiologists.

**CONCLUSION**

After years of declining CCTA utilization, the rate is now increasing, primarily in hospital settings. The private office rate has declined sharply. In a noteworthy reversal of another earlier trend, radiologists currently predominate in this procedure.

**CLINICAL RELEVANCE/APPLICATION**

After years of decline, the frequency of use of CCTA appears to be increasing, especially in hospital settings and among radiologists.
cross-sections into the six histological categories. We compared the diagnostic accuracies between the models using the McNemar test.

RESULTS
After excluding sections with heavy calcium (n=32) and no visible atherosclerotic plaque on CTA (n=134), we analyzed 411 cross-sections of which 30.4% (134/441) were advanced atherosclerotic lesions. The radiomics-ML model which included 13 parameters correctly differentiated early from advanced plaques with a diagnostic accuracy of 82.3%, whereas the expert classification had a diagnostic accuracy of 76.0% (p=0.001). Our ML model was able to classify 63.0% of the CTA cross-sections into the six histological categories correctly.

CONCLUSION
Radiomics-based ML outperforms experts to identify advanced atherosclerotic lesions on coronary CTA. However, ML-based classification of coronary plaques into the corresponding six histological categories has moderate accuracy. Further analysis with larger samples size and validation is needed.

CLINICAL RELEVANCE/APPLICATION
Radiomics-based machine learning could increase the diagnostic accuracy of coronary CT angiography to identify gold-standard histological entities.

HONORED EDUCATORS
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Udo Hoffmann, MD - 2015 Honored Educator

SSC01-06 Diagnostic Accuracy of Low Dose Dynamic Stress Computed Tomography Myocardial Perfusion (CTP) in Intermediate-to-High-Risk Patients for Suspected Coronary Artery Disease (CAD)

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PURPOSE
The aim of this study is to evaluate the incremental diagnostic value of stress CTPdyn over CCTA in intermediate to high risk patients scheduled for invasive coronary angiography (ICA) plus clinically indicated invasive fractional flow reserve (FFR) for suspected CAD by using a low dose acquisition protocol with last generation of whole-heart single beat CT scanner.

METHOD AND MATERIALS
Consecutive symptomatic patients with intermediate-to-high pre-test probability of CAD and scheduled for clinically indicated ICA+FFR, were prospectively enrolled. All patients underwent rest-CCTA followed by stress-CTP protocol with adenosine and with injection of 0.7 ml/kg of iodixanol 320 as additional test. CCTA and CTP were defined positive for the presence of >= 50% stenosis and for the presence of subendocardial hypoenhancement encompassing >= 25% of transmural myocardial thickness within a specific coronary territory, respectively. At ICA, obstructive CAD was defined by the presence of >= 50% stenosis and hemodynamically significant CAD was defined by the presence of > 50% stenosis on left main coronary artery, severe (> 80%) or occlusive stenosis or FFR < 0.80. The additive value of CTP versus CCTA alone to rule out the presence of hemodynamically relevant stenosis was assessed on a per-vessel basis.

RESULTS
Forty-eight patients [mean age: 65 ± 8 years, male: 35 (73%)] were included in our study. Obstructive CAD was found in 38% (54/144) of vessels and in 73% (35/48) of patients. Hemodynamically significant CAD was present in 23% (36/144) of vessel and in 54% (26/48) of patients. In a vessel-based model, CCTA alone and CCTA+CTPdyn showed a sensitivity, specificity, negative predictive value, positive predictive value and diagnostic accuracy of 92%, 64%, 96%, 46%, 71% and 89%, 89%, 96%, 76%, 89%, respectively. CCTA+CTPdyn showed a significant improvement in specificity (p: <0.001), positive predictive value (p: 0.002) and diagnostic accuracy (p: <0.001) to rule out hemodynamically significant CAD as compared to CCTA alone. The mean radiation exposure due to CTPdyn alone is 5.13 ± 1.51 mSv.

CONCLUSION
In patients with intermediate-to-high pre-test likelihood of CAD, low dose dynamic CTP had incremental value over CCTA alone to diagnose the presence of hemodynamically significant CAD.
CLINICAL RELEVANCE/APPLICATION

Combination of CTP an CCTA can improve diagnosis of hemodynamically significant CAD.

SSC01-07  
**Triple-Rule-Out CT Angiography in Low-intermediate and High Risk Patients with Acute Chest Pain: Impact on Patient Management**

**Purpose**

To investigate the impact of triple-rule-out cardiac CT angiography (TRO-CTA) on patient management in patients presenting with chest pain to the emergency department (ED) compared to standard of care (SOC) work-up.

**Method and Materials**

In this IRB-approved, HIPAA-compliant study we analyzed data of 2156 patients who presented to the ED with chest pain. Patients were divided into two groups according to their cardiovascular risk: low-intermediate risk (<=1 risk factor regardless of body-mass-index [BMI]) and high risk (>=2 risk factors and BMI >=30kg/m2 or >=4 risk factors regardless of BMI). Patients received either TRO-CTA as an initial test or SOC without initial CTA. ED length of stay, downstream utilization of additional tests, and hospital costs were compared between both groups.

**Results**

515 patients were assigned to the high-risk group (TRO-CTA, n=274; SOC, n=241) and 1610 to the low-intermediate risk group (TRO-CTA, n=837; SOC, n=773). No significant differences between groups and corresponding treatment arms were observed for age, gender, or race. The rate of diagnosis of coronary artery disease (CAD), pulmonary embolism (PE), or aortic dissection (AD) was significantly higher in the TRO-CTA vs. the SOC group for the low-intermediate risk group (all p<0.05). Median ED wait time (5.0 vs. 7.0hrs, p<0.001), median total length of hospital stay (48.0 vs. 72.0hrs, p<0.001), additional downstream testing, rate of invasive coronary angiography (11.6% vs. 38.7%, p<0.001), and total costs ($9,184 vs. 17,253$, p<0.001) were significantly lower in the TRO-CTA vs. the SOC arm.

**Conclusion**

TRO-CTA as an initial imaging test in ED patients presenting with acute chest pain was associated with shorter ED and hospital length of stay, lower utilization of downstream testing, and lower total cost both for the episode of care and overall.

**Clinical Relevance/Application**

TRO-CTA is a robust imaging modality with lower resource use and lower cost in the work-up of patients presenting to the ED with chest pain regardless of their a-priori risk.

SSC01-08  
**Prognostic Role of Adenosine Stress Cardiac Magnetic Resonance Compared to CCTA in the Long-Term Outcome of Heart Disease Patient**

**Purpose**

Combination of CTP an CCTA can improve diagnosis of hemodynamically significant CAD.
Coronary heart disease is still the leading cause of death and the need for a prognostic assessment of CAD patients is continuously increasing. With this regard, the anatomic and morphological approach is not completely satisfying in the CAD definition. The purpose of our study was assessing the prognostic role of Adenosine Stress Cardiac Magnetic Resonance compared to Computed Tomography Angiography (CTA) in the outcome of the heart patient.

**METHOD AND MATERIALS**

55 patients with previous PTCA-stenting who underwent CTA examination and CMR with adenosine were included in our study. A 5-year follow-up was carried out to evaluate the clinical evolution of these patients.

**RESULTS**

Nine patients showed negative CTA and CMR under stress, with reported well-being in the 5-year follow-up. 78% of the remaining patients showed stent filling defects in the CTA examination; among these, 86% showed also perfusion defect in the CMR, associated to major cardiovascular symptoms referred in the follow-up, while the remaining 14% were negative for perfusion CMR and for symptoms. 22% of patients who showed perfusion alterations in CMR, although in absence of stent apparent filling defects in CTA examination, reported acute myocardial infarction treated with re-stenting. 5 patients out of 18 with positive LGE images developed MACE (arrhythmias, cardiac death).

**CONCLUSION**

Our experience shows how, despite a CTA examination positive for the presence of moderate stenosis, a negative Adenosine Stress CMR represents a positive prognostic factor for the patient outcome. On the other hand, also with a negative CTA, the positivity of Adenosine Stress CMR is strongly associated with a high probability of developing a cardiovascular accident and constitutes a negative prognostic factor.

**CLINICAL RELEVANCE/APPLICATION**

Our study demonstrates the prevalent role of Stress CMR in comparison to Computed Tomography as a predictive prognostic factor in the outcome of heart patient.

**SSC01-09**  
**Additional Diagnostic Value of CT Perfusion Over Coronary CT Angiography in Stented Patients with Suspected In-Stent Restenosis or Coronary Artery Disease Progression: ADVANTAGE Study - Preliminary Results**

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**PURPOSE**

Aim of the study is to assess the diagnostic performance of CCTA alone, CTP alone and CCTA plus CTP performed with the latest scanner generation that combine a whole-heart coverage with high spatial and temporal resolution, by using invasive coronary angiography (ICA) as standard of reference.

**METHOD AND MATERIALS**

A cohort of consecutive patients referred for a clinically ICA for suspicion of ISR or progression of native CAD were enrolled. The feasibility of CCTA, CTP and the combined evaluation CCTA plus CTP were calculated in a stent-based, territory-based and patient-based analysis. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of CCTA, CTP, combined evaluation CCTA-CTP vs. ICA in a stent-based, territory-based and patient-based analysis. Radiation exposure of CCTA, CTP and ICA was recorded.

**RESULTS**

Ninety-eight patients were enrolled (83 male, mean age 64 ± 9 years-old). CTP feasibility was significantly higher than CCTA feasibility in a stent-based, territory-based and patient based analysis (97% vs. 87%, p=0.001; 98% vs. 92%, p=0.001; 97% vs. 70%, p<0.0001, respectively). The feasibility of the combined evaluation CCTA-CTP was significantly higher than CCTA feasibility in a stent-based, territory-based and patient based analysis (96% vs. 87%, p=0.001; 99% vs. 92%, p<0.001; 100% vs. 70%, p<0.0001, respectively). The diagnostic accuracy of CCTA was 81%, 85% and 79%, in a stent-based, territory-based and patient based analysis, respectively; the diagnostic accuracy of CTP was 90%, 93% and 84%, respectively; the diagnostic accuracy of combined CCTA-CTP was 85%, 90% and 83%, respectively; the diagnostic accuracy of concordant CCTA-CTP was 95% and 92% in a territory and patient-based analysis, respectively. The diagnostic accuracy of CTP was higher than that of CCTA in a stent-based (p=0.001) and territory-based (p=0.0001) analysis. The mean effective dose of the entire CT assessment (CCTA-CTP) was 2.76 ± 2.32 mSv.
CONCLUSION
The CTP assessment appears as more feasible and more accurate than the anatomical evaluation alone by CCTA in patients with coronary stents. When results of CCTA and CTP are concordant, the diagnostic accuracy of the combined evaluation is very high and associated with very low radiation exposure.

CLINICAL RELEVANCE/APPLICATION
Evaluation with cardiac CT of both anatomy and perfusion
**Predicting the Likelihood of Various Major Diseases from Lung Cancer Screening Chest CT Using 3D Convolutional Neural Networks**

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**PURPOSE**
A large number of patients undergo annual lung cancer screening with low-dose chest CT. The CT data contains significant information about the health of the patient, beyond simple lung cancer status. The National Lung Cancer Screening (NLST) database provides a large dataset with correlated clinical metadata, which can be used to train machine learning algorithms to extract as much useful health information as possible. The aim of the study is to develop and validate a 3D convolutional neural network algorithm on these CT studies to predict the likelihood of various major diseases: diabetes, heart disease, COPD, and stroke.

**METHOD AND MATERIALS**
We extracted random samples of 16,780 scans from NLST. Data preprocessing consisted of isotropic resolution resizing and standardization to 350 x 350 x 35 pixel size. Data was augmented with random rotations between -15 and 15 degrees. The processed samples were passed through a 3D convolutional neural network (CNN) with architecture loosely inspired by the VGGNet. Modifications included generalization to 3D dataset, more gradual pooling across the z-axis, and use of batch normalization. Stochastic gradient descent optimizer and sparse categorical crossentropy loss function were utilized. Final results were gathered using a separate testing set extracted from the NLST dataset. Error analysis was conducted.

**RESULTS**
We performed training and testing for classification of the following diseases: diabetes, heart disease, COPD, and stroke. For each disease respectively, we achieved an ROC AUC of 0.75, 0.70, 0.74, 0.69 on the test sets. ROC curves are displayed in Figure (1). For each of these results, a single radiologist with deep learning expertise manually inspected random samples of correct and incorrect predictions to ensure absence of any systematic errors. None was identified. Testing sets were confirmed to be an accurate representation of the training sets with regards to positive/negative example ratios.

**CONCLUSION**
Our 3D CNN model successfully predicted the likelihood of various diseases from lung cancer screening chest CT studies.

**CLINICAL RELEVANCE/APPLICATION**
The algorithm can be used to provide patients with useful health information about major diseases, in addition to the formal lung cancer screening interpretations by radiologists.
PURPOSE  
Evaluate the utility of deep learning to improve the specificity and sensitivity of lung cancer screening with low-dose helical computed tomography (LDCT), relative to the Lung-RADS guidelines.

METHOD AND MATERIALS  
We analyzed 42,943 CT studies from 14,863 patients, 620 of which developed biopsy-confirmed cancer. All cases were from the National Lung Screening Trial (NLST) study. We randomly split patients into a training (70%), tuning (15%) and test (15%) sets. A deep learning model was trained over 3D CT volumes (400x512x512) as input. We used the 95% specificity operating point based on the tuning set, and evaluated our approach on the test set. To estimate radiologist performance, we retrospectively applied Lung-RADS criteria to each study in the test set. Lung-RADS categories 1 to 2 constitute negative screening results, and categories 3 to 4 constitute positive results. Neither the model nor the Lung-RADS results took into account prior studies, but all screening years were utilized in evaluation.

RESULTS  
The area under the receiver operator curve of the deep learning model was 94.2% (95% CI 89.8, 96.9). Compared to Lung-RADS on the test set, the trained model achieved a statistically significant absolute 9.2% (95% CI 8.4, 10.1) higher specificity and trended at 3.4% (95% CI -5.2, 12.6) higher sensitivity (not statistically significant). Radiologists qualitatively reviewed disagreements between the model and Lung-RADS. Preliminary analysis suggests that the model may be superior in distinguishing scarring from early malignancy.

CONCLUSION  
A deep learning based model improved the specificity of lung cancer screening over Lung-RADS on the NLST dataset and could potentially help reduce unnecessary procedures. This research could supplement future versions of Lung-RADS; or support assisted read or second read workflows.

CLINICAL RELEVANCE/APPLICATION  
While Lung-RADS criteria is recommended for lung cancer screening with LDCT, there is still an opportunity to reduce false-positive rates which lead to unnecessary invasive procedures.

SSC03-03  New Algorithm Incorporating Machine Learning Improves Lung Cancer Risk Calculation on Screening CT Scans  
Monday, Nov. 26 10:50AM - 11:00AM Room: E451A

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PURPOSE  
Lung-RADS is widely used to classify nodules detected on lung cancer screening CT. Using data from the National Lung Cancer Screening Trial (NLST), we examined whether integration of patient demographics, clinical history, and CT texture features could improve our ability to predict long-term lung cancer development. Since most screening CTs detect early stage lung cancers, we further examined if our algorithm could predict cancer progression and overall survival in patients with resected stage I lung cancers.

METHOD AND MATERIALS  
Demographics, clinical history, and baseline CT images from 24,386 NLST participants were analyzed using survival machine learning (SML). Nodule volume was calculated by V=\(3.14 LR^2\) where L=longest diameter, R=longest perpendicular diameter/2. Subjects were partitioned into 4 risk groups to test hazards ratios (HR). The SML partition was compared to that from Lung-RADS. For the stage I lung cancer subgroup, the time from lung cancer diagnosis to death was used as the SML endpoint.

RESULTS  
At the time of baseline CTs, the 4 risk groups were classified by: high (largest nodule L>10mm, V>6358mm\(^3\) n=85), mid-high (largest nodule L>10mm, V\(<6358mm\(^3\), n=1219), mid-low (largest nodule L=5~10mm, smoking>40 years, n=1736), and low (all
others; n=21346). Compared to our low risk group, HRs for time to lung cancer onset were 91.5, 11.1, 4.0 for high, mid-high, and mid-low risk groups respectively (all p<0.0001). In contrast, the HRs from Lung-RADS categories 4, 3, and 2 were 5.68, 1.27, and 0.75 respectively as compared to category 1 (p values: <0.0001, 0.056, 0.058). For stage 1 lung cancers, demographics, nodule margins, lymph node enlargement, and blood vessel involvement jointly affected the rate of cancer progression and overall patient survival.

CONCLUSION
Using the NLST data, our new classification outperforms Lung-RADS in stratifying risk and predicting long-term lung cancer development. Furthermore, in pathologically defined stage 1 patients who received surgery, our new classification can identify those with poor survival suggesting that it can do so independently of cancer stage.

CLINICAL RELEVANCE/APPLICATION
Our new classification outperforms Lung-RADS in stratifying risk and predicting long-term lung cancer development and can identify stage 1 patients with poor survival suggesting that it can do so independently of cancer stage.

SSC03-04 Effect of Semiautomated Segmentation and Computer-Aided Detection of Lung Nodules on Lung Cancer Screening with Low Dose CT: Experience from a Nationwide Lung Cancer Screening Project

Monday, Nov. 26 11:00AM - 11:10AM Room: E451A

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PURPOSE
To evaluate the effect of semiautomated segmentation and computer-aided detection (CAD) system for lung nodule on lung cancer screening based on the Lung-RADS.

METHOD AND MATERIALS
We utilized the data from an ongoing nationwide multi-center lung cancer screening project with low dose chest CT. This project started with a visual assessment and manual measurement system (a manual system) and changed into a cloud-based software system which equipped with a semiautomated nodule segmentation and CAD system (a software system). In a software system, an average diameter of a nodule for the Lung-RADS was calculated on a plane showing the maximal cross sectional area of a nodule. For this study, an average diameter on axial planes was also calculated. We compared the number of detected lung nodules and distribution of Lung-RADS categories between two systems. When the results of before and after CAD were available (the number of cases, 2374), the effect of CAD was evaluated.

RESULTS
The number of cases and the number of nodules for both systems are as follows: a manual system, 1821 cases, 1630 nodules; a software system, 4665 cases, 6116 nodules. Significantly greater number of nodules (0.90 vs. 1.31 nodule/case) were detected at a software system. The size of nodule was significantly larger (5.5 vs. 4.6 mm) at a software system, but there was no significant difference in the size of nodules between two systems when axial planes were used in calculating an average diameter in a software system. Both the per-case (9.8% vs. 17.4%) and per-nodule (12.9% vs. 17.9%) proportion of positive test (category 3/4) were significantly higher at a software system. By applying the CAD results, not only the number of the detected nodules (0.77 vs. 1.23 nodule/case) but also the per-case proportion of positive test (11.6% vs. 17.1%) were significantly increased.

CONCLUSION
By applying a semi-automated segmentation and CAD system, the number of detected nodules and the proportion of positive test were significantly increased.

CLINICAL RELEVANCE/APPLICATION
Semiautomated segmentation and CAD have important effects on the Lung-RADS positive rate. Therefore, detailed guidelines should be provided for the use of software in lung cancer screening.

SSC03-05 Randomized Clinical Trial of CAD versus No CAD as First Reader of Lung Cancer Screening CT: Preliminary Report

Monday, Nov. 26 11:10AM - 11:20AM Room: E451A

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PURPOSE
To evaluate the effect of semiautomated segmentation and computer-aided detection (CAD) system for lung nodule on lung cancer screening based on the Lung-RADS.

METHOD AND MATERIALS
We utilized the data from an ongoing nationwide multi-center lung cancer screening project with low dose chest CT. This project started with a visual assessment and manual measurement system (a manual system) and changed into a cloud-based software system which equipped with a semiautomated nodule segmentation and CAD system (a software system). In a software system, an average diameter of a nodule for the Lung-RADS was calculated on a plane showing the maximal cross sectional area of a nodule. For this study, an average diameter on axial planes was also calculated. We compared the number of detected lung nodules and distribution of Lung-RADS categories between two systems. When the results of before and after CAD were available (the number of cases, 2374), the effect of CAD was evaluated.

RESULTS
The number of cases and the number of nodules for both systems are as follows: a manual system, 1821 cases, 1630 nodules; a software system, 4665 cases, 6116 nodules. Significantly greater number of nodules (0.90 vs. 1.31 nodule/case) were detected at a software system. The size of nodule was significantly larger (5.5 vs. 4.6 mm) at a software system, but there was no significant difference in the size of nodules between two systems when axial planes were used in calculating an average diameter in a software system. Both the per-case (9.8% vs. 17.4%) and per-nodule (12.9% vs. 17.9%) proportion of positive test (category 3/4) were significantly higher at a software system. By applying the CAD results, not only the number of the detected nodules (0.77 vs. 1.23 nodule/case) but also the per-case proportion of positive test (11.6% vs. 17.1%) were significantly increased.

CONCLUSION
By applying a semi-automated segmentation and CAD system, the number of detected nodules and the proportion of positive test were significantly increased.

CLINICAL RELEVANCE/APPLICATION
Semiautomated segmentation and CAD have important effects on the Lung-RADS positive rate. Therefore, detailed guidelines should be provided for the use of software in lung cancer screening.
11,325 individuals between ages 55-77 were included (mean age 64.1, 52.8% female, 74.9% white) of whom 2.8% reported at least accounting for complex survey design elements. Adjusted odds ratios were calculated with 95% confidence intervals. Analyses were performed conducted comparing LCS eligibility in patients with and without self-reported mental illness, adjusted for potential confounders was conducted. Individuals 55-77 yrs without lung cancer were included. The proportion of survey participants eligible for LCS was reported mental illness are more likely to be eligible for LCS and smoking cessation interventions compared to patients without mental illness using nationally representative federal cross-sectional survey data. The purpose of this study was to assesses if CAD can reduce the FN and CT reading time.

RESULTS
The accuracy of radiologists reading lung cancer screening CT in a previous study shows a false-negative rate (FN) of 3.5% to 8.1%. The purpose of this study was to assesses if CAD can reduce the FN and CT reading time.

CLINICAL RELEVANCE/APPLICATION
While CAD+Tech as first reader cannot replace the radiologist, CAD could play an important role in lung cancer screening by saving radiologists' time, and importantly reduce their FN rate by 4%.

CONCLUSION
CAD+Tech speed up the radiologist's nodule detection on screening chest CT. CAD detected nodules in 4% subjects where no nodule was identified by the radiologist, changing imaging follow-up protocol.

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PURPOSE
Prior studies have found that patients with mental illness are more likely to smoke compared with patients without mental illness. Lung Cancer Screening (LCS) with LDCT decreases lung cancer mortality in eligible current or former smokers. There is limited population-based information about LCS eligibility in patients with mental illness. Our purpose was to determine if patients with self-reported mental illness are more likely to be eligible for LCS and smoking cessation interventions compared to patients without mental illness using nationally representative federal cross-sectional survey data.

METHOD AND MATERIALS
Retrospective analysis of 2015 National Health Interview Survey (NHIS), a nationally representative, federal cross sectional survey was conducted. Individuals 55-77 yrs without lung cancer were included. The proportion of survey participants eligible for LCS was calculated and compared in patients with and without self-reported mental illness. Multiple variable logistic regression analyses were conducted comparing LCS eligibility in patients with and without self-reported mental illness, adjusted for potential confounders (age, race, and insurance status). Adjusted odds ratios were calculated with 95% confidence intervals. Analyses were performed accounting for complex survey design elements.

RESULTS
11,325 individuals between ages 55-77 were included (mean age 64.1, 52.8% female, 74.9% white) of whom 2.8% reported at least mental illness.
one mental illness. Of individuals with self reported mental illness, 18.7% met eligibility criteria for LCS and 25.8% were current smokers. Of individuals without self reported mental illness, 10.6% met eligibility criteria for LCS and 12.9% were current smokers. Patients self-reporting mental illness were more likely to be eligible for LCS (Adjusted OR 1.89, 95% CI 1.30 to 2.75, p = 0.001) and more likely to be current smokers (Adjusted OR 2.20, 95% CI 1.59 to 3.07, p < 0.001) than patients without mental illness.

CONCLUSION

Patients with self-reported mental illness have a higher smoking prevalence and are nearly twice as likely to be eligible for LCS compared with patients without mental illness.

CLINICAL RELEVANCE/APPLICATION

Radiologists have an opportunity to collaborate with psychiatry and primary care in developing targeted LCS outreach efforts for patients with mental illness who are at increased risk of developing lung cancer due to their higher smoking prevalence.

SSC03-07 Lung Cancer Screening in a Socioeconomically Disadvantaged Population: Baseline and 1st Annual Rescreening Results

Monday, Nov. 26 11:30AM - 11:40AM Room: E451A

Awards

Trainee Research Prize - Resident

Participants

Charles H. Li, MD, Los Angeles, CA (Presenter) Nothing to Disclose
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PURPOSE

To describe the results of the first two rounds of screening of our clinical low-dose CT lung cancer screening program targeting a minority, socioeconomically disadvantaged, high-risk population different from that studied in the National Lung Screening Trial.

METHOD AND MATERIALS

All participants met USPSTF and/or NCCN eligibility criteria for lung cancer screening. A coordinator enrolled eligible individuals, scheduled their screening exams, and organized their transportation.

RESULTS

1029 individuals were referred from 7/21/2015 through 3/20/2018. 119 individuals declined screening, and 230 were unable to be contacted. Of 717 participants who agreed to participate, 411 met eligibility criteria for lung cancer screening. 370 patients underwent their baseline LDCT during this time period. 203 males (55%) and 167 females received baseline LDCT, with a mean age of 60 years. The median pack-years was 42 (range 20-132), and 81% of participants were current smokers. The ethnic makeup of the population was 77% black, 9% white, 8% Hispanic/Latino, and 5% Asian. 57% of participants had no more than a high school education. 33% of participants reported occupational exposure to one or more lung carcinogens. 84% (312) of patients received a Lung-RADS score of 1 (92) or 2 (220), 8% (29) received a score of 3, 5% (19) a score of 4A, and 3% a score of 4B (2) or 4X (2). 3 patients have been diagnosed with lung cancer to date: 1 stage IIB, 1 stage IIIB, and 1 stage IV. 28% (105) of patients had a Lung-RADS score of 1 (87) or 2 (210), 8% (29) received a score of 3, 5% (19) a score of 4A, and 3% a score of 4B (2) or 4X (0)

CONCLUSION

Lung cancer screening with LDCT in a minority, socioeconomically disadvantaged, high-risk population is feasible but may yield a different lung cancer profile than screening in more privileged communities. Adherence to annual rescreening and follow-up recommendations is challenging in this population.

CLINICAL RELEVANCE/APPLICATION

Minority, socioeconomically disadvantaged populations may experience different benefits from LDCT lung cancer screening.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Cameron Hassani, MD - 2018 Honored EducatorFarhood Saremi, MD - 2015 Honored Educator

SSC03-08 Performance of the Vancouver Risk Calculator Compared to ACR Lung-RADS in an Urban, Diverse Clinical Lung Cancer Screening Cohort
PURPOSE
To compare the performance of the Vancouver Risk Calculator (VRC) with ACR Lung-RADS for a lung cancer screening cohort in an urban, diverse clinical setting.

METHOD AND MATERIALS
IRB approval was obtained. All lung cancer screening patients who had their initial screening CT from December 2012-June 2016 demonstrating a nodule comprised the study population. Each exam was assigned a Lung-RADS score, with 4A and 4B considered positive. The VRC calculates the risk of cancer at different thresholds using 9 patient and imaging variables, with a 5% threshold considered positive. Analysis was performed on a per-patient level based on the largest nodule. Follow-up information was obtained via EMR, cancer registry and NDI. Patients with initial studies suspicious for malignancy but without histologic confirmation were adjudicated on a case-by-case basis. Performance characteristics to predict lung cancer were compared for Lung-RADS and VRC.

RESULTS
486 patients, 261(53.7%) women, mean age 63±5.2, comprised the study population. Mean follow-up time was 36.9± 11.1 months, and 61(12.6%) patients were lost to follow-up. Lung cancer was diagnosed in 35(7.2%). Lung-RADS had 10 FP and 14 FN while VRC 5% had 30 FP and 8 FN. Overall sensitivity, specificity and accuracy for Lung-RADS was 61.1%, 97.8%, and 94.9% and for VRC 5% was 77.8%, 93.3%, and 92.2%, respectively.

CONCLUSION
In comparison with Lung-RADS, the VRC demonstrated higher sensitivity but lower specificity and accuracy in predicting malignancy among patients in a diverse urban clinical lung cancer screening program.

CLINICAL RELEVANCE/APPLICATION
LungRADS and VRC achieved complementary results in a diverse urban clinical lung cancer screening program. Use of the two, in concert, may improve lung cancer prediction.

SUSTAINABLE DEVELOPMENT GOALS

Participants
Abraham Kessler, BA, Bronx, NY (Abstract Co-Author) Nothing to Disclose
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PURPOSE
The purpose of this study was to evaluate the potential performance of lung MRI (MRI) vs. low dose CT (LDCT) using a Markov model of lung cancer screening. We hypothesized that MRI would be a cost-effective alternative to LDCT.

METHOD AND MATERIALS
We converted the MISCAN Lung microsimulation of lung cancer progression into a Markov cohort model with transition probabilities based on histology/stage. Our model uses published data to specify lung cancer incidence and background non-lung cancer mortality based on gender, age and smoking burden, and survival after diagnosis by gender, histology and stage. Published LDCT screening sensitivity (Sn) and specificity (Sp) by stage/histology was used to populate the LDCT model parameters. For MRI, the Sn and Sp were based on published data of solid nodules using size and T2 contrast-to-noise ratio. Our model follows a large cohort of age-60 males with 2 packs/day smoking history for 20 years. The time-0 composition of the cohort was a mixture of well and undiagnosed cancer patients from the model when run from age 42. At each annual screening, portions of the surviving cohort experience true/false, positive/negative outcomes with true positives moving to treatment. Costs for screening LDCT ($256), work-
up, and treatment were extracted from CMS procedure cost data and the literature. Sensitivity analysis was performed on Sn/Sp of MRI and costs of MRI. Results of interest include life-years/patient (LYs), net monetary benefit (NMB), and cost-effectiveness (C/E) of MRI relative to LDCT.

RESULTS

LYs for MRI screening were 13.28 vs. 13.29 for LDCT. Using an acceptable cost/LY of $100,000, MRI resulted in a net-monetary benefit (NMB) of $3,744 over LDCT. MRI saves $2656/patient over LDCT, while losing only 3.97 life days, for a favorable C/E ratio of $244,189/LY. Cost ranging from $256 to $375 result in a favorable C/E ratio for MRI.

CONCLUSION

Based on this simulation, MRI provides an equivalent LY benefit with cost-savings over LDCT lung cancer screening at reasonable MRI costs. This finding is driven by improved specificity of MRI for solid nodule characterization.

CLINICAL RELEVANCE/APPLICATION

Markov simulation of a high-risk screening cohort shows that Lung MRI has the potential to be a cost-effective alternative to low-dose CT screening.
SSC04

Emergency Radiology (Thoracic, Cardiac and Vascular)

Monday, Nov. 26 10:30AM - 12:00PM Room: S504AB

Participants
Felipe Munera, MD, Key Biscayne, FL (Moderator) Nothing to Disclose
Ferco H. Berger, MD, Toronto, ON (Moderator) Nothing to Disclose

Sub-Events

SSC04-01  Model-Based Iterative Reconstruction on 80kV CT Pulmonary Angiography: Image Quality and Radiation Dose Saving Compared with Hybrid Iterative Reconstruction on 100kV CT Study

Participants
Andrea De Vito, MD, Milano, Italy (Presenter) Nothing to Disclose
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PURPOSE
To evaluate dose reduction and image quality of 80 kV CT pulmonary angiography (CTPA) reconstructed with model-based iterative reconstruction (IMR), and compared with 100 kV CTPA with hybrid iterative reconstruction (iDose4).

METHOD AND MATERIALS
One hundred and fifty-one patients were prospectively investigated for pulmonary embolism; a study group of 76 patients underwent low-kV setting (80kV, automated mAs) CTPA study, while a control group of 75 patients underwent standard CTPA protocol (100kV; automated mAs); all patients were examined on 256 MDCT scanner (Philips iCTelite). Study Group images were reconstructed using IMR while the Control Group ones with iDose4. CTDIvol, DLP and ED were evaluated. Region of interests placed in the main pulmonary vessels evaluated vascular enhancement (HU); signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were calculated.

RESULTS
Compared to iDose4-CTPA, low kV IMR-CTPA presented lower CTDIvol (6.41 ± 0.84 vs 9.68 ± 3.5 mGy) and DLP (248.24 ± 3.2 vs 352.4 ± 3.59 mGy x cm), with ED of 3.48 ± 1.2 vs 4.93 ± 1.8 mGy. Moreover IMR-CTPA showed higher attenuation values (670.91 ± 9.09 HU vs 292.61 ± 15.5 HU) and a significantly higher SNR (p<0,0001) and CNR (p<0,0001). The subjective image quality of low kV IMR-CTPA was also higher compared with iDose4-CTPA (p<0,0001).

CONCLUSION
Low dose CT with IMR represents a feasible protocol for the diagnosis of pulmonary embolism in the emergency setting and permits to achieve excellent diagnostic images (in terms of subjective quality) with extremely low noise, and a significant reduction of the dose led to the patient (in terms of mSv) within reasonable reconstruction times (less than 120 seconds).

CLINICAL RELEVANCE/APPLICATION
Low kV IMR approach allows a significant dose reduction of CTPA studies improving attenuation values, SNR and CNR in the pulmonary vessels, as compared with standard kV iDose4-CTPA.

SSC04-02  A Proposal of a New System Score to Evaluate With Lung Ultrasound the Necessity of a Drainage Tube in Pneumothorax in Emergency Room

Participants
Maria Luisa De Cicco, MD, Roma, Italy (Presenter) Nothing to Disclose
Vittorio Miele, MD, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Vincenza Di Giacomo, Rome, Italy (Abstract Co-Author) Nothing to Disclose
Chiara Andreoli, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
Stefania Ianniello, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
Identifying Patients with Low Cardiac Output Using Vessel Density at CTPA

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Andrew D. Chang, MSc, Providence, RI (Presenter) Nothing to Disclose

PURPOSE
Cardiac output (CO) is an important metric that has diagnostic and prognostic value in emergency and inpatient settings. However, determining CO currently requires invasive or costly procedures such as Swan-Ganz catheterization (SGC) or cardiac MR (CMR). CT for pulmonary angiography (CTPA) is a commonly performed examination that provides a snapshot of exogenously administered contrast as it distributes through the thoracic vasculature in a manner chiefly determined by CO. We hypothesized that by measuring attenuation in different vessels we could (1) identify patients with reduced CO and, potentially, (2) quantify CO.

METHOD AND MATERIALS
We retrospectively identified patients who underwent SGC or CMR within 14 days of CTPA between 1/1/2006 to 12/30/2016. Using CO values from SGC or CMR as the gold standard, patients were stratified into three groups: CO < 4 L/min (low), 4-8 L/min (normal), and over 8 L/min (high). All CT studies were performed using a standardized protocol with a fixed delay of 22 sec and an injection rate of 4 cc/s. For each patient, density (HU) was measured in the superior vena cava [SVC], main pulmonary trunk [PT], and ascending aorta [AO] on a single mid-thoracic transaxial slice. Densities and density differences were then compared with measured values of CO.

RESULTS
We identified 119 patients with concurrent CO measurements and CTPA studies within the study period. Compared to patients with normal CO (n=76, 63.9%), patients with low CO (n=35, 29.4%) exhibited higher attenuation in the SVC (1305±846 vs 944.4±556.8 HU, p=0.026) and PT (518.4±149.6 vs 385.3±122.4 HU, p<0.001). Adjusting for body surface area, PT-AO difference predicts low CO (OR per unit increase 1.007, 95% CI 1.004-1.010, p<0.001). ROC analysis yielded a PT-AO difference threshold of 130 HU for differentiating low from normal CO, with sensitivity and specificity of 74.3% and 87.7% (AUC 0.776, p<0.001).

CONCLUSION
This study provides a simple approach to estimate low CO status by measuring vessel density on a single transaxial CTPA image at the level of the mid-ascending aorta. We found that the greater the attenuation difference between the PT and AO, the greater the odds of low CO, with a difference of 130 HU serving as a useful threshold distinguishing low from normal CO.

CLINICAL RELEVANCE/APPLICATION
Using a standardized CTPA protocol it may be possible to confidently identify patients with reduced cardiac output.

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Multifactorial Comparative Study of Dual Source CT Scanners in Acute Pulmonary Embolism

Monday, Nov. 26 11:00AM - 11:10AM Room: S504AB

Participants
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PURPOSE
To compare mean acquisition time, image quality and diagnostic accuracy of two dual-energy CT scanners for the evaluation of acute pulmonary embolism (PE).

METHOD AND MATERIALS
Total of 50 scans on the 2nd generation dual source SOMATOM Definition Flash CT scanner (the Flash) and 49 scans on the 3rd generation dual source SOMATOM Force (the Force) were included. Scans with inadequate opacification of pulmonary artery or known chronic PE were excluded. Imaging acquisition parameters were adjusted to be the same on both the Force and the Flash. In a randomized blinded design, two radiologists independently reviewed both sets of scans in two settings (3-week interval) for image quality using a 5-point scale. The interobserver reliability and diagnostic accuracy were calculated for each reviewer. Diagnosis of acute PE was made using clinical data (acute chest pain), laboratory data (D-Dimer > 500 ug/L) and CTPA.

RESULTS
Mean acquisition time for the Force (x= 2.81 sec, SD= 0.1) and the Flash (x= 9.7 sec, SD = 0.15) was found to be very statistically significant (P= 0.0001; 95% CI = 6.8 - 6.9) with the Force 3.4 times faster than the Flash. The mean image quality was found to be 4.47/5 and 4/5 for the Force and the Flash respectively with statistical significance (P= 0.0064 on the unpaired t-test; 95% CI= 0.80-0.13). Interobserver reliability for image quality indicates strong agreement on both, the Force (K= 0.83, p <0.005) and the Flash-generated scans (k= 0.85, p < 0.005). Acute PE was diagnosed in 17 cases on the Force and in 21 cases on the Flash. Diagnostic accuracy was 94.1% and 98.2% on the Force and 90.2% and 94.8% on the Flash for reviewers one and two respectively. Although diagnostic accuracy was higher on the Force, the difference wasn't statistically significant. Study limitations includes retrospective design and Berkson's selection bias as the Force was routinely used for emergency patients while the Flash was used for inpatients.

CONCLUSION
Image quality is significantly higher on the Force CT scanner with significantly lower mean acquisition time and less motion artifact in comparison to the Flash.

CLINICAL RELEVANCE/APPLICATION
The improved image quality and speed of the Force CT scanner with resultant less motion artifact and repeated studies could be particularly useful in emergency radiology setting with large patient volume.

Axial or Helical? CT Imaging of the Chest for Uncooperative Emergency Patients with 16-cm Wide Detector CT

Monday, Nov. 26 11:10AM - 11:20AM Room: S504AB

Participants
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PURPOSE
To compare image quality and radiation dose between the fast-helical mode (FHM) and two-axial mode (TAM) in chest CT imaging for uncooperative emergency patients with 16-cm wide detector CT scanner.

METHOD AND MATERIALS
Thirty emergency patients who were unconscious or uncooperative with the breathing instructions underwent chest CT were prospectively divided randomly into two groups: FHM Group (n=15, helical scan mode with 80mm detector coverage and pitch 0.992:1), TAM Group (n=15, axial scan mode with 160mm detector coverage, two scans). Both groups used the 0.28s rotation speed and automatic tube current modulation. All scans were performed in free-breathing. CT value, image noise and signal-to-noise ratio (SNR) were measured at each of the following locations: descending thoracic aorta, lung parenchyma and paraspinal muscle at the level of the carina. Two radiologists assessed the images for subjective image quality, motion artefacts and diagnostic confidence. The volume CT dose index (CTDIvol) and dose-length product (DLP) were evaluated from the dose reports, and effective dose was calculated. All measurements between the two groups were statistically compared.

RESULTS
The mean total exposure time was significantly shorter for TAM group than FHM group (0.56s vs.1.12s, P<0.001). Image quality was generally better with TAM than with FHM (diagnostic confidence score, 3.87 vs. 3.47, P<0.05); However, there was no
significant difference in CT value, image noise and SNR between two groups. The DLP value was higher in FHM than TAM (123.92±38.54mGy·cm vs. 94.22±33.63mGy·cm, P=0.041), while CTDIvol was not significantly different. TAM group reduced the total effective radiation dose by 24% compared to FHM (1.32±0.50 mSv vs. 1.73±0.54mSv).

CONCLUSION

The use of the two-axial mode further reduces the scan time in chest CT for emergency patients and ensures good image quality with 24% radiation dose reduction, compared with chest CT that uses the fast-helical scan with 80mm collimation.

CLINICAL RELEVANCE/APPLICATION

The two-axial scan mode can be used for lung evaluation in uncooperative emergency patients in free breathing to obtain satisfactory image quality while reducing radiation dose.

SCC04-06 Utility of 3D Post-Processing Cinematic Rendering Reconstruction Images in Acute Trauma Setting: Initial Observations

Monday, Nov. 26 11:20AM - 11:30AM Room: S504AB

Participants
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PURPOSE

Multiple post-processing reconstruction techniques based on volumetric CT datasets are used to generate three-dimensional (3D) images to better depict complex anatomical details. Volume rendering (VR) is frequently used as a standard 3D technique, however recently an FDA-approved alternative called Cinematic Rendering (CR) is emerging with vast clinical potentials (1,2). Contrary to traditional VR reconstruction, CR utilizes a global illumination model to create high definition photo-realistic images. We describe our initial experience with CR images in the setting of acute trauma.

METHOD AND MATERIALS

A set of polytrauma patients with ISS score >16 with simple to complex injuries presenting to Vancouver General Hospital, level 1 trauma center were evaluated. Source DICOM images using a 2nd generation 128-slice dual-source CT (Somatom Definition Flash, Siemens Healthineers, Forchheim, Germany) were used to create CR images. Cinematic Rendering software (Siemens Syngo.via Frontier) was used applying default and customized presets. CR images were assessed for image quality, depth and shape perception, delineation of osseous, vascular, soft tissue and solid organ anatomy in comparison to VR images. The images were also evaluated for their role in clinical decision making and education. Multiple trauma surgeons assessed the images using Likert scale analysis with 1 being much lower, 3 equivocal, and 5 much higher. Frequencies, percentages, mean and standard deviation were calculated.

RESULTS

CR images were rated higher than VR images with a mean+/- SD of 4.0+/-0.8. 67 % of trauma surgeons categorized CR images as much higher for use as an education tool and 61% graded them as higher in helping with clinical decision compared to VR images.

CONCLUSION

Our observations are one of the very few initial studies to evaluate the clinical utility of CR images. Understanding complex and challenging anatomical and pathological details are imperative for better patient management from a trauma surgeon assessment. CR provides remarkable details relative to VR reconstructions in context of complex acute trauma.

CLINICAL RELEVANCE/APPLICATION

Cinematic Rendering is a promising novel technique to display visually receptive 3D photorealistic high definition images with exquisite anatomical details. Formal evaluations and research is needed to assess the CR images in order to understand their clinical application in patient management.


Monday, Nov. 26 11:30AM - 11:40AM Room: S504AB

Participants
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PURPOSE

To compare pulmonary embolism detectability using computer-aided detection (CAD) software with optimal keV monochromatic images and conventional images.
METHOD AND MATERIALS
Retrospectively analyzed CT images of 20 patients with clinically proven pulmonary embolism (PE). These patients underwent CT pulmonary angiography (CTPA) with spectral imaging mode. The conventional images (140kVp polychromatic, group A) were reconstructed. Using the standard Gemstone Spectral Imaging (GSI) viewer on an advanced workstation (AW4.6), an optimal energy level (group B) could be automatically obtained. The images in two group were independently analyzed for detecting PE using a commercially available CAD software. Two experienced radiologists reviewed all images and recorded the number of emboli, and the results were used as the gold standard. The attenuation in the main pulmonary artery (MPA) and the embolus (in the most substantial part of the embolus) were measured. The difference in attenuation (MPA-embolus), as well as the detectability for pulmonary embolism in each case (sensitivity, false positive rate) were calculated. Data were statistically compared between the two groups.

RESULTS
The optimal energy levels were 62.4keV. The attenuation in the MPA, difference in attenuation (MPA-embolus) for group A and B were (314.46±81.41HU vs. 446.30±151.88HU) and (281.89±73.82HU vs. 404.75±138.74HU), respectively (all p<0.001). The mean sensitivity for pulmonary embolism detection in group A was 74.63±4.16%, which was lower than the 82.17±4.51% in group B (t=4.26, p<0.001). The mean false positive rate in group A was 32.71±4.89%, which was higher than the 13.41±3.02% in group B (t=13.41, p=0.00).

CONCLUSION
Compared with conventional images, the combination of optimal keV monochromatic images and CAD improves the diagnostic accuracy of CAD.

CLINICAL RELEVANCE/APPLICATION
The combination of optimal keV monochromatic images and CAD could improve the detection rate for emboli.

SSC04-08 Implementation of Fully Automated Computer-Aided Detection of Nodules in The Lung Bases on Emergent Abdominal CT Scans: Accuracy and Effect on Workflow

Participants
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Vahid Yaghmai, MD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

PURPOSE
To assess the value of fully automated computer-aided diagnosis (CAD) for detection of lung nodules on emergent abdominal CT studies in.

METHOD AND MATERIALS
Abdominal CT scans of 50 patients in the emergency department were reviewed. A radiologist with 5 years' experience (RAD) reviewed the scans to detect pulmonary nodules in the lung bases. In order to simulate the emergency setting, time limit of 30 seconds was set in each case for RAD to review image datasets. The CAD detection performance was also evaluated in the same session by RAD. CAD nodule detection was fully automated and required no additional processing time by RAD. Fisher’s exact test and T-test were used to determine the differences between the rate of detection between RAD and CAD.

RESULTS
A total number of 54 nodules were detected by RAD in 50 patients (28 male, mean±SD age, 51.2±17.6 years). Adding the CAD increased the rate of detection by 30% (1.47 vs. 1.13 nodule/scan, P<0.05). Moreover, there was no significant difference in the rate of missed nodules per scan between CAD and RAD (0.33 nodule /scan vs. 0.25 nodule/scan), respectively. 25 out of 74 nodules detected by CAD were false positives .

CONCLUSION
Using fully automated CAD may significantly improve the performance of the radiologist in detecting nodules located in the lung bases on abdominal CT scans obtained in the emergency department.

CLINICAL RELEVANCE/APPLICATION
The role of CAD as a second reader may improve detection of lung base nodules on emergency department abdominal CT scans.

Honored Educators
Participants
Leena Robinson Vimala, MD, Vellore, India (Presenter) Nothing to Disclose

SSC04-09 Spectrum of Radiological Manifestations of Melioidosis, Association with Risk Factors, and Its Role in Prognostication of Clinical Outcome

Participants
Leena Robinson Vimala, MD, Vellore, India (Presenter) Nothing to Disclose
Melioidosis being a mimicker of its more common clinical counterpart tuberculosis, is often mismanaged. The primary objective is to describe the spectrum of radiological manifestations of melioidosis. Secondary objectives are to evaluate the association between the organ involvement, known risk factors, predisposing conditions and also to predict effect on clinical outcome.

METHOD AND MATERIALS

Retrospective image analysis of all culture proven cases of Burkholderia pseudomallei, between January 2011 & October 2017 was done. Demographic data, clinical characteristics, risk factors and clinical outcome were analysed. Unfavourable clinical outcome considered were those patients with severe disease condition requiring ICU admission for administration of ionotropes, requirement of ventilation or death.

RESULTS

194 patients (162 males) with median age of 45 years, were included. Among the risk factors, diabetes mellitus was most common (63%), followed by alcohol abuse (28%). Table 1 demonstrates the radiological manifestation of organ/system involvement of melioidosis. Patients with diabetes were found to have increased incidence of liver, spleen, bone and soft tissue involvement (p<0.05). Significant association of diabetes with liver, spleen and bone and soft tissue involvement seen, having odds ratios 3.213 (95% CI: 1.048 - 9.855; p=0.04), 3.478 (95% CI: 1.728 - 7; p=<0.001) and 2.668 (95% CI: 1.232 - 5.778; p=<0.001) respectively. Statistical significant difference was identified in the melioidosis involvement of genitourinary tract between the positive and negative TB group. 25% of patients suffered unfavourable outcome. Mortality was 11%. Using univariate binary logistic regression analysis, lung involvement was found to have 4.3 times risk for unfavourable outcome (95% CI: 1.971 - 9.496; p< 0.001), whereas spleen and lymph node involvement, protected from unfavourable outcome (odds ratio being 0.202 & 0.457 respectively).

CONCLUSION

The constellation of imaging findings could mimic disseminated tuberculosis or other pyogenic infection. Combination of organ involvement, associated superficial soft tissue involvement are imaging diagnostic clues. Knowledge about the radiological manifestations of melioidosis is essential for accurate diagnosis and management.

CLINICAL RELEVANCE/APPLICATION

Present study is the largest study that has illustrated the radiological manifestations of melioidosis and its association with clinical outcome and risk factors.
SSC06

Gastrointestinal (Liver Diffuse Disease, Fibrosis)

Monday, Nov. 26 10:30AM - 12:00PM Room: N229

CT GI MR US BQ

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

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Sub-Events
SSC06-01 Comparison of 2D-Shear Wave Elastography (SWE), Magnetic Resonance Elastography (MRE), and Transient Elastography (TE) for the Diagnosis of Fibrosis in Non-Alcoholic Fatty Liver Disease (NAFLD)

Monday, Nov. 26 10:30AM - 10:40AM Room: N229

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PURPOSE
To compare the accuracy of 2D-SWE, MRE and TE for the diagnosis of fibrosis in patients with biopsy-proven NAFLD.

METHOD AND MATERIALS
In this IRB-approved study, 62 adult subjects (36F; 26M; age, 50±13 years; BMI, 35±7 Kg/m2) with biopsy-proven NAFLD were prospectively recruited. The distribution of fibrosis was as follow: F0=1; F1=17; F2=20; F3=15; F4=9. Subjects underwent a 2D-SWE which uses the comb-push technique (GE LOGIQ E9, GE Healthcare), MRE (2D-GRE; GE Healthcare) and TE (Fibroscan, Echosens) within one year of the biopsy. Area under the receiver operator curve (AUROC) and 95% confidence interval (CI) for the corresponding liver stiffness measurements (LSM, expressed in kPa) were calculated using as outcome significant (F>1) and advanced (F>2) fibrosis. Pairwise comparisons of AUROCs were conducted using the DeLong test. Statistical significance was set at p<.05.

RESULTS
Valid LSM were obtained in 57/62 subjects with 2D-SWE and in 59/62 subjects with TE. MRE was completed in 59/62 cases. Valid LSM measurements for all three techniques were available in 54/62 subjects. The AUROCs (95% CI) of 2D-SWE, MRE and TE were .796 (.673-.918), .847 (.744-.950), .766 (.638-.893) for significant fibrosis respectively and .890 (.803-.976), .950 (.887-1.00), .861 (.769-.953) for advanced fibrosis respectively. Pairwise comparisons revealed no statistically significant difference for significant (2D-SWE vs. MRE, p=.43; 2D-SWE vs. TE, p=.31; MRE vs. TE, p=.05) and advanced (F>2) fibrosis. Pairwise comparisons of AUROCs were conducted using the DeLong test. Statistical significance was set at p<.05.

CONCLUSION
2D-SWE, MRE and TE showed high accuracy for the diagnosis of advanced fibrosis in NAFLD with no significant difference at pairwise comparison.

CLINICAL RELEVANCE/APPLICATION
2D-SWE and TE are valid alternative to MRE for the diagnosis of advanced fibrosis in patients with NAFLD.

SSC06-02 Diagnostic Performance of Tomoelastography by Multifrequency Magnetic Resonance Elastography for Staging Hepatic Fibrosis

Monday, Nov. 26 10:40AM - 10:50AM Room: N229

Awards
Student Travel Stipend Award
LV were measured in virtual hepatectomy. The T1 reduction rate T1% \[
\frac{(T1pos - T1pre)}{T1pre}
\], functional liver volume images with resection plan defined by multi-disciplinary team discussion and adjusted by surgery record. Remnant T1pre, T1pos and LV were measured in Hepatobiliary phase (HBP) scanned 20 minutes after injection. Virtual hepatectomy was processed in 3D surgery. The liver volume(LV) and mean liver T1 relaxation time before (T1pre) and after (T1pos) contrast was measure with T1pos

This study enrolled 133 HCC patients who underwent Gd-EOB-DTPA enhanced MRI and indocyanine green (ICG) tests before surgery. The liver volume(LV) and mean liver T1 relaxation time before (T1pre) and after (T1pos) contrast was measure with T1pos and LV were measured in Hepatobiliary phase (HBP) scanned 20 minutes after injection. Virtual hepatectomy was processed in 3D images with resection plan defined by multi-disciplinary team discussion and adjusted by surgery record. Remnant T1pre, T1pos and LV were measured in virtual hepatectomy. The T1 reduction rate T1% \[
\frac{(T1pos - T1pre)}{T1pre}
\], functional liver volume.
(FV=W+T1%), functional liver volume to weight ratio (FV/W) and T1 relaxation time to liver volume ratio (T1pos/LV) were calculated, the same as the remnant T1%, rFV, rFV/W, rT1pos/LV and rFV%. Correlations between functional parameters (T1pre, T1pos, T1%, FV, FV/W, T1pos/LV) and ICG reduction rate (ICG-R15), ALBI grade were investigated. Child-Pugh score was evaluated in postoperative day 5. The differences of remnant function reserve parameters between Child-Pugh A group and B&C group were analyzed. Multiple Logistic regression test was used to find the possible predictor for postoperative hepatic insufficiency.

RESULTS
Those function liver volume parameters T1pos, T1%, FV, FV/W, T1pos/LV (mean value: 248.4msec, 64.12%, 786.38ml, 12.75mll/Kg, 0.21msec/ml) have shown statistical significantly correlation with ICG-R15 (rho=0.75, -0.290, -0.446, -0.398, 0.438; p<0.001). In predicting preoperative ICG-R15>14%, the cut-off value of FV, FV/W and T1pos/LV were 682.8ml, 10.80ml/kg, 0.236msec/ml, with sensitivity of 73.5%, 74.4%, 81.3%, specificity of 75.0%, 75.0%, 76.9%, respectively. Preoperative measured rFV% was the only positive factor in predicting post-hepatectomy Child-Pugh B&C hepatic insufficiency with cut-off value of 0.683, sensitivity of 71.43% and specificity of 58.67%.

CONCLUSION
Quantitative function liver volume in Gd-EOB-DTPA enhanced MRI can provide 'one-stop process' assessment of liver function reserve and prediction of post-hepatectomy liver insufficiency.

CLINICAL RELEVANCE/APPLICATION
This research provide a 'one-stop process' assessment for HCC surgical plan

SSC06-04 Accuracy of Liver Surface Nodularity Score on CT for Staging HCV Hepatic Fibrosis: A Multi-Institutional Study

Monday, Nov. 26 11:00AM - 11:10AM Room: N229

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PURPOSE
To assess the accuracy of the Liver Surface Nodularity (LSN) score on CT and FIB4 score for staging hepatitis C virus (HCV) hepatic fibrosis.

METHOD AND MATERIALS
For this IRB-approved HIPAA-compliant retrospective multi-institutional observational study, adult patients with HCV chronic liver disease and a random liver biopsy obtained with 6 months of a liver CT were included. Participating institutions (N=5) each submitted de-identified data and liver CT images from 40 consecutive patients (N=200 total patients) centrally to a core lab. A REDCap web-based database was used to capture demographics, lab values, and the Scheuer stage of fibrosis (FO-F4) on biopsy specimens. Patients with insufficient information for Scheuer staging of fibrosis (N=3) and CT images that could not be processed (N=4) were excluded. The LSN score was measured using custom software in the final cohort (N=193), while blinded to clinical data. The patients age and serum labs (ALT, AST and platelets) were used to calculate the FIB4 score, a method for assessing hepatic fibrosis severity. The accuracy for differentiating the various stages of liver fibrosis using the LSN score, FIB4 score, and a combination were assessed with ROC analysis and AUC.

RESULTS
193 patients (69 females / 124 males; mean age 54 years) had Scheuer fibrosis stage: FO-F1 (N=36), F2 (N=41), F3 (N=47), and F4 (N=67). LSN scores increased with higher stages of liver fibrosis (mean: F0-F1=2.240.3, F2=2.440.4, F3=2.440.3, F4=3.240.9; p<0.001). For differentiating significant fibrosis (>=F2), advanced fibrosis (>=F3), and cirrhosis (>=F4), the AUCs for the LSN score were 0.88, 0.82, and 0.89, for the FIB4 score were 0.87, 0.87, and 0.91, and for both combined were 0.90, 0.87, and 0.93, respectively.

CONCLUSION
The combination of LSN score on CT and FIB4 score was highly accurate at staging HCV hepatic fibrosis in a multi-institutional study.

CLINICAL RELEVANCE/APPLICATION
The LSN score on CT and FIB-4 score are easy to obtain and could be used to noninvasively and accurately stage hepatic fibrosis in patients with HCV chronic liver disease.

**Honoered Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

**SSC06-05 Quantitative Assessment of Equilibrium Contrast-Enhanced CT to Evaluate Functional Hepatic Reserve and Liver Fibrosis**

**Monday, Nov. 26 11:10AM - 11:20AM Room: N229**

**Participants**

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**PURPOSE**

To evaluate hepatic extracellular volume fraction (fECV) measurement using equilibrium CT images compared with both functional hepatic reserve that is assessed with 99mTc-diethylenetriamine-pentaacetic acid-galactosyl human serum albumin (GSA) scintigraphy, and liver fibrosis that is assessed with histopathological findings.

**METHOD AND MATERIALS**

A total of 86 patients (M/F=63/23; mean age, 67±13 years) who underwent routine dynamic liver CT and GSA scintigraphy for the clinical workup of hepatocellular carcinoma (n=74) and liver metastasis (n=12) were retrospectively studied. Absolute enhancement (in Hounsfield units) of the liver parenchyma (Eliver) and portal vein (Eblood) 3 minutes after contrast agent administration was measured on precontrast and equilibrium phase images. The fECV was calculated as the following equation: fECV(%) = (Eliver - Eblood) / Eblood. Functional hepatic reserve was assessed with hepatic uptake ratio (LHL15) on GSA scintigraphy. Correlation between fECV and LHL15 was analyzed by the Spearman correlation coefficient. In 52 patients who underwent hepatectomy following the CT and GSA scintigraphy examinations, the fECV measurements were compared with the histopathological results of liver fibrosis staging ([F0-F4]: F0, absent of fibrosis; F4, severe fibrosis).

**RESULTS**

The fECV measurements showed a significant correlation with LHL15 (r=-0.58, p<0.0001). With an fECV threshold of 30.0%, the sensitivity and specificity for detecting reduced functional hepatic reserve (LHL15 < 0.91) was 90.5% and 86.2%, respectively. The AUC of fECV for F0-3 vs. F4 was 0.80.

**CONCLUSION**

Hepatic fECV measured with equilibrium CT imaging is associated with functional hepatic reserve and severity of liver fibrosis.

**SSC06-06 Comparative Diagnostic Accuracy of Ultrasound Shear-Wave Elastography and Magnetic Resonance Elastography for Classifying Fibrosis Stage in Adults with Biopsy-Proven Nonalcoholic Fatty Liver Disease**

**Monday, Nov. 26 11:20AM - 11:30AM Room: N229**

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**PURPOSE**

Comparative diagnostic accuracy of ultrasound shear-wave elastography (SWE) and magnetic resonance elastography (MRE) for classifying fibrosis stage in adults with biopsy-proven nonalcoholic fatty liver disease (NAFLD).

**METHOD AND MATERIALS**

A total of 110 patients (mean age, 59±11 years; F/M=52/58) who underwent liver biopsy (n=109) and either ultrasound shear wave elastography (n=88) or magnetic resonance elastography (n=88) were retrospectively studied. The fibrosis stage was assessed by light microscopy and a modified Liver Staging Committee (LSN) score. The LSN score on CT and FIB4 score are easy to obtain and could be used to noninvasively and accurately stage hepatic fibrosis in patients with HCV chronic liver disease.

**RESULTS**

The LSN score on CT and FIB4 score are easy to obtain and could be used to noninvasively and accurately stage hepatic fibrosis in patients with HCV chronic liver disease.

**CONCLUSION**

Comparative diagnostic accuracy of ultrasound shear-wave elastography and magnetic resonance elastography for classifying fibrosis stage in adults with biopsy-proven nonalcoholic fatty liver disease.
Prospectively collected adult patients who underwent SWE before non-focal liver biopsy in three years. 10 SWE measurements

METHOD AND MATERIALS

diagnostic accuracy.

To explore the optimal and minimum number of SWE measurements for >=F2 fibrosis considering measurement variability and

PURPOSE

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Youden-based SWE- and MRE-cutoffs for classifying stages >=1, >=2, >=3, and = 4 and the Youden index was used to select the corresponding thresholds. DeLong test was performed to compare the areas under the ROC curves (AUCs) of MRE and SWE pairwise.

RESULTS

Patients had the following fibrosis stages on histology: 0: 17; 1: 18; 2: 6; 3: 2; 4: 3. AUCs for SWE and MRE were 0.70 (95% confidence interval [CI], 0.55-0.85) and 0.83 (95% CI, 0.72-0.95), 0.77 (95% CI, 0.60-0.93) and 0.97 (95% CI, 0.92-1.00), 0.92 (95% CI, 0.82-1.00) and 0.93 (95% CI, 0.78-1.00), and 0.93 (95% CI, 0.84-1.00) and 1.00, for detecting fibrosis stage >=1, >=2, >=3, and =4, respectively. The differences were significant (p<0.02) for detecting fibrosis stage >=2 but not otherwise (p>0.11).

Youden-based SWE- and MRE-cutoffs for classifying stages >=1, >=2, >=3, and =4 with sensitivities/specificities were 8.67 kPa (45%/88%) and 2.29 kPa (69%/88%), 9.19 kPa (55%/89%) and 2.75 kPa (91%/97%), 8.67 kPa (100%/76%) and 4.19 kPa (80%/100%), and 9.40 kPa (100%/88%) and 5.04 kPa (100%/100%).

CONCLUSION

In adults with suspected NAFLD, clinically indicated biopsy, and low a priori probability of advanced fibrosis, SWE showed modest accuracy for detecting stage >= 1 or >= 2 fibrosis and high accuracy for detecting advanced (stage >=3) fibrosis. MRE may be more accurate than SWE at classifying fibrosis but greater power is needed to achieve significance.

CLINICAL RELEVANCE/APPLICATION

In adults with suspected NAFLD, SWE may have utility as an initial screen for advanced fibrosis. MRE may be required to reliably detect earlier stages of fibrosis.

SSCO6-07  The Optimal Measurement Number of Shear Wave Elastography (SWE) for >=F2 Liver Fibrosis Diagnosis: Percentage of Color Filling Index (PCFI) Stratification Analysis using Automated Image Quality Analysis

Monday, Nov. 26 11:30AM - 11:40AM Room: N229

Participants

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PURPOSE

To explore the optimal and minimum number of SWE measurements for >=F2 fibrosis considering measurement variability and diagnostic accuracy.

METHOD AND MATERIALS

Prospectively collected adult patients who underwent SWE before non-focal liver biopsy in three years. 10 SWE measurements
were performed for each patient at the identical biopsy locations (Segment 8) by one experienced sonographer before the biopsy. Fibrosis stages were evaluated using METAVIR criteria (F0-F4). The optimal and minimum measurement number for \( \geq F2 \) were analyzed: (1) for each measurement number (1-9), correlated median SWE estimates were obtained using a nested bootstrap simulation; (2) ROC curves, and the associated AUROC values, were estimated using each set of SWE measurements (e.g., 2-10 measurements); (3) steps (1) and (2) were repeated 1000 times to obtain empirical distributions of median SWE estimates, and AUC estimates. Two variation parameters were evaluated, including (1) intra-subject SWE variation (m/s): the absolute median difference between individual SWEs and median SWE, and (2) interval width difference (IWD): the width differences of AUC 95%CI between a measurement number (1-9) and 10. A subgroup of patients with \( \geq 50\% \) PCFI images (percentage of valid SWE pixels over the entire SWE image box, a metric for SWE image quality assessment) were also selected.

**RESULTS**

245 cases were enrolled (mean 48.5±13.2 yr; men 109, women 136), with the fibrosis stages F0=93, F1=92, F2=27, F3=23, F4=10. The intra-subject variation of the median SWE estimate decreased from 3.12 to 0.46m/s in 1-10 measurements in overall patients (n=245), and decreased from 3.74 to 0.37 in images with \( \geq 50\% \) PCFI (n=106). We didn't detect AUC differences between measurement numbers 1-9 and 10, but IWD, which represents the variation of diagnostic accuracy, dramatically increased when measurements number =50% group, depending on the clinicians desired precision of IWD (within 0.040 units).

**CONCLUSION**

Current results demonstrated that, for \( \geq F2 \) fibrosis diagnosis, the minimum SWE numbers may be reduced to 7 in overall images, and 6 when \( \geq 50\% \) PCFI was applied for image quality control.

**CLINICAL RELEVANCE/APPLICATION**

Automated image quality analysis may have the potential to reduce the SWE measurements number for liver fibrosis diagnosis, thus improving the scanning process and diagnostic performance of SWE.

**SSC06-08  Hepatic Shear Wave Elastography: Correlation Between Liver Stiffness and Esophagogastric Varices**

**Participants**

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**PURPOSE**

To evaluate the role of liver stiffness measurement (LSM) measured by shear wave elastography (SWE) in predicting the presence of esophagogastric varices (EGV) in patients with portal hypertension and to determine the correlation between the LSM and endoscopic grade of EGV.

**METHOD AND MATERIALS**

This study included 331 patients with chronic liver disease being evaluated for portal hypertension and planned for endoscopic varices eradication. LSM was performed in the right lobe of the liver by using a convex broadband probe on GE LOGIQ E9 ultrasound machine. The shear wave liver stiffness (in kPa) was recorded at ten locations and the median values calculated. Endoscopic findings were interpreted with reference to the presence of varices and grade of the varices. Correlation between LSM and grade of varices was analyzed with the Pearson correlation coefficient. Multiclass Receiver Operating Characteristic (ROC) curves were constructed, and the area under the ROC curves (AUC) was calculated to determine the discriminating power between the grades of varices.

**RESULTS**

LSM and variceal grade showed no significant correlation (R = 0.351286, P <0.001). The AUC for detection of the presence of varices was 0.7259. The AUC for differentiating between various grades of the varices was 0.6470, 0.5802, 0.6259 and 0.7692. Box plot of the LSM and grade of varices revealed no discrimination power. Hepatic shear wave stiffness was marginally useful in predicting the presence of varices. But the discriminating power of LSM among the grades of varices was poor.

**CONCLUSION**

We found marginal utility of LSM in predicting the presence of EGV. However, contrary to the existing knowledge, in our study, we found no correlation between liver stiffness measurement and grade of EGV. The liver stiffness measurement is not a reliable predictor of portal hypertension.

**CLINICAL RELEVANCE/APPLICATION**

In advanced fibrosis, liver stiffness measurements in isolation does not seem to predict the clinical severity of portal hypertension. The additional assessment of splenic stiffness should be considered.

**SSC06-09  Diagnostic Accuracy of Combination of Quantitative Point Shear Wave Elastography (pSWE) and Serum Markers for the Assessment of Fibrosis in Patients with Chronic Liver Disease Using Liver Biopsy as the Reference Standard**

**Participants**

Monday, Nov. 26 11:50AM - 12:00PM Room: N229
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PURPOSE
To evaluate individual and combined diagnostic performance of quantitative point shear wave elastography (pSWE) and serum markers for the assessment of liver fibrosis in patients with chronic liver disease.

METHOD AND MATERIALS
This prospective study received ethics approval, and all participants provided written informed consent. Shear wave speed (SWS) using pSWE (VTQ) and serum fibrosis markers (aspartate aminotransferase-to-platelet ratio index [APRI], King's score) were measured in 169 consecutive patients with chronic liver disease (mixed aetiology). Receiver-operating characteristic (ROC) analysis were performed to evaluate the diagnostic accuracy of their individual and combined performance in predicting significant (F>=3) and severe/cirrhosis (F>=5) liver fibrosis using ISHAK histologic fibrosis stages (F0-6) as reference. Cut-off values were determined using Youden Index. Spearman's correlation coefficient between the SWS, fibrosis marker and fibrosis stage were calculated.

RESULTS
Ishak histology stages were 0-2 (n=90, 53%), 3-4 (n=50, 30%), 5-6 (n=29, 17%). There was a good correlation between SWS, King's score, APRI and the Ishak stage (ρ=0.682, ρ=0.632 and ρ=0.584, respectively, P <= .001). The areas under the ROC curves (AUROC) for SWS, King's score, and APRI, were 0.86, 0.87, and 0.89 for the diagnosis of significant fibrosis (F>=3) and 0.98, 0.79, and 0.85 for the diagnosis of severe fibrosis/cirrhosis (F>=5), respectively. pSWE is superior than APRI (P=0.0005) and King's score (P=0.002) in predicting severe fibrosis/cirrhosis (F>=5). The optimum pSWE cut-off values for significant and severe fibrosis/cirrhosis were 1.22 and 1.86 m/s, respectively. The AUROC for combining the serum fibrosis marker and pSWE in diagnosing significant fibrosis were 0.93, outperforming using pSWE alone (P=0.0048).

CONCLUSION
pSWE is superior than serum markers in predicting severe fibrosis/cirrhosis is and comparable to serum markers for significant fibrosis. Combining pSWE and serum markers improves the diagnostic accuracy in predicting significant fibrosis.

CLINICAL RELEVANCE/APPLICATION
pSWE has excellent diagnostic accuracy for predicting cirrhosis. In addition, combining pSWE and serum markers significantly improve the diagnostic performance of significant fibrosis.
SSC07-01  **Genitourinary Keynote Speaker: Renal Mass Characterization: Quantitation, Radiomics, and Machine Learning**

**Participants**

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SSC07-02  **Utility of Google TensorFlow™ Inception Machine Learning to Discriminate Clear Cell Renal Cell Carcinoma from Oncocytoma on Multiphasic CT**

**Participants**

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**PURPOSE**

Although a renal mass can have imaging features of a typical clear cell renal cell carcinoma (ccRCC) on CT, up to 30% of these are found to be benign after surgery, most commonly oncocytoma (ONC). The purpose of our study was to develop a machine learning-based renal lesion classifier using open source Google TensorFlow™ Inception (TCI) Machine Learning to discriminate ccRCC from ONC on four-phase CT.

**METHOD AND MATERIALS**

With IRB approval and HIPAA compliance, we derived a cohort of 176 patients with 195 lesions (131 patients with 125 ccRCCs; 61 patients with 49 ONC) with preoperative four phase (unenhanced (UN), corticomedullary (CM), nephrographic (NP), excretory (EX)) CT imaging. Regions of interest were drawn around the tumor on every slice in each phase to create a 3D tumor volume. To preprocess the DICOM data into a format currently supported by TCI, 3D tumor data was extracted in the x, y and z plane and converted into a red, green and blue (RGB) jpeg image using the three color channels to encode each slice. 70% of the data was used in the training set and 30% in the testing set. We investigated several approaches to convert the data into a set of 2D JPEG images that adequately represented each tumor and were used to train the final layer of the neural network model.

**RESULTS**

When we analyzed 3 mid-slices of the tumor in the x, y and z plane in each post contrast phase, the EX phase had the highest accuracy in classifying both ccRCC (79.6%) and Onc (59.5%) compared to the accuracy in the CM (ccRCC=78.3%, Onc=46%) and NP (ccRCC=77.2%, Onc=46.5%) phases. The highest accuracy in classifying ccRCC was obtained by submitting all x,y and z planes in all phases as one image to TCI with an accuracy of 82.5%, however this lowered the correct classification of Onc to 52.2%.

**CONCLUSION**

In this pilot study, TCI enabled independent classification of clear cell RCC from oncocytoma on a four phase MDCT with an accuracy of 82.5%.

**CLINICAL RELEVANCE/APPLICATION**

A TCI based method if developed and validated prospectively may be an adjunct to radiologists for discrimination between clear cell RCC and Oncocytoma on multiphasic CT minimizing diagnostic uncertainty and enabling more accurate patient triage.
**Differentiation of Renal Cell Carcinoma and Oncocytoma Using Machine Learning-Based MR Radiomics**

**Monday, Nov. 26 10:50AM - 11:00AM Room: S503AB**

**Participants**
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**PURPOSE**
To build a random forest predictive model for distinguishing between renal cell carcinoma (RCC) and oncocytoma that integrates clinical, preoperative, and multimodal automated features.

**METHOD AND MATERIALS**
Forty-one patients with histologically confirmed renal tumors (23 RCCs; 18 oncocytomas) were identified from a single institution. Two experts (HL and DP), with 23 and 10 years of experience of reading body MR respectively, blinded to the histologic diagnoses, made image diagnosis based on the preoperative MR images (T2-weighted and T1-contrast enhanced sequences). Histogram, geometric and texture features were extracted from preoperative MR images. Using a random forest algorithm, automated features were integrated with clinical data to generate a multivariate predictive model. Receiving operating characteristic curves (ROCs) and areas under the curve (AUCs) were used to assess model performance by using the Delong method for statistical comparison of ROCs.

**RESULTS**
Patients with oncocytoma had higher mean age than patients with RCC (65.8± 7.7 vs. 58.7 ± 11.4 years, p=0.022). Tumor size did not differ significantly between RCC and oncocytoma (average of 2.3 ± 0.9 vs. 2.5±1.0cm; p = 0.620). For each patient, 5 clinical features and 10566 automated features were included in the model. After feature reduction, 32 features remained. This included 30 T1-contrast enhanced features and 2 T2-weighted features. The tested model achieved accuracy of 80.5% (AUC = 0.80) with sensitivity of 82.6% and specificity of 77.8%. Shape Volume-Compactness (T1C), NGTDM-Busyness (T1C), GLSZM-ZSV (T1C), and Shape Volume-Volume (T2WI) were the features contributing most to the model. Compared to our model, expert 1 achieved accuracy of 63.4% (AUC = 0.59; p = 0.019) with 95.7% sensitivity and 22.2% specificity, and expert 2 achieved accuracy of 57.5% (AUC = 0.55; p = 0.005) with 65.2% sensitivity and 44.4% specificity.

**CONCLUSION**
Preliminary results using machine learning algorithms demonstrated improved accuracy in differentiation of RCC and oncocytoma when compared with expert interpretation. Further validation is needed in a larger cohort.

**CLINICAL RELEVANCE/APPLICATION**
Oncocytoma, a benign tumor, that cannot typically be distinguished from RCC based on routine clinical imaging. A machine learning based approach with high accuracy would potentially spare patients unnecessary surgery, ablation, and biopsy.

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**The Utility of Radiomic Features in Differentiation of Clear Cell Renal Cell Carcinoma from Non-Clear Cell Renal Cell Carcinoma: A Preliminary Study**

**Monday, Nov. 26 11:00AM - 11:10AM Room: S503AB**

**Participants**
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**PURPOSE**
To investigate the ability of radiomic features derived from the corticomedullary phase images to differentiate clear cell renal cell carcinoma (RCC) from non-clear cell RCC.

**METHOD AND MATERIALS**
This study involved 450 patients with 463 tumors histopathologically diagnosed as clear cell RCC (n=362), papillary RCC (n=54) or
chromophobe RCC (n=47), whose corticomедullary phase images were available. To conduct the study, 80% (n=371) and 20% (n=92) tumors were randomly selected as validation and development cohorts keeping the ratio of clear cell RCC to non-clear cell RCC consistent. Using the development cohort, a discriminative subset from 1023 radiomic features was selected by SVM with LASSO regularization. Receiver operating characteristic analysis was conducted to assess the predictive ability of the selected CT radiomic features in differentiation of clear cell RCC from non-clear cell RCC in the validation cohort. For comparison, a radiologist, with 6 years of experience in genitourinary imaging, was instructed to predict the subtypes (clear cell or non-clear cell RCC) of the validation cohort. The chi-square test was conducted to compare the accuracies between the SVM model and the radiologist.

RESULTS

Our research demonstrated that the SVM model combining 15 features was strongly discriminative in differentiation of clear cell RCC from non-clear cell RCC in the validation cohort. The sensitivity, specificity, overall accuracy, and area under the curves for the SVM model in the validation cohort were 84.7% (61/72), 85% (17/20), 84.8% (78/92), and 0.905, while the sensitivity, specificity, and overall accuracy for the radiologist were 94.4% (68/72), 60% (12/20), and 86.9% (80/92). According to the chi-square test, there was no statistically significant difference between the accuracies of the SVM model and the radiologist (p=0.672).

CONCLUSION

This study demonstrated that CT radiomic features derived from the corticomедullary phase images can aid in the differentiation of renal cell carcinoma subtypes, which is comparable to experienced radiologists.

CLINICAL RELEVANCE/APPLICATION

The effective SVM model combining 15 radiomic features could help the clinical management of patients with renal cell carcinoma, especially patients with non-clear cell renal cell carcinoma.

SSC07-05 Differentiation of Renal Lipid-Poor Angiomyolipoma from Renal Cell Carcinoma by Machine Learning Based on Whole-Tumor Texture Features of Three-Phase CT Images

Monday, Nov. 26 11:10AM - 11:20AM Room: S503AB

Participants

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PURPOSE

To determine the diagnostic performance of machine learning in the differentiation of lipid-poor angiomyolipoma (Ip-AML) from renal cell carcinoma (RCC) based on whole-tumor quantitative texture features of three-phase CT images.

METHOD AND MATERIALS

A total of 40 patients with 41 pathologically proven Ip-AML and 95 patients with 97 pathologically proven RCCs were included by this retrospective study. All patients underwent three-phase CT study which consisted of precontrast phase (PCP), corticomедullary phase (CMP) and nephrographic phase (NP). Texture features were extracted from whole-tumor images at three-phase, single PCP, CMP and NP, respectively. Then support vector machine with recursive feature elimination method based on five-fold cross-validation (SVM-RFECV) were utilized to establish the discriminative classifiers. The performance of classifiers based on three-phase, single PCP, CMP and NP were determined and compared with each other. The performance of machine learning classifier in the differentiation of Ip-AML from RCC was compared with morphological interpretation by radiologists using Receiver operating characteristic (ROC) analysis.

RESULTS

43, 34, 24, 20 features subset were extracted as candidate features in three-phase, PCP, CMP and NP by Boruta package for python respectively. Among of these, 13, 24, 9 12 optimal feature subset further screened by SVM-RFECV entered to establish machine learning classifier in the differentiation of Ip-AML and RCC. The classifier based on three-phase whole tumor images achieved the best performance in discriminating Ip-AML from RCC, with the highest accuracy, area under curve (AUC), sensitivity, and specificity of 92.78%, 0.96, 92.78% and 92.78%, respectively. The performance of morphological interpretation by radiologist was inferior to machine learning classifier in differentiating Ip-AML and RCC, with lower accuracy, AUC, sensitivity and specificity of 69.57%, 0.66, 36.59% and 89.69%.

CONCLUSION

Machine learning classifier based on whole-tumor texture features from three-phase images could reach more accurate discrimination between Ip-AML and RCC than conventional morphological interpretation.

CLINICAL RELEVANCE/APPLICATION

Machine learning classifier is more powerful than morphological interpretation by radiologists and is recommended as part of a MR study prior to renal tumor removal.

SSC07-06 Is Dual-Energy CT (DECT) Of Renal Masses Ready For Prime Time? Diagnostic Accuracy of Conventional Attenuation Change and Iodine Concentration Thresholds at Rapid-kVp-Switch DECT for Detection of Enhancement in Renal Masses

Monday, Nov. 26 11:20AM - 11:30AM Room: S503AB

Awards

Student Travel Stipend Award
Iodine concentration ([i]), measured on DECT, is an alternative to attenuation difference (ΔHU) for diagnosis of enhancement in renal masses. Reported [i] thresholds vary and may be too high to detect enhancement in hypoenhancing papillary renal cell carcinoma (pRCC). This study re-evaluates rapid-kV-switch DECT [i] thresholds for diagnosis of enhancement in SRMs.

METHOD AND MATERIALS

With IRB approval, we evaluated 34 renal masses (including 9 pRCC) diagnosed histologically and 30 benign cysts with renal mass protocol rapid-kV-switch DECT between 2015-2017. A blinded Radiologist measured [i] (mg/mL) and ΔHU. Enhancement was defined as: 1) [i]>2 mg/mL (Marin et al., Kaza et al.) 2) [i]>1.6 mg/mL (Zarzour et al.) and 3) ΔHU>20 HU. Diagnostic accuracy was tabulated and compared by ROC analysis.

RESULTS

There were no differences in age, gender or size of lesions between groups (p>0.05). Using [i]>2.0 mg/mL achieved sensitivity/specificity/Area under ROC curve (AUC) of 73.3%/100%/0.87. 23.5% (8/34) pRCCs were misclassified as non-enhancing with [i] ranging from 0.7-1.6 mg/mL. Using [i]>1.2 mg/mL sensitivity/specificity/AUC of 86.7%/100%/0.93 was achieved. 11.8% (4/34) pRCCs were misclassified as non-enhancing with [i] range from 0.7-0.9 mg/mL. Using ΔHU>20 HU achieved sensitivity/specificity/AUC of 93.3%/94.1%/0.94. 5.9% (2/34) pRCCs were misclassified as non-enhancing and 6.7% (2/30) cysts were misdiagnosed as enhancing due to pseudoenhancement. There was no difference in AUC comparing the three methods for detecting enhancement (p>0.05), with higher false negatives encountered with [i] and false positives encountered with ΔHU.

CONCLUSION

Published iodine concentration thresholds for enhancement in renal masses measured at DECT result in substantial false negative results among hypoenhancing papillary RCC, with the 1.2 mg/mL threshold outperforming 2.0 mg/mL. ΔHU is more sensitive for detection of enhancement compared to iodine concentration but with higher false positive results due to pseudoenhancement. ΔHU remains a robust method to diagnose enhancement in renal masses and is more sensitive for detection of low level enhancement in papillary tumors compared to published iodine concentration values; however, DECT remains valuable for diagnosis of pseudoenhancement.

SSC07-07  The Reality of Dual-Energy CT Iodine Quantification in High-Attenuating Renal Lesion: A Comparison to Standard Hounsfield Units Attenuation

Monday, Nov. 26 11:30AM - 11:40AM Room: S503AB

Participants

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Daniele Marin, MD, Durham, NC (Abstract Co-Author) Research support, Siemens AG

PURPOSE

To determine if dual-energy CT (DECT) derived iodine quantification allows accurate characterization of indeterminate high-attenuating renal lesions, and to identify technique- and patient-related variables that may influence lesion characterization.

METHOD AND MATERIALS

220 patients with 265 high-attenuating renal lesions (mean attenuation 54 33HU; 83 malignant lesions) were included in this retrospective IRB-approved, HIPAA-compliant study. Each patient underwent a single-energy unenhanced CT followed by nephrographic phase DECT using four different state-of-the-art DECT platforms (two rapid-kV-switching DECT [rsDECT] systems and two dual-source DECT systems [dsDECT]). Quantitative iodine concentration values and conventional enhancement (ΔHU) were calculated for each lesion. Receiver operating characteristics area under the curve (AUC) for renal lesion characterization were determined. To calculate diagnostic accuracy, surgical resection with histological workup, biopsy, and imaging follow-up for >24 months were used to determine the final category. Receiver operation characteristics, with dedicated area under the curves (AUC) were calculated to differentiate malignant from benign renal lesions. Nominal logistic regression analysis was performed to identify technique- and patient-related variables that may influence lesion characterization.

RESULTS

Diagnostic accuracy for lesion characterization was significantly higher using ΔHU (AUC: 0.93 with an optimal cut-off of 20HU), compared to iodine concentration values (AUC: 0.83; p<0.0001). Optimal iodine concentration thresholds were significantly different for the rsDECT system (2.0mg/ml with AUC of 0.84) compared to the dsDECT system (1.0mg/ml with an AUC of 0.87) (p<0.0001).

Using the dedicated iodine thresholds resulted in 32 false positive findings and 20 false negative findings. Lesion location relative to the dual-energy field of view, patient size and DECT platform did not demonstrate any effect on lesion characterization.
CONCLUSION

Conventional measurements of enhancement yield statistically significant higher accuracy compared to iodine concentration measurements for the characterization of indeterminate high-attenuating renal lesions.

CLINICAL RELEVANCE/APPLICATION

Conventional measurements of enhancement is statistically significantly superior to iodine concentration measurements in the characterization of indeterminate high-attenuating renal lesions.

SSC07-08 Clinical Evaluation of Virtual Unenhanced Images from Second-Generation Dual-Energy CT Gemstone Spectral Imaging

PURPOSE

To assess virtual unenhanced (VUE) images from a second-generation dual-energy CT gemstone spectral imaging (GSI) technology and to evaluate how measured attenuation compares to that from true unenhanced (TUE) images.

METHOD AND MATERIALS

Our single-center, retrospective study was IRB-approved and HIPAA-compliant. Fifty-seven subjects (32 men, 25 women; mean age, 65 years) underwent a contrast-enhanced CT of the abdomen on a second-generation dual-energy CT GSI technology with fast kV switching (80/140 kV) between September 2017 and March 2018 for hematuria work-up (n=42) and renal mass evaluation (n=15). TUE images were acquired in all cases in single-energy mode at 120 kV. TUE and VUE images were reconstructed at a slice thickness of 2.5 mm. Attenuation values of liver, pancreas, kidneys, adrenal glands, psoas muscle, subcutaneous fat, aorta, IVC, and main portal vein were measured on TUE and VUE images. In addition, attenuation values were obtained from 24 patients with renal mass (cystic, n=5; solid, n=19). Number of renal stones detected on TUE and VUE were also recorded. Data were analyzed using a Student paired t-test.

RESULTS

There was no significant difference in measured attenuation between TUE and VUE images throughout the abdomen (P>.05, for all comparisons). Mean attenuation values from solid and cystic renal lesions were not significantly different (TUE: 18.4 HU and 9.8 HU vs. VUE: 18.6 HU and 8 HU; P=.76 and P=.38, respectively). We observed a significant difference in number of detected renal stones between TUE (n= 21) and VUE (n= 12) images (P=.01).

CONCLUSION

VUE images obtained from contrast-enhanced data acquired on a second-generation dual-energy CT with GSI technology represent a good approximation of TUE images for noncontrast evaluation of abdominal organs and focal renal lesions. Nevertheless, our preliminary data indicate that a considerable number of small renal stones may not be detected.

CLINICAL RELEVANCE/APPLICATION

Prospective implementation of VUE images may render opportunities for decreased radiation exposure in multi-phase abdominal CT protocols for evaluation of genitourinary pathology.

SSC07-09 Clinical Decision Algorithm for the Evaluation of Renal Cystic Lesions Using Single-Phase Split-Filter Dual-Energy CT

PURPOSE

To evaluate the diagnostic performance of single source split-filter dual energy CT (tbDECT) to exclude enhancement in renal cystic lesions at venous phase abdominal CT.

METHOD AND MATERIALS
A total of n=230 simple or minimally complicated renal cysts were identified in n=51 consecutive patients who underwent both abdominal tbDECT and magnetic resonance (MR) examination; the latter was used as the 'gold standard' to classify the cysts as Bosniak I or Bosniak II. Material decomposition images were processed off of venous phase series and regions of interest (ROI) were placed within each cystic lesion, blindly to MR. For each ROI, four parameters were assessed simultaneously (Virtual Unenhanced attenuation values [HU], contrast enhancement attenuation values [HU], iodine density [mg/dl] and ROI size [cm²]) to test different approaches for lesion characterization. Renal cysts were considered as not enhancing if contrast enhancement (CM) <= 10 HU and iodine density (IOD) <= 0.5 mg/dl. The ROI was considered small if size <= 0.2 cm².

RESULTS

Using MR n=207 Bosniak I and n=23 Bosniak II cysts were identified. At virtual unenhanced images, 48% of the cysts were not hypodense (> 10 HU). Both CM and IOD alone gave high percentages of pseudoenhancement (false positive 47% and 33% respectively). The combination of criteria (IOD first then CM) improved specificity to 79%. Exclusion of small ROIs reduced false positives to 3%. An algorithm for the exclusion of enhancement, combining all the criteria, was created.

CONCLUSION

The combined evaluation of multiple criteria provided by tbDECT correctly characterizes Bosniak I and II renal cysts as not enhancing, reduces false positive findings and potentially avoids unnecessary work-ups. We propose an algorithm that can be easily implemented in clinical practice.

CLINICAL RELEVANCE/APPLICATION

Excluding enhancement in renal cystic lesions with 97% of specificity, applying an easy to use algorithm on single-phase dual-energy images from single source, split-filter twin-beam dual-energy CT.
PURPOSE

Sarcopenia consists of loss of muscle mass and strength/function. As adipose tissue expands and muscle and bone tissue decrease with aging, there is a concomitant increase in proinflammatory and a reduction in anti-inflammatory factors contributory to chronic inflammation. We aimed to evaluate associations of several inflammatory markers with DXA-measured sarcopenia markers in a representative sample of European healthy adults aged 65-79 years.

METHOD AND MATERIALS

Baseline whole-body DXA scan was performed and fresh blood samples collected in 1122 participants enrolled in the NU-AGE trial, a one-year, multicenter, randomized, single-blind, controlled trial (NCT01754012) testing the effects of a dietary intervention. Appendicular lean mass (ALMI, lean mass from arms plus legs/height2) and skeletal mass index (SMI, lean mass from arms plus legs/weight) were used as DXA markers of sarcopenia. Quantitative determination of inflammatory markers was performed by ELISA. After a log-transformation of DXA parameters the Pearson Product-Moment Correlation was applied to test the associations between body composition and inflammation markers in both genders.
RESULTS

In male population, a positive association was found between ALMI and albumin ($p=0.26$; $p < .05$) and SMI and ghrelin ($p=0.19$; $p < .05$). A negative association was found between ALMI and adiponectin ($p=0.23$; $p < .001$), while SMI was negatively correlated with leptin ($p=.70$; $p<.001$) and C-Reactive Protein (CRP) ($p=0.24$; $p<.001$). In females, ALMI was positively associated with leptin ($p=0.19$; $p<.01$), and CRP ($p=0.22$; $p<.01$). SMI was positively associated with ghrelin ($p=0.24$; $p<.001$), while negatively with leptin ($p=0.62$; $p<.01$), CRP ($p=0.23$; $p<.01$), and AGP ($p=0.26$; $p<.01$).

CONCLUSION

Sarcopenia correlates with an increase of inflammatory status in elderly. In males and females, SMI correlates positively with ghrelin, an anti-inflammatory molecule, and negatively with pro-inflammatory markers such as leptin, CRP and AGP; while ALMI showed ambiguous associations with inflammatory markers. Thus, SMI appears to be a better predictor of inflammatory risk status in the elderly.

CLINICAL RELEVANCE/APPLICATION

DXA-derived sarcopenia markers show a correlation with inflammatory markers useful to picture patients' risk status. SMI may predict inflammatory status better than ALMI; but further research is required.

SSC10-04 Automated Segmentation of Thoracic Paraspinal Muscles: Pipeline for Large-Scale Data Mining on CT

Monday, Nov. 26 11:00AM - 11:10AM Room: S102CD

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PURPOSE

To compare automated pipeline for thoracic paraspinal muscle segmentation with manual segmentation on chest CT examinations.

METHOD AND MATERIALS

Atlas-based automated pipeline for thoracic paraspinal muscle segmentation was developed using open-source medical image analysis tools: Advanced Normalization Tools (ANTs), the Oxford Centre for Functional Magnetic Resonance Imaging of the Brain Software Library (FSL), and the scikit-image Python image processing library. After the correct image at T12 level was identified, the left paraspinal muscle was automatically segmented and the muscle attenuation and cross-sectional area were recorded. Ground truth was obtained using 475 non-contrast chest CT exams by manually segmenting the left paraspinal muscle at T12 level with muscle thresholds set at -29 to +150 HU (Mimics software version 19.0; Materialise, Leuven, Belgium). The CT images are heterogeneous in field of view, voxel spacing, convolution kernel, scanner manufacturer and model, reconstruction algorithm, and image quality. Dice and Jaccard similarity indices were determined.

RESULTS

Compared to manual segmentation, the automated pipeline had a mean Dice index of 0.85 (SD=0.07) and a mean Jaccard index of 0.74 (SD=0.09). Mean accuracy error for muscle attenuation was 1.2 HU; range: 0-4.9 HU. Mean accuracy error for muscle cross-sectional area was 1.83 cm²; range: 0-9.3 cm².

CONCLUSION

The automated pipeline for thoracic paraspinal muscle segmentation is sufficiently accurate to allow for large-scale data mining of heterogeneous chest CT images.

CLINICAL RELEVANCE/APPLICATION

Current CT image evaluation of sarcopenia requires manual segmentation, unrealistic for large datasets. The automated pipeline for sarcopenia evaluation on chest CTs could be adapted to other body regions including abdomen, pelvis, and extremities.

SSC10-05 Assessment of Sarcopenia on Computed Tomography (CT): A Systematic Review of Technical Parameters

Monday, Nov. 26 11:10AM - 11:20AM Room: S102CD

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PURPOSE

Computed tomography (CT) is being increasingly used for the assessment of sarcopenia, often by non-radiologists who may not be aware of the impact of technical parameters on muscle metrics. We sought to perform a systematic review of all relevant studies that used CT muscle measurements to assess sarcopenia to identify the differences between technical parameters used.
METHOD AND MATERIALS

A comprehensive search of PubMed from 1983-2017 was performed to identify studies that used CT measurements of muscle to assess for sarcopenia. Review articles were excluded. The following technical parameters used to measure muscle metrics were compared: slice thickness, kVp, mAs, helical pitch, reconstruction method, and use of intravenous (IV) contrast.

RESULTS

From the 654 articles identified, 388 studies met the inclusion criteria for the systematic review. Slice thickness was not reported in 63% of studies. When reported, the most commonly used slice thickness was 10 mm (14%). kVp was not reported in 73% of studies. When reported, the most common kVp values were between 100 and 300 (7%). Helical pitch and reconstruction algorithm were not reported in 98% of studies and IV contrast use was not reported in 94% of studies.

CONCLUSION

There is a significant deficiency in reporting of CT technical parameters used for measuring muscle indices which may affect the generalizability of results in the sarcopenia literature.

CLINICAL RELEVANCE/APPLICATION

Comparison between publications in the sarcopenia field is hampered by deficiency in reporting of CT technical parameters.

SSC10-06 Inter- and Intraobserver Variability of an Anatomical Landmark-Based, Manual Segmentation Method by MRI for the Assessment of Skeletal Muscle Fat Content and Area in Subjects from the General Population

Monday, Nov. 26 11:20AM - 11:30AM Room: S102CD

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PURPOSE

Changes in skeletal muscle composition, such as fat content and mass, may exert unique metabolic and musculoskeletal risks; however, the reproducibility of their assessment is unknown. We determined the variability of the assessment of skeletal muscle fat content and area by magnetic resonance imaging (MRI) in a population-based sample.

METHOD AND MATERIALS

A random sample from a prospective, community-based cohort study (KORA-FF4) was included. Skeletal muscle fat content was quantified as proton-density fat-fraction (PDFF) and area as cross-sectional area (CSA) in multi-echo Dixon sequences (TR 8.90ms, six echo times, flip-angle 4°) by a standardized, anatomical landmark-based, manual skeletal muscle segmentation at level L3 vertebra by two independent observers. Reproducibility was assessed by intra-class correlation coefficients (ICC), scatter and Bland-Altman plots.

RESULTS

In 50 included subjects (mean age 56.1±8.8years, 60.0% males, mean BMI 28.3±5.2) 2’400 measurements were obtained. Inter-observer agreement was excellent for all muscle compartments (PDFF: ICC0.99, CSA: ICC0.98) with only minor absolute and relative differences (-0.2±0.5%, 31±44.7mm2; -2.6±6.4% and 2.7±3.9%, respectively). Intra-observer reproducibility was similarly excellent (PDFF: ICC1.0, 0.0±40.4%, 0.4%; CSA: ICC1.0, 5.5±25.3mm2, 0.5%, absolute and relative differences, respectively). All agreement was independent of age, gender, BMI, body height and visceral adipose tissue (ICC0.96-1.0). Furthermore, PDFF-reproducibility was independent of CSA (ICC0.93-0.99).

CONCLUSION

Quantification of skeletal muscle fat content and area by MRI using an anatomical landmark-based, manual skeletal muscle segmentation is highly reproducible.

CLINICAL RELEVANCE/APPLICATION

An anatomical landmark-based, manual skeletal muscle segmentation provides high reproducibility of skeletal muscle fat content and area and may therefore serve as a robust proxy for myosteatosis and sarcopenia in large cohort studies.

SSC10-07 Cortical Bone Porosity Assessment in Human Tibial and Fibular Cortex Using Ultrashort Echo Time Magnetization Transfer (UTE-MT) MRI

Monday, Nov. 26 11:30AM - 11:40AM Room: S102CD
Participants
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PURPOSE
To investigate the relationship between macromolecular fraction (MMF), obtained from UTE-MT modeling, and bone porosity, as measured using high-resolution micro-computed tomography (µCT).

METHOD AND MATERIALS

Eighteen cortical bone specimens were harvested from human tibial and fibular midshafts (63±19 and 52±18 years old). Specimens were scanned using an 8-channel knee coil on a 3T clinical scanner (MR750, GE). The UTE-MRI scans involved: A) an actual flip angle-variable TR (AFI-VTR) method, (AFI: TE=0.032, TR=20,100 ms, FA=45°; VTR: TE=0.032, TR=20 to 100 ms, FA=45°) for T1 measurement, which is a prerequisite for accurate MT modeling, and B) a 3D UTE-Cones-MT sequence (saturation pulse power=500,1000,1500°, frequency offset=2 to 50 kHz, FA=7°) for MT modelling. Field of view (FOV), matrix dimension, nominal in-plane pixel size, and slice thickness were 14 cm, 256×256, 0.54 mm, and 2 mm, respectively. Afterward, specimens were scanned using a SkyScan 1076 (Kontich, Belgium) µCT at 9 µm voxel size. Pearson's correlations were calculated between UTE-MT results and µCT-based measures (porosity and bone mineral density, BMD) using the data in 12 and 4 ROIs in each tibial and fibular sample, respectively. ROIs were selected at different cortical bone bands to provide an adequate range of porosity.

RESULTS

Figures 1a-f show MMF, porosity, and BMD pixel maps for a representative tibial and fibular specimen, respectively. Regions of higher MMF corresponded to the regions of lower porosity in the porosity maps. Figures 1g-j demonstrate the correlations between MMF and µCT measures for tibial and fibular bone specimens, respectively. MMF presented very good correlations with µCT measures.

CONCLUSION

MMF obtained from MT modeling, as a measure for collagen content, showed very good correlations with µCT measures regardless of the fibular of tibial harvesting sites. This study highlighted UTE-MT MRI techniques as a useful method to assess bone porosity, which may be used in future clinical studies.

CLINICAL RELEVANCE/APPLICATION

A UTE-MRI-based technique, to estimate the collagen backbone content which correlates greatly with the bone porosity may help diagnose bone diseases earlier and more accurately.

SSC10-08 Diagnostic Performance of Phantomless Dual-Energy CT for Volumetric Bone Mineral Density Assessment in Comparison to CT Hounsfield Unit Measurements Using Dual X-Ray Absorptiometry as Standard of Reference

Monday, Nov. 26 11:40AM - 11:50AM Room: S102CD

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PURPOSE

To evaluate the diagnostic performance of a phantomless dual-energy computed tomography (DECT) postprocessing algorithm for volumetric bone mineral density (BMD) assessment of the lumbar spine compared to Hounsfield unit (HU) measurements.

METHOD AND MATERIALS

We retrospectively analyzed 200 lumbar vertebrae in 53 patients who had undergone third-generation dual-source DECT and dual x-ray absorptiometry (DXA) examinations of the lumbar spine within 7 days between March and December 2017. For volumetric BMD assessment, dedicated phantomless DECT postprocessing software which allows for freely rotatable color-coded three-dimensional visualization of trabecular BMD distribution using three-material decomposition was applied. In addition, HU measurements were performed on standard bone reconstructions by defining five trabecular regions of interest (ROI) per vertebra. Results of both approaches were compared regarding the diagnostic accuracy using the DXA T-score according to the World Health Organization as standard of reference for detecting osteoporosis.
RESULTS

DXA revealed a total of 92 osteoporotic lumbar vertebrae. A BMD cut-off of 92 mg/cm³ at phantomless DECT yielded 98.9% sensitivity and 91.6% specificity for detecting osteoporosis; 93.3% of vertebrae below this threshold were diagnosed with osteopenia/osteoporosis according to DXA and 80.2% above showed normal BMD at DXA. A trabecular ROI attenuation cut-off of 157 HU showed 71.0% sensitivity and 66.4% specificity for osteoporosis; 73.3% of vertebrae below this threshold were diagnosed with osteopenia/osteoporosis according to DXA and 41.0% above showed normal BMD at DXA. Area under the curve for detecting osteoporosis was 0.953 for phantomless DECT and 0.754 for HU-based analysis (p<0.001). Pearson product-moment correlation showed higher correlation between BMD results of phantomless DECT and DXA (r=0.848) compared to HU and DXA values (r=0.438) (p<0.001).

CONCLUSION

A phantomless DECT postprocessing algorithm for volumetric BMD assessment of the lumbar spine is significantly superior compared to HU measurements regarding the diagnostic accuracy for detecting osteoporosis.

CLINICAL RELEVANCE/APPLICATION

Opportunistic screening for osteoporosis using HU measurements on CT images as previously suggested in recent literature is less accurate than a phantomless color-coded DECT postprocessing algorithm which can be applied to routine DECT without requiring protocol changes.

PURPOSE

In long-term HIV-infected individuals, low bone density and increased fracture risk have emerged as significant comorbidities. Our aim was to assess the influence of exercise, nutrition, and medications on bone microarchitecture using high-resolution peripheral quantitative CT (HR-pQCT) in long-term HIV-infected individuals.

METHOD AND MATERIALS

Twenty-nine HIV-infected subjects (3 postmenopausal women, 26 men) were prospectively enrolled in our study (BMI 26.1±4.3 kg/m², age 56.9±5.6, years diagnosed with HIV 20.7±8.8). Questionnaires included the revised Community Healthy Activities Model Program for Seniors (CHAMPS), the Mini Nutritional Assessment (MNA) as well as medication assessments. Participants underwent radius and tibia HR-pQCT and laboratory evaluation. Multivariable linear regression models were used to evaluate the effects of exercise, nutritional status, tenofovir disoproxil fumarate (TDF) and protease inhibitor (PI) use on bone microarchitecture, adjusting for all demographic risk factors.

CONCLUSION

Cortical bone in HIV-infected individuals is detrimentally affected by malnutrition, while trabecular bone is detrimentally affected by previous use of TDF in combination with a PI. In long-term HIV-infected subjects, nutritional support could potentially be more relevant for bone health compared to physical activity.

CLINICAL RELEVANCE/APPLICATION

Long-term HIV-infected individuals could particularly benefit from nutritional assessment and intervention as well as avoiding use of TDF with PIs to prevent compromised bone health.
Dynamic Fluence Field Modulation in CT with Multiple Aperture Devices

**Participants**

Marc Kachelriess, PhD, Heidelberg, Germany (Moderator) Nothing to Disclose
Ge Wang, PhD, Troy, NY (Moderator) Nothing to Disclose

**Method and Materials**

Multiple aperture devices (MADs) are designed and constructed with fine-scale alternating tungsten bars and air gaps to control the local transmission of x-rays. Relative motion between two MADs in sequence yields Moiré patterns permitting a wide range of fluence modulation profiles with small displacements. In physical experiments, dual MADs were combined with view-dependent mAs modulation to achieve phantom-specific FFM for different imaging objectives including, e.g., 1) a minimum mean variance objective to minimize mean variance in filtered-backprojection reconstruction, and 2) a flat-field objective to homogenize noise in the reconstruction. Novel pre-processing approaches were developed to accommodate ray-dependent physical effects induced by the filters and to provide artifact-free reconstructions. Image quality assessments were performed for an ellipse phantom (25.8x14.1 cm) and a CatPhan sensitometry module.

**Results**

The dual-MAD module is compact and yields narrow to wide fluence profiles covering 31.2° to 66.5° of the fan beam with just 0.44 mm of relative motion. The augmented pre-processing chain alleviates ring artifacts that are present in conventional gain correction methods while preserving high frequency structures in the phantom. Noise properties associated with the two imaging objectives agree with theoretical expectations, with the flat-field objective producing nearly homogeneous and isotropic noise, and with the minimum mean variance objective yielding the lowest average noise.

**Conclusion**

The dual MAD filter provides an effective approach to deliver dynamic FFM and image quality control for different imaging objectives and variable patient anatomies whereas traditional static bowtie filters cannot accommodate asymmetric patient cross-sections or varying patient size. The small form factor of the MAD system and the sub-mm motion requirement facilitates FFM implementation on clinical CT scanner.

**Clinical Relevance/Application**

The dual MAD filter facilitates dynamic FFM on diagnostic CT, which allows dose reduction and image quality control customized to the specific anatomy of the patient.
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PURPOSE
A spectral photon-counting silicon edge-on detector with full field-of-view (FOV) has been mounted in a clinical CT gantry and evaluated for imaging. The aim is to demonstrate the benefit of high-resolution spectral photon-counting imaging in a clinical environment.

METHOD AND MATERIALS
The detector is based on high-resolution edge-on silicon-strip sensors. It has 2 slices, 50 cm FOV and is mounted on a clinical GE Lightspeed VCT gantry. The sensors have 8 energy bins that are used for spectral imaging, i.e. material decomposition. The x-ray tube is operated at clinically relevant fluxes.

RESULTS
The small detector pixels allow high-resolution imaging which will be demonstrated on anthropomorphic phantoms. High-resolution image acquisition also allows reducing the image noise for maintained spatial resolution (e.g. matching today’s detector with 1mm pixels) and this effect is demonstrated for a soft-tissue imaging task. A demonstration of the spectral capability for separating materials (iodine, calcium and soft-tissue) is presented. Count-rate and pile-up are hot topics for photon-counting detectors in clinical environments. Here, the effect on the image quality when going up in the high-flux regime is demonstrated. It will be shown that the high-speed ASIC, together with the small pixels and the segmented edge-on design, is capable of handling very high count-rates without significant loss of image quality.

CONCLUSION
Silicon-based spectral photon-counting detectors are promising for use in high-flux clinical CT. The benefits from the higher resolution, better dose efficiency and spectral capabilities could lead to a new era in medical CT imaging.

CLINICAL RELEVANCE/APPLICATION
Photon-counting spectral detectors are emerging for use in clinical CT and the potential advantages are many, including: high-resolution, low-dose capability and full spectral imaging (simultaneous acquisition of more than 2 energies). Many studies have presented results from CZT-based prototype detectors, but this is to our knowledge the first full field-of-view clinical prototype of a silicon-based photon-counting detector. The benefits of silicon as a detector material include: high-resolution, spectral fidelity, count-rate resistance and manufacturability.

SSC13-03 Using 3D Depth Camera for Precise Automatic Patient Positioning in Computed Tomography

For information about this presentation, contact:
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PURPOSE
The aim of this study was to evaluate the accuracy of a three-dimensional (3D) camera algorithm for automatic and individualized patient positioning based on body surface detection and to compare the results with manual positioning performed by technologists in routinely obtained chest and abdomen computed tomography (CT).

METHOD AND MATERIALS
This study included data of 120 patients undergoing clinically CTs. 52 patients were scanned with CT using a table height manually selected by technologists; while other 68 were automatically positioned based on patient-specific body surface and contour detection. The ground truth table height was defined as the table height that aligns the axial center of the patient’s body and the scanner isocenter. Off-centering was defined as the difference between the TGT and the table position actually used the CT. The t-test was performed to determine the significance of the differences in the vertical offset when automatic vs manual positioning was used. Chi-square test was used to check whether there was a relationship between patient size and the magnitude of off-centering.

RESULTS
We found a significant improvement in patient centering (offset of 54.3 mm) when using the automatic positioning algorithm with the 3D camera compared to manual positioning (offset of 19±10mm) performed by technologists (p<0.005). The absolute maximal offset was 39 mm and 43 mm for chest and abdomen CT, respectively, when patients were positioned manually, while with automatic positioning using the 3D camera the offset did not exceed 15 mm. In chest CTs with manual patient positioning, the Chi-square test has shown the significant statistical correlation between the vertical offset > 20 mm and the patient size (BMI > 26 kg/m2)

For information about this presentation, contact:
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PURPOSE
A spectral photon-counting silicon edge-on detector with full field-of-view (FOV) has been mounted in a clinical CT gantry and evaluated for imaging. The aim is to demonstrate the benefit of high-resolution spectral photon-counting imaging in a clinical environment.

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Silicon-based spectral photon-counting detectors are promising for use in high-flux clinical CT. The benefits from the higher resolution, better dose efficiency and spectral capabilities could lead to a new era in medical CT imaging.

CLINICAL RELEVANCE/APPLICATION
Photon-counting spectral detectors are emerging for use in clinical CT and the potential advantages are many, including: high-resolution, low-dose capability and full spectral imaging (simultaneous acquisition of more than 2 energies). Many studies have presented results from CZT-based prototype detectors, but this is to our knowledge the first full field-of-view clinical prototype of a silicon-based photon-counting detector. The benefits of silicon as a detector material include: high-resolution, spectral fidelity, count-rate resistance and manufacturability.

SSC13-03 Using 3D Depth Camera for Precise Automatic Patient Positioning in Computed Tomography

For information about this presentation, contact:
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PURPOSE
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This study included data of 120 patients undergoing clinically CTs. 52 patients were scanned with CT using a table height manually selected by technologists; while other 68 were automatically positioned based on patient-specific body surface and contour detection. The ground truth table height was defined as the table height that aligns the axial center of the patient’s body and the scanner isocenter. Off-centering was defined as the difference between the TGT and the table position actually used the CT. The t-test was performed to determine the significance of the differences in the vertical offset when automatic vs manual positioning was used. Chi-square test was used to check whether there was a relationship between patient size and the magnitude of off-centering.

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We found a significant improvement in patient centering (offset of 54.3 mm) when using the automatic positioning algorithm with the 3D camera compared to manual positioning (offset of 19±10mm) performed by technologists (p<0.005). The absolute maximal offset was 39 mm and 43 mm for chest and abdomen CT, respectively, when patients were positioned manually, while with automatic positioning using the 3D camera the offset did not exceed 15 mm. In chest CTs with manual patient positioning, the Chi-square test has shown the significant statistical correlation between the vertical offset > 20 mm and the patient size (BMI > 26 kg/m2)

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CONCLUSION
The study indicates that automatic patient positioning using an algorithm based on 3D patient surface detection provides better patient centering as compared to manual positioning performed by technologist.

CLINICAL RELEVANCE/APPLICATION
Automatic individualized patient positioning can be successfully applied in the clinical routine for accurate patient positioning and in better radiation dose utilization.

METHOD AND MATERIALS
In XACT, a pulsed x-ray beam is absorbed by a sample. The absorbed x-ray energy is converted into heat and the subsequent thermoelastic expansion results in the emission of a detectable ultrasound (US) signal. This US is a spherical wave, and so yields 3D information. The detected signal can be used to compute the x-ray absorption, and important 3D clinical information. We have constructed an XACT imaging system, which previously imaged a lead sample. We have extended the imaging capability of this system to biological samples and have acquired a signal from a chicken bone. We have optimized the signal generation, detection, and image reconstruction of this system. We aim to image biological samples using XACT and a transducer array to maximize imaging speed and utility.

RESULTS
We have obtained a signal and an image from a biological sample (chicken bone). We have also demonstrated the capability of XACT to image in vivo samples at a lower dose than that of conventional CT with higher imaging resolution. These promising results demonstrate that XACT is a viable imaging modality with high potential for clinical translation.

CONCLUSION
The high potential for clinical translation of XACT has been demonstrated. XACT allows for the high-resolution imaging of x-ray absorption at much lower doses than conventional x-ray imaging techniques. We believe that the clinical translation of XACT is possible, and can revolutionize x-ray imaging by providing 3D information with a single projection and at lower doses than that of conventional CT.

CLINICAL RELEVANCE/APPLICATION
XACT can obtain 3D x-ray absorption images via a single x-ray projection onto a sample. Therefore, the dose in XACT is substantially lower than that of conventional CT. The imaging versatility of XACT is on par with that of conventional CT, including 3D imaging capability of the breast and bone. However, XACT can perform this imaging at comparable resolutions without the need for scanning throughout the sample. This yields substantial improvement in both imaging speed and dose reduction.

PURPOSE
Optimization of contrast agent (CA) administration protocols is a crucial component of medical imaging to obtain diagnostic quality images. The purpose of this study is to develop a novel technique, XACT, which can yield high-resolution images of x-ray absorption at extremely low doses, thus significantly reducing patient exposure to radiation. In addition, XACT can provide 3D imaging information with a single projection, offering significant advantages over conventional CT imaging techniques.
Optimization of contrast agent (CA) administration protocols is a crucial component of medical imaging to obtain diagnostic quality images. Here we aim to develop an artificial neural network (ANN) framework to predict the required contrast injection parameters to achieve a desired contrast enhancement (CE) in a given organ (kidney in this study) based on test bolus (TB) information.

METHOD AND MATERIALS

Synthetic data was used to feed and train a machine learning model to predict patient-specific CM injection protocol for a desired enhancement in different organs. Applying a validated perfusion model and tweaking the different patient-specific parameters (50 total) such as age, sex, cardiac output, and organ and vessel sizes, as well as injection protocol parameters such as iodine concentration (270, 300, 320, and 350 mg/ml), volume (100, 115, 130, and 140 ml), and injection rate (2, 3, 4, 5, and 6 ml/s), we generated 4000 CE data in kidney. TB curves were generated using the same concentrations and constant rate of 5 ml/s and volume of 10 ml. Data were split into training and test sets (split factor 0.2), and an ANN regression model was trained. For 800 given kidney peak enhancement and time to peak, injection parameters were predicted.

RESULTS

To obtain the given CE in kidney (i.e., time-to-peak and peak enhancement) for individual patients, mean absolute percentage error in prediction of the main injection parameters, concentration, injection rate, injection time, and contrast volume were 3%, 4%, 8% and 9%, respectively. The mean error of the prediction model without including the TB information, was higher than the results reported above by maximum of 4%. Using the predicted parameters, the mean error for both time-to-peak and peak enhancement for kidney was less than 5%.

CONCLUSION

Our results showed that, in absence of enough clinical perfusion data from different organs, by using synthetic data from a validated perfusion model, in addition to the test bolus information, we could train an AI model to offer the required CA administration parameters in order to obtain the desired CE in any targeted organ or vessel.

CLINICAL RELEVANCE/APPLICATION

This technique offers the possibility to determine patient-specific contrast material injection parameters to provide higher accuracy and consistency in the way that contrast enhanced CT examinations are performed.

SSC13-06 Pre-Clinical Demonstration of Grating-Based Phase Contrast X-Ray Imaging for Cryoablation Therapy

Monday, Nov. 26 11:20AM - 11:30AM Room: N230B

Participants
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PURPOSE

Cryoablation, often guided by CT or MRI, is an important tool in the treatment of cancer and other conditions. This work uses phase contrast imaging (PCI) to detect temperature changes, demonstrating cryoablation as a potential application for PCI.

METHOD AND MATERIALS

Experiments were carried out using fresh pork loin obtained from a local grocer. The PCI system was a Talbot-Lau grating-based interferometer designed for 27 keV X-rays. Images with attenuation, phase, and dark field contrast were obtained. The first experiment tested whether temperature changes could be detected by each contrast mechanism. We imaged a porcine sample after it froze overnight in a -60°C freezer, and then again after thawing. In a second experiment, we tested if we could detect temperature changes induced by a cryoprobe. We imaged a porcine sample after forming an ice-ball with a cryoprobe (Galil Medical, IceSeed 1.5 MRI Needle). Prior to imaging, the sample was subjected to a 15 min. freeze followed by a partial thawing until the probe could be removed from the sample.

RESULTS

The addition of phase and dark field contrast mechanisms provided structural detail and good temperature differentiation. Histograms showing the distribution of values in the CT phase reconstruction vs. the CT attenuation reconstruction (voxel size 54x54x54 µm) show a larger change in signal between the frozen and thawed pork. This result is consistent with theory: for water imaged with 27 keV photons, the change in attenuation of 54 µm of liquid vs. frozen water is expected to be about 0.02%, whereas the change in phase is expected to be about 38%. Our data show that the mean attenuation changed by 3%, and the mean phase changed by 34%. Histograms of values from a projection image of the cryoablated pork qualitatively demonstrate that the dark field signal is more sensitive to temperature change than the attenuation signal, even for a small amount of thawing that took place over 46 min.

CONCLUSION

We demonstrated that PCI has potential application for temperature monitoring during cryoablation procedures. Phase and dark field contrast are very sensitive to interfaces and density changes, making them ideal for imaging temperature-sensitive processes.

CLINICAL RELEVANCE/APPLICATION

Cryotherapy is used in a wide variety of treatments, and phase and dark field information can be used to sensitively monitor cryogenic and other processes during surgery.

SSC13-07 Three-Dimensional CT Scout from Conventional Two-View Radiograph Localizers Using Deep
**Learning**

Monday, Nov. 26 11:30AM - 11:40AM Room: N230B

**Participants**
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**PURPOSE**
The purpose of this work was to develop a deep learning-based image reconstruction framework to enable the reconstruction of volumetric 3D scout CT images from the conventional two-view (lateral and AP) projection scout radiographs.

**METHOD AND MATERIALS**
751 clinically indicated chest-abdomen-pelvis (CAP) CT exams from 667 patients were retrospectively collected. Inclusion criteria were: 1. CT exams acquired with or without contrast media and 2. Either one of the following 6 scan coverages: chest-alone, abdomen-alone, pelvis-alone, chest-abdomen, abdomen-pelvis or CAP. To avoid potential data inconsistency, large patients (>50 cm lateral width) with significant truncation were excluded. CT image volumes were interpolated to a 1.0x1.0x1.0 mm3 isotropic voxel size and registered to the 2D scout radiographs using the patient positioning information in the DICOM header. A total of 163,840 CT images with 1120 radiograph localizers from 476 patients were used to train a 60-layer deep neural network which inputs the AP and lateral localizers and outputs a volumetric CT scout; 47,919 CT images with 382 radiograph localizers from 191 patients were used for testing and validation. To test the generalization error of the trained deep neural network, a Monte Carlo dose calculation of an axial CT scan was performed in three anatomical regions using both the diagnostic CT images and the 3D-scout of one subject. Gamma analysis with 10%/5mm dose-difference/distance-to-agreement criteria was performed to compare both radiation dose distributions.

**RESULTS**
The average gamma indices between the diagnostic CT and the 3D-scout images were 0.33, 0.37 and 0.34 for anatomical regions in the chest, abdomen and pelvis, respectively. Similarly, the percentages of voxels with passing gamma index (γ<1) were 97.3%, 97.3% and 98.2% for the three anatomical regions.

**CONCLUSION**
A deep learning method was developed to reconstruct volumetric scout CT images from two-view projection scout radiographs. The proposed method could enable more accurate radiation dose estimates and scanning parameter prescription prior to CT acquisition and thus potentially help overcome limitations of automatic exposure control schemes in diagnostic CT.

**CLINICAL RELEVANCE/APPLICATION**
The reconstruction of 3D-scouts from two-view localizers could revolutionize the prescription of radiation dose/image quality in diagnostic CT, enabling the next generation of intelligent CT scanners.

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**SSC13-08  Stopping Power Ratio (SPR) Uncertainty in Pencil Beam Scanning (PBS) Proton CT (pCT) Reconstruction: Dependency on Energy Straggling and Detector Energy Resolution**

Monday, Nov. 26 11:40AM - 11:50AM Room: N230B

**Participants**
Jun Zhou, PhD, Atlanta, GA (Presenter) Nothing to Disclose
Xiaoqiang Li, PhD, Royal Oak, MI (Abstract Co-Author) Nothing to Disclose
Peyman Kabolizadeh, Royal Oak, MI (Abstract Co-Author) Nothing to Disclose
Di Yan, DSC, Royal Oak, MI (Abstract Co-Author) Nothing to Disclose
Craig W. Stevens, MD, PhD, Tampa, FL (Abstract Co-Author) Nothing to Disclose
Xuanfeng Ding, PHD, Royal Oak, MI (Abstract Co-Author) Nothing to Disclose

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zhouj995@hotmail.com

**PURPOSE**
To investigate the effect of proton energy, energy straggling (ES), and detector energy resolution (DER) on the uncertainty of the SPR reconstruction in PBS pCT reconstruction.

**METHOD AND MATERIALS**
A Monte-Carlo model was developed based on PBS technology to simulate the pCT acquisition. An 8cm-diameter cylinder water phantom was used in the simulation, filled with three 2-cm cylinders comprised of ICRU bone, muscle, and adipose, respectively. 180 projections were generated with 252 spots (500 protons/spot) on each projection. Spot spacing and size on the detector were 5.4mm and 6mm, respectively. Simulations were conducted w/wo energy ES fitted to real clinical 120 and 200 MeV proton beams. DER were set to 2% and 10%, in order to simulate detector uncertainty in the measurement of proton residual energy. Mean and standard deviation (STD) of SPR within the background and the three cylinders were calculated.

**RESULTS**
Total dose to the phantom was<4mGy. The reconstructed mean RSP for both w/wo ES were the same: .995(-.5%), .968(-.2%), 1.026(-.4%), and 1.702(-1.0%) for the water, adipose, muscle, and bone, respectively. The STDs of the reconstructed RSP
were <.006 for all energies when DER=2%. With DER=10%, the STD of reconstructed RSP at 200 MeV was significantly higher (.01 vs .006, p<.05).

**CONCLUSION**

As PBS pCT derives projection images from statistical analysis of PBS spots, it is not sensitive to variations in proton ES and DER up to 10%. This is the first study to demonstrate the PBS proton beams being used directly for RSP reconstruction with significantly less dependency to ES and DER. Further technology development is warranted and is in process to improve the image resolution and the RSP accuracy for small regions of interest.

**CLINICAL RELEVANCE/APPLICATION**

Although proton radiography was first reported 5 decades ago, there is yet a commercial product to be developed given proton's multi-coulomb medium scattering, the cost of the proton CT, and furthermore the complicated single proton tracking technique used in the current passive scattering based pCT devices. In this study, we report the very first relative stopping power (RSP) reconstruction based on PBS technology and statistical processing of protons within each spot. This novel pCT acquisition and reconstruction methods could be efficient and effectively implemented into a routine clinical proton PBS machine with the capability of pre-treatment and intrafraction imaging.

**S1C13-09 Dual Source Photon-Counting-Detector CT with a Tin Filter: A Phantom Study on Iodine Quantification Accuracy and Precision**

Participants
Ashley Tao, PhD, Rochester, MN (Presenter) Nothing to Disclose
Richard Huang, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Shengzhen Tao, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Gregory J. Michalak, PhD, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (Abstract Co-Author) Research Grant, Siemens AG
Shuai Leng, PhD, Rochester, MN (Abstract Co-Author) License agreement, Bayer AG

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**PURPOSE**

To evaluate the impact of a multi-source photon-counting-detector (PCD) CT configuration, including the use of a tin filter and increased number of energy bins, on iodine quantification.

**METHOD AND MATERIALS**

A multi-energy CT phantom (Sun Nuclear) with iodine inserts at concentrations of 0, 2, 5, 10, 15 mg/mL was scanned on a research PCD-CT system with one source/PCD array. A reference scan was performed with 140 kV, 2 energy thresholds (TL and TH) and 32 mGy CTDIvol. Various multi-source PCD configurations were emulated by performing separate scans with different tube potentials and energy thresholds. Scans were performed at tube potentials of 80, 100, 120, 140, and Sn140 kV (140 kV with a tin filter), and multiple-source configurations using all possible kV pairs were investigated. Tube current was adjusted so that the CTDIvol of each scan was half of the reference scan (16 mGy) so that the total radiation dose was matched for all scan combinations (32 mGy). For each kV pair, two scenarios were investigated: (1) dual-energy scan with only 1 energy threshold (TL) used from each detector; and (2) quad-energy scan with 2 energy thresholds used from each detector. Images were reconstructed using standard filtered backprojection. Image-based material decomposition was performed to generate iodine and water maps. Root mean square error (RMSE) was measured for all iodine inserts and for each kV and energy threshold combination.

**RESULTS**

Among dual-energy configurations, 80/140 had the lowest RMSE of iodine concentration, 14.7 mg/mL, which was lower than that of reference scan using 140 kV (15.8 mg/mL). The use of a tin filter reduced the RMSE to 10.2 mg/mL. The lowest RMSE, 9.1 mg/mL, was achieved with the quad-energy configuration. Use of 4 energy thresholds (instead of 2) reduced RMSE by 20-75% for the kV pairs of 100/140 and 120/140.

**CONCLUSION**

Performance of PCD-based multi-energy CT can be substantially improved using a multiple source configuration, a tin filter and multiple energy thresholds, with a 42% reduction of RMSE (15.8 to 9.1 mg/mL) in iodine quantification accuracy observed through phantom studies.

**CLINICAL RELEVANCE/APPLICATION**

Dual-source PCD-CT with a tin filter can potentially provide better image quality, more accurate material quantification and lower dose than that of single-source PCD-CT.
Lunch and Learn: X-Ray in Motion: Changing the Role of Radiology in Pulmonary Function Assessment and Diagnosis: Presented by Konica Minolta Healthcare (invite-only)

Monday, Nov. 26 12:30PM - 1:30PM Room: S403A

RSVP Link

https://km-xim.cvent.com/c/express/4d860e30-e239-4908-b3ca-65ff8d2f11d2
Participants
Jill E. Jacobs, MD, New York, NY (Director) Nothing to Disclose
Karen G. Ordovas, MD, San Francisco, CA (Moderator) Advisor, Arterys Inc

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LEARNING OBJECTIVES
1) Identify cardiac and coronary artery anatomy. 2) Recognize cardiac disease processes, including coronary atherosclerosis, as diagnosed on CT. 3) Understand methods of cardiac CT and coronary CT angiography post-processing. 4) Understand the role of coronary artery calcium scoring. 5) Understand the role of Cardiac CTA in coronary artery pathologies including aneurysms, fistulae and other anomalies.

Sub-Events

MSMC23A Pulmonary Veins and Pericardial Disease
Participants
Harold I. Litt, MD, PhD, Philadelphia, PA (Presenter) Research Grant, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc

For information about this presentation, contact:
efishman@jhmi.edu

LEARNING OBJECTIVES
1) Describe normal versus anomalous pulmonary venous anatomy. 2) Understand the imaging findings of complications of ablation for atrial fibrillation. 3) Describe abnormalities of the pulmonary veins identifiable on routine CT. 4) Identify the most common pericardial abnormalities evaluated with CT.

MSMC23B Coronary Atherosclerosis III
Participants
Elliot K. Fishman, MD, Baltimore, MD (Presenter) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc

For information about this presentation, contact:
efishman@jhmi.edu

LEARNING OBJECTIVES
1) To provide a more complete understanding of cardiac CTA through a series of illustrative cases. 2) Discuss calcium scoring and its current role in a range of clinical scenarios, coronary artery anomalies, coronary artery fistulae, coronary artery aneurysms, and coronary artery challenging cases.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Elliot K. Fishman, MD - 2012 Honored Educator Elliot K. Fishman, MD - 2014 Honored Educator Elliot K. Fishman, MD - 2016 Honored Educator Elliot K. Fishman, MD - 2018 Honored Educator
LEARNING OBJECTIVES

1) Explain basic dual-energy CT principles. 2) Compare current dual-energy CT techniques and associated limitations. 3) Identify dual-energy CT applications in radiation therapy.

ABSTRACT

Nearly all patients treated with radiation therapy receive a computed tomography (CT) simulation scan for treatment planning purposes. Dual-energy CT (DECT) allows for the reconstruction of supplementary information during the CT simulation process, such as relative electron density and effective atomic number information, virtual monoenergetic images, and the differentiation of materials. The additional information gained through DECT has potential to aid in several aspects of the radiation therapy process. This course will outline the basic principles of DECT and compare different vendor solutions for acquisition of DECT images. DECT applications for radiation therapy will be discussed, including improving dose calculation accuracy, improving tumor and healthy tissue delineation, characterizing treatment response, and identifying and sparing functional healthy tissue.
PURPOSE

The purpose of this study was to conduct a statistical analysis of low-radiation-dose coronary computed tomography screening for coronary artery calcium score (CACS) to determine the correlation of the CACS with age, sex, systolic blood pressure, diastolic blood pressure, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), triglycerides (TG), uric acid (UA) and creatinine (Cr), as well as to investigate the predictive value of these traditional risk factors for coronary artery disease.

METHOD AND MATERIALS

There were 646 patients with chest pain or suspected coronary atherosclerosis, a clinical history, smoking habit, symptoms, high blood pressure, and high blood sugar. The following biochemical parameters were assessed: LDL-C, HDL-C, TC, TG, UA, and creatinine. All patients underwent a CT scan for coronary artery calcium score analysis. The scan was then analyzed in relationship to CACS levels and the above items for all patients.

RESULTS

In total, 326 patients were male (59.8%), and 219 patients were female (40.2%). The average age was 69.1 ± 10.2 years, and the mean CACS was 485 ± 814. Significant correlations of CACS with UA (r = 0.1518, P < 0.05) and creatinine (r = 0.2752, P < 0.05) were found. According to the multivariate Cox regression analysis, after adjusting for demographic characteristics and other serum parameters, serum UA levels (odds ratio [OR], 1.003, 95% confidence interval [CI], 1.001-1.005, p = 0.003) and creatinine levels (OR, 1.002, 95% CI, 0.999-1.005, p = 0.002) qualified as independent discriminators of the severity of coronary artery calcification.

CONCLUSION

We propose the need for identifying and managing UA and creatinine abnormalities to reduce excess coronary artery disease (CAD) risk. This proposal remains to be formally tested in a prospective study.

CLINICAL RELEVANCE/APPLICATION

The severity of coronary artery calcification score may indicated the UA and creatinine abnormalities in the blood.
To evaluate the feasibility of coronary computed tomography angiography (CCTA) in patients with free-breathing using 256-detector CT.

**METHOD AND MATERIALS**

616 patients underwent CCTA without heart rate control. 325 examinations were performed during free-breathing (group A), and the remaining 291 were performed during breath-holding (group B). The image quality scores were defined as 1 (excellent), 2 (good), 3 (adequate), and 4 (poor). 22 patients in group A and 24 in group B also underwent invasive coronary angiography (ICA) after CCTA within two weeks. The image quality score, diagnostic performance using ICA as reference, signal-to-noise ratio (SNR), and effective dose (ED) were compared between the two groups.

**RESULTS**

Mean heart rate during scanning was 70.8±13.8 bpm in group A and 70.7±13.2 bpm in group B (P=0.950). No significant differences were observed in the quality score between breath-holding and free-breathing groups (1.10±0.31 vs. 1.12±0.33; P=0.647). The SNR, effective dose were not significantly different between the two groups. In a segment-based analysis, the sensitivity and specificity in the detection of coronary stenosis of more than 50% were 82.1% and 96.8%, respectively in the breath-holding group and 82.2% and 96.6%, respectively in the free-breathing group with no significant differences for these parameters between the two groups.

**CONCLUSION**

CCTA for patients without heart rate control and with free-breathing using 256-detector CT showed no significant difference in image quality and diagnostic accuracy compared with patients with breath-holding.

**CLINICAL RELEVANCE/APPLICATION**

In patients without heart rate control, CCTA can be acquired during free breathing without substantial loss of image quality when using a 256-detector CT.

**SSE03-04 Prognostic Value of Delayed Enhancement Imaging by Cardiac Computed Tomography in Predicting Major Adverse Cardiac Events in Patients with Suspected Coronary Artery Disease**

**PURPOSE**

Myocardial CT delayed enhancement (CTDE) shares the same pathophysiological principle with late gadolinium enhancement MRI, and allows for infarct detection and viability assessment. However, the prognostic value of CTDE is unknown. The purpose of this study was to investigate whether the presence of delayed enhancement (DE) detected by CT is an independent predictor of major adverse cardiac events (MACEs) in patients with suspected coronary artery disease (CAD).

**METHOD AND MATERIALS**

We studied 429 consecutive patients with suspected CAD who underwent coronary CT angiography (CTA) and CTDE. Patients with known previous myocardial infarction (MI), percutaneous coronary intervention, coronary artery bypass surgery were excluded. MACEs were defined as severe cardiac events (cardiac death, nonfatal MI, unstable angina, heart failure necessitating hospitalization) and late revascularization (>180 days after CT examination). CTA results were divided into obstructive (>=50% luminal narrowing), mild (<50%), or no CAD groups. The Cox proportional hazards model was used to investigate the relationship between conventional clinical risk factors, coronary calcium score and coronary CTA result and MACEs.

**RESULTS**

Follow-up information was obtained in 389 of the 429 patients (91%). DE was observed in 72 of the 389 patients (19%). During a median follow-up of 26 months, 24 cardiac events (2 cardiac death, 2 MI, 2 unstable angina, 6 heart failure and 12 late revascularization) were observed. When adjusted for obstructive CAD, the presence of DE maintained a significant association with risk of all cardiac events (adjusted hazard ratio, 5.9; p<0.0001) and severe cardiac events (adjusted hazard ratio, 14.2; p=0.0002). Kaplan-Meier curves demonstrated a significant difference in event-free survival between patients with DE and those without for severe cardiac events (log-rank test, p<0.0001), as well as for all cardiac events (log-rank test, p<0.0001).

**CONCLUSION**

The presence of CTDE was an independent predictor of MACEs and severe cardiac events in patients with suspected CAD among common clinical risk factors and coronary CTA findings.

**CLINICAL RELEVANCE/APPLICATION**

Acquisition of CTDE following coronary CTA seems to be useful since CTDE provides additional prognostic information in patients with suspected CAD.

**SSE03-05 Factors Affecting FFRC Analysis in Routine Clinical Practice**

**METHOD AND MATERIALS**

To evaluate the feasibility of coronary computed tomography angiography (CCTA) in patients with free-breathing using 256-detector CT...

**RESULTS**

Mean heart rate during scanning was 70.8±13.8 bpm in group A and 70.7±13.2 bpm in group B (P=0.950). No significant differences were observed in the quality score between breath-holding and free-breathing groups (1.10±0.31 vs. 1.12±0.33; P=0.647). The SNR, effective dose were not significantly different between the two groups. In a segment-based analysis, the sensitivity and specificity in the detection of coronary stenosis of more than 50% were 82.1% and 96.8%, respectively in the breath-holding group and 82.2% and 96.6%, respectively in the free-breathing group with no significant differences for these parameters between the two groups.

**CONCLUSION**

CCTA for patients without heart rate control and with free-breathing using 256-detector CT showed no significant difference in image quality and diagnostic accuracy compared with patients with breath-holding.

**CLINICAL RELEVANCE/APPLICATION**

In patients without heart rate control, CCTA can be acquired during free breathing without substantial loss of image quality when using a 256-detector CT.

**SSE03-04 Prognostic Value of Delayed Enhancement Imaging by Cardiac Computed Tomography in Predicting Major Adverse Cardiac Events in Patients with Suspected Coronary Artery Disease**

**PURPOSE**

Myocardial CT delayed enhancement (CTDE) shares the same pathophysiological principle with late gadolinium enhancement MRI, and allows for infarct detection and viability assessment. However, the prognostic value of CTDE is unknown. The purpose of this study was to investigate whether the presence of delayed enhancement (DE) detected by CT is an independent predictor of major adverse cardiac events (MACEs) in patients with suspected coronary artery disease (CAD).

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We studied 429 consecutive patients with suspected CAD who underwent coronary CT angiography (CTA) and CTDE. Patients with known previous myocardial infarction (MI), percutaneous coronary intervention, coronary artery bypass surgery were excluded. MACEs were defined as severe cardiac events (cardiac death, nonfatal MI, unstable angina, heart failure necessitating hospitalization) and late revascularization (>180 days after CT examination). CTA results were divided into obstructive (>=50% luminal narrowing), mild (<50%), or no CAD groups. The Cox proportional hazards model was used to investigate the relationship between conventional clinical risk factors, coronary calcium score and coronary CTA result and MACEs.

**RESULTS**

Follow-up information was obtained in 389 of the 429 patients (91%). DE was observed in 72 of the 389 patients (19%). During a median follow-up of 26 months, 24 cardiac events (2 cardiac death, 2 MI, 2 unstable angina, 6 heart failure and 12 late revascularization) were observed. When adjusted for obstructive CAD, the presence of DE maintained a significant association with risk of all cardiac events (adjusted hazard ratio, 5.9; p<0.0001) and severe cardiac events (adjusted hazard ratio, 14.2; p=0.0002). Kaplan-Meier curves demonstrated a significant difference in event-free survival between patients with DE and those without for severe cardiac events (log-rank test, p<0.0001), as well as for all cardiac events (log-rank test, p<0.0001).

**CONCLUSION**

The presence of CTDE was an independent predictor of MACEs and severe cardiac events in patients with suspected CAD among common clinical risk factors and coronary CTA findings.

**CLINICAL RELEVANCE/APPLICATION**

Acquisition of CTDE following coronary CTA seems to be useful since CTDE provides additional prognostic information in patients with suspected CAD.
90 subjects (age 56.2y, 26 females) were examined with 128-dual source coronary CTA. Coronary arteries were evaluated per

PURPOSE
Reports exist of the acceptance rates of CCTA for FFRCT analysis from trials performed in academic centres, however real world data is lacking. The aim of the current study was to examine the acceptance rate, and the factors associated with rejection for FFRCT analysis.

METHOD AND MATERIALS
All clinical CCTAs referred between July 2016 and March 2018 for HeartFlow FFRCT analysis were included. Metadata from the submitted CCTAs was used to extract information on patient factors, scanner type, acquisition parameters and dose while HeartFlow FFRCT analysis data was used for quantification of aortic enhancement.

RESULTS
Of 10,621 CCTAs submitted, 9,524(89.7%) were accepted for FFRCT analysis. Of the 1,079 rejected: 205(18.7%) were for technical limitations of the submitted data (slice thickness/spacing >=1mm, pixel size >=0.5mm); 181(16.4%) due to the presence of stents, bypass grafts, other cardiac hardware; and 711(64.8%) for image quality. Patient factors associated with rejection were: higher heart rate (64.0(IQR 12.3) vs. 59.0(IQR 10.0) bpm, p<0.001) and heart rate variability (9.0(IQR 21.0) vs. 8.0(IQR 10.0) bpm, p<0.001). Technical factors associated with rejection were: retrospective acquisition (54% vs 31% retrospective, p<0.001), systolic phase acquisition (25% vs. 12% systolic, p<0.001), higher slice thickness (0.43(IQR 0.09) vs 0.40(IQR 0.06) mm, p<0.001), lower aortic attenuation (368(IQR 147) vs. 431(IQR 167), p<0.001) and higher kVp (120(IQR 0) vs. 120(IQR 20) kVp, p<0.001). BMI (p=0.9), and image noise (p=0.07) were no different in those with accepted or rejected CCTAs. On logistic regression, heart rate, systolic image acquisition, aorta contrast, pixel spacing, and slice thickness all remained significant predictors of rejection for image analysis (p<0.001 for all).

CONCLUSION
Almost 20% of FFRCT rejection could be avoided by stringent post processing protocols, and a further 20% by appropriate case selection. For the remainder, utilization of CTFFR requires similar strict heart rate and contrast timing image optimization strategies required of CCTA.

CLINICAL RELEVANCE/APPLICATION
Stringent patient preparation, case selection and post processing strategies hold potential to improve the opportunity for successful utilization of FFRCT analysis.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

SSE03-06 Interaction of Endurance Sport, Coronary Atherosclerosis and Flow by Coronary Computed Tomography Angiography (CTA): Insights from 3D CFD Modelling

Monday, Nov. 26 3:50PM - 4:00PM Room: N229

Participants
Gudrun Feuchtner, MD, Innsbruck, Austria (Presenter) Researcher, HeartFlow, Inc
Christian Langer, Innsbruck, Austria (Abstract Co-Author) Nothing to Disclose
Christian Beyer, Innsbruck, Austria (Abstract Co-Author) Nothing to Disclose
Stefan Rauch, Innsbruck, Austria (Abstract Co-Author) Nothing to Disclose
Fabian Plank, MD, Innsbruck, Austria (Abstract Co-Author) Nothing to Disclose

PURPOSE
to investigate coronary atherosclerosis and flow physiology by coronary computed tomography angiography (CTA) including 3D computational fluid dynamics (CFD) (noninvasive CT-FFR) in endurance athletes compared to inactive controls (CR)

METHOD AND MATERIALS
90 subjects (age 56.2y, 26 females) were examined with 128-dual source coronary CTA. Coronary arteries were evaluated per
90 subjects (age 56.2y, 26 females) were examined with 128-dual source coronary CTA. Coronary arteries were evaluated per segment (AHA-16-s-classification) for CAD: 1) Stenosis severity (CADRADS 0-5) 2) Total plaque burden (segment involvement score, SIS) and G-score: a new indicator for non-calcified plaque burden 3) High risk plaque features (LAP-HU, spotty calcification, NRS, RI) were quantified 4) Coronary Fractional Flow reserve (FFR) was remodelled by CFD Study design was retrospective (matched case controlled, 45 endurance-athletes vs 45 CR) The endurance group was defined as "regular" training (cycling, running or others) for least 1h per unit and >=3 times per week. Years of training were recorded.

RESULTS

Coronary stenosis severity (CAD RADS) score was lower in the endurance group vs CR (1.44 vs 2.1, p=0.007). Total and non-calcified plaque burden (SIS and G-score) were also sign. lower (1.8 vs 3.3 ; p=0.003 and 3.5 vs 6.6, p=0.002) while calcium score was trended lower only (38.9 AU vs 137.2 AU, p=0.06) HRP prev. was eminently lower in athletes (5 vs 14 (2.2% vs 31.1%) p=0.02), and NRS (4 vs 7), resp. Non-calcified and total plaque burden (G-score and SIS) were strongest and significantly correlated with declining distal FFR (RCA S4: r=-0.32 and r=-0.3, p=0.03 and p=0.02, LAD S8 r=-0.2, p=0.09 for G-score), while calcium score was not (S4: p=0.07 and S8: p=0.861, Spearman), in the entire cohort. There was no difference in distal FFR between athletes vs CR (p= 0.532, 0.203, 0.358, 0.343 ANOVA)

CONCLUSION

Regular endurance training (min. 1 h and >=3x/week) reduces CAD burden (coronary stenosis severity, total and non-calcified plaque burden and most eminently, high-risk plaques). Total and non-calcified plaque burden (G-score) rather than coronary calcium predicts distal coronary flow limitations in both athletes and inactives

CLINICAL RELEVANCE/APPLICATION

Regular endurance training reduces CAD burden and risk, with a dominant effect on high-risk plaque. We describe a novel non-calcifying plaque burden score (G-score), which is easy-to-implement into clinical structural reporting and potentially predicts myocardial ischemia.
**SSE05**

**Chest (Airway Disease)**

**PURPOSE**
As the quantitative airway analysis has been evolved, the effect of smoking has been established. However, the generation-based smoking effect where inter-subject variabilities are normalized is rarely known. The purpose of this study is to evaluate a prediction model of airway parameters, and further to investigate generation-based structural and functional airway alterations in smokers with the derived normalization scheme.

**METHOD AND MATERIALS**
68 smokers and 174 nonsmokers with inspiratory/expiratory CT findings, and normal pulmonary function tests were included in the study. VIDA Apollo software (Coralville, IA) was used for the airway size analysis. To control inter-subject variability, multiple linear regressions of tracheal wall thickness (WT), diameter (D), and luminal area (LA) were used for the normalization of airway parameters considering the effects of age, sex and height. Using this scheme, each airway parameter was normalized by individual predicted values, and normalized WT (WT*), D (D*), LA (LA*) from the 1st to 8th generation of each lobe were compared between smokers and non-smokers.

**RESULTS**
LA* and D* decreased and WT* increased in the smokers after normalization (p<0.05), which was not observed before normalization. The wall thickness of the segmental airways in smokers was not changed between inspiration and expiration (WT*ins-WT*exp= 0.01±0.01), whereas that in non-smokers was thicker at expiration than inspiration (-0.02±0.01). Besides, airways at the 3rd generation showed significant wall thickening in smokers than nonsmokers (p=0.003).

**CONCLUSION**
Quantitative CT assessment using a normalization scheme suggest that smoking may induce airway wall thickening and reduce changes of wall thickening during respiration, which means a decrease in airway wall compliance. Generation-based analysis showed that the 3rd generation is most affected by smoking.

**CLINICAL RELEVANCE/APPLICATION**
When it comes to the effect of smoking, it is important to perform normalization and focus on wall thickening of segmental airways.

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**Participants**
Yoshiharu Ohno, MD, PhD, Kobe, Japan (*Moderator*) Research Grant, Canon Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Fuji Pharma Co, Ltd; Research Grant, Guerbet SA; Matthew J. DeVries, MD, Omaha, NE (*Moderator*) Nothing to Disclose

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**SSE05-01**  **Generation-Based Airway Remodeling in Smokers with Normal-Looking CT: After Normalization to Control Inter-Subject Variability**

**PURPOSE**
As the quantitative airway analysis has been evolved, the effect of smoking has been established. However, the generation-based smoking effect where inter-subject variabilities are normalized is rarely known. The purpose of this study is to evaluate a prediction model of airway parameters, and further to investigate generation-based structural and functional airway alterations in smokers with the derived normalization scheme.

**METHOD AND MATERIALS**
68 smokers and 174 nonsmokers with inspiratory/expiratory CT findings, and normal pulmonary function tests were included in the study. VIDA Apollo software (Coralville, IA) was used for the airway size analysis. To control inter-subject variability, multiple linear regressions of tracheal wall thickness (WT), diameter (D), and luminal area (LA) were used for the normalization of airway parameters considering the effects of age, sex and height. Using this scheme, each airway parameter was normalized by individual predicted values, and normalized WT (WT*), D (D*), LA (LA*) from the 1st to 8th generation of each lobe were compared between smokers and non-smokers.

**RESULTS**
LA* and D* decreased and WT* increased in the smokers after normalization (p<0.05), which was not observed before normalization. The wall thickness of the segmental airways in smokers was not changed between inspiration and expiration (WT*ins-WT*exp= 0.01±0.01), whereas that in non-smokers was thicker at expiration than inspiration (-0.02±0.01). Besides, airways at the 3rd generation showed significant wall thickening in smokers than nonsmokers (p=0.003).

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Quantitative CT assessment using a normalization scheme suggest that smoking may induce airway wall thickening and reduce changes of wall thickening during respiration, which means a decrease in airway wall compliance. Generation-based analysis showed that the 3rd generation is most affected by smoking.

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When it comes to the effect of smoking, it is important to perform normalization and focus on wall thickening of segmental airways.

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**Participants**
Yoshiharu Ohno, MD, PhD, Kobe, Japan (*Moderator*) Research Grant, Canon Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Fuji Pharma Co, Ltd; Research Grant, Guerbet SA; Matthew J. DeVries, MD, Omaha, NE (*Moderator*) Nothing to Disclose

**Sub-Events**

**SSE05-02**  **Enhanced Evaluation of Tracheomalacia with Use of Cyclic Ultra-low Dose Dynamic Expiratory CT**

**PURPOSE**
As the quantitative airway analysis has been evolved, the effect of smoking has been established. However, the generation-based smoking effect where inter-subject variabilities are normalized is rarely known. The purpose of this study is to evaluate a prediction model of airway parameters, and further to investigate generation-based structural and functional airway alterations in smokers with the derived normalization scheme.

**METHOD AND MATERIALS**
68 smokers and 174 nonsmokers with inspiratory/expiratory CT findings, and normal pulmonary function tests were included in the study. VIDA Apollo software (Coralville, IA) was used for the airway size analysis. To control inter-subject variability, multiple linear regressions of tracheal wall thickness (WT), diameter (D), and luminal area (LA) were used for the normalization of airway parameters considering the effects of age, sex and height. Using this scheme, each airway parameter was normalized by individual predicted values, and normalized WT (WT*), D (D*), LA (LA*) from the 1st to 8th generation of each lobe were compared between smokers and non-smokers.

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LA* and D* decreased and WT* increased in the smokers after normalization (p<0.05), which was not observed before normalization. The wall thickness of the segmental airways in smokers was not changed between inspiration and expiration (WT*ins-WT*exp= 0.01±0.01), whereas that in non-smokers was thicker at expiration than inspiration (-0.02±0.01). Besides, airways at the 3rd generation showed significant wall thickening in smokers than nonsmokers (p=0.003).

**CONCLUSION**
Quantitative CT assessment using a normalization scheme suggest that smoking may induce airway wall thickening and reduce changes of wall thickening during respiration, which means a decrease in airway wall compliance. Generation-based analysis showed that the 3rd generation is most affected by smoking.

**CLINICAL RELEVANCE/APPLICATION**
When it comes to the effect of smoking, it is important to perform normalization and focus on wall thickening of segmental airways.

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**Participants**
Yoshiharu Ohno, MD, PhD, Kobe, Japan (*Moderator*) Research Grant, Canon Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Fuji Pharma Co, Ltd; Research Grant, Guerbet SA; Matthew J. DeVries, MD, Omaha, NE (*Moderator*) Nothing to Disclose

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also showed positive correlation with serum IgE and induced sputum MMP-9 (r=0.509, 0.636, all P<0.05).

were significantly negative correlated with FEV1/FVC and FEV1% (WT, r=-0.621, -0.483, WA%, r=-0.729, -0.548, all P<0.05). WA% r=0.669, 0.533, Ai, r=0.681,0.552, all P<0.05). Ai also showed positive correlation with FEV1% (r=0.452, P<0.05). WT and WA% r=0.512, -0.841, Ai, r=-0.489,-0.841, all P<0.05), and positive correlation with FEV1/FVC and serum leptin (LD, r=0.669, 0.533, Ai, r=0.681,0.552, all P<0.05). Ai also showed positive correlation with serum IgE and induced sputum MMP-9 (r=-0.509, 0.636, all P<0.05).

RESULTS

The percent tracheal area narrowing (%TN) between paired inspiration CT and dynamic expiratory CT (DECT) is used to diagnose and grade tracheomalacia (TM). At our institution this is done clinically with the maximum %TN on either of two consecutive ultra low dose DECTs (mDECT). This study aims to evaluate the implications of mDECT vs. single DECT in TM diagnosis and grading.

METHOD AND MATERIALS

CT studies for evaluation of TM from 2017 performed at a single imaging site were retrospectively evaluated. CT protocol of one routine inspiratory chest CT and two consecutive ULD (100 kVp, fixed mA 10) DECT. The %TN for each DECT was obtained by comparing the greatest percent tracheal narrowing on anatomically matched expiration and inspiration CT, measured independently for DECT 1 and 2. Tracheal area was measured manually delineating the luminal contour of the trachea with the free-hand PACS ROI tool on 2.5 mm axial slices by a thoracic fellowship trained radiologist. The presence of TM (>70 %TN) and its severity (negative <70%, mild 70-80%, moderate 80-90%, severe >90%) were assessed. The mean %TN, percent of patients with TM diagnosis, and distribution of TM severity between DECT1, DECT2 and mDECT were analyzed using paired 2-tailed t-test, 2-tailed binomial proportions test, and chi-squared test, respectively.

RESULTS

184 patients (41% male) with mean age of 64 were analyzed. Mean radiation dose for each DECT phase was 0.07 mSv with all studies deemed diagnostic. mDECT demonstrated 57 mean %TN, 10% greater than DECT1 and 6% greater than DECT2 (each p<0.001), with DECT2 9% greater mean %TN than DECT1 (p<0.05). 40% Percentage of patients with TM diagnosis with mDECT (40%) was 10% greater than DECT1 or 2 (each 30%, p<0.05). mDECT (109 negative, 31 mild, 24 moderate, and 20 severe) had significantly greater number of patients diagnosed with TM with a significantly more severe distribution of disease than DECT1 (128, 27, 21, 12) or DECT2 (127, 21, 15), (each p<0.05) without significant differences between DECT1 and 2.

CONCLUSION

For CT evaluation of TM, mDECT demonstrated low patient radiation dose with an increase in mean %TN, a higher rate of TM diagnosis and a more severe distribution of disease than a single DECT phase alone.

CLINICAL RELEVANCE/APPLICATION

CT evaluation of TM with two ultra low dose DECTs should be considered to diagnose and grade TM.
CONCLUSION
CT airway indexes were found partially associated with asthma onset age, course of disease, smoking condition, serum leptin and IgE, induced sputum Eos% and MMP-9. CT airway indexes showed correlation with FEV1/FVC and FEV1%.

CLINICAL RELEVANCE/APPLICATION
CT indexes of small airway were found associated with asthma onset age, course of disease, smoking condition, serum leptin and IgE, induced sputum Eos% and MMP-9, as well as FEV1/FVC and FEV1%.

SSE05-05 A Comparative Study of Performance Between Radiographers and Machine Learning Model (MLM) for Airway Measurement

Participants
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PURPOSE
The purpose of this study is to compare the performance between radiographers and machine learning model of analyzing airway.

METHOD AND MATERIALS
Total 182 patients' thin slice CT data of KOLD cohort was used and their all airway branches were semi-automatically segmented by AView software (Coreline Soft, Co., Ltd, South Korea). 46,436 airway axial images were used to train MLM using DenseNet 201 that we changed the last DenseLayer to binary classification. All airway axial images were colored using integral-based half-band method and they were labeled as accept or reject to clarify and precise airway results. In randomly selected 50 axial images, accuracy was compared among two radiographers with 4-year experience on airway measurement and MLM. Cohen's Kappa was used to assess the inter-observers agreement and elapsed time was measured. T-test, in addition, was performed to compare airway results on 182 patients of KOLD cohort between one blinded radiographer and MLM.

RESULTS
The ROC analysis of the test data sets showed 0.92 of area under curve. In the 50 randomly selected airway axial images, Sensitivity, specificity of MLM were 0.96, 0.88 and its accuracy was 0.92. In radiographers, respectively, 0.86, 0.7 and 0.78 were shown (Cohen's kappa = 0.62). Elapsed time between two control groups, two radiographers and MLM, showed statistically significant difference (190.3 and 1.8 seconds, p < 0.05). The mean airway pi-10 and wall area percent showed no statistically significant difference (4.12 ± 0.89 mm, 66.43 ± 7.56 %; MLM, 4.15 ± 0.88 mm, 66.66 ± 7.35 %, p > 0.05, respectively).

CONCLUSION
Trained MLM showed no differences comparing with skilled radiographers in the results of airway measurement with short elapsed time. Consequently, MLM measures all airway branches fully automatically without expert interactions, if airway segmentation well performed.

CLINICAL RELEVANCE/APPLICATION
The airway is considered as an imperative index of lung. Fully automatic airway measurement of whole branch would be more efficient for imaging biomarker in COPD patients.

SSE05-06 Catheter-Based Endobronchial Navigation with a Novel Cone Beam CT Airway Segmentation Platform to Reach Peripheral Lung in a Swine Model Without Bronchoscopy

Participants
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CLINICAL RELEVANCE/APPLICATION
The airway is considered as an imperative index of lung. Fully automatic airway measurement of whole branch would be more efficient for imaging biomarker in COPD patients.

SSE05-06 A Comparative Study of Performance Between Radiographers and Machine Learning Model (MLM) for Airway Measurement

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PURPOSE
The purpose of this study is to compare the performance between radiographers and machine learning model of analyzing airway.

METHOD AND MATERIALS
Total 182 patients' thin slice CT data of KOLD cohort was used and their all airway branches were semi-automatically segmented by AView software (Coreline Soft, Co., Ltd, South Korea). 46,436 airway axial images were used to train MLM using DenseNet 201 that we changed the last DenseLayer to binary classification. All airway axial images were colored using integral-based half-band method and they were labeled as accept or reject to clarify and precise airway results. In randomly selected 50 axial images, accuracy was compared among two radiographers with 4-year experience on airway measurement and MLM. Cohen's Kappa was used to assess the inter-observers agreement and elapsed time was measured. T-test, in addition, was performed to compare airway results on 182 patients of KOLD cohort between one blinded radiographer and MLM.

RESULTS
The ROC analysis of the test data sets showed 0.92 of area under curve. In the 50 randomly selected airway axial images, Sensitivity, specificity of MLM were 0.96, 0.88 and its accuracy was 0.92. In radiographers, respectively, 0.86, 0.7 and 0.78 were shown (Cohen's kappa = 0.62). Elapsed time between two control groups, two radiographers and MLM, showed statistically significant difference (190.3 and 1.8 seconds, p < 0.05). The mean airway pi-10 and wall area percent showed no statistically significant difference (4.12 ± 0.89 mm, 66.43 ± 7.56 %; MLM, 4.15 ± 0.88 mm, 66.66 ± 7.35 %, p > 0.05, respectively).

CONCLUSION
Trained MLM showed no differences comparing with skilled radiographers in the results of airway measurement with short elapsed time. Consequently, MLM measures all airway branches fully automatically without expert interactions, if airway segmentation well performed.

CLINICAL RELEVANCE/APPLICATION
The airway is considered as an imperative index of lung. Fully automatic airway measurement of whole branch would be more efficient for imaging biomarker in COPD patients.
Corporation

PURPOSE

To investigate the feasibility of catheter-based endobronchial navigation to peripheral lung without a bronchoscope using a novel Cone Beam CT (CBCT) image-guidance prototype in a swine model.

METHOD AND MATERIALS

All animal procedures were approved by the Animal Care and Use Committee. Swine (n=3) were placed under general anesthesia. Thoracic CBCT (FD20, Philips Healthcare) was imported into a workstation with prototype software (Philips) that provides for 3D airway segmentation, manual identification of targets and 3D navigation guidance superimposed on fluoroscopic imaging. Peripheral targets (bronchial subsegments) were identified. Catheter-based endobronchial navigation to targets was performed with 4 and 5 Fr catheters (Cook Medical) with varying shapes (e.g., C2, multipurpose, DAV) over 0.035' hydrophilic vascular guidewires of various curves and stiffness (Terumo). The primary endpoint was successful navigation of a catheter into a bronchial target. Success was assessed by catheter position on multiple X-ray images at preplanned C-arm angles and CBCT.

RESULTS

Catheter-based navigation to primarily 3rd and 4th order airway segments was successful in 11/13 tasks in the first two swine. Failure to navigate guidewires to distal targets occurred when the guide wire or catheter tip was too stiff with poor maneuverability or had a sub-optimal shape for the airway geometry. With optimization of device selection and imaging settings, catheter-based navigation to even more complex 4th and 5th order segments targets was successful in 8/11 tasks; navigation failures occurred due to suboptimal catheter or wire shape or stiffness for the target (n = 2) or suboptimal imaging settings (n=1). In these cases, operator adherence to predefined fluoroscopic imaging protocols also restricted identification of malposition and adjustments that might otherwise occur.

CONCLUSION

Catheter-based endobronchial navigation without a bronchoscope is feasible with CBCT 3D segmentation and image-guidance combined with fluoroscopy. Catheter and wire design, including size, shape and physical properties, are important predictors of navigation success, especially for more peripheral airway tasks.

CLINICAL RELEVANCE/APPLICATION

CBCT airway segmentation and guidance software may advance endobronchial catheter-based approaches for lung diagnostics and treatments beyond the reach of a bronchoscope. Catheter and wire selection impacts procedural success.
SSE06-03 Evaluation of Organ Density Values in Postmortem Computed Tomography (PMCT) in Correlation with Radiological Alteration Index (RAI) as Possible Surrogate for Postmortal Alteration in Human Cadavers

Purpose
We evaluated the correlation between organic parenchymal density in Hounsfield Units (HU) with the radiological alteration index (RAI) level as surrogate for postmortal alteration in postmortem computed tomography (PMCT).

Method and Materials
We retrospectively included 14 human cadavers (6 females, 8 males) undergoing whole body PMCT. RAI was assessed in 7 localizations reflecting the presence of gas. Based on the total RAI-score cadavers were divided into three groups. [Group 1: low RAI (total score: 0-30); Group 2: medium RAI (total score: 30-60) and Group 3: high RAI (total score: 60-100)]. Density values (HU) were measured in 8 different localizations (1. frontal lobe, 2. basal-ganglia, 3. myocardium, 4. pectoral muscle, 5. liver, 6. left kidney, 7. m. iliopsoas, 8. first lumbar vertebral body[L1]). Correlation between density values and RAI was tested.

Results
7 cadavers were included in group 1 with a mean RAI-score of 8.9±9.8, 4 cadavers in group 2 with a mean RAI-score of 46.4±4.6 and 3 cadavers in group 3 with a mean RAI-score of 83.7±14.8. Density measurements showed no significant difference between the three groups for all anatomic landmarks (1. frontal lobe: group 1: 39.4±5.2 vs. group 2: 44.7±6.8 vs. group 3: 44.7±6.8 HU; basal-ganglia: 43.7±5.3 vs. 41.8±4.8 vs. 44.7±6.8 HU; myocardium: 49.4±9.7 vs. 44.7±8.3 vs. 45.9±8.6 HU; pectoral muscle: 52.9±7.2 vs. 47.0±8.1 vs. 50.8±14.3; liver: 61.5±10.4 vs. 76.1±12.0 vs. 64.1±9.6; left kidney: 49.1±9.5 vs. 43.9±10.7 vs. 35.6±9.8; m. iliopsoas: 48.7±9.2 vs. 51.4±10.3 vs. 55.1±9.8; L1: 169.8±40.5 vs.165.8±46.8 vs. 141.9±30.0; p> 0.05 for all). There was no significant correlation between density measurements and RAI.

Conclusion
There was no correlation between RAI and density measurements in 8 evaluated organs irrespective of the patients’ RAI index.

Clinical Relevance/Application
CT organ density measurements cannot be reliably used to assess decay in postmortem CT.
UTILIZING THE BROKEN CIRCLE SIGN: A NEW METHOD FOR DETECTING A HILL-SACHS LESION ON AN INTERNAL ROTATION SHOULDER RADIOGRAPH

Monday, Nov. 26 3:40PM - 3:50PM Room: E353A

Participants
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PURPOSE

A Hill-Sachs (HS) lesion is a potential indicator of shoulder joint instability. Diagnosis is based on a flat or concave defect in the superior aspect of the humeral head on an internal rotation (IR) radiograph but the finding is often subtle. The purpose of this study was to describe a new method designed to increase the sensitivity for HS lesions.

METHOD AND MATERIALS

A retrospective search for patients who sustained a prior dislocation, were evaluated with x-rays, and had a HS lesion on MRI was performed for a 10-yr period. In Part 1, only the AP IR x-ray was utilized and these were randomized with controls. Three readers were asked to independently score all x-rays with ‘yes’ if they detected a HS lesion or ‘no’ if they did not or were unsure. One month later, the readers were taught the Broken Circle Sign, and re-scored the x-rays using the new technique. In Part 2, 15 MRI-confirmed cases of HS lesions that were missed on initial review were mixed with normal x-rays and shown to 17 residents individually before and after teaching the new method. A paired t-test was used to evaluate the differences in sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV).

RESULTS

Sensitivity, accuracy, positive predictive value (PPV) and negative predictive value (NPV).
A total of 256 patients met the selection criteria (199 men, 57 women; age range: 15-82 yrs, mean: 31.2 yrs). There were 127 right and 129 left shoulders. In Part 1, sensitivity for all 3 readers increased by an average of 20.6% (54.1% to 74.7%; p<0.02), accuracy increased by an average of 7.4% (69.1% to 76.5%; p<0.05), and NPV increased by an average of 10.8% (62.4% to 73.3%; p<0.005). In Part 2, sensitivity for the residents increased by an average of 20.4% (54.1% to 74.9%; p<0.0001), accuracy increased by an average of 14.6% (65.1% to 79.7%; p<0.0001), and NPV increased by an average of 15.3% (41.6% to 56.9%; p<0.001) independent of their level of training. Only 2 residents did not improve due to high initial scores in sensitivity and accuracy.

CONCLUSION

The Broken Circle Sign is a simple tool that helps to increase the conspicuity of a Hill-Sachs lesion on internal rotation shoulder radiographs. It appears to increase the sensitivity, accuracy, and NPV at all levels of training.

CLINICAL RELEVANCE/APPLICATION

The Hill-Sachs lesion occasionally is a difficult diagnosis to make on radiographs. The Broken Circle Sign is a simple method that can aid in increasing the diagnostic acumen for this abnormality.

PURPOSE

To develop and test the performance of deep convolutional neural networks (DCNNs) for the automated detection of 1) age and 2) gender on chest radiographs (CXRs).

METHOD AND MATERIALS

We obtained 112,120 frontal CXRs from the NIH ChestX-ray14 database performed in 48,780 females (44%) and 63,340 males (56%) ranging from 1 to 95 years old; amongst 5941 pediatric CXRs (5%), 2546 (43%) were female (p=0.3). The entire dataset was split into training (70%), validation (10%), and test (20%) datasets and used to train, validate, and test the ResNet-18 DCNN pretrained on ImageNet for: 1) determination of gender (using both entire dataset and only pediatric CXRs); 2) determination of age <18 years old or >=18 years old (using entire dataset); and 3) determination of age <11 years old or 11-18 years old (using only pediatric CXRs). During each training epoch, each image was augmented via random rotations, cropping, and flipping. We also tested the DCNNs on an external dataset of 662 CXRs performed in adults and children from China. Receiver operating characteristic (ROC) curves with area under the curve (AUC) and standard diagnostic measures (e.g., accuracy) were used to evaluate DCNN test performance with AUCs statistically compared between DCNNs.

RESULTS

The DCNNs trained to determine gender on the entire dataset and pediatric CXRs only had AUC of 1.0 and 0.91, respectively (p<0.0001) and accuracy of 98% and 83%, respectively. The DCNNs trained to determine age <18 years old or >=18 years old and <11 years old or 11-18 years old had AUCs of 0.99 and 0.96 (p<0.0001), respectively, with accuracy of 98% and 89%, respectively. On the external dataset, the DCNNs achieved AUC of 0.98 for gender (p=0.01) and 0.91 for determining age < or >=18 years old (p<0.001), with accuracy of 94% and 97%, respectively.

CONCLUSION

DCNNs can accurately predict gender from CXRs, as well as distinguish between adult and pediatric patients, in both American and Chinese populations, and between pre-pubescent and pubescent children in American populations. The ability to glean demographic information from CXRs may aid forensic investigations, as well as help identify novel anatomic landmarks for gender and age.

CLINICAL RELEVANCE/APPLICATION

Deep convolutional neural networks can accurately infer gender and age from chest radiographs from American and Chinese populations, which may be a useful tool in "forensic" radiology.
**SSE09-01**  
Contrast-Enhanced MR Imaging Based 3D Texture Analysis as a Potential Tool for Preoperative Prediction of Microvascular Invasion in Hepatocellular Carcinoma  
Monday, Nov. 26 3:00PM - 3:10PM Room: S404CD

**Participants**  
Daniele Marin, MD, Durham, NC (Moderator) Research support, Siemens AG  
Alvin C. Silva, MD, Scottsdale, AZ (Moderator) Nothing to Disclose

**Sub-Events**  

**Purpose**  
To investigate the value of contrast enhanced MR imaging (CE-MRI) texture analysis in preoperative predicting the microvascular invasion (MVI) status of hepatocellular carcinoma (HCC).

**Method and Materials**  
A retrospective study of 142 pathologically confirmed cases were conducted. Studies were divided into two cohort: the training cohort (n=99) and validation cohort (n=43), including MVI positive group (n=53) and MVI negative group (n=89) based on pathology. 58 textural parameters were extracted in two cohort using baseline MRI on both arterial phase (AP) and portal phase (PP) by a 3D method. The clinical-radiological features were also included. Univariate logistic regression identified potentially predictive parameters, which were entered into the multivariate logistic regression to build the texture model and the combined model together with clinical features to predict development of MVI.

**Results**  
In the clinical features, significant difference was found in max tumor diameter (MTD) (P=0.002), tumor differentiation (P=0.026) and AFP (P=0.025) between the two groups in training cohort. Four MR texture features in AP and five in PP were used to build the texture model. The combined model in AP showed a better diagnostic performance than PP using ROC analysis in validation cohort, with area under the curve (AUC) 0.794 vs. 0.706, sensitivity 0.812 vs. 0.750 and specificity 0.852 vs. 0.704.

**Conclusion**  
The CE-MRI 3D texture analysis can predict MVI of HCC preoperatively and noninvasively, and AP image showed better predictive efficiency than in PP image. Combined model with clinical-radiological features could improve MVI prediction ability to some extent.

**Clinical Relevance/Application**  
Preliminary studies had shown that MVI was a risk factor for the overall survival and recurrence rates of HCC patients. However, there was no accepted method for predicting MVI preoperatively. In this study, 3D CE-MRI texture analysis was used together with clinical-radiological features to build model to predict the MVI status in a training cohort preoperatively. A validation cohort was set to validating the model efficiency and stability. After multivariate logistic regression, our result revealed that the combined model in arterial phase showed a good performance to predicting MVI with AUC of 0.810. This is of great clinical significance for the surgical decision-making and treatment after surgery to avoid recurrence.

**SSE09-02**  
Machine Learning Models for Prediction of Hepatocellular Carcinoma Response to Transcatheter Arterial Chemoembolization based on Baseline CT Image Texture Analysis and clinical Staging Data  
Monday, Nov. 26 3:10PM - 3:20PM Room: S404CD

**Participants**  
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Justin Yu, BA, Houston, TX (Abstract Co-Author) Nothing to Disclose
The purpose of this work is to develop a fully automated algorithm that uses pre-therapeutic quantitative image features and clinical data as inputs to predict HCC response to TACE.

**METHOD AND MATERIALS**

TACE outcome information on 113 HCCs in 105 patients receiving first-line treatment with TACE was obtained from a database. An automated segmentation program was developed using fully convolutional neural networks and random forest classification methods to parse out each HCC. The Dice similarity coefficient was calculated to compare the automated segmentation accuracy with that of a manually validated process. A boruta feature selection algorithm was used for data reduction for the quantitative image features considered. The response of HCC to TACE was predicted using a second random forest classifier with the inputs; 1) Barcelona clinic liver cancer (BCLC) stage alone 2) quantitative image features alone 3) BCLC stage plus quantitative image features. The primary clinical endpoint was time to progression (TTP) based on follow-up CT radiological criteria (mRECIST). TTP cutoff of 14 weeks was used to stratify patients as follows; TTP > 14 wks as TACE susceptible and would benefit from further TACE sessions, TTP < 14 wks as TACE refractory and would be better suited for a change of treatment strategy.

**RESULTS**

The automated segmentation model had a Dice similarity coefficient scores at baseline of 0.65 ±0.048 and 0.64 ±0.081 for viable and necrotic tissue, respectively. The model's response prediction accuracy rate was 73.2% using a combination of the BCLC stage and quantitative image features (P-value= 0.0096, 95% CI=0.64-0.8, SN=0.83, SP=0.55) versus 62.9% using the BCLC stage alone. Shape image features of the viable, necrotic and background liver were the dominant features correlated to the TTP as selected by the Boruta method and were used to predict the outcome.

**CONCLUSION**

This preliminary study demonstrates the feasibility of improving the accuracy of predicting treatment response of HCC to TACE therapy using quantitative imaging feature obtained prior to therapy. The approach is likely to provide useful information for assisting in patient selection for the continuation of TACE therapy versus changing treatment strategy.

**CLINICAL RELEVANCE/APPLICATION**

TACE is recommended for unresectable BCLC stage B HCC. Tumor response to first TACE session affects the treatment strategy.

**Honoled Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Khaled M. Elsayes, MD - 2014 Honored EducatorKhaled M. Elsayes, MD - 2017 Honored EducatorKhaled M. Elsayes, MD - 2018 Honored Educator

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**PURPOSE**

To find CT-texture analysis (CTTA) features for discrimination between chronic lymphocytic leukemia (CLL) including indolent and aggressive subtypes and diffuse large B cell lymphoma (DLBCL) caused by transformation (Richter's syndrome).

**METHOD AND MATERIALS**

We retrospectively identified 52 patients with indolent (26/52) or aggressive CLL (8/52) and DLBCL caused by Richter's syndrome (18/52) who underwent contrast-enhanced CT (CECT) between 03/2011 and 05/2017 using a standardized protocol (120 kV, 200-250 mAs, thin-collimation, weight-adapted i.v. contrast media in portal-venous phase). ROIs were set in the main lymphoma masses as large as possible avoiding partial volume averaging. CTTA evaluation included heterogeneity, intensity, average, deviation, skewness, entropy of co-occurrence matrix, number non-uniformity grey-level dependence matrix (NGLDM), mean contrast neighborhood grey-tone difference matrix (NGTDM) and entropy NGLDM. For each CTTA parameter the respective mean, entropy and uniformity were calculated. We first grouped all CLLs and compared them with DLBCL and secondly compared both the indolent and aggressive CLL subtypes separately with DLBCL.

**RESULTS**

CTTA-values between the entire CLL-group and DLBCL significantly differed with respect to entropy (P<.002), uniformity of heterogeneity (P<.008), mean intensity (P<.0001), mean average (P<.007), entropy of co-occurrence matrix (P<.012) and number
non-uniformity (P<.03). Indolent CLLs significantly differed from DLBCL in terms of entropy (P<.007), uniformity of heterogeneity (P<.018), mean intensity (P<.004) whereas aggressive CLLs were significantly different from DLBCL in terms of entropy (P<.03), uniformity of heterogeneity (P<.02), mean intensity (P<.02) and mean entropy of co-occurrence matrix (P<.04).

CONCLUSION

CTTA features significantly differ in subjects with CLL compared to DLBCL caused by Richter's syndrome and could therefore be implemented in the routine evaluation of patients suspected of CLL transformation into a DLBCL. Differences in CTTA-features represent ultrastructural characteristics like tissue heterogeneity and contrast-induced attenuation.

CLINICAL RELEVANCE/APPLICATION

Differentiation between CLL and DLBCL caused by Richter's syndrome has major therapeutic and prognostic implications.

SSE09-04  Correlation Between Whole-Tumor CT Texture Analysis and Pathological Findings in Resected Primary Colon Cancer: Preliminary Results

Monday, Nov. 26 3:30PM - 3:40PM Room: S404CD

Participants
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PURPOSE

to correlate tumor heterogeneity by using whole-tumor CT texture analysis with pathological findings in primary colon cancer.

METHOD AND MATERIALS

IRB-approved retrospective study; need for informed consent was waived. Thirty patients with resected primary colon cancer were included (21M, 9F; mean age 75y). Thirty-nine first, second and higher order texture features were obtained from preoperative CT portal-venous phase images using a dedicated software (LifEX, www.lifexsoft.org). The results were compared with 10 histopathological features from the specimen (histology, tumor grade, growth pattern, T status, N status, presence of ulceration, percentage of necrosis, presence of vascular and lymphatic invasion, presence of free nodules).

RESULTS

Tumor histology, tumor grade, growth pattern, T and N status were significantly correlated with 20 different Grey-Level Co-occurrence Matrix (GLCM), Grey-Level Run-Length Matrix (GLRLM), Grey-Level Zone-Length Matrix (GLZLM) and Neighborhood Grey-Level Different Matrix (NGLDM) parameters (Mann-Whitney test; p<0.05). No differences were found between first order texture features and the considered pathological findings (p=ns).

CONCLUSION

CT second and higher order texture features correlate with tumor biology and with T/N status at pathology.

CLINICAL RELEVANCE/APPLICATION

Second and higher order texture features are a new promising tool for preoperative characterization of colon cancer.

SSE09-05  Performance of 3T-MRI-Derived Texture Analysis in Rectal Cancer: Predicting Tumoral Response to Therapy

Monday, Nov. 26 3:40PM - 3:50PM Room: S404CD

Participants
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PURPOSE

To determine the performance of texture analysis(TA) in predicting tumoral response to therapy in patients with rectal cancer.

METHOD AND MATERIALS

Forty consecutive patients with clinical suspicion of rectal cancer were prospectively enrolled and had undergone 3T-MRI examination pre- and post- chemo-radiotherapy(CRT). All patients underwent total mesorectal excision 6-8 weeks after the end of CRT. The gross specimens were analyzed by an expert gastrointestinal pathologist and the histological results were considered the reference standard. A region-of-interest was manually drawn around the largest tumour area on a single axial oblique T2-w slice. Slices were analyzed with a dedicated software(TextRad) and the following first order statistical TA parameters were computed: Skewness, Kurtosis, Entropy, and Mean Value of Positive Pixels[MPP]). Non-parametric Mann-Whitney U test was used to compare
TA parameters and the response rate among complete responders (CR), partial responders (PR), and non-responders (NR) before and after CRT. Receiver operating characteristic curves (ROC) were used to assess the discriminatory power of TA parameters to predict complete response to CRT.

RESULTS

Thirteen patients (32.5%) showed CR, twenty-two patients (55%) showed PR and five patients (12.5%) were classified as NR. After CRT, CR showed significant reduction of Entropy (6.17 ± 0.54 vs 6.49 ± 0.43), Kurtosis (0.72 ± 1.05 vs 2.60 ± 2.01) and MPP (306.33 ± 168.97 vs 414.24 ± 219.26); all P < 0.002. After CRT, PR/NR showed significant reduction of Entropy (6.47 ± 0.57 vs 6.70 ± 0.50) and Kurtosis (0.33 ± 0.65 vs 1.87 ± 1.85; MPP: 357.54 ± 155.07); all P < 0.042. Entropy was the only TA parameter showing significance in the predicting CR (AUC 0.64 [95% CI: 0.57 - 0.71]), P < 0.001 with the best cut-off value of >= 6.68, with a sensitivity of 76.9% and a specificity of 38.46% in predicting CR.

CONCLUSION

Among TA parameters Entropy might be a good predictor of tumor response showing the best AUC in ROC curves with good sensitivity and specificity. Kurtosis and MPP showed a significant decrease in patients with CR.

CLINICAL RELEVANCE/APPLICATION

TA parameters derived from T2 images such as Kurtosis, Skewness and Entropy might potentially play an important role as imaging biomarkers of tumoral response to CRT in patients with rectal cancer.

SSE09-06 Texture Analysis of Pancreas MRI: Utility for Differentiating Pancreatic Head Cancer from Mass-Forming Chronic Pancreatitis at the Pancreatic Head

Participants
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PURPOSE

To investigate Haralick texture analysis of pancreatic head mass MRI for differentiating pancreatic head cancer (PHC) from mass-forming chronic pancreatitis at the pancreatic head.

METHOD AND MATERIALS

58 PHC patients, 23 mass-forming chronic pancreatitis patients prior to pancreatoduodenectomy or biopsy and 30 healthy controls undergoing MRI were included. Whole-lesion volumes of interests were placed on T2WI, pre- and post-contrast T1WI, which based on pathological information. Histogram-based parameters and textural features extracted from VOIs were analyzed using generalized estimating equations. The resulting data were processed with Kruskal-Wallis test and binary logistic regression models. Diagnostic accuracy was assessed by area under the receiver operating characteristic curves.

RESULTS

For pre-contrast T1WI, significant differences were observed for 26 matrixes. At binary logistic regression, among the 17 matrixes (AUCs>0.8), significant independent predictors of PHC were Quantile95, Compactness1 with a combined AUC of 0.953 (P=0.000). Combining these two matrixes achieved sensitivity of 89.7% and specificity of 89.7%. On post-contrast T1WI, significant differences were observed for thirty-nine matrixes. At binary logistic regression, among the 18 matrixes (AUCs>0.8), significant independent predictors of PHC were RelativeDeviation, Uniformity, and Compactness1, with a combined AUC of 0.948 (P<0.0001). Combining these three matrixes achieved sensitivity of 86.2% and specificity of 84.9%. PHC has the highest degree of compactness, followed by chronic pancreatitis, and the lowest normal pancreas. PHC shows higher Relative Deviation and lower uniformity than chronic pancreatitis and normal pancreatic tissue. However, chronic pancreatitis and normal pancreas did not differ between these two matrixes. For T2WI significant differences were observed for Skewness, Haralick Correlation, and Inverse Difference Moment, but the AUCs of these parameters were not greater than 0.8.

CONCLUSION

Texture metrics obtained on various MRI sequences, post-contrast T1WI provided the highest, and T2WI the lowest performance for differentiating pancreatic head mass. Several Haralick-based texture features appear useful for distinguishing chronic inflammatory mass from PHC.

CLINICAL RELEVANCE/APPLICATION

Several Haralick-based texture features appear useful for distinguishing chronic inflammatory mass at the pancreatic head and PHC.
SSE10-01 18F-FDG PET/MRI versus PET/CT in Staging of Gastro-Esophageal Junction Cancer

Participants

Jessica B. Robbins, MD, Madison, WI (Moderator) Nothing to Disclose
Lauren F. Alexander, MD, Jacksonville, FL (Moderator) Spouse, Stockholder, Abbott Laboratories; Spouse, Stockholder, AbbVie Inc; Spouse, Stockholder, General Electric Company

Sub-Events

SSE10-01
18F-FDG PET/MRI versus PET/CT in Staging of Gastro-Esophageal Junction Cancer

Participants

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PURPOSE

To compare F-18-Fluorodeoxyglucose (FDG)-positron-emission-tomography/magnetic-resonance-imaging (PET/MRI) and PET/computed-tomography (PET/CT) in staging of gastro-esophageal junction (GEJ) cancer.

METHOD AND MATERIALS

Following IRB approval and informed consent, 24 patients with histologically proven GEJ cancer were prospectively recruited; 4 patients were excluded for technical reasons (19 male, 1 female; mean 68.3+/-9.1 years). Patients were injected with 326+/-28 MBq FDG intravenously for the clinical PET/CT. Uptake time was 60 minutes. PET/MRI was acquired directly after the PET/CT. 2 experienced radiologists and nuclear physicians reviewed the images and defined the PET/MRI-TNM stage in consensus. PET/CT NM-stage was defined for clinical routine. Standard of reference was the multidisciplinary team meeting (MDT) stage, which was defined by contrast enhanced CT +/-endoscopic ultrasonography (EUS) and PET/CT. Sensitivity (SE), Specificity (SP), positive predictive value (PPV), negative predictive value (NPV) and accuracy (AC) were calculated. McNemar test was performed to assess differences between different modalities.

RESULTS

For PET/MRI T-stage was concordant with MDT stage in 14 (70%) of 20 patients. Differences in T-stages between PET/MRI and MDT were statistically significant (p=0.03) (Table 1). In our cohort, PET/MRI upstaged three T3 primary lesions as T4 and correctly assigned two T4 lesions. Both PET/MRI and PET/CT agreed in N- and M-staging in all patients. Differences in N-stage between hybrid modalities and MDT were significant (p=0.03) (6 of 20 patients) (Table 2). SE, SP, PPV, NPV and AC for detection of lymph node metastases were 94%, 100%, 100%, 67% and 95% for both imaging modalities.

CONCLUSION

PET/MRI and PET/CT performed similarly in N and M staging. PET/MRI has advantages over PET/CT in providing additional T-stage.

CLINICAL RELEVANCE/APPLICATION

PET/MRI might be used for staging of patients with GEJ cancer in the future.

SSE10-02 Arterial Enhancement Patterns on MR imaging as Preoperative Prognostic Markers of Intrahepatic Mass-forming Cholangiocarcinoma

Participants

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PURPOSE

To develop a non-invasive, low-cost, high-throughput technique for the identification of liver cancer in a community setting.

METHOD

A total of 50 patients with a suspicion of liver cancer underwent a comprehensive imaging work-up, including a MR angiography (MRA) and a liver biopsy. The MRA images were analyzed using a novel software tool that automatically identifies areas of arterial enhancement. The results of this analysis were then compared to the histopathological findings from the liver biopsy.

RESULTS

The software tool was able to accurately identify areas of arterial enhancement in 48 out of 50 patients. In 2 cases, the tool failed to detect areas of arterial enhancement that were subsequently found to be cancerous. The overall accuracy of the tool was 96%.

CONCLUSION

The software tool developed in this study is a promising tool for the identification of liver cancer in a community setting. Further research is needed to validate the tool in a larger patient population.
PURPOSE
This study aimed to evaluate the prognostic factors of intrahepatic mass-forming cholangiocarcinoma (IMCC) and to determine the relationship between the magnetic resonance imaging (MRI) features of IMCC including arterial enhancement pattern, the clinicopathologic factors, and the clinical outcomes.

METHOD AND MATERIALS
The institutional review board approved this retrospective study. The need for informed patient consent was waived. This study included 134 patients who underwent curative hepatic resection and preoperative MRI for IMCCs (median size: 4.5 cm). The MRIs were reviewed for the IMCCs, which were classified according to the arterial enhancement pattern (diffuse hypoenhancement vs. peripheral rim enhancement vs. diffuse hyperenhancement). We performed survival analysis according to preoperative and postoperative clinicopathologic factors as well as imaging findings.

RESULTS
In multivariate analysis, the CA 19-9 level (P = 0.010), tumor size (P = 0.001), tumor number (P = 0.008), tumor differentiation (P = 0.036), vascular invasion (P < 0.001), and arterial enhancement pattern (P < 0.001) were significant prognostic factors for overall survival (OS). The CA 19-9 level (P = 0.013), tumor size (P = 0.018), T classification (P = 0.013), necrosis (P = 0.019), and arterial enhancement pattern (P = 0.005) were significant prognostic factors for recurrence-free survival (RFS). There were significant differences in clinicopathologic features among the three arterial enhancement groups. The OS and RFS of the diffuse hyperenhancement group were significantly better than those of the peripheral rim or diffuse hypoenhancement group (P < 0.001).

CONCLUSION
The arterial enhancement pattern on MRI, along with the CA 19-9 level and tumor size may be a useful prognostic marker in the preoperative evaluation of patients with IMCC.

CLINICAL RELEVANCE/APPLICATION
The arterial enhancement patterns on MRI are the potential prognostic marker in the preoperative evaluation of patients with IMCC. Patients with IMCC with diffuse hyperenhancement had significantly better clinical outcomes than those with peripheral rim enhancement or diffuse hypoenhancement.

SSE10-03  
Clinical Value of Single-Source, Dual-Energy Spectral CT Imaging in Differentiating Small Liver Cyst from Micro-Metastatic Lesion

Monday, Nov. 26 3:20PM - 3:30PM Room: S403A

Participants
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PURPOSE
To evaluate the value of single-source, dual-energy CT in the differential diagnosis of small liver cysts from micro-metastatic lesions.

METHOD AND MATERIALS
From January 2014 to Oct 2016, 30 patients with 55 liver lesions underwent spectral CT scans. The lesions were divided into two groups: group A (micro-metastatic) and group B (small liver cysts) (all lesions were diagnosed by medical history and follow-up). The mean CT value of the 40-140keV monochromatic images, iodine (water) concentration and effective atomic number (eff-Z) for the lesions were measured on an AW 4.5 workstation The slope of the spectral curve (K) was measured in the two groups and were statistically compared. Receiver operating characteristic (ROC) curves were constructed to evaluate the effectiveness of each parameter.

RESULTS
In multivariate analysis, the CA 19-9 level (P = 0.010), tumor size (P = 0.001), tumor number (P = 0.008), tumor differentiation (P = 0.036), vascular invasion (P < 0.001), and arterial enhancement pattern (P < 0.001) were significant prognostic factors for overall survival (OS). The CA 19-9 level (P = 0.013), tumor size (P = 0.018), T classification (P = 0.013), necrosis (P = 0.019), and arterial enhancement pattern (P = 0.005) were significant prognostic factors for recurrence-free survival (RFS). There were significant differences in clinicopathologic features among the three arterial enhancement groups. The OS and RFS of the diffuse hyperenhancement group were significantly better than those of the peripheral rim or diffuse hypoenhancement group (P < 0.001).

CONCLUSION
Single-source dual-energy CT provides multiple parameters for relatively high diagnostic accuracy in differentiating small liver cysts from micro-metastatic lesions.
SSE10-04  Volumetric Measurement of Split and Merged Target Lymph Nodes on CT in Clinical Trials, Compared with RECIST Version 1.1

Monday, Nov. 26 3:30PM - 3:40PM Room: S403A

Participants
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PURPOSE
To investigate the volumetric changes of split or merged target lymph node on CT scans compared with Response Evaluation Criteria in Solid Tumors (RECIST) version 1.1 measurements.

METHOD AND MATERIALS
Target lymph nodes (short axis diameter ≥ 1.5 cm) that separated from a conglomerate node (split node) or merged with other nodes (merged node) were retrospectively examined at multiple time points in a cohort of 182 patients with cancers enrolled in clinical trials. Each target node was measured in PACS (Carestream Health) based on RECIST 1.1 before and after splitting or merging, and percent size change was calculated. Volumetric changes of the nodes were also calculated using Vitrea Enterprise Suite V:6.8.0, with percent change recorded as the ground truth. RECIST and volumetric measurements were compared using a t-test. Our cohort was categorized into 3 groups: a conglomerate node splits, one target node merge with other nodes (one-target merged), and two neighboring target nodes merge (two-target merged) as RECIST allows a maximum of two target lymph nodes per patient.

RESULTS
Our cohort consisted of 20 split nodes and 30 merged nodes (19 were 1-target merged, and 11 were 2-target merged). A significant difference (p<0.001) was seen in all groups between RECIST and volumetric measurements. Mean percent change in size of split nodes was +1% range -48% to +52%) by RECIST and -66% (range from -98% to -13%) by volumetric method. Mean percent change in size of one-target merged nodes was 65% (range 29% to 107%) by RECIST and 210% (range 15% to 607%) by volumetric method. Mean percent change in size of two-target merged nodes was -15% (ranging from -31% to -4%) by RECIST and 110% (ranging from 15% to 234%) two-target merged. While volumetric measurements indicated a decrease in size of all split nodes, RECIST measurements indicated an increase in size in 60% of cases. In merged nodes, volumetric measurements indicated an increase in size for both merged groups, while RECIST measurement showed a decrease in size in all 2-target merged nodes (11 of 11).

CONCLUSION
RECIST 1.1 may not accurately represent the volumetric increase or decrease in size of target lymph nodes during merging or splitting events.

CLINICAL RELEVANCE/APPLICATION
Volumetric analysis of split and merged lymph nodes indicates a need for revision of target lymph node measurement methodologies of RECIST version 1.1.

SSE10-05  Is There a Direct Correlation Between Microvascular Wall Structure and K-Trans Values Obtained from Perfusion-CT Measurements in Lymphomas?

Monday, Nov. 26 3:40PM - 3:50PM Room: S403A

Participants
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Konstantin Nikolau, MD, Tuebingen, Germany (Abstract Co-Author) Advisory Panel, Siemens AG; Speakers Bureau, Siemens AG; Speaker Bureau, Bayer AG
Jan Fritz, MD, Baltimore, MD (Abstract Co-Author) Research Grant, Siemens AG; Scientific Advisor, Siemens AG; Scientific Advisor, Alexion Pharmaceuticals, Inc; Speaker, Siemens AG
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PURPOSE
To test the hypothesis that ultrastructural wall abnormalities of lymphoma vessels correlate with CT perfusion kinetics.

METHOD AND MATERIALS
Our local institutional review board approved this prospective study. Between February 2013 and June 2016, we included 23 consecutive subjects with newly diagnosed lymphoma, who were referred for CT-guided biopsy (6 female, 17 male; median age, 60.61±12.43 years; age range, 28-74 years) and additionally agreed to undergo perfusion-CT of the target lymphoma tissues. Perfusion-CT was performed for 40 seconds using 80 kV, 120 mAs, 64 x 0.6 mm collimation, 6.9 cm z-axis coverage, and 26 volume measurements. Mean and maximum k-trans (ml/100g/min), blood flow (BF; ml/100g/min) and blood volume (BV) were quantified using the deconvolution and the maximum slope + Patlak calculation models. Immunohistochemical staining was performed for microvessel density (MVD) quantification (vessels/m^2) and electron microscopy was used to determine the presence or absence of tight junctions, endothelial fenestration, basement membrane, pericytes and for measurement of extracellular matrix thickness.

RESULTS
Extracellular matrix thickness as well as the presence/absence of tight junctions, basal lamina and pericytes did not correlate with CT perfusion parameters. Endothelial fenestrations correlated significantly with mean BF (r=0.047, p=0.418), and additionally was significantly associated with higher mean BV (r=0.005). Mean k-trans Patlak correlated strong with mean k-trans deconvolution (r=0.939, p=0.001), and both correlated with mean BF deconvolution (r=0.748, p<0.001). Max BF deconvolution (r=0.564) and mean BV deconvolution (r=0.752) and Max BV deconvolution (r=0.771). MDV correlated with mean k-trans deconvolution (r=0.564, p=0.023).

CONCLUSION
K-trans values of perfusion CT do not correlate with ultrastructural microvascular features, whereas endothelial fenestrations correlate with increase intra-tumoral blood volumes.

CLINICAL RELEVANCE/APPLICATION
Numerous imaging studies have been conducted with the aim of non-invasively quantify tumor vascularization and vessel wall leakiness. However, to the best of our knowledge, an association between electron microscopy-based ultrastructural vessel wall features and CT perfusion kinetics has not been investigated. Therefore, we tested the hypothesis that ultrastructural wall abnormalities of lymphoma vessels correlate with PCT kinetics.

SSE10-06 Nationwide, Longitudinal Trends in CT Colonography Usage: Cross Sectional Survey Results from the 2010 and 2015 National Health Interview Survey

Participants
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Debra A. Gervais, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose

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Improved public awareness and coverage expansion to Medicare age populations will promote increased CT colonography utilization and improvements in overall colorectal cancer screening.

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Debra A. Gervais, MD - 2012 Honored Educator
SSE11

Genitourinary (Imaging of Renal Stones)

Monday, Nov. 26 3:00PM - 4:00PM Room: S102CD

Three Dimensional Texture Analysis with Machine Learning Provides Incremental Predictive Information for Successful Shock Wave Lithotripsy in Patients with Kidney Stones

PURPOSE
To determine the predictive value of three-dimensional texture analysis (3D-TA) in computed tomography (CT) images for successful shock wave lithotripsy (SWL) in patients with kidney stones.

METHOD AND MATERIALS
Patients with pre and postoperative CT scans, previously untreated kidney stones and a stone diameter of 5-20 mm were included. A total of 224 3D-TA features of each kidney stone, including the attenuation measured in Hounsfield Units (HU), and the clinical variables body mass index (BMI), initial stone size, and skin-to-stone distance (SSD) were analyzed using five commonly used machine learning models. The data set was split in a ratio of 2/3 for model derivation and 1/3 for validation. Machine learning-based predictions for SWL success in the validation cohort were evaluated calculating sensitivity, specificity, and the area-under-the-curve (AUC).

RESULTS
For SWL success the three clinical variables BMI, initial stone size and SSD showed AUCs of 0.68, 0.58 and 0.63 respectively and no predictive information for HU could be noted. By use of a RandomForest classifier using three 3D-TA features an AUC of 0.79 could be observed. By combining 3D-TA features and clinical variables, the discriminatory accuracy improved further with an AUC of 0.85 for 3D-TA features and SSD, an AUC of 0.8 for 3D-TA features and BMI and an AUC of 0.81 for 3D-TA and stone size.

CONCLUSION
Our in-vivo study indicates the potential of 3D-TA of urinary stone CT enabling the prediction of successful stone disintegration with SWL with high accuracy.

CLINICAL RELEVANCE/APPLICATION
Selected 3D-TA features provide incremental predictive value for successful SWL, which allows stratifying patients with symptomatic kidney stones to either primary SWL or Ureterorenoscopy.

SSE11-02
Usefulness of Computer Aided Detection of Urinary Stones in Computed Tomography Kidney Ureter Bladder using Convolutional Neural Networks: Preliminary Study

PURPOSE
For information about this presentation, contact:
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Computed tomography kidney ureter bladder (CTKUB) is the method of choice for diagnosing urinary stones. The purpose of this study is to develop a computer aided detection (CAD) algorithm for identifying a urinary stone in thin slice CTKUB.

**METHOD AND MATERIALS**

Thin slices (3 mm) CTKUB (120 kVp and 150 mAs) in patients with suspicious of stone disease were included in the study. The labeling of urinary stones or not in CTKUB as reference standard was performed by an expert radiologist. 5,288 urinary stones and 4,980 non-urinary stones on CTKUB images were evaluated for training dataset. 551 urinary stones and 528 non-urinary stones on CTKUB images were evaluated for validation dataset. The convolutional neural network was consisted of 8 convolution layers, 9 fully connected layers and softmax classifier. The diagnostic performance of CAD algorithm for identifying a urinary stone from combination of three different image planes (axial, coronal and sagittal) in thin slice CTKUB using convolutional neural network was analyzed.

**RESULTS**

In training dataset, the performance was almost perfect. In validation dataset, the CAD algorithm was classified all 551 urinary stones as stones. It was also classified 528 non-urinary stones as 527 non-urinary stones and 1 urinary stone. The sensitivity, specificity, accuracy, positive predictive value and negative predictive value of CAD algorithm were 100%, 99.8%, 99.9%, 99.8% and 100%, respectively.

**CONCLUSION**

CAD algorithm in thin slice CTKUB using convolutional neural network can have high diagnostic performance for urinary stone detection. Prospective further studies involving more participants and focusing on the factors affecting clinical practice such as stone size, location (ureter, kidney) are needed.

**CLINICAL RELEVANCE/APPLICATION**

In view of its high accuracy, we believe CAD algorithm in thin slice CTKUB using convolutional neural network can be used as an initial examination in patients with suspicious of stone disease.

**Awards**

**Student Travel Stipend Award**

**Participants**

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**PURPOSE**

To investigate the accuracy of rapid kV-switching single-source dual-energy computer tomography for prediction of classes of non-uric acid stones.

**METHOD AND MATERIALS**

Non-uric-acid renal stones retrieved via percutaneous nephrolithotomy were prospectively collected between January 2017 and February 2018 in a single institution. Only stones >5mm and with pure composition (i.e. >80% composed of one element) were studied. Stone composition was determined using Fourier Transform Infrared Spectroscopy. The stones were scanned in 32 cm-wide anthropomorphic whole body phantom in a location mimicking the kidneys. Image acquisition was performed using a single-source rapid-kVp switching CT scanner. The effective atomic number \((\text{Zeff})\) and the attenuation \((\text{HU})\) at 40 keV, 70 keV, and 140 keV virtual monochromatic sets of images were extracted by placing a ROI at the largest cross-sectional areas. Ratios between the attenuations at different energy levels were calculated. Mean values of different stone classes were compared using ANOVA and student t-test. Difference between the actual class of stone and the predicted class of stone based on vendor-recommended Zeff thresholds were assessed. A p-value <0.05 was considered statistically significant. Receiver operating curves (ROC) and area under curve (AUC) with 95% confidence intervals were calculated to assess the efficacy of each parameter.

**RESULTS**

The final study sample included 31 stones from 31 patients consisting of 2 (6%) struvite, 4 (13%) cysteine and 25 (81%) calcium-based pure stones. The mean size of the stones was 9.9 ± 2.4 mm. The mean Zeff of the stones was 12.0±0.41 for calcium-based, 10.1 ± 0.14 for struvite, and 9.9 ± 0.57 for cysteine stones which were statistically different \((p<0.001)\). In 16 cases (51.6%), there was discrepancy between the actual stone class and the predicted class based on vendor-recommended Zeff thresholds were assessed. A p-value <0.05 was considered statistically significant. Receiver operating curves (ROC) and area under curve (AUC) with 95% confidence intervals were calculated to assess the efficacy of each parameter.

**CONCLUSION**

Zeff has superior performance to HU and attenuation ratios for differentiation of different classes of non-uric-acid stones.

**CLINICAL RELEVANCE/APPLICATION**

Non-invasive determination of composition of urinary stone has important clinical implication in guiding the decision making algorithm...
SSE11-04  Dual-Energy Spectral CT Characterization of Urinary Calculi In Vivo

Participants
Xiaohu Li, MD, Hefei, China (Presenter) Nothing to Disclose
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Jianying Li, Beijing, China (Abstract Co-Author) Employee, General Electric Company

PURPOSE
To explore the feasibility of using dual-energy energy spectral CT to determine the components of urinary calculi in vivo

METHOD AND MATERIALS
Fifty-seven cases of patients with urinary calculi were included in the present eighty-nine stones, with GSI (gemstone spectral imaging) scan using AW4.6 workstation for image analysis indexes: GSI scan mode (Effective atomic number), the material (Material Density) calcium water ratio (calcium water ratio, CWR), 50keV and 70keV single energy CT value. The differences of 4 indexes were compared. According the infrared spectrum analysis results as the reference standard. Compared with spectrum diagnosis, we can conclude that sensitivity, specificity and positive predictive value, negative predictive value of pure uric acid stones, pure non-uric acid stones, stones mixed. Retrospective study of involving 24 cases of single component calculi (11 pieces of uric acid stones, 9 pieces of calcium oxalate, 3 pieces of calcium phosphate stones) and 53 cases of mixed stones. Stones were respectively measuring the effective atomic number, CWR, 50keV, 70keV single energy CT value and we can compare the indexes of different groups with the one way anova.

RESULTS
The infrared spectrum analysis results as the reference standard, the sensitivity for analysis pure uric acid calculi, pure non-uric acid calculi, and mixed stones were 100%, 91.7%, 97.0% respectively; with specificity of 100%, 97.4%, 95.7% respectively; with the positive predictive value of 100%, 84.6% 98.5% respectively and the negative predictive value were 100%, 98.7%, 91.7% respectively.

CLINICAL RELEVANCE/APPLICATION
It is useful to reduce the occurrence of complications if we can make a definite diagnosis of stone composition before surgery.

SSE11-05  Role of Single Source Dual Energy CT in Evaluation of Chemical Composition of Urinary Tract Calculi

Participants
CHANDRESH O. KARNAVAT, Mumbai, India (Abstract Co-Author) Nothing to Disclose
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Ritu M. Kakkar, MBBS, DMRD, Mumbai, India (Abstract Co-Author) Nothing to Disclose
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PURPOSE
To evaluate the diagnostic accuracy of Single Source Dual Energy CT in characterisation of renal stones with biochemical analysis as reference

METHOD AND MATERIALS
This was a prospective study carried out at a tertiary care centre for a period of 3 years using Gemstone Spectral Imaging in single source dual energy CT scanner- GE Discovery CT750 HD. A total of 70 patients with renal calculi who underwent single source dual energy CT and subsequent surgery were included in the study. Both high and low energy data sets are acquired simultaneously for axial and helical acquisitions at the full 50 cm field of view. Dual-energy data were processed by the GSI general protocol on the CT workstation (Advantage Windows, version 4.2; GE Healthcare). A region of interest (ROI) was applied over the renal stone viewed on the bone window settings occupying approximately 50% of the stone area on axial images. Using GSI software effective atomic number of the ROI area Z (Zeff) was calculated and stones were characterised. Post surgery biochemical analyses of these stones were sent to a common laboratory. All results of dual energy CT were compared to the biochemical analysis by applying kappa statistics

RESULTS
Out of 70 patients, 43 were male and rest were female. The age group of patients ranged from 25 to 70 years (mean 47 years). Out of 48 calcium oxalate stones on dual energy CT, 47 were calcium oxalate and one was mixed. Out of 12 struvite stones on dual energy CT, 10 were struvite and 2 were mixed. Single cysteine stone detected on dual energy CT was found to be mixed stone on biochemistry. All 7 ammonium urate stones on dual energy were found to be same on biochemistry. Single mixed stone detected on dual energy CT showed similar result on biochemistry. Weighted kappa was found to be 0.835 which indicates very good agreement between two different diagnostic tests

CONCLUSION
Single Source Dual energy CT scan has a role in accurately assessing the chemical composition of the urinary tract calculi

CLINICAL RELEVANCE/APPLICATION
Chemical composition of the urinary tract calculi using Single Source Dual Energy CT has significant impact on medical management of patient with stone disease
Comparison of CT-Index and Effective Z Analysis for Characterization of Urinary Stones with Dual-Energy CT: A Phantom Study

Participants
Felice A. Burn, MD, Aarau, Switzerland (Presenter) Nothing to Disclose
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PURPOSE
To assess the accuracy of CT-index and effective Z value (atomic number) derived from dual-energy CT for differentiation of uric acid from non-uric acid stones and to further characterize the subgroup of non-uric acid stones.

METHOD AND MATERIALS
Total of 64 urinary stones from humans (32 uric acid and 32 non-uric acid stones with subgroups of oxalate, struvite, brushite and apatite) were included in the study. The stones were placed in an anthropomorphic CT-phantom (diameter, 30 cm). All stones underwent an x-ray diffraction analysis representing the gold standard and they had a high purity and homogeneity of at least 90% in their compositions. The phantom was scanned on a 360-slice MDCT scanner (Aquilion ONE Vision, Canon Medical) with a dual-energy mode using tube voltages of 135 and 80 kVp. The acquired datasets were automatically segmented and postprocessed with commercially available software. The CT-index and the effective Z, which was derived from raw data-based dual-energy analysis, was assessed. A statistical receiver operating characteristics (ROC) analysis and multivariable discrimination analysis was performed.

RESULTS
The differentiation of uric acid stones from non-uric acid stones were significant, using the CT-index (p < 0.001) and the effective Z value (p < 0.01). The use of the effective Z and CT-index allow further separation in subcategories as uric acid, oxalate, apatite, brushite and struvite stones (Figure 1), whereas this separation is less accurate than for the differentiation of uric acid from non-uric acid stones. If the CT-index and the effective Z values were taken both in consideration a subgroup analysis shows more powerful options in differentiation.

CONCLUSION
CT-index and effective Z values, derived from dual-energy CT, allow very accurate differentiation of uric acid from non-uric acid stones. The differentiation of non-uric acid subgroups is not very reliable for both parameters separately. However, the combinations of both parameters in the evaluation of subgroups can improve the separation of non-uric acid stones.

CLINICAL RELEVANCE/APPLICATION
Improved characterization of renal stone compositions with dual-energy CT using CT index and effective Z value in combination has a direct impact on the clinical management and therefore may improve patient outcome and may reduce treatment costs.
SSE12

Science Session with Keynote: Genitourinary (Adrenal Imaging)
Monday, Nov. 26 3:00PM - 4:00PM Room: S103AB

Participants
Elaine M. Caoili, MD, MS, Ann Arbor, MI (Moderator) Nothing to Disclose
Hebert Alberto Vargas, MD, Cambridge, United Kingdom (Moderator) Nothing to Disclose

Sub-Events

SSE12-01 Genitourinary Keynote Speaker: Imaging of the Adrenal Glands—What More Do We Need to Know?
Monday, Nov. 26 3:00PM - 3:10PM Room: S103AB

Participants
Michael T. Corwin, MD, Sacramento, CA (Presenter) Nothing to Disclose

SSE12-02 The Diagnostic Value of Modified Dixon Fat Quantification Technique in the Evaluation of Adrenal Masses
Monday, Nov. 26 3:10PM - 3:20PM Room: S103AB

Participants
Andreas Feist, Bonn, Germany (Presenter) Nothing to Disclose
Leonie Kramer, Bonn, Germany (Abstract Co-Author) Nothing to Disclose
Daniel Kuetting, MD, Bonn, Germany (Abstract Co-Author) Nothing to Disclose
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Hans H. Schmid, MD, Bonn, Germany (Abstract Co-Author) Nothing to Disclose
Guido M. Kukuk, MD, Bonn, Germany (Abstract Co-Author) Nothing to Disclose

PURPOSE
To evaluate the diagnostic value of six-echo modified Dixon (mDixon) fat quantification techniques in the differentiation between benign and malignant adrenal masses.

METHOD AND MATERIALS
All dedicated upper abdominal MRI examinations including proton density fat fraction (PDFF) maps of the year 2015 (n=535) were re-evaluated for the presence of adrenal incidentalomas. PDFF values acquired by placing one single ROI were compared to adrenal signal intensity index (ASII, [(signal intensity on in-phase imaging - signal intensity on opposed-phase imaging) / (signal intensity on in-phase imaging)] × 100%) and adrenal-to-spleen chemical-shift ratio (ASR, [((signal intensity of lesion on opposed-phase imaging - signal intensity of spleen on opposed-phase imaging) / (signal intensity of lesion on in-phase imaging - signal intensity of spleen on opposed-phase imaging)]-1) × 100%) for all lesions by two independent readers. All lesions were interpreted in the clinical context including -if available- histological results, interdisciplinary tumor board decisions and follow-up examinations.

RESULTS
Fifty-five patients with 70 lesions were identified. 47 lesions (67.1%) were finally diagnosed as adenomas, 23 lesions (32.9%) were confirmed adrenal metastases. Applying PDFF maps a fat fraction of at least 8.3% was 100% sensitive and 91.7% specific for the diagnosis of adrenal adenoma (AUC: 0.996). A fat fraction of at least 12.25% showed a sensitivity of 91.5% and specificity of 100% in detecting adenomas ruling out all possible malignant adrenal masses. PDFF measurements were significantly more observer independent than calculations of ASII and ASR (p < 0.05).

CONCLUSION
Six-echo mDixon fat quantification technique provides a robust, fast and highly observer independent tool for the distinction between benign and malignant adrenal masses.

CLINICAL RELEVANCE/APPLICATION
Providing a high diagnostic accuracy and superior inter-rater variability compared to ASII and ASR PDFF maps might replace the established indices in the evaluation of adrenal masses.

SSE12-03 Adrenal Nodules Greater Than 10 Hounsfield Units (HU) on Non-Contrast CT: Still Indeterminate?
Monday, Nov. 26 3:20PM - 3:30PM Room: S103AB

Participants

Awards
Student Travel Stipend Award
PURPOSE
To determine if a Gaussian-based algorithm (GA) analysis with and without noise correction can help characterize indeterminate adrenal nodules (>10HU) on non-contrast CT as lipid-poor adenomas.

METHOD AND MATERIALS
IRB-approved, HIPAA-compliant retrospective study evaluated adrenal nodules greater than 1 cm on non-contrast CT using the GA based region of interest histogram analysis with and without noise correction (normalization of mAs, kVp, and slice thickness to published data). Two independent readers evaluated the nodules and were blinded to final pathology. Lesions were characterized as malignant if pathology proven by biopsy or surgical resection or likely benign due to pathology or imaging features (stability > 1 year, adrenal CT washout, MRI signal loss, or negative FDG PET/CT with a FDG positive primary). Inter-reader agreement was assessed using intraclass correlation coefficient (ICC). Sensitivity, specificity and area under the curve (AUC) were derived.

RESULTS
There were 91 adrenal nodules in 83 patients that averaged 2.6 cm in size (±1.9 cm). 33 nodules were pathologically confirmed metastases most commonly lung cancer: average size 1.7 ± 0.7 cm, mean attenuation 23.8 ± 8.8 HU. 58 nodules were presumed to be adenomas based on imaging characteristics: average size 3.9 ± 2.6 cm, mean attenuation 32.2 ± 8.2 HU. Inter-reader agreement was excellent (ICC > 0.8) for multiple variables, including nodule size, mean attenuation, SD of attenuation, and G-index. The noise-corrected GA had significantly higher specificity (85% vs. 59%, p<0.001) and lower sensitivity (38% vs. 58%, p<0.001) for identifying adenoma than the uncorrected GA. The AUC for the corrected GA-index was 0.74, which was statistically improved compared to uncorrected GA-index (0.52, p=0.04) while being similar to the mean attenuation (0.78, p=0.1) and size (0.81, p=0.3).

CONCLUSION
A Gaussian-based algorithm based on histogram analysis can discriminate between lipid-poor adrenal adenomas and non-adenomas, although it performed no better than an alternative mean attenuation cutoff.

CLINICAL RELEVANCE/APPLICATION
Noise correction Gaussian based algorithm can be used to assess indeterminate adrenal nodules >10HU with high specificity, however further workup may still be needed in patients with a history of cancer.

SSE12-04 Correlation Between Subclinical Hypercortisolism and Adrenal Volumetry in Patients with Incidental Adrenal Adenoma

Monday, Nov. 26 3:30PM - 3:40PM Room: S103AB

Participants
Nicolas Mertens Folch, Santiago, Chile (Presenter) Nothing to Disclose
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Alvaro Huete Garin, MD , Santiago, Chile (Abstract Co-Author) Nothing to Disclose

PURPOSE
To correlate lesion and contralateral adrenal gland volume (CLAV) measurements in asymptomatic patients with incidental adrenal adenoma (IAA) found on computed tomography (CT) with the presence of subclinical hypercortisolism (SCH).

METHOD AND MATERIALS
50 consecutive subjects with IAA were prospectively enrolled after obtaining informed consent between August 2016 and January 2018 according to local scientific ethics committee guidelines. Dexamethasone suppression test and ACTH quantification in peripheral blood was performed in all patients to diagnose SCH. All subjects underwent an adrenal protocol CT with iodinated intravenous contrast and lesion was confirmed as adenoma using known diagnostic criteria (non contrast density < 10 HU, relative washout > 40%, absolute washout > 60%). Volume of the IAA and the CLAV was calculated with Osirix® viewer software by 2 independent readers. Inter-reader agreement was excellent (ICC > 0.8) for multiple variables, including nodule size, mean attenuation, SD of attenuation, and G-index. The noise-corrected GA had significantly higher specificity (85% vs. 59%, p<0.001) and lower sensitivity (38% vs. 58%, p<0.001) for identifying adenoma than the uncorrected GA. The AUC for the corrected GA-index was 0.74, which was statistically improved compared to uncorrected GA-index (0.52, p=0.04) while being similar to the mean attenuation (0.78, p=0.1) and size (0.81, p=0.3).

RESULTS
Subjects included had a mean age of 57.2 years, 82% (n=41) were female. 12 subjects (24%) from the group were diagnosed with SCH. Patients with SCH had larger IAA volumes (p<0.0001) and lower CLAV (p=0.005) than those without SCH. The Bland-Altman analysis showed acceptable inter-reader measurement agreement and moderate dispersion of the results, especially at higher IAA and CLAV volumes, with a mean difference of 0.09 cm³, 95% CI [-1.4, 1.58] for IAA volume and a mean difference of 0.42 cm³, 95% CI [-2.69, 3.53] for CLAV. Area under the ROC curve (AUC) for IAA volume and CLAV was 0.936, 95% CI [0.869, 1] and 0.822, 95% CI [0.668, 0.976] respectively.

CONCLUSION
IAA volume and CLAV appear to be useful and reproducible tools predicting the presence of SCH in asymptomatic patients with IAA.

CLINICAL RELEVANCE/APPLICATION

Hollowed Adrenal Gland Sign in Patients of Septic Shock: Incidence, CT Appearance and Prognosis

Participants
Yang Peng, Guangzhou, China (Presenter) Nothing to Disclose
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PURPOSE
To investigate the incidence, CT appearance and prognosis of hollowed adrenal gland sign in septic shock patients.

METHOD AND MATERIALS
From January 2014 to May 2017, there were 181 patients with septic shock in ICU (mean 60.7 years; range 19-89 years; 112 males, 69 females). All the patients received dual-phase enhanced CT scan in one week after diagnosis. CT findings and clinical records were reviewed retrospectively. When patients showed diffuse enlargement of bilateral adrenal glands on CT, and in arterial phase the central area of adrenal gland showed much lower attenuation while in venous phase the central "hollowed" area showed further enhancement and was similar to the peripheral area, they were defined as hollowed adrenal gland sign positive. Single factor analysis was performed.

RESULTS
59 patients showed hollowed adrenal gland sign (32.6%, 59/181) as positive group, while the remain 122 patients were negative. Total mortality rates of positive group and negative group were 81.3% (48/59) and 49.1% (60/122), respectively. According to the primary diseases causing septic shock, patients in both groups were divided into 4 subgroups (intestinal diseases, biliary and pancreatic diseases, postoperative infection and others). The mortality rates of 4 subgroups in positive group were 75.0% (12/16), 66.7% (10/15), 91.7% (22/24), and 100% (4/4), respectively. And the mortality rates of 4 subgroups in negative group were 43.8% (14/32), 28.6% (8/28), 64.3% (27/42) and 55.0% (11/20), respectively. There were significant difference of total mortality rates and mortality rates of matching subgroups between two groups (P<0.01). Single factor analysis of variance showed that the hollowed adrenal gland sign was an independent factor to predict a poor prognosis (death) for septic shock patients.

CONCLUSION
Hollowed adrenal gland sign is common on CT in septic shock patients and predicts a poor prognosis.

CLINICAL RELEVANCE/APPLICATION
Hollowed adrenal gland sign is a typical CT appearance of septic shock patient with relative adrenal insufficiency, and appears to be an independent adverse prognostic factor.

Adrenal Incidentalomas: A New Risk Factor for Overall Mortality?

Participants
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PURPOSE
To determine the mortality risk of adrenal incidentaloma on abdominal CT.

METHOD AND MATERIALS
Retrospective cohort study at a multicenter academic medical center. Cohort was identified from patients with newly detected adrenal incidentaloma on CT abdomen report; the primary outcome was all-cause mortality. Study population was derived from patients >=18 years with CT abdomen within 24 hours of emergency department presentation 1/1/05-12/31/09 without history of adrenal disease, adrenal lab testing, or cancer. Incidentaloma cohort was identified by database query of CT reports, followed by manual review to exclude misclassifications. Confirmed incidentaloma cohort was matched to 'no nodule' controls at 3:1 on age ±1 year and exam date ±3 months. Mortality was ascertained by database query for in-hospital deaths and supplemented with National Death Index query for those lost to follow-up. Survival analysis performed with Kaplan-Meier curves and Cox proportional hazards model examining the effect of adrenal incidentaloma on all-cause mortality.

RESULTS
Initial query yielded a population of 42,575 adults with CT abdomen, mean age 50 ±19 years, 63% women. 969 (2.3%) patients had confirmed adrenal incidentalomas and were matched with 2,907 controls. These, 3,876 individuals entered survival analysis with 31,182 total person-years follow-up, median follow-up 8.8 years (IQR 6.0-10.6) in the incidentaloma cohort and 9.0 years (IQR 7.1-
10.7) in the no nodule cohort. Mortality was 36.4% (353/969) in the incidentaloma cohort and 31.6% (919/2907) in the no nodule cohort for a rate difference of 7.6 deaths/1000 person-years (95% CI 2.1-13.0; p=0.005). Adrenal incidentaloma presence was associated with an unadjusted 19% increased risk of death (HR 1.19; 95% CI 1.05-1.36) and a 14% increased risk of death when adjusted for age, sex, race, and other significant predictors including diabetes (HR 1.14; 95% CI 1.01-1.29).

CONCLUSION
Incidentally discovered adrenal nodules are associated with a significant though small increased risk of all-cause mortality.

CLINICAL RELEVANCE/APPLICATION
The clinical significance of adrenal incidentalomas remain understudied; results of the present study suggest that incidentalomas may not be as harmless as previously thought.
PURPOSE
To compare fully sampled slice-encoding for metal artifact correction (SEMAC) and vastly undersampled compressed sensing (CS)-SEMAC sequences for metal artifact reduction MRI in patients with total hip arthroplasty (THA).

METHOD AND MATERIALS
Following internal review board approval and informed consent, 30 patients with pain and dysfunction following THA underwent prospectively 1.5 T MRI, including coronal intermediate-weighted (IW)- and short tau inversion recovery (STIR) SEMAC (22:39 min) and CS-SEMAC (9:55 min) pulse sequences with otherwise identical parameters. Following anonymization and randomization, two fellowship-trained musculoskeletal radiologists independently evaluated the datasets. Outcome variables included image quality parameters, bone implant interface visibility, overall reader satisfaction, detection rate of abnormalities of the hip joint. Statistical analysis included kappa statistics and paired rank sum tests. P-values <= 0.05 were considered significant.

RESULTS
The inter-observer agreements were at least adequate for all categories (kappa > 0.58). There was no significant difference for the technical parameters, including motion (p = 0.69), blur (p = 0.37), noise (p = 0.06), metal artifact reduction (p = 0.46), tissue contrast (p = 0.81), and fat-suppression (p > 0.99). The visibility of bone implant interface of the acetabular and femoral component was rated on average as "good" indicating minimal impairment with preservation of all structural details without significant differences between SEMAC and CS-SEMAC (p = 0.51). The overall reader satisfaction was "good" for both SEMAC and CS-SEMAC (p=0.85). For SEMAC versus CS-SEMAC, readers found an average of 18 versus 18 osteolyses (p = 0.87), 15 versus 17 cases of synovitis (p = 0.38), 23 versus 21 peritrochanteric fluid accumulations (p = 0.55) and 23 versus 19 abductor tendon tears (p = 0.34), respectively.

CONCLUSION
In patients with painful hip arthroplasty implants, fully sampled and vastly undersampled SEMAC pulse sequences produce similar image quality and afford similar detection rates of abnormalities.

CLINICAL RELEVANCE/APPLICATION
The vastly undersampled CS-SEMAC technique allows for 55% faster MRI of THA implants, thereby preserving the detection rates of abnormalities, when compared to fully sampled SEMAC technique.
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PURPOSE
To compare the Slice-encoding metal artifact correction (SEMAC)-View-angle tilting (VAT) sequence with the standard turbo-spin echo (TSE) MR sequence for image quality, visibility of periprosthetic structures, and diagnostic confidence for detection of postoperative complications in patients with pedicle screw fixation at 1.5 T.

METHOD AND MATERIALS
Seventy patients with pedicle screw fixation between the thoracic vertebrae and the sacrum were included. SEMAC-VAT imaging were compared with standard TSE images. The MR imaging were retrospectively evaluated by two radiologists for SNR (signal-to-noise ratio) of anatomical structures and size of artifacts, visibility of periprosthetic anatomical structures, and diagnostic confidence for detection of postoperative complications. Paired t-tests and Wilcoxon signed-rank tests were used for comparisons, and intra-class correlation and kappa values were used for inter-observer agreement.

RESULTS
For all anatomical structures, the signal-to-noise ratio was significantly lower for SEMAC-VAT than for TSE images (p < 0.001). SEMAC-VAT images demonstrated effective artifact reduction compared to TSE images (p < 0.001). The visibility of most periprosthetic anatomical structures, and diagnostic confidence for detection of postoperative complications, were better for SEMAC-VAT than for TSE imaging (p < 0.001). For the spinal canal, however, TSE was better (p < 0.001).

CONCLUSION
MR images with SEMAC-VAT can significantly reduce metal artifact, providing improved delineation of periprosthetic anatomical structures and diagnostic confidence for detection of postoperative complication compared with standard TSE images. For the spinal canal, however, TSE was better.

CLINICAL RELEVANCE/APPLICATION
Taking into account the results of our own, we propose the following guidelines for performing SEMAC-VAT image on patients with pedicle screw fixation.

SSE16-03 Metal Artifact Reduction on Photon-Counting-Detector CT Using Tin Filtration and Detection of High-Energy Photons

Monday, Nov. 26 3:20PM - 3:30PM Room: N227B

Awards
Student Travel Stipend Award

Participants
David J. Bartlett, MD, Rochester, MN (Presenter) Nothing to Disclose
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PURPOSE
To evaluate the use of photon-counting-detector CT with tin filtration (PCD-CT Sn) to improve diagnosis in patients with orthopedic metal implants.

METHOD AND MATERIALS
Adult patients with orthopedic metal implants underwent CT using commercial energy-integrating-detector CT (EID-CT) followed by PCD-CT Sn (140 kV, 0.4 mm Sn, energy thresholds of 25 and 75 keV). EID-CT and PCT-CT Sn Bin 2 (75 - 140 keV) 2-mm images were reconstructed. Three radiologists blindly evaluated images in a side-by-side fashion, comparing predefined anatomic structures using a 6-point scale (0 = critical structures totally obscured to 5 = anatomic recognition with high confidence in diagnosis). Preference for PCD-CT Sn was assessed using the Wilcoxon signed rank test, where p<0.05 was considered statistically significant.

RESULTS
20 patients with orthopedic metal implants were included in the study, with hardware in the spine in 12 patients, shoulder in 3, and extremities in 5. The mean overall visualization scores of the cortex, trabeculae, and implant-trabecular interface were significantly better for PCT-CT Sn (4.4. vs. 3.3, p<0.0001). For spinal hardware, PCD-CT Sn showed improved image quality score for the central canal (3.3 v 0.9, p<0.0001), with similar findings for neural foramina. The mean overall preference score for PCT-CT Sn was +1.6 ± 0.7 compared to EID (p<0.0001), indicating improved diagnostic confidence. The effects of metal artifact on diagnosis were
less at PCD-CT Sn (1.9 v 2.6, p<0.0001), and the width of the metal artifact was substantially reduced (from 1.1 ± 1.4 cm to 0.5 ± 0.5 cm, p<0.0001).

**CONCLUSION**

Selection of high-energy photons using a Sn filter and PCD-CT bin 2 images markedly improves visualization of key anatomic structures and improves diagnostic confidence by reducing the size of metal-related artifacts.

**CLINICAL RELEVANCE/APPLICATION**

PCD-CT with tin filtration and reconstruction of images obtained using high-energy photons provides additional critical diagnostic information compared to commercial EID-CT systems to patients with metal implants.

**SSE16-04 Utility of CT Metal Artifact Reduction Algorithms for Intervertebral Devices: Experimental Study in Ex Vivo Bovine Coccyx Using Micro-CT as the Reference Standard**

**Monday, Nov. 26 3:30PM - 3:40PM Room: N227B**

**Participants**

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**PURPOSE**

The accuracy of radiological assessments of bony fusion following spinal fusion is affected by radiographic interference from metallic components of the intervertebral devices. Therefore, this study evaluated the utility of dedicated CT metal artifact reduction algorithms (SEMAR and MAR) for measuring trabecular bone microarchitecture in a comparison using micro-CT as the gold standard.

**METHOD AND MATERIALS**

Twenty bovine coccyges with and without titanium or poly-ether-ether-ketone (PEEK) interbody devices were scanned by ultra-high resolution MDCT (Aquilion Precision, SEMAR), 256-MDCT (Revolution CT, MAR), and micro-CT as the gold standard. The quality of the MDCT images was evaluated in terms of the visibility of trabecular bone using a 3-point Likert scale. Trabecular thickness (Tb.Th), trabecular number (Tb.N), trabecular separation (Tb.Sp), fractal dimension (FD), and volumetric bone mineral density (vBMD) of the same 10-mm-thick portion of coccyx including a metal artifact were obtained for MDCTs and micro-CT. Relationships between MDCT- and micro-CT-derived trabecular bone indices were compared.

**RESULTS**

The mean reduction in the width of the artifact was 48.7% for SEMAR/titanium, 20.6% for SEMAR/PEEK, 15.8% for MAR/titanium, and 18.9% for MAR/PEEK. The image quality analysis revealed that the artifact was removed from the trabecular bone space in 72.7% of the SEMAR/titanium images and 18.2% of the images obtained using the three other combinations. FD, Tb.Th, Tb.Sp, and vBMD measured by ultra-high resolution MDCT were found to be significantly correlated with micro-CT values (p=0.486~0.499, p<0.001~0.05) while no significant correlation was observed between 256-MDCT- and micro-CT values. For coccyx with titanium, the correlations of Tb.Th, Tb.Sp, and vBMD with micro-CT values were improved by SEMAR (p=0.491~0.489, p<0.001~0.05). For coccyx with PEEK, correlations of FD, Tb.Sp, and vBMD with micro-CT values were improved by SEMAR (p=0.502~0.525, p<0.001~0.05).

**CONCLUSION**

SEMAR combined with ultra-high resolution MDCT objectively and subjectively decreases metal artifacts when compared to 256-MDCT with MAR. Correlations of trabecular indices and vBMD with micro-CT values were improved with SEMAR.

**CLINICAL RELEVANCE/APPLICATION**

Trabecular bone architecture can be assessed using ultra-high resolution MDCT with a metal artifact reduction algorithm, suggesting that it is possible to evaluate bony fusion after spinal fusion.

**SSE16-05 Combined Iterative Metal Artifact Reduction Reconstruction and Virtual Monoenergetic Extrapolation at Higher Photon Energies in CT Imaging of Ankle Arthroplasty Implants**

**Monday, Nov. 26 3:40PM - 3:50PM Room: N227B**

**Awards**

**Student Travel Stipend Award**

**Participants**

Iman Khodarahmi, MD, PhD, Baltimore, MD (Presenter) Nothing to Disclose
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Jan Fritz, MD, Baltimore, MD (Abstract Co-Author) Research Grant, Siemens AG; Scientific Advisor, Siemens AG; Scientific Advisor, Alexion Pharmaceuticals, Inc; Speaker, Siemens AG

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**PURPOSE**
To compare the effects of combined virtual monoenergetic extrapolation (VME) and iterative metal artifact reduction (iMAR) at higher photon energies on low and high-density metal artifacts and overall image quality.

**METHOD AND MATERIALS**
Six total ankle arthroplasties were implanted into human cadaveric ankles and underwent computed tomography with a dual-source scanner at tube voltages of 80 and tin-filtered 150 kVp to produce mixed 120 kVp equivalent polychromatic images. Image datasets were created with six protocols including polychromatic weighted filtered back projection (WFBP), polychromatic iMAR, monoenergetic WFBP at 150 and 190 keV, and monoenergetic iMAR at 150 and 190 keV. High- and low-density artifacts were separately quantified with a threshold-based MATLAB script. After anonymization and randomization, two observers independently ranked the datasets for overall image quality. A conservative p-value of less than 0.001 was considered significant for all statistical analyses.

**RESULTS**
Least amount of high-density artifacts were visualized with iMAR 190 keV and iMAR 150 keV (all p-values < 0.001), whereas polychromatic iMAR was the most effective method of mitigating low-density streaks (p-values < 0.001). For both low and high-density artifacts, polychromatic iMAR acquisition was superior to WFBP 150 keV and WFBP 190 keV (p-values < 0.001). Readers ranked the overall image quality of polychromatic iMAR images highest on sharp kernel reconstructions (p-values < 0.001). Similarly, on soft tissue kernel reconstructions, the polychromatic iMAR images were ranked the highest with a statistically significant difference over other techniques (p-values < 0.001), except for iMAR 150 keV (p = 0.356).

**CONCLUSION**
iMAR with polychromatic spectra and VME result in fewer metal artifacts and better image quality than WFBP with polychromatic spectra and VME. The combination of iMAR and VME at higher photon energies results in mixed effects on implant-induced metal artifacts, including decreasing high-density artifacts and increasing low-density artifacts, which in combination may not improve image quality for a particular implant when compared to polychromatic iMAR images at lower photon energies.

**CLINICAL RELEVANCE/APPLICATION**
Combined iMAR and VME at higher photon energies results in mixed effects on metal-related artifacts, which overall may not improve image quality for a particular implant.

**Honored Educators**
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Elliot K. Fishman, MD - 2012 Honored Educator Elliot K. Fishman, MD - 2014 Honored Educator Elliot K. Fishman, MD - 2016 Honored Educator Elliot K. Fishman, MD - 2018 Honored Educator

**SSE16-06 Improved Visualization of Juxtaprosthetic Tissue Using Metal Artifact Reduction MRI: Experimental and Clinical Optimization of Compressed Sensing SEMAC**

**METHOD AND MATERIALS**
In an experimental setup, a total hip arthroplasty (THA) embedded in gadolinium containing agarose was scanned at 1.5T. Pulse sequences included coronal STIR, T1w and T2w CS-SEMAC sequences. All pulse sequences were acquired with 11, 19 and 27 slice-encoding steps (SES). Post-processing was performed with variations of the parameters (i) number of iterations (5, 10, 20, 30, 50) and (ii) normalization factor (0.0005, 0.001, 0.002, 0.003, 0.005). Following, identical STIR, T1w and T2w pulse sequences with 11 and 19 SES were acquired in patients with THA. Semi-quantitative outcome measures were assessed on a five-point scale (1=best, 5=worst). The overall best image quality was determined. Statistical analyses included descriptive statistics, t-tests, multivariate regression models and partial Spearman correlations.

**RESULTS**
Scan times varied between 2:24 and 8:49 minutes. Reconstruction times varied between 3:14 and 85:00 minutes. Artifact reduction was optimal with an intermediate normalization factor (0.001) and improved with higher SES and iterations. Iterations >20 did not improve artifact reduction or image quality further. Ripple artifacts increased with higher SES and iterations. A normalization factor of 0.001 or 0.002 was best for reduction of blurring, while the soft tissue contrast was better and the distortion of soft tissue was less severe with lower normalization factors. Overall best soft tissue image quality was found for STIR and T1w images with 19 SES, 10 iterations and a normalization factor of 0.001 and for T2w images with 11 SES, 10 iterations and a normalization factor of 0.0005.

**CONCLUSION**
For the advanced acceleration and reconstruction algorithms of CS-SEMAC, optimal SES, iterations and normalization factors could
be identified. 19 SES and 20 iterations were sufficient for optimal artifact reduction, enabling an imaging protocol with clinically feasible acquisition and reconstruction times.

**CLINICAL RELEVANCE/APPLICATION**

Identified optimal CS-SEMAC MRI parameters may be applied in clinical practice and allow for improved evaluation of juxtaprosthetic tissue in patients with THA due to excellent artifact reduction.
**SSE18**

**Neuroradiology/Head and Neck (Thyroid and Parathyroid Imaging)**

Monday, Nov. 26 3:00PM - 4:00PM Room: E351

- **AI**
- **CT**
- **HN**
- **NR**
- **US**

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

**Participants**

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Paul M. Bunch, MD, Winston-Salem, NC (Moderator) Nothing to Disclose

**Sub-Events**

**SSE18-01**  **Thyroid Nodules on Ultrasound: Effect of Computer-Aided Diagnosis (CAD) on Radiologists' Performance with a Large Clinical Diagnostic Population**

Monday, Nov. 26 3:00PM - 3:10PM Room: E351

**PURPOSE**

To evaluate the effect of computer-aided diagnosis (CAD) on different level radiologists’ performance for discriminating malignant from benign thyroid nodules on US images.

**METHOD AND MATERIALS**

From January 2013 to December 2017, thyroid nodules with decisive diagnosis on the basis of pathologic results were consecutively enrolled. The observer study was conducted with four experienced radiologists and four radiology fellows, all of whom analyzed the thyroid nodules using 2017 ACR TIRADS first without and subsequently with CAD software. The performance of each observer without and with the CAD was assessed by measuring the area under the receiver operating characteristics curve (Az), sensitivity, specificity, PPV and NPV. To quantify the changes in clinical management decisions with the CAD aid, we computed for each radiologist the number of malignant and benign nodules for which the clinical management decision was changed. Concordance between observers in classing the thyroid nodules was measured in without and with CAD conditions.

**RESULTS**

In total, 1065 thyroid nodules from 1035 patients were included; 382 (35.87%) were benign and 683 (64.13%) were malignant. Use of the CAD resulted in an improvement of the average performance of the 8 observers, as measured by means of a statistically significant increase in Az value (0.840-0.853; p < .000), sensitivity (86.44%-87.52%; p < .000) and inter-observer agreements(0.744-0.769; p < .05). A statistically significant difference was not found in the specificity without and with the computer aid (38.74%-38.55%; p =.20). On the basis of TI-RADS assessments, it was estimated that with CAD, each observer, on average, correctly recommended 1.02% (7/683) of additional biopsies and also increased 0.37% (1.4/382) of unnecessary biopsies.

**CONCLUSION**

Computer-aided diagnosis can help radiologists improve their sensitivity in detection of thyroid malignancies and also increased the rate of unnecessary biopsies.

**CLINICAL RELEVANCE/APPLICATION**

To aid diagnosis for inexperienced radiologists and decrease workload

**SSE18-02**  **Comparision of Morphology and Enhancement Characteristics of Ectopic and Eutopic Parathyroid Adenomas.**

Monday, Nov. 26 3:10PM - 3:20PM Room: E351

**Participants**

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**PURPOSE**

To evaluate the effect of computer-aided diagnosis (CAD) on different level radiologists’ performance for discriminating malignant from benign thyroid nodules on US images.

**METHOD AND MATERIALS**

From January 2013 to December 2017, thyroid nodules with decisive diagnosis on the basis of pathologic results were consecutively enrolled. The observer study was conducted with four experienced radiologists and four radiology fellows, all of whom analyzed the thyroid nodules using 2017 ACR TIRADS first without and subsequently with CAD software. The performance of each observer without and with the CAD was assessed by measuring the area under the receiver operating characteristics curve (Az), sensitivity, specificity, PPV and NPV. To quantify the changes in clinical management decisions with the CAD aid, we computed for each radiologist the number of malignant and benign nodules for which the clinical management decision was changed. Concordance between observers in classing the thyroid nodules was measured in without and with CAD conditions.

**RESULTS**

In total, 1065 thyroid nodules from 1035 patients were included; 382 (35.87%) were benign and 683 (64.13%) were malignant. Use of the CAD resulted in an improvement of the average performance of the 8 observers, as measured by means of a statistically significant increase in Az value (0.840-0.853; p < .000), sensitivity (86.44%-87.52%; p < .000) and inter-observer agreements(0.744-0.769; p < .05). A statistically significant difference was not found in the specificity without and with the computer aid (38.74%-38.55%; p =.20). On the basis of TI-RADS assessments, it was estimated that with CAD, each observer, on average, correctly recommended 1.02% (7/683) of additional biopsies and also increased 0.37% (1.4/382) of unnecessary biopsies.

**CONCLUSION**

Computer-aided diagnosis can help radiologists improve their sensitivity in detection of thyroid malignancies and also increased the rate of unnecessary biopsies.

**CLINICAL RELEVANCE/APPLICATION**

To aid diagnosis for inexperienced radiologists and decrease workload
PURPOSE

4D-CT is a novel technique for pre-surgical localization of parathyroid adenomas (PA). PA can be eutopic or ectopic. Detection of ectopic PA is crucial for surgical success especially if patient has multigland disease with both eutopic and ectopic PA. Purpose of our study is to determine the differences in morphology and enhancement characteristics between eutopic and ectopic PA which will help in increasing the confidence of radiologist for suggesting high probability.

METHOD AND MATERIALS

This is an IRB approved retrospective study of 232 patients with surgically proven PA who underwent 4D CT imaging for pre-surgical localization of PA between 2014 and 2017. All 4D CT scans were performed with initial noncontrast followed by 30 sec and 90 sec postcontrast images on 64 slice MDCT scanner. Contrast washout ratios (CWR) were calculated by measuring Hounsfield units (HU) of PA on the noncontrast, 30 sec and 90 sec post contrast delayed exam (90D). CWR = [100 x (HU on 30A - HU on 90D)/HU on 90D].

RESULTS

Out of 232 patients, 186 patients - 1 gland, 37 patients - 2 gland, 6 patients - 3 gland and 3 patients - 4 gland adenomas constituting a total of 290 radiologically diagnosed lesions. Out of these, 25 (6M, 17F) PA were in ectopic and 265 (37M, 228F) PA were eutopic. Out of 290 radiologically reported lesions, 242 lesions (21 Ectopic and 221 Eutopic) matched to the adenomas found on surgery and pathology constituting to 242 radiological-surgical-pathology matched lesions. 48 lesions were false positive, which did not correlate with the location on surgical pathology. Morphological characteristics like shape, size, heterogeneity were studied and compared between eutopic and ectopic adenomas. Enhancement characteristics of eutopic and ectopic adenomas were compared and were categorized at 10% washout intervals, for example: 1-10%, 11-20% and so on.

CONCLUSION

1. 217 out of 265 eutopic adenomas and 20 out of 25 ectopic adenomas demonstrated contrast washout ratios between 31%-80% and did not demonstrate significant difference in washout characteristics. 2. Size and shape of ectopic PA did not show significant influence on washout characteristics. 3. Measurement of contrast enhancement and washout dynamics is limited in lesions with large cystic areas.

CLINICAL RELEVANCE/APPLICATION

Detection of ectopic PA is crucial for surgical success especially in the setting of multigland disease.
multiphasic CT. Metastatic lymph nodes from PTC show strong uptake of contrast in the arterial phase and wash out of contrast in the venous phase. Whereas, metastatic lymph nodes from MTC show progressive enhancement in the venous phase.

**CLINICAL RELEVANCE/APPLICATION**

Determination of metastatic lymph nodes is an important problem in thyroid cancers. Complete resection of the primary disease and metastases is the one of the important factor in the survival.

**SSE18-04 Retrospective Analysis of Thyroid Ultrasound Recommendations Using Thyroid Imaging Reporting and Data System (TI-RADS) Scoring**

Monday, Nov. 26 3:30PM - 3:40PM Room: E351

**Awards**

**Student Travel Stipend Award**

**Participants**

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**PURPOSE**

Breast Imaging, Reporting, and Data System (BI-RADS) has been used to standardize mammogram reports and recommendations; Thyroid Imaging, Reporting, and Data System (TI-RADS) seeks to do the same. We compared our institution's prior biopsy recommendations on ultrasound reports to what the recommendations would have been using TI-RADS.

**METHOD AND MATERIALS**

Our study was a retrospective review of 449 thyroid nodules which were assessed by ultrasound and subsequently biopsied. We collected the description of the lesion and the original recommendations from the radiology report. Pathology results were collected. Three radiologists then performed blinded and independent evaluations of each exam; a TI-RADS score was assigned to each thyroid nodule. Recommendations based on TI-RADS were compared with prior recommendations and biopsy results.

**RESULTS**

449 thyroid nodules were identified by review of biopsies. Had we implemented TI-RADS, we would have recommended 102 fewer biopsies (23%). No nodules for which a biopsy was initially recommended but not recommended by TI-RADS criteria demonstrated a clinically significant malignancy at biopsy. Incidental foci of papillary carcinoma found within benign follicular nodules less than 0.5cm were considered not clinically relevant, as studies have shown that 5-30% of autopsies have found occult papillary carcinoma in patients who died of unrelated causes. Our positive predictive value before implementing TI-RADS was 8.2%. Utilizing TI-RADS, our positive predictive value is 10.5%, a ~25% difference.

**CONCLUSION**

There was a decrease in the number of thyroid biopsies that would have been recommended when using TI-RADS. We demonstrated a 23% decrease in the number of recommended biopsies without decreasing our ability to identify clinically significant malignancies. Findings suggest that implementing TI-RADS will decrease the number of negative biopsies performed, which will decrease patient risk and worry as well as save the health system from the cost of these additional procedures. Our study is limited by only selecting patients who underwent biopsy. Due to our inclusion criteria, we did not assess for any missed malignancies in nodules presumed to be benign on prior ultrasound reports.

**CLINICAL RELEVANCE/APPLICATION**

Use of TI-RADS for thyroid nodule biopsy recommendations can greatly reduce the number of biopsies recommended without missing a clinically significant malignancy.

**SSE18-05 Machine Learning Optimization of 4D-CT and 99m-Technetium Sestamibi for Preoperative Localization in Patients with Primary Hyperparathyroidism**

Monday, Nov. 26 3:40PM - 3:50PM Room: E351

**Participants**

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**PURPOSE**

The purpose of this study is to apply machine learning to 4D-CT and 99mTechnetium sestamibi (MIBI) for preoperative localization of hyperfunctioning parathyroid glands in patients with primary hyperparathyroidism (PHPT). Our aim is to develop a model and decision tree algorithm to maximize diagnostic accuracy.

**METHOD AND MATERIALS**

A retrospective study of 400 patients who underwent combined imaging protocol of 4D-CT and MIBI SPECT/CT and subsequent parathyroidectomy was performed. Four parathyroid glands were assumed for each patient (n=1600). Reference standard was surgical pathology. Both 4D-CT and MIBI were interpreted by two nuclear radiologists. Using machine learning, a random-forest tree
algorithm using 3-fold cross validation was trained and validated to predict the probability of a parathyroid gland as positive hyperfunctioning gland on pathology (adenoma or hyperplasia). A total of 17 variables were used, including 4 clinical, 10 biological, and 3 imaging variables. Imaging variables included 4D-CT, MIBI, and combined 4D-CT+MIBI.

RESULTS

Of 1600 parathyroid glands, 521 were abnormal on surgical pathology. The model output was probability of a gland as positive on pathology. The final model selected variables of combined 4D-CT+MIBI and preoperative serum PTH and Calcium cross product (PTH*Ca). The AUC of the model was 0.99 (95 CI: .984-.996) and outperformed AUC of radiologist interpretation of 4D-CT and MIBI, alone and in combination. When both 4D-CT and MIBI are positive, the probability of a true positive is 97% (n=305) and when either test is positive, the probability is 75% (n=164). When both tests are negative, the gland is a true negative in 96% of cases if PTH*Ca > 1232 (n=333), 92% of cases if PTH*Ca > 875 and <1232 (n=563) and 81% of cases if PTH*Ca < 875 (n=297).

CONCLUSION

Diagnostic accuracy of preoperative 4D-CT and MIBI is improved with machine learning compared with radiologist interpretation. A decision tree algorithm simplified into three variables selected by machine learning can provide probability of correct classification of each parathyroid gland as normal or abnormal and guide the surgeon to pursue minimally invasive parathyroidectomy or 4-gland exploration.

CLINICAL RELEVANCE/APPLICATION

Machine learning-derived model and decision tree algorithm can improve diagnostic accuracy of preoperative localization of 4D-CT and 99mTechnetium Sestamibi for patients with primary hyperparathyroidism.

Participants

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PURPOSE

In this study we consider applying the technique of ARFI with Virtual Touch Quantification (a type of quantitative elastography) in diagnosis of parathyroid adenomas (most common cause of primary hyperparathyroidism), to prospectively assess whether this technique can increase the diagnostic value of ultrasound approaching nearer to or more than the sensitivity and specificity of sestamibi scan.

METHOD AND MATERIALS

This was a prospective observational study conducted in the department of radiodiagnosis of our institution from October 2016 to December 2017. The study population consisted of 36 patients(n=36) with clinical suspicion of primary hyperparathyroidism with positive Sestamibi scan for parathyroid adenoma irrespective of ultrasound results (done prior to the Sestamibi scan). The parathyroid adenoma was first identified by grey scale imaging features and then a region of interest for elastography was placed within the lesion and the stiffness of the lesion using ARFI-VTQ values were obtained. Five successful measurements were taken for ARFI -VTQ (measured in meters per second) and the median value was calculated.

RESULTS

Ultrasound elastography was performed on all the 36 cases of adenomas and the median ARFI-VTQ values were calculated. The mean ARFI values of the corresponding adjacent thyroid tissue were also calculated. The mean ARFI-VTQ values of adenomas was (1.72±0.45m/s). The mean ARFI-VTQ values of normal thyroid tissue was (2.66±0.38m/s). There was a statistically significant difference between the two variables with [p <0.0001]. The study shows a consistently low elastography values for adenomas than adjacent thyroid tissue and other lesions which mimic adenomas like lymph nodes. Thus ultrasound along with ARFI-VTQ values has high accuracy in diagnosing adenomas.

CONCLUSION

Ultrasound elastography(withARFI-VTQ)is an excellent tool which enhances the diagnostic value of ultrasound in parathyroid adenomas when used along with B-mode ultrasound and doppler.

CLINICAL RELEVANCE/APPLICATION

In clinically diagnosed patients of hyperparathyroidism ultrasound ARFI-VTQ can be applied as a solitary imaging modality (in place of sestamibi), since it is an excellent diagnostic imaging tool in the diagnosis of normally located parathyroid adenomas with high accuracy.
CONCLUSION
This study showed widespread vertical off-centering across all sites and for all CT protocols. The effectiveness of individualized training of technologists is demonstrated by the significant (p < 0.0001) reduction in cases where patients were placed vertically off-center, as compared to the insignificant reduction following the classroom style annual training.

Background
Due to technological innovations, many aspects of CT systems have become automated to optimize patient dose and image quality. However, for some CT vendors, patient centering, which is critical for the proper performance of automatic exposure control, still remains a manual task. We sought to assess the frequency of patient vertical off-centering across the institution. We also investigated the effectiveness of methods used to re-educate technologists on optimal CT imaging practices.

Evaluation
Using a commercially available automated dose monitoring system (ADMS) (Dose Watch, GE), CT scan acquisition data for all protocols was collected from 12 CT scanners beginning in January 2017. The scanners were located at the main cancer hospital (n=3) and at 6 affiliated outpatient locations (OPL)(n=9). Data on vertical centering within the CT gantry were sorted by scanner location and operator. Comparisons of vertical off-centering were made across all locations. Re-education about optimal CT imaging practices was performed with each technologist at 1 OPL. The staff at the main cancer hospital and 6 other OPL received classroom-style annual training on optimal CT imaging practices.

Discussion
During the 2nd quarter of 2017, out of a total of n = 22708 patients, 50.5% percent of patients (n=11469) undergoing CT scans were positioned vertically off-center by a range of -11.8 cm to 10.9 cm, with a median (interquartile range) of 0.818 cm (-0.491 to 2.13 cm). Of these, 34.9% (n=7921) were scanned at OPLs. After individualized re-education with technologists at one OPL, patient vertical off-centering at that site decreased by 31.8% in the 3rd quarter. For all other locations where a classroom style annual training was delivered, a reduction of 1% in vertical off-centering was observed.
PURPOSE
This work determines typical image reconstruction and display settings for CT imaging and compares them to the reference values published by the AAPM.

METHOD AND MATERIALS
Scan protocol parameters were collected from reports of 100 annual CT scanner medical physics surveys in two states for adult head and abdomen and pediatric head and abdomen protocols per the ACR accreditation procedures. Data collection spanned academic and community hospitals and freestanding imaging centers; the data set includes pooled data collected by academic and consulting medical physicists. Reconstruction kernel/algorithm, image thickness, and image interval were tabulated for four protocols for all scanners; subgroups were analyzed to compare scanner manufacturers and different types of imaging facilities. Values were compared to reference protocols published by AAPM and recommended and required parameters given in the ACR CT Accreditation Clinical Image Quality Guide.

RESULTS
Protocols for CT scanners at ACR-accredited facilities adhered to the maximum slice width values specified by the ACR accreditation program. There was variability in adherence to AAPM-recommended reference parameters, ranging from 80% agreement on adult head protocols to 44% agreement for pediatric abdomen protocols. There was wide variation in the chosen reconstruction algorithm; subgroups were used to compare protocols within each manufacturer since direct comparison between different manufacturers’ proprietary algorithms was not possible within the scope of this work.

CONCLUSION
There is substantial variation in image reconstruction parameters among ACR-accredited CT facilities that conform to ACR requirements. These parameters impact key image quality characteristics and radiation doses used for imaging, so appropriate choices are crucial to achieving optimization of imaging. Further work is needed to understand the nature of the deviation between the data collected at clinical sites and the AAPM reference protocols; while the ACR protocols were published relatively recently, it is not clear whether the standard practice reflects changes that run ahead of updates to the AAPM protocols or whether the community is lagging in adopting the AAPM recommendations.

CLINICAL RELEVANCE/APPLICATION
This work validates reference CT protocols against protocols used in real imaging departments. Deviations from reference protocol can be used in troubleshooting image quality.

SSE22-03  CT Resolution, Noise, and Dose Reference Levels Across a Multi-Center Patient Population

Participants
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PURPOSE
The diagnostic reference level (DRL) is useful as a first-order tool to compare radiation exposures of one’s imaging clinic against those of one’s peers in computed tomography. Ria et al. have advocated for the addition of a Noise Reference Level (NRL), Noise Reference Range (NRR), a Dose Reference Level (DoRL) and a Dose Reference Range (DoRR) as a means of extending the first steps of optimization of clinical operation to image quality in addition to radiation exposure (ICRP 135). In this work, we investigate and establish another reference level, for the case of resolution, called the Resolution Reference Level (RRL) and Resolution Reference Range (RRR).

METHOD AND MATERIALS
Over 10000 anonymized scans were sampled from 109 institutions in the United States which represented 13 large (estim. > 36,000 scans/yr), 32 medium (6000 - 36,000), 64 small (< 6000) imaging centers. CTDIvol, Noise and resolution (MTF) were measured for chest and abdominopelvic (AP) helical single-acquisitions of the trunk (extremity/head scans, multiple reconstructions excluded). Noise was taken as a modified version of the Global Noise Level measured in air. MTFs were measured from the air-skin interface. Patients were binned by their effective diameter. DoRL, NRL, and RRLs were measured for each size bin. Reference Levels for each were defined as the median values. Reference Ranges were defined as interquartile intervals.

RESULTS
Measurements of the f50 MTF in AP exams in all sizes had RRR lower bounds from 0.33 - 0.42 mm^-1. The RRR upper bounds for these exams ranged from 0.38 - 0.46 mm^-1. In chest exams these ranges were from 0.39 - 0.42 mm^-1 and 0.45 - 0.46 mm^-1 respectively. The lower bound of DoRR in the AP exams in all sizes ranged from 5.3 - 11.2 mGy. The upper bounds of DoRR ranged from 7.4 - 16.5 mGy. In chest exams these lower and upper bounds of the DoRR ranged from 5.4 - 11.5 mGy and 7.5 - 14.4 mGy.

CONCLUSION
An extension to the reference level methodology has been proposed. With this new RRL and RRR, and existing NRL, NRR, DoRL, and DoRR, a clinic can begin to make holistic decisions regarding population-based imaging-protocol adjustments with consideration to dose, noise, and resolution.

CLINICAL RELEVANCE/APPLICATION
This work extends the notion of NRL to the assessment of resolution. It represents a more generalizable sampling, with more vendors and kernels, and an order of magnitude increase in population.
Image Quality Metric Extraction Based on Machine Learning Techniques for Clinical CT Protocol Optimization

Participants
Zhye Yin, Niskayuna, NY (Abstract Co-Author) Employee, General Electric Company
Rajesh Langoju, Bangalore, India (Abstract Co-Author) Nothing to Disclose
Xin Wang, PhD, Niskayuna, NY (Abstract Co-Author) Employee, General Electric Company
Bruno De Man, PhD, Niskayuna, NY (Abstract Co-Author) Employee, General Electric Company
Jean-Baptiste Thibault, PhD, Brookfield, WI (Presenter) Employee, General Electric Company

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PURPOSE
To extract standard image quality metrics (image noise and spatial resolution) directly from clinical CT images using machine learning techniques. This capability is desired to guide optimization and customization of clinical protocols to achieve desired diagnostic image quality and clinical task performance.

METHOD AND MATERIALS
For training and testing of the machine learning networks, we acquire a series of clinical datasets and use post-processing techniques to generate datasets with various noise levels and various spatial resolution levels. We use the full-width-at-half-maximum (FWHM) of the point spread function (PSF) as spatial resolution metric and the standard deviation of the noise as image noise metric. 9 cardiac acquisitions with 224 images are post-processed to create various (5) levels of blurring, resulting in a combined training and test set of 10,080 images. We use both feature-based machine learning techniques and deep convolution neural networks (CNN) to execute supervised learning to estimate traditional analytic IQ metrics such as noise and spatial resolution. For example, to demonstrate the feasibility of the framework, we selected and implemented random forest regression approach for the supervised learning task. 7 features are extracted from the raw image and 8 features are extracted from the edge map. We extend this framework to deep convolution neural network (CNN) based machine learning method using Keras

RESULTS
Mean and standard deviation of estimation error is (0.0003mm, 0.0352mm) where true FWHM was emulated at [0.66mm, 1.174mm]. The figure below shows two example results: (a) an emulated image with a FWHM of 0.77 mm and the corresponding estimated FWHM has an error of 1.6%; (b) an emulated image with a FWHM of 1.02 mm and the corresponding estimated FWHM has an error of 4.7%.

CONCLUSION
It is feasible to extract image quality directly from clinical images. Both feature-based machine learning techniques and deep learning techniques are implemented and evaluated. Preliminary results show an accurate estimation of image quality with average errors of 3%.

CLINICAL RELEVANCE/APPLICATION
IQ estimation directly from clinical images is a critical enabler to guide optimization and customization of clinical protocols to achieve desired diagnostic image quality and clinical task performance.

Predicting Major CT Scanner Failures Using Routine Quality Control Data

Participants
Rose Al Helo Jr, MS, Cleveland, OH (Presenter) Nothing to Disclose
Atallah Baydoun, MD, Cleveland, OH (Abstract Co-Author) Nothing to Disclose
David W. Jordan, PhD, Cleveland, OH (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Data collected for daily equipment quality control (QC) on computed tomography (CT) scanners contain patterns that may predict near term failure of major scanner components. Such defects are usually time consuming and hamper significantly the clinical workflow. The purpose of this study is to identify, from determinable QC parameters, the key performance values that can predict scanner hardware failure.

METHOD AND MATERIALS
Our retrospective review included 37 CT scanners from four different manufacturers. Available QC data for all CT scanners included the daily records of mean and standard deviation (SD) of the CT number (HU) using the manufacturer's factory water phantom and a custom scan protocol. Data was stored in a cloud-based compliance solution and monitored using statistical process control according to our institution protocol. We identified two identical clinical CT units that had tube replacement within the last year. We collected the SD values over three month period before and after the replacement date. We then calculated the mean SD values before and after the repair for both units. We also determined pre- and post-repair cumulative SD and cumulative SD error relatively to each scanner mean SD.

RESULTS
The mean SD of the CT numbers (HU) before and after the tube replacement for CT1 were respectively 5.75 and 5.33 (Ratio=1.078) and for CT2 5.92 and 5.48 (Ratio=1.080). Pre-repair cumulative SD and cumulative SD error for CT1 were 517 and 745% and for CT2 538.9 and 842%. Post-repair cumulative SD and cumulative SD error for CT1 were 463.5 and 271% and for CT2...
460.5 and 277%. The pre- and post-repair cumulative SD and SD error satisfy a linear model curve that correlates the QC measurements with the tube defect of both CT units.

**CONCLUSION**

Daily scanner HU noise values are insufficient to anticipate a major defect. However, a three-month cumulative SD and SD error above 500 and 700% respectively can predict failure of the tube component. Future studies are needed to highlight the possible use of such observed trends to predict impending failures. Thus, collection of data in an electronic database for a large scanner fleet would allow early intervention ultimately improving patient care.

**CLINICAL RELEVANCE/APPLICATION**

To our knowledge, this study is the first to introduce the cumulative SD and cumulative SD error as a predictive tool of a major CT performance failure.

**SSE22-06 Realism and Potential of Population-Based Virtual Clinical Trials in Computed Tomography: Are We There Yet?**

Participants
- Ehsan Abadi, Durham, NC (Presenter) Nothing to Disclose
- William P. Segars, PhD, Durham, NC (Abstract Co-Author) Nothing to Disclose
- Brian Harrawood, MS, Durham, NC (Abstract Co-Author) Nothing to Disclose
- Shobhit Sharma, BEng, MSc, Durham, NC (Abstract Co-Author) Nothing to Disclose
- Anuj Kapadia, PhD, Durham, NC (Abstract Co-Author) Nothing to Disclose
- Ehsan Samei, PhD, Durham, NC (Abstract Co-Author) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc

**PURPOSE**

Medical imaging systems are currently evaluated using either physical phantoms or patient images, both with limitations. Physical phantoms are generally simplistic, not representative of a human population, and thus limited to fully reflect task-based or patient-specific assessments. Patient images are ground truth-limited, expensive, and ethically unattainable in repetitive studies. Virtual clinical trial (VCT), defined as conducting clinical experiments using realistic simulations, can overcome these challenges. This work aimed to develop a comprehensive package to conduct realistic VCT using realistic human models with known ground truth and representative CT imaging conditions.

**METHOD AND MATERIALS**

A realistic VCT requires two main toolsets: computational anthropomorphic phantoms and scanner simulators. We developed a series of high-resolution phantoms including highly detailed intra-organ anatomies. We also developed a rapid, realistic, and scanner-specific CT simulator to image the phantoms. Our simulator included geometry and physics (spectrum and bowtie filter) of commercial scanners, axial/helical trajectories, focal spot wobbling, poly/monochromacity, noise and detector response characteristics, scatter, tube current modulation, beam hardening correction, and a commercial processing box for scanner-specific reconstructions. Two pilot VCTs were performed: characterizing noise across reconstruction algorithms, and quantifying information loss as a function of beam collimation and pitch values.

**RESULTS**

Our simulator produced CT images with NPS, MTF, and HU values close to real CT scans of same physical phantoms, under different acquisition settings and reconstruction kernels. The pilot VCT showed that iterative images have non-stationary noise texture with higher noise magnitude in the edges.

**CONCLUSION**

We developed a package that conducts VCTs in the context of CT imaging and demonstrated its applicability in clinical studies where those studies need realistic heterogeneous models and repetitive measurements and therefore unattainable using physical phantoms or patient images. Our tool enables the imaging scientists and clinicians to explore and optimize the imaging systems more comprehensively.

**CLINICAL RELEVANCE/APPLICATION**

A realistic virtual clinical trial enables the medical imaging community to conduct clinically-relevant experiments that are impossible to perform using patient images or physical phantoms.
Cardiac CT Mentored Case Review: Part IV (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Nov. 26 3:30PM - 5:30PM Room: S406A

**Participants**

Jill E. Jacobs, MD, New York, NY (Director) Nothing to Disclose

Stefan L. Zimmerman, MD, Ellicott City, MD (Moderator) Project consultant, Siemens Healthcare; Research grant, American Heart Association;

**LEARNING OBJECTIVES**

1) Understand the clinical indications for retrospective ECG gated cardiac CT. 2) Illustrate methods to assess myocardial function from cine cardiac CT images. 3) Illustrate methods to assess normal and abnormal valvular function from cine cardiac CT images.

**Sub-Events**

**MSMC24A  Coronary Atherosclerosis and Bypass Grafts**

Participants

Gregory Kicska, MD, PhD, Seattle, WA (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Recognizing anatomic subsets coronary artery bypass. 2) Technical considerations when imaging a bypass graft. 3) Stenosis and aneurysms in vein grafts. 4) Patterns of stenosis in internal mammary grafts. 5) Evaluating a bypass patient before reoperation.

**ABSTRACT**

Cardiac CT is often used to evaluate coronary bypass graft function. To accurately interpret these images, the imager needs to be familiar with the patterns of stenosis, aneurysms or other complications associated with different bypass types. In addition to assessing function and need for intervention, CT can identify patients with unique risks associated with reoperation.

**MSMC24B  Congenital Heart Disease**

Participants

Carlo N. De Cecco, MD, PhD, Atlanta, GA (Presenter) Research Grant, Siemens AG

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**LEARNING OBJECTIVES**

1) Recognize the most common congenital heart disease (CHD) findings found in adults with unsuspected CHD. 2) Recognize and understand findings of CHD in patients with known CHD and the findings which may trigger surgical intervention. 3) Recognize the CT findings of commonly performed surgical procedures for palliation of CHD. 4) Develop an organized pattern for search and reporting of CHD findings. 5) Understand why CT is chosen as the advanced imaging modality over MR.

**ABSTRACT**

Adults with congenital heart disease (CHD) now outnumber children with CHD two to one. This phenomenon is due to the success of surgical palliation and medical management of patients with even the most severe forms of CHD. Surgical intervention is often performed at the time of diagnosis and in patients with residual hemodynamic lesions is often required throughout life. Though echocardiography is typically the initial imaging modality of choice, diagnosis and imaging surveillance of complex hemodynamic and anatomic CHD lesions is now most often accomplished with CT and MR. CT and CTA imaging techniques may be used to show detailed anatomic and functional images of the heart, postoperative changes and long term consequences of CHD. An organized, reproducible approach to identify cardiac anatomy of CHD lesions and surgical palliations should be adopted in order to accurately and thoroughly describe findings.

**MSMC24C  Coronary Artery Disease and Incidental Non-cardiac Findings**

Participants

Diana Litmanovich, MD, Haifa, Israel (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Recognizing non-cardiac and non-coronary anatomic structures that can be seen on cardiac CT. 2) Become familiar with possible non-cardiac and non-coronary pathological findings that could be seen on cardiac CT. 3) Review the suggested work-up for patients with incidentally found non-cardiac and non-coronary pathologies on cardiac CTA.

**ABSTRACT**
ABSTRACT Cardiac CT often includes information about surrounding structures such as lungs, mediastinum, airways, pleura, liver and bones. To accurately interpret the scan and not to overlook the possible non-cardiac pathologies, familiarity with potential incidental findings is required. Clinical importance and severity of incidental findings varies, thus currently existing algorithms for incidental findings on cardiac CT are helpful for further work-up.
Case-based Review of Nuclear Medicine: PET/CT Workshop-Head and Neck PET/CT (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Nov. 27 8:30AM - 10:00AM Room: E450B

CT NR NM

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

Participants
Samuel E. Almodovar-Reteguis, MD, Orlando, FL (Director) Nothing to Disclose
Katherine A. Zukotynski, MD, Ancaster, ON (Director) Nothing to Disclose
Katherine A. Zukotynski, MD, Ancaster, ON (Moderator) Nothing to Disclose

LEARNING OBJECTIVES
1) Discuss appropriate use criteria for PET in the work-up of dementia. 2) Review imaging signs of amyloid deposition and pitfalls of image interpretation. 3) Illustrate a systematic approach to interpretation of PET imaging in dementia.

Participants
Rathan M. Subramaniam, MD,PhD, Dallas, TX (Presenter) Consultant, Blue Earth Diagnostics Ltd; Speaker, Blue Earth Diagnostics Ltd

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LEARNING OBJECTIVES
1) To review the best clinical practices of head and neck PET/CT in oncologic imaging. 2) To review the common sites of tumor location in head and neck and patterns of tumor spread. 3) To review pitfalls of head and neck PET/CT interpretations.

ABSTRACT
This talk will review the best clinical practices of head and neck PET/CT in oncology, patterns of tumor spread and common and unusual interpretation pitfalls.
MSE31A  CT of Pleural Diseases

Participants
Travis S. Henry, MD, San Francisco, CA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Differentiate the common causes of unilateral and bilateral pleural effusions. 2) Prioritize a differential diagnosis of unilateral pleural effusions on CT based on relevant imaging findings. 3) Produce a differential of at least 3 causes of pleural masses.

Active Handout: Travis S. Henry

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

MSE31B  Lung Cancer Staging 8th Edition

Participants
Jeremy J. Erasmus, MD, Houston, TX (Presenter) Nothing to Disclose

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

MSE31C  ACR Lung RADS / Lung Cancer Screening

Participants
Ella A. Kazerooni, MD, Ann Arbor, MI (Presenter) Nothing to Disclose

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

MSE31D  2017 Fleishner Society Criteria for Pulmonary Nodules

Participants
Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Consultant, HeartFlow, Inc; Consultant, General Electric Company;

LEARNING OBJECTIVES
1) To apply the 2017 Fleishner Society Guidelines for the assessment and management of incidentally detected pulmonary nodules in clinical practice.

ABSTRACT
The Fleishner Society Guidelines for management of solid nodules were published in 2005, and separate guidelines for subsolid nodules were issued in 2013. Since then, new information has become available; therefore, the guidelines have been revised to reflect current thinking on nodule management. The revised guidelines incorporate several substantive changes that reflect current thinking on the management of small nodules. The minimum threshold size for routine follow-up has been increased, and recommended follow-up intervals are now given as a range rather than as a precise time period to give radiologists, clinicians, and patients greater discretion to accommodate individual risk factors and preferences. The guidelines for solid and subsolid nodules have been combined in one simplified table, and specific recommendations have been included for multiple nodules. These guidelines represent the consensus of the Fleishner Society, and as such, they incorporate the opinions of a multidisciplinary international
Pulmonary Vascular Imaging

Tuesday, Nov. 27 8:30AM - 10:00AM Room: S104B

**CH**  **CT**  **MR**  **VA**

AMA PRA Category 1 Credits ™: 1.50  
ARRT Category A+ Credit: 1.75

**FDA** Discussions may include off-label uses.

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**RC301A  Imaging of Acute Pulmonary Embolism**

Participants  
Ioannis Vlahos, MRCP,FRCR, London, United Kingdom (Presenter) Research Consultant, Siemens AG Research Consultant, General Electric Company

**LEARNING OBJECTIVES**

1) Overview current imaging strategies and key facts in acute pulmonary embolism imaging. 2) Provide an update on current issues and challenges in acute pulmonary embolism imaging.

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Ioannis Vlahos, MRCP,FRCR - 2015 Honored Educator

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**RC301B  Imaging of Chronic Pulmonary Embolism and Pulmonary Hypertension**

Participants  
Carole J. Dennie, MD, Ottawa, ON (Presenter) Speaker, Bayer AG; Spouse, Consultant, Abbott Laboratories

For information about this presentation, contact:  
cdennie@toh.ca

**LEARNING OBJECTIVES**

1) Review the classification of pulmonary hypertension. 2) List CT and MRI features of PH. 3) Describe imaging characteristics of chronic pulmonary embolism.

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**RC301C  Imaging of Pulmonary Arteriovenous Malformations**

Participants  
Kristopher W. Cummings, MD, Phoenix, AZ (Presenter) Nothing to Disclose

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Cummings.Kristopher@mayo.edu

**LEARNING OBJECTIVES**

1) Explain the role MDCT plays in the evaluation of suspected hereditary hemorrhagic telangiectasia. 2) List the most important information provided by MDCT for management of pulmonary arteriovenous malformations.

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**RC301D  Pulmonary MRA: Practical Applications**

Participants  
Christopher J. Francois, MD, Madison, WI (Presenter) Departmental research support, General Electric Company;

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cfrancois@uwhealth.org

**LEARNING OBJECTIVES**

1) Identify roles for magnetic resonance angiography (MRA) in imaging patients with pulmonary artery disease, particularly on the use of MRA in pulmonary embolism. 2) Describe techniques and protocols for robust, clinical pulmonary MRA. 3) Summarize the evidence supporting the use of pulmonary MRA for pulmonary embolism.

**ABSTRACT**

1) Pulmonary MRA is appropriate for imaging patients suspected of having pulmonary embolism who have contra-indications to CTA, particularly those in whom avoiding iodinated contrast (due to allergy or decreased renal function) or minimizing radiation exposure
(younger patients) would be beneficial. 2) Current, commercially available MRA sequences that take advantage of newer parallel imaging techniques help ensure consistent pulmonary MRA in a clinical setting. 3) Following multi-center studies (using older MRA techniques and protocols) in the last decade that indicated that pulmonary MRA may not be accurate enough for routine clinical use, more recent studies suggest that pulmonary MRA is effective in identifying clinically significant pulmonary embolism.

Active Handout: Christopher Jean-Pierre Francois

Purpose
Computed tomography is imaging method of choice for procedural planning in patients prior to transcatheter aortic valve replacement (TAVR). The patients eligible for TAVR constitute an elderly population which frequently have an impaired kidney function. We aimed to evaluate if TAVR imaging with reduced contrast media is enabled by spectral detector computed tomography (SDCT).

Method and Materials
60 patients (31 female, mean age 81.6±10.3) were included in this retrospective, IRB-approved and HIPPA-compliant study. The imaging protocol comprised a prospective-ECG gated study of the entire chest (Th) immediately followed by a retrospective, ECG-gated covering the heart (Car) and a non-gated study of the abdomen and pelvis (Abd). For both, Th/Car and Abd, 25 ml of iodinated contrast media (c=350 mg/ml ioversol) was administered through an antecubital vein followed by a 40 ml saline flush. 25 ml constitutes a reduction by 50% as compared to the institutional standard. Th/Car/Abd images were reconstructed in axial plane with a slice thicknesses of 2/0.9/2 mm as conventional images (CI) and virtual monoenergetic images of 40-200 keV (VMI).

Objective image evaluation was performed based on regions of interest placed in the aortic bulb, the descending aorta and the external iliac arteries. Further, one cardiologist and one radiologist evaluated the studies with respect to their utility for TAVR planning. Pre- and post-procedural serum creatinine was collected. Data was assessed statistically using ANOVA with Dunnet’s post-hoc or Wilcoxon test.

Results
VMI 40keV resulted in a significant improvement in image contrast as compared to CI, this accounts for all, e.g. in the aortic bulb.
**Purpose**

To assess the utility of resting CT dual energy myocardial perfusion in improving the diagnostic performance of CT coronary angiography in assessment of coronary artery stenosis in areas of artefact due to calcified plaque and motion: direct comparison with catheter coronary angiography.

**Method and Materials**

1347 CT coronary angiograms were performed in our institute from January 2104 to December 2017, out of with 32 cases with dual energy CT angiography (DE-CTA) and catheter coronary angiography performed within a span on 2 weeks from each other were included in this study. DE-CTA was performed using a 64 detector row CT scanner with fast KvP switching and ECG gating in the prospective mode. High calcium score in these patients prompted the use of DE-CTA. Iodine-water material decomposition images in the short axis plane using minimum intensity projections of 5 mm thickness, were reviewed for the presence of resting perfusion defects. Diagnostic accuracy was assessed by comparison with CAG. Coronary segments with indeterminate stenosis due to blooming artefact from heavily calcified plaque or motion artefact were reclassified as significant stenosis if there was a perfusion defect in the corresponding myocardial segment. Significant coronary stenosis was defined as a > 50% stenosis on CAG. Sensitivity, specificity, positive predictive value and negative predictive value of DE-CTA alone and DE-CTA combine with perfusion assessment for the detection of significant stenosis were calculated.

**Results**

DE-CTA combined with perfusion assessment for the detection of significant stenosis showed improvement over DE-CTA alone. mean age of 58 ± 7. The calcium scores ranged from 40 to 344 AU. The sensitivity, specificity, positive predictive value and negative predictive value increased from 81% to 85%, 87% to 94%, 63% to 79% and 95% to 96%, respectively. The area under the receiver operating characteristic curve for detecting CAD also increased from 0.84 to 0.89 (p=0.02).

**Conclusion**

Dual energy CT with rapid KvP switching showed a high sensitivity and negative predictive value of the detection of significant coronary stenoses. There was improvement in diagnostic performance when both CTCA and perfusion assessment were used for stenosis evaluation.

**Clinical Relevance/Application**

Myocardial rest perfusion CT has additional value in assessment of coronary stenoses in vessels with heavily calcified plaque and motion artefacts.

**Awards**

Student Travel Stipend Award

**Participants**

Prashanth Reddy, MBBS, MD, Bangalore, India (Presenter) Nothing to Disclose

Bharath B. Das, MD, MBBS, Bangalore, India (Abstract Co-Author) Nothing to Disclose

Sikantch Sola, MD, Bangalore, India (Abstract Co-Author) Nothing to Disclose

Bhavana Nagabhushana Reddy, MBBS, MD, Bangalore, India (Abstract Co-Author) Nothing to Disclose

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**Learning Objectives**

1) Describe the principle architecture of the LV related to cardiac function. 2) Describe the principles of regional myocardial function assessment. 3) Compare different imaging approaches for quantification of regional myocardial function. 4) Identify
ABSTRACT

A complex joint effort of the entire heart muscle facilitates normal ventricular output. While the evaluation of cardiac volumes and global function aims at assessment of the gross ventricular status, measures of regional myocardial function provide a more detailed analysis of myocardial function at tissue level.

Parameters of regional myocardial function generally describe the relationship between force and resulting deformation of finite elements. Furthermore, such regional parameters are used to describe these relationships along various directions of the cardiac axis and coordinate system. The complex composition of myocardial layers including the change of fiber orientation with location may also allow more insight into the effect of pathologies on function. Different modalities (Echo, MRI, CT) have been proposed for the assessment of such parameters. While in MRI regional parameters have predominately been used for research purposes, the development of speckle-tracking echocardiography (STE) and its evaluation has pushed towards clinical applications of regional myocardial functional parameters. In MRI, the recent push towards analysis of strain based on standard cine SSFP techniques enables further analysis without impact on scanning workflow; and with the use of modern post-processing semi-automated/automated approaches appear feasible. At this stage, normal ranges and the test-retest variability of the different algorithms are under evaluation. The clinical use of such techniques may allow for earlier identification of subclinical pathology and as such may trigger therapy decisions at earlier time points. Standardization of approaches and definition of normal ranges may be required for different techniques; preferably black box approaches should be avoided.

PURPOSE

While post-processing feature tracking cardiac magnetic resonance (FT-CMR) imaging is rapidly evolving, the literature available still remains scarce. This is especially striking for the right ventricle (RV), where only 9 out of the 17 publications recently compiled in a meta-analysis by Vo et al. included the RV. In order to establish imaging biomarkers however, it is essential to have a broad dataset to analyze and then standardize for various influencing factors.

METHOD AND MATERIALS

CMR was performed on 62 carefully selected healthy volunteers at 3T (Magnetom Skyra®, Siemens Healthineers). Eligible for inclusion were adults without any cardiac disease history from 20 to 80 years old who were then stratified in 3 age groups with uniform distribution of men and woman. A semi-automatic tissue tracking software (CVI42 Circle®) then subsequently tracked the myocardial movement enabling us to calculate strain parameters, standardize for age and sex using ANOVA and establish reference values for the right ventricle.

RESULTS

The following mean normal values for the RV were found: global radial strain 13.47% (+- 6.46), global circumferential strain -7.61% (+- 3.92) and median global longitudinal strain -24.35% (+- 5.22). RV strains values were significantly different between old and young individuals (p<0.05), while sex had a smaller impact. Interestingly, all global left ventricular strains showed statistically significant differences with regard to sex (all p<0.05) but not with regard to age.

CONCLUSION

Parts of our results contrast those of recently published studies. These differences might be explained by the use of different software, number of slices used for tracking and measured strain parameters. This stresses the urgent need of further standardization before we can effectively employ FT-CMR in clinical routine.

CLINICAL RELEVANCE/APPLICATION

FT-CMR derived imaging biomarkers hold a great potential to increase the diagnostic accuracy for myocardial pathologies while simultaneously reducing the need for more invasive diagnostic measures.
PURPOSE
To determine the strength of peak circumferential and radial strain analysis by FT-CMR using routinely acquired cine images in differentiating between viable and non-viable myocardium in chronic ischemic patients.

METHOD AND MATERIALS
CMR exams were performed on a 1.5T machine to assess viability in 30 patients with chronic ischemia, 26 males and 4 females, with a mean age of 55 (range=33-85 years). Mean ejection fraction was 40±12%. Short axis standard steady-state in free-precession(SSFP) cine images were used in peak circumferential and radial strain quantification, and results were compared with regional wall motion and visually evaluated late gadolinium enhancement (LGE) scar transmurality. A total of 480 segments for ischemic patients were analyzed. 135 segments were hypokinetic, 78 were akinetic and only 1 segment was dyskinetic. 76 segments were non-viable and 404 segments were viable based on LGE. CMR exams of a control group of 10 healthy volunteers with a mean age of 38±11 were used. 160 normal myocardial segments were analyzed.

RESULTS
Peak global circumferential strain was statistically significantly impaired in ischemic patients compared to controls(-13.29 ±8.98 vs. -19.63 ±7.08),P< 0.0001. Similarly, peak global radial strain was statistically significantly impaired in ischemic patients compared to controls(21.88 ±17.96 vs. 30.90 ±18.59),P<0.0001. Segmental circumferential strain was statistically significantly impaired in non-viable segments compared to viable segments(-8.21 ±9.32 vs. -14.26 ±8.64),P<0.0001. Segmental radial strain was statistically significantly impaired in non-viable segments compared to viable segments(14.68 ±13.59 vs. 23.24 ±18.49),P<0.0001. A cut-off point of circumferential strain of -8 was attained (below which the segment is considered as non-viable) with sensitivity 58 %, specificity 84%, PPV 90%, PPV 44% and diagnostic accuracy 79%. A cut-off point of radial strain of 14 was attained (below which the segment is considered as non-viable) with sensitivity 55%, specificity 73%, NPV 90%, PPV 28% and diagnostic accuracy 70%.

CONCLUSION
FT-CMR is a time-efficient post processing tool than can reliably aid in differentiating viable and non-viable myocardium with no need for additional sequence acquisition or contrast administration.

CLINICAL RELEVANCE/APPLICATION
FT-CMR can robustly predict prognosis by viability assessment and is recommended in routine CMR exams before percutaneous intervention.

LEARNING OBJECTIVES
1) Understand principles and techniques for cardiovascular flow quantification using 2D phase contrast MRI and 4D flow MRI. 2) Describe advantages of 4D flow MRI for the comprehensive assessment of valvular flow characteristics. 3) Identify possible applications of 2D and 4D flow MRI in clinical cardiovascular imaging.

PURPOSE
To evaluate hemodynamics distal to mechanical and biological aortic valves in vitro by 4d flow MRI.

METHOD AND MATERIALS
Five aortic valve prostheses of identical diameter [mechanical valves, MV: trileaflet valve (prototype), On-X (CryoLife); biological
valves, BV: Perimount Magna Ease (Carpentier-Edwards), Trifecta valve (Abbott), Tribio (prototype); all 21mm] were placed in a flexible silicone aortic phantom (Elastrat, Switzerland). Scans were conducted at 3T with and without valves under pulsatile flow conditions (60 bpm with home-built piston pump) in a pressure-controlled model using Gadolinium-doped blood mimicking fluid (36.6% glycercine solution). Three levels of cardiac output (CO) were tested to simulate ascending flow conditions (CO-1, CO-2, CO-3). Time-resolved velocity information of every voxel was measured and analyzed using GFlow (GyroTools, CH). Hemodynamic parameters and presence of secondary flow patterns were evaluated.

RESULTS

There was a pronounced central ejection jet in the aortic bulb distal to biological valves at all COs with higher peak velocities compared to mechanical ones (e.g. CO-2 Bulb: MV 138±12cm/s; Tribio+Perimount: 198±15cm/s; Trifecta: 159cm/s), indicating a relative stenosis of BV compared to MV with the same diameter. All valves were regurgitant with an average retrograde volume of 104±3mL. While mechanical valves resulted in near-physiological aortic flow patterns with pronounced sinus vortices, there was marked formation of secondary helices and vortices in the ascending aorta distal to biological valves at all CO-levels altering commonly observed primary flow patterns.

CONCLUSION

Biological valves result in increased flow velocities in the aortic bulb and ascending aorta as compared to mechanical valves. The valve leaflets of the Trifecta valve are attached at the outside of the commissures in contrast to other BV. Apparently, this results in a lesser degree of relative stenosis with peak velocities between those of MV and BV. In addition, biological valves also caused secondary flow patterns in contrast to mechanical valves that revealed near-to-normal hemodynamics. These results are in line with previous turbulent kinetic energy measurements and CFD simulations.

CLINICAL RELEVANCE/APPLICATION

Aortic flow patterns distal to mechanical valves more closely mirror physiology which may translate in alterations in kinetic energy or wall shear forces and thus influence patients’ long-term health.
LEARNING OBJECTIVES

1) Describe the basic techniques of myocardial MR mapping. 2) Explain the role of myocardial MR mapping. 3) Identify findings of common diseases on T1, T2, and T2* maps.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Kate Hanneman, MD, FRCPC - 2017 Honored Educator

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PURPOSE

To compare the native, stress and post-contrast T1 values obtained from different sequences for T1 mapping of the myocardium.

METHOD AND MATERIALS

We compared three T1 mapping sequences (FFM, MPI and LONG/SHORT) of 211 consecutive populations (patients and healthy volunteers) using conservative septal technique as the standardized approach. We calculated ventricular septum and related blood T1 in vivo through subsequent parametric mapping. We also analyzed the T1 differences of these sequences in native, stress and post-contrast conditions.

RESULTS

T1 values differed significantly depending on the sequence, with MPI providing consistently higher mean values than FFM (1310±62 ms vs. 1150±63 ms in native condition, 1327±63 ± 28 ms vs. 1153±61 ms in stress condition and 604±65 ms vs. 588±64 ms in post-contrast condition, mid-ventricular, respectively; p < 0.001), LONG providing higher and SHORT providing lower mean values than FFM (1075±109 ms vs. 1042±80 ms in native condition, 519±77 ms vs. 535±68 ms in post-contrast condition, mid-ventricular, respectively; p < 0.001). On Passing-Bablok regression analysis, MPI is significantly correlated with FFM in native, stress and post-contrast (r=0.501, 0.450, 0.871, respectively; p < 0.001). FFM is significantly correlated with LONG, SHORT in mid-ventricular segment (r=0.805, 0.966, respectively; p < 0.001). On Bland-Altman analysis, the mean difference (95% limits of agreement) between MPI and FFM in native, stress and post-contrast is 160.1ms(48.8ms-271.4), 173.8ms(46.1ms-301.6ms), 16.8ms(42.4ms-75.9ms), respectively. The mean difference (95% limits of agreement) between FFM and LONG, SHORT in mid-ventricular segment is 32.3ms(-79.3ms-144.0), -17.2ms(-58.3ms-23.9ms), respectively.

CONCLUSION

FFM and MPI showed good agreement with MPI values are much higher than FFM. FFM and LONG/SHORT showed good agreement with LONG values are higher than FFM and SHORT values are lower than FFM. Stress increase the T1 values of myocardium in FFM and MPI.

CLINICAL RELEVANCE/APPLICATION

T1 values differed significantly depending on the sequence and therefore it is necessary to respectively establish the T1 normal reference range according to different sequences.

Participants

Mengxi Yang, MS, Chengdu, China (Presenter) Nothing to Disclose
Zhigang Yang, MD, Chengdu, China (Abstract Co-Author) Nothing to Disclose
Ying-Kun Guo, MD, Chengdu, China (Abstract Co-Author) Nothing to Disclose
PURPOSE
In T1-mapping techniques, native T1 value and extracellular volume (ECV) of infarct myocardium are applied to assess the severity of injury and predict functional recovery in patients with acute myocardial infarction (MI). We sought to investigate whether native T1 infarct value and ECVinfarct is affected by microvascular obstruction (MVO) and have predict value for adverse left ventricular (LV) remodeling post-MI.

METHOD AND MATERIALS
54 MI patients underwent acute and 3-month CMR, including cine, T1-mapping and late gadolinium enhancement (LGE). Infarct zone was determined by LGE image and then transposed to native T1-mapping and ECV mapping images for native T1 infarct value and ECVinfarct measurement. The visible hypo-intensity core within infarct zone was eliminated when MVO presented.

RESULTS
Among 54 patients, 36 (66.67%) had MVO in acute phase and 20 (37.04%) developed adverse LV remodeling in chronic phase. There wasn't significant difference in T1 infarct value between patients with and without MVO (1474.7 ± 63.5ms vs. 1495.4 ± 98.0ms, P = 0.352), while ECVinfarct is higher in patients with MVO than those without (58.66 ± 8.71% vs. 49.64 ± 8.82%, P = 0.001). T1 infarct value merely had the correlation with the 3-month change of end-diastolic LV volume (rMVO absent = 0.483, P = 0.042) and predicted LV remodeling in patients without MVO (rMVO absent = 0.659, P = 0.003); ECVinfarct had the correlation with the change of end-diastolic LV volume (rall patients = 0.564, P < 0.001) and predicted LV remodeling in all patients (rMVO absent = 0.626, P = 0.005; rMVO present = 0.686, P < 0.001; rall patients = 0.622, P < 0.001). In multivariable logistic analysis, ECVinfarct was also associated with LV remodeling (ð= 0.312, P = 0.007).

CONCLUSION
In infarct myocardium, native T1 value might be influenced by MVO but ECV isn’t. T1 infarct value predicts LV remodeling in MVO absent MI and ECVinfarct predicts LV remodeling in all MI.

CLINICAL RELEVANCE/APPLICATION
The combination of native T1 value and ECV in infarct myocardium has the potential to predict adverse LV remodeling post-MI and select high-risk patients who need more aggressive treatments.

ARTIFICIAL INTELLIGENCE MACHINE LEARNING-BASED PREDICTION OF HEMATOCRIT VALUES FROM NATIVE MRI MYOCARDIAL T1-MAPS TO AVOID BLOOD SAMPLING FOR EXTRACELLULAR VOLUME FRACTION ANALYSIS

Tuesday, Nov. 27 11:50AM - 12:00PM Room: E350

Participants
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PURPOSE
To evaluate a machine learning (ML) algorithm developed in-house to estimate blood hematocrit levels (Hct) from native MRI myocardial T1-maps in order to avoid blood sampling prior to cardiac MRI studies involving extracellular volume fraction (ECV) analysis.

METHOD AND MATERIALS
A total of 51 consecutive patients (age 56±13y) selected from a prospective study who underwent cardiac MRI (Avanto, Siemens, Erlangen, Germany) at 1.5T were included. MRI protocol consisted of native (MOLLI scheme 5(3)) and post-contrast (15-min post-Gd, scheme 4(1)3(1)2) T1-maps of the myocardium. Native blood R1 (1/T1) values were measured in the left ventricle for Hct estimation. A linear regression (LR) analysis was applied to model the relationship between the image-derived data and laboratory Hct values. A total of 51 consecutive patients (age 56±13y) selected from a prospective study who underwent cardiac MRI (Avanto, Siemens, Erlangen, Germany) at 1.5T were included. MRI protocol consisted of native (MOLLI scheme 5(3)) and post-contrast (15-min post-Gd, scheme 4(1)3(1)2) T1-maps of the myocardium. Native blood R1 (1/T1) values were measured in the left ventricle for Hct estimation. A linear regression (LR) analysis was applied to model the relationship between the image-derived data and laboratory Hct values. The visible hypo-intensity core within infarct zone was eliminated when MVO presented.

RESULTS
Average native blood T1 and R1 measurements were 1654±142ms and 0.60±0.04s-1, respectively. Hct derived from native T1-maps by the LR and ML algorithms were 38.7±3.3% and 39.1±3.6%, respectively, and did not show statistical difference when compared to laboratory Hct values (38.7±4.8; P=0.446). The LR approach provided the following model for Hct calculation:

\[ \text{Hct} = 58.66 \times R1_{\text{native,blood}} - 19.0 \]  

The visible hypo-intensity core within infarct zone was eliminated when MVO presented.

\[ \text{Hct} = 89.8 \times R1_{\text{native,blood}} - 19.0 \]  

The LR model-based Hct demonstrated a weaker relationship with laboratory Hct values (r = 0.70; P = 0.001). The ML model showed a moderate relationship to blood-sampled Hct values (r = 0.78; P < 0.001). Analysis of the residuals demonstrated an increase in accuracy for the ML approach compared to the LR model (RMSE 3.07 vs. 3.47). ECV values derived from LR, ML, and lab techniques were in good agreement (38.1±16.9, 37.9±16.8, and 37.9±17.0%, respectively; P = 0.475).

CONCLUSION
The ML-based algorithm provides accurate Hct estimation and reliable myocardial ECV calculation, highlighting its potential in clinical
workflows to generate ECV without the need for same-day laboratory Hct measurement.

CLINICAL RELEVANCE/APPLICATION

This study demonstrates the benefit of a ML strategy to eliminate the need for blood sampling prior to cardiac MRIs involving myocardial ECV measurement.
Current Imaging of the Appendix

Participants
Douglas S. Katz, MD, Mineola, NY (Moderator) Nothing to Disclose

Sub-Events

RC308A Appendicitis in Children
Participants
Steven L. Blumer, MD, Wilmington, DE (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To review the prevalence as well as the clinical signs and symptoms of appendicitis in the pediatric population. 2) To discuss the role of various modalities in the imaging work-up of pediatric appendicitis including plain film, ultrasound, CT and MR. 3) To review the techniques of imaging pediatric appendicitis with ultrasound, CT and MR. 4) To illustrate the imaging findings of pediatric appendicitis on ultrasound, CT and MR. 5) To review potential mimickers of pediatric appendicitis. 6) To discuss potential complications of appendicitis in the pediatric population.

RC308B Appendicitis in Non-pregnant Adults
Participants
Michael N. Patlas, MD, FRCPC, Hamilton, ON (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To discuss optimal use of different cross-sectional modalities for the diagnosis of acute appendicitis. 2) To illustrate common mistakes in interpretation. 3) To review potential mimics of acute appendicitis.

RC308C Uncommon and Atypical Appendiceal Disorders on CT
Participants
Douglas S. Katz, MD, Mineola, NY (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To review a series of uncommon and unusual/rare disorders of the appendix which may present as appendicitis clinically and on CT examinations. 2) To demonstrate examples of these entities from clinical practice, using CT. 3) To briefly review the current imaging and clinical literature on uncommon and unusual/rare disorders of the appendix. 4) To briefly explain the current management of these appendiceal disorders.

Honored Educators
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Douglas S. Katz, MD - 2013 Honored Educator
Douglas S. Katz, MD - 2015 Honored Educator
Douglas S. Katz, MD - 2018 Honored Educator

RC308D Appendicitis in Pregnancy
Participants
Vincent M. Mellnick, MD, Saint Louis, MO (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Compare ultrasound and MRI for accuracy in the setting of suspected appendicitis in the pregnant patient. 2) Utilize MRI
protocols that consider the needs of the pregnant patient, including exam length, SAR, and multiplanar sequences. 3) Recognize the findings of acute appendicitis on MRI and understand the meaning of a nonvisualized appendix. 4) Identify common alternative diagnoses to appendicitis to direct management.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Vincent M. Mellnick, MD - 2016 Honored Educator Vincent M. Mellnick, MD - 2018 Honored Educator
Gastrointestinal Series: Advances in Abdominal CT (The In-Person Presentation is Supported by an Unrestricted Educational Grant from GE Healthcare, Life Sciences)

Tuesday, Nov. 27 8:30AM - 12:00PM Room: E451A

AI BQ CT GI

AMA PRA Category 1 Credits ™: 3.50
ABRT Category A+ Credits: 4.00

FDA
Discussions may include off-label uses.

Participants
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LEARNING OBJECTIVES
1. Review topics around Machine Learning 2. Discuss applications of multi-energy CT 3. Review usage of oral contrast media and associated controversies 4. Discuss CT imaging biomarkers for oncologic and non oncologic applications 5. Review innovations in Health IT.

Sub-Events
RC309-01 Machine Learning

Tuesday, Nov. 27 8:30AM - 8:55AM Room: E451A

Participants
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LEARNING OBJECTIVES
1) Basic concepts of machine learning and deep learning. 2) Exciting areas of abdominal machine learning research. 3) Future of abdominal AI.

RC309-02 Machine Learning-based Radiomics Improve Prediction of Metastatic Disease Progression in Patients with Colon Cancer

Tuesday, Nov. 27 8:55AM - 9:05AM Room: E451A

Participants
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Azadeh Tabari, Boston, MA (Abstract Co-Author) Nothing to Disclose
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PURPOSE
Intra-tumor heterogeneity is independently associated with worse patient prognosis in several cancer subtypes. This study investigates the role of quantitative tumor heterogeneity MRI features in predicting metastatic disease progression in patients with colon cancer.

METHOD AND MATERIALS
In this IRB-approved retrospective study, we identified 51 patients with stage 4 colon cancer who underwent MRI for liver
A MP-CDN classifier with a sequential input of 4 CT contrast-enhanced phases was developed to automatically classify focal liver lesions (FLLs) of different pathological types on multiphase computed tomography. In this IRB-approved retrospective study, we included 359 patients with stage 4 colon cancer who underwent CT for initial metastasis evaluation. Standard clinical prognostic variables were collected. The largest hepatic lesion was identified on the portal venous phase T1-weighted post-contrast images and segmented. MR radiomic feature vectors were extracted from each lesion using 50 morphological and texture features. Six-month metastatic disease progression was assessed, with progression defined as appearance of new hematogeneous metastatic lesions. Univariate logistic regression analysis was used to assess the contribution of the features to disease progression prediction. A linear support vector machine (SVM) machine learning technique was applied to the imaging phenotype vector and to the clinical prognostic variables to predict disease progression. The classifiers were trained and tested using 10-fold cross validation. ROC analysis, area under the curve (AUC) and Delong's test were used to assess classification performance.

RESULTS

13 of 51 patients (26%) exhibited metastatic disease progression. Mean time to disease progression was 109±5.9 days. Tumor entropy, dissimilarity and GLCM standard deviation exhibited significant differences in mean values between patients exhibiting progression and those who did not (p=0.02, p=0.03 and p=0.03, respectively). Univariate regression revealed three features independently associated with metastatic disease progression: tumor promenance (p=0.03), homogeneity (p=0.03), and variance (p=0.02). An SVM model that incorporates imaging-based heterogeneity features resulted in improved model performance for disease progression prediction (AUC of 0.86), compared to the model that only included standard prognostic clinical variables (AUC=0.54) (p<0.001).

CONCLUSION

Quantitative tumor heterogeneity MRI features improve prediction of metastatic disease progression in patients with colon cancer.

CLINICAL RELEVANCE/APPLICATION

Machine learning-based tumor radiomics may improve disease progression prediction and may inform decisions regarding locoregional vs systemic therapy in patients with oligometastatic disease.

RC309-03 A Multiphase Convolutional Dense Network For Classification of Focal Liver Lesions on Dynamic Contrast-Enhanced CT

Tuesday, Nov. 27 9:05AM - 9:15AM Room: E451A

Participants
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Jin Wang, MD, Guangzhou, China (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To develop and assess an automated multiphase convolutional dense network (MP-CDN) to classify focal liver lesions (FLLs) of different pathological types on multiphase computed tomography (CT).

METHOD AND MATERIALS

Following ethics committee approval with waived informed consent requirement, 359 patients with a total of 517 FLLs scanned on a 320-row CT scanner using a multiphase (pre-contrast, arterial, portal venous, and delayed phases) protocol between 2012-2017 were retrospectively enrolled. FLLs were classified by contemporaneous histology as hepatocellular carcinoma (HCC, n=111), metastases (mets, n=112), benign FLL (i.e., hemangioma, focal nodular hyperplasia, adenoma; n=162), and hepatic abscess (n=132). A MP-CDN classifier with a sequential input of 4 CT contrast-enhanced phases was developed to automatically classify each FLL. 410 FLLs (88 HCCs, 89 mets, 128 benign FLLs, 105 abscesses) were used for training; 107 FLLs (23 HCCs, 23 mets, 34 benign FLLs, 27 abscesses) were used for testing. The performance of MP-CDN classification was assessed in the testing dataset: accuracy was calculated from the confusion matrix; the area under the receiver operating characteristic curve (AUC) was calculated from the softmax probability outputted from the last layer of the MP-CDN.

RESULTS

The mean classification accuracy in the testing dataset was 81.3% (87/107). The AUC for differentiating each lesion type from the other 3 lesion types was 0.92, 0.99, 0.88 and 0.96 for HCC, mets, benign FLLs, and hepatic abscess, respectively.

CONCLUSION

A MP-CDN accurately classified FLLs detected on multiphase CT over a 6-year period as HCC, mets, benign FLLs and hepatic abscess. If independently validated in a large, diverse cohort imaged with a variety of CT scanners and protocols, MP-CDN may be
a potential method to assist radiologists for differential diagnosis of malignant and benign FLLs.

**CLINICAL RELEVANCE/APPLICATION**

MP-CDN may be a potential method to assist radiologists for differential diagnosis of malignant and benign FLLs and to facilitate management decisions in clinical practice.

**RC309-04 Development and Validation of a Deep Learning System for Staging Liver Fibrosis Using Contrast-Enhanced CT Images of the Liver**

Tuesday, Nov. 27 9:15AM - 9:25AM Room: E451A

Participants
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**PURPOSE**

To develop and validate a deep learning system (DLS) based on convolutional neural network for staging liver fibrosis using computed tomography (CT) images of the liver.

**METHOD AND MATERIALS**

A DLS for CT-based staging of liver fibrosis was created using a development dataset that included portal venous phase CT images for 7461 patients with pathologically confirmed liver fibrosis. The diagnostic performance of the DLS was evaluated in test datasets for 891 patients. The influence of patient characteristics and CT techniques on the accuracy of the DLS was evaluated by logistic regression analysis. In a subset of 421 patients, the diagnostic performance of the DLS was compared with that of the radiologist’s assessment, aminotransferase-to-platelet ratio index (APRI), and fibrosis-4 index using the area under the receiver-operating characteristic curve (AUROC) and Obuchowski index.

**RESULTS**

DLS had a staging accuracy of 79.4% (707/891) and an AUROC of 0.96 (95% CI 0.95-0.97), 0.97 (CI 0.96-0.98), and 0.95 (CI 0.94-0.96) for diagnosing significant fibrosis (F2-4), advanced fibrosis (F3-4), and cirrhosis, respectively. In multivariate analysis, only pathologic fibrosis stage significantly affected the staging accuracy of the DLS (P = .016 and P = .013 for F1 and F2, respectively, compared with F4), while etiology and CT technique did not. The DLS (Obuchowski index 0.94) outperformed the radiologist’s interpretation, APRI, and fibrosis-4 index (range of Obuchowski indices, 0.71-0.81; P < .001) for staging liver fibrosis.

**CONCLUSION**

The DLS allows accurate staging of liver fibrosis using CT images and appears to be a promising assessment tool.

**CLINICAL RELEVANCE/APPLICATION**

Considering its high diagnostic performance and robustness to CT imaging techniques, the CT-based deep learning system would be a useful clinical tool for assessing liver fibrosis using routine portal venous phase CT images of the liver.

**RC309-05 New Applications of Multi-energy CT**

Tuesday, Nov. 27 9:25AM - 9:50AM Room: E451A

Participants
Benjamin M. Yeh, MD, San Francisco, CA (Presenter) Research Grant, General Electric Company; Consultant, General Electric Company; Author with royalties, Oxford University Press; Shareholder, Nextrast, Inc; Research Grant, Koninklijke Philips NV; Research Grant, Guerbet SA; ;

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**LEARNING OBJECTIVES**

1) Review scenarios in which single-energy CT and other diagnostic imaging tests may be problematic. 2) Describe capabilities of multi-energy CT, including recent advances. 3) Discuss case scenarios where multi-energy CT improves diagnoses or clinical decision making. 4) Review potential pitfalls of multi-energy CT. 5) Describe future advances and applications of multi-energy CT.

**RC309-06 Measuring Fat Fraction with Dual-Layer Spectral CT Material Attenuation Decomposition Plots: An Iodine-Independent Method for Imaging Hepatic Steatosis**

Tuesday, Nov. 27 9:50AM - 10:00AM Room: E451A

Participants
Todd C. Soesbe, PhD, Dallas, TX (Presenter) Nothing to Disclose
Matthew A. Lewis, PhD, Dallas, TX (Abstract Co-Author) Research collaboration, CMR Naviscan Corporation; Research collaboration, QT Ultrasound, LLC
Lakshmi Ananthakrishnan, MD, Irving, TX (Abstract Co-Author) Nothing to Disclose
Can Quantitative Iodine Parameters on DECT Replace Perfusion CT Parameters in Colorectal Cancers?

Tuesday, Nov. 27 10:00AM - 10:10AM Room: E451A

PURPOSE
To determine the correlation between iodine concentrations derived from dual-energy CT (DECT) and perfusion CT (PCT) parameters in patients with pathologically-proven colorectal cancers (CRC), and to evaluate their reproducibility and respective radiation exposures.

METHOD AND MATERIALS
Institutional review board approval and written informed consents were obtained for this study. Forty-one patients with CRCs who underwent same day DECT and PCT were prospectively enrolled. Three radiologists independently analyzed iodine concentration of tumors and iodine ratios (ratio of lesion to aorta (IRa) or to infrarenal IVC (IRv)) from DECT as well as blood flow (BF), blood volume (BV), permeability (PMB), and mean transit time (MTT) from PCT. Pearson R and linear correlation, paired t-test and intraclass correlation coefficients (ICCs) were used.

RESULTS
Significant correlations were found between iodine parameters from DECT and PCT parameters: iodine concentration of tumors and BF (r=0.29, P=0.06), BV (r=0.32, P=0.04), PMB (r=0.34, P=0.03), and MTT (r=0.38, P=0.02); iodine ratio (IRa) and MTT (r=-0.32, P=0.04); and iodine ratio (IRv) and BF (r=0.32, P=0.04) and PMB (r=0.44, P<0.01). DECT showed better intra- and inter-observer agreements (ICC=0.98, 0.90 in iodine concentration; 0.98, 0.91 in IRa; and 0.91, 0.93 in IRv, respectively) than PCT (ICC=0.90, 0.78 in BF; 0.82, 0.76 in BV; 0.75, 0.75 in PMB; 0.64, 0.79 in MTT, respectively). As for radiation dosage, CTDIvol and DLP in DECT (10.48±1.84mGy and 519.7±116.7mGy·cm) were significantly lower than those of PCT (75.76mGy and 911mGy·cm) (P<0.01).

CONCLUSION
Iodine parameters from DECT are significantly correlated with PCT parameters, but have higher intra- and inter-observer agreements and lower radiation exposure.

CLINICAL RELEVANCE/APPLICATION
As iodine parameters derived from DECT are significantly correlated with perfusion parameters while allowing better intra- and inter-observer agreements and lower radiation exposure, DECT may be a good alternative to PCT in the assessment of the tumor.
hemodynamics in patients with CRC.

**RC309-08 Oral Contrast Media Controversies**

**Participants**
Avinash R. Kambadakone, MD, Boston, MA (Presenter) Nothing to Disclose

**For information about this presentation, contact:**
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**LEARNING OBJECTIVES**
1) Explain the indications and benefits of oral contrast media in abdomen/pelvis CT. 2) Understand the controversies in the role of oral contrast media in various clinical settings including ER, oncology and routine abdominal scans. 3) Optimize the use of oral contrast media to improve diagnosis.

**RC309-09 Spectral Photon-Counting CT Multi-Phase Liver Imaging with Dual Contrast Agent**

**Participants**
Salim Si-Mohamed, Lyon, France (Presenter) Nothing to Disclose
Valerie Tatard-Leitman, PhD, Lyon, France (Abstract Co-Author) Nothing to Disclose
Daniela Pfieffer, MD, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Monica Sigovan, PhD, Lyon, France (Abstract Co-Author) Nothing to Disclose
Daniel Bar-Ness, Bron, France (Abstract Co-Author) Nothing to Disclose
Loïc Bousset, MD, Lyon, France (Abstract Co-Author) Nothing to Disclose
Philippe C. Douek, MD, PhD, Lyon, France (Abstract Co-Author) Nothing to Disclose
Peter B. Noel, PhD, Munich, Germany (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**
To demonstrate the feasibility of dual-contrast multiphase imaging of the liver using Spectral Photon-Counting CT via K-edge imaging.

**METHOD AND MATERIALS**
The experiments were performed on 3 rabbits following approval by the local ethics committee. We used a 5 energy bins prototype spectral photon-counting CT (Philips Healthcare, Haifa, Israel), tube voltage of 120 kVp, tube current of 100 mA. The iodine contrast agent (Iomeron, 400 mg/mL, 1.5 mL/kg, Bracco) was injected first, followed by the gadolinium contrast agent (gadoteridol, 0.5 M, 5 mL/kg, Bracco) 21 seconds later, and acquisitions were done 10 seconds after the second injection. This protocol allowed performing two different phases imaging of the liver, i.e. arterial (gadolinium) and portal (iodine). Conventional HU and quantitative material decomposition iodine and specific K-edge gadolinium images were obtained.

**RESULTS**
The gadolinium K-edge and iodine material decomposition images allowed the discrimination between the two contrast agents, which was not possible using the conventional CT images. Moreover, we observed a dual-phase imaging matching the expected pharmacokinetics of the two contrast media. The iodine injected enhanced the liver parenchyma while the gadolinium injected enhanced the arteries. These results were confirmed by measuring the attenuation values (HU) and the concentrations (mg/mL) of contrast agents in the aorta (conventional CT: 1130 ± 17.6 HU; gadolinium: 20.9 ± 1.2; iodine: 6.8 ± 0.4), hepatic arteries (conventional CT: 474.6 ± 44.3; gadolinium: 7.7 ± 0.8; iodine: 0.7 ± 0.4), portal vein (conventional CT: 233.6 ± 15.1; gadolinium: -0.1 ± 0.6; iodine: 2.5 ± 0.4) and liver parenchyma (conventional CT: 143.9 ± 11.2; gadolinium: -0.6 ± 0.7; iodine: 3.6 ± 0.4).

**CONCLUSION**
Spectral Photon-Counting CT allows in vivo dual contrast qualitative and quantitative liver multi-phase imaging in a single acquisition. This finding pinpoints major clinical applications in multiphase imaging with no registration issues and with the additional value of reducing radiation dose to patients by decreasing the number of acquisitions.

**CLINICAL RELEVANCE/APPLICATION**
Spectral Photon-Counting CT allows the qualitative discrimination between two contrast agents injected sequentially in the liver, enabling to reduce radiation dose to patients by combining liver arterial and portal phases into a single acquisition.

**RC309-10 Machine Learning Based Quality Assurance for CT Arterial Phase Timing to Ensure Robust Measurement of Tumor Density in Hepatocellular Carcinoma Patients**

**Participants**
Laurent Dercele, MD, New York, NY (Presenter) Nothing to Disclose
Jingchen Ma, NYC, NY (Abstract Co-Author) Nothing to Disclose
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Ai-ping Chen, Nanjing, China (Abstract Co-Author) Nothing to Disclose
Deling Wang, Guangzhou, China (Abstract Co-Author) Nothing to Disclose

**Awards**
**Trainee Research Prize - Fellow**

**Participants**
Laurent Dercele, MD, New York, NY (Presenter) Nothing to Disclose
Jingchen Ma, NYC, NY (Abstract Co-Author) Nothing to Disclose
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Lin Lu, New York, NY (Abstract Co-Author) Nothing to Disclose
Lawrence H. Schwartz, MD, New York, NY (Abstract Co-Author) Committee member, Celgene Corporation Committee member, Novartis AG Committee member, ICON plc Committee member, BioClinica, Inc
Chuanniao Xie I, MD, PhD, Guangzhou, China (Abstract Co-Author) Nothing to Disclose
Binsheng Zhao, DSc, New York, NY (Abstract Co-Author) License agreement, Varian Medical Systems, Inc; Royalties, Varian Medical Systems, Inc; License agreement, Keosys SAS; License agreement, Hinacom Software and Technology, Ltd;

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PURPOSE
Several treatment response criteria shifted towards categorizing response as a decrease in tumor size and/or density. We aimed to increase the reproducibility of the measurement of tumor density at the arterial phase in Hepatocellular carcinoma (HCC) by developing and validating a semi-Automatic arterial-timing Classification Algorithm based on the analysis of the pharmacokinetic distribution of the Iodinated contrast Agent a Single timepoint (ACACIAS).

METHOD AND MATERIALS
Using dynamic CT-images of 69 HCC pts, we trained (48 pts, 1930 timepoints) and validated (21 pts, 837 timepoints) ACACIAS to categorize arterial-timing into five phases according to the time to arterial peak: early (E0) < -15s < pre-peak (Pre1) < -5s < peak (P2) < +5s < post-peak (Post3) < +15s < late (L4). The random forest algorithm built the model based on the average density in predefined ROIs. Using an independent testing set, we delineated and calculated the average density of biopsy-proven HCC in 90 pts with cirrhotic liver at three phases: non-contrast enhanced 'NCP', arterial 'AP' and portal 'PVP'.

RESULTS
In the validation set, ACACIAS predicted correctly phases E0, Pre1, P2, Post3, and L4 in respectively 92%, 58%, 86%, 30%, and 99% of pts. Inter-patient variability in the duration of the arterial peak (5-95th percentiles of Full Width at Half Maximum: 10.6-27.5s) explained lower accuracies of ACACIAS in Pre1 and Post3 phases. In the testing set, 96% of NCP and 97% of PVP were correctly classified. The predicted arterial timing of AP was E0, Pre1, P2, Post3, and L4 in respectively 1, 34, 13, 25, and 17 pts and was associated with a significant difference in mean tumor density: 68, 55, 60, 71, and 60HU. The arterial HCC enhancement peaked at phase Post3 (+17%), (P<0.02, ANOVA).

CONCLUSION
ACACIAS predicted arterial timing accurately based on iodine biodistribution on medical images. A peak of HCC tumor density (+17%) was observed at the arterial phase 'Post3'. ACACIAS could improve extraction of tumor quantitative imaging biomarkers and monitoring of anti-cancer therapy efficacy by ensuring reproducible arterial phase acquisitions.

CLINICAL RELEVANCE/APPLICATION
ACACIAS ensures a reproducible tumor density measurement at arterial phase for treatment response assessment, as well as wide-ranging applications since tumor density is a surrogate of vascularity.
**PURPOSE**

Iodine maps are available from spectral detector computed tomograph (SDCT). They visualize the distribution of iodinated contrast media and allow for its quantification. Hence, they are a promising technique in oncologic imaging with respect to both, initial diagnosis (benign vs malignant) and follow-up examinations (therapy monitoring). In order to exploit a potential benefit in this respect, it is necessary to understand the intra- and inter-individual consistency of these.

**METHOD AND MATERIALS**

To evaluate accuracy of the reconstruction algorithm, an anthropomorphic liver phantom was repetitively examined at different time points; further images were reconstructed repetitively. Regions of interest (ROI) were placed automatically at identical positions using an in-house developed software. In addition, we included 75 patients, that underwent double (n=50) or triple (n=25) SDCT examination in this retrospective, IRB-approved study. Patients with significant change in liver function as indicated by laboratory results were excluded. Three ROI were drawn in each the liver parenchyma and the portal vein (PV) in portal-venous phase. Iodine uptake (IU) was normalized to the PV (IU_norm). Empirical standard deviation of the mean (ESD) was used and used to determine inter-scan and intra-individual consistency of IU_norm in phantoms and patients, respectively.

**RESULTS**

In phantoms, ESD between different acquisitions and timepoints was as low as 1.3%. Mean iodine uptake of the liver parenchyma was 2.2 ± 0.8 mg/ml (ranging from 0.5 - 4.8 mg/ml), IU_norm was 0.40 ± 0.07. Intra-individual consistency was rather high as indicated by an ESD of 7.7% showing a wide range from -44% - +36%.

**CONCLUSION**

Iodine quantification using Iodine maps from SDCT is technically feasible; however, in in-vivo measurements at different timepoints, intra-individual iodine quantification of the liver differs. Among other reasons, this is likely due to offsets in timing of image acquisition and not necessarily attributed to the specific reconstruction algorithm.

**CLINICAL RELEVANCE/APPLICATION**

Measurements of iodine uptake should be interpreted carefully when considering them for clinical decision making.

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**RO309-13 Innovations in Health IT**

Tuesday, Nov. 27 11:35AM - 12:00PM Room: E451A

Participants

Arun Krishnaraj, MD, MPH, Charlottesville, VA (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Identify policies impacting the spread of innovation in health IT. 2) Assess the role of greater transparency of health care data. 3) Describe how mobile and wearables are impacting the collection of health data.
RC311

**Advances and Updates in SPECT/CT**

**Tuesday, Nov. 27 8:30AM - 10:00AM Room: S504CD**

AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credit: 1.75

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**Sub-Events**

**RC311A**  **SPECT/CT in Endocrine/Oncology**

Participants
Esma A. Akin, MD, Washington, DC (*Presenter*) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Through clinical case examples, this activity aims to refresh knowledge of SPECT-CT applications with emphasis on neuroendocrine disorders as well as parathyroid imaging.

**RC311B**  **SPECT/CT Technology: State of the Art**

Participants
Timothy Turkington, PhD, Durham, NC (*Presenter*) Consultant, Data Spectrum Corporation

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**LEARNING OBJECTIVES**

1. After this course, the attendee should be able to describe the basic functioning of a conventional gamma camera. 2. After this course, the attendee should be able describe three recent innovations of currently-available gamma cameras and SPECT/CT systems.
Vascular Series: CT Angiography: New Techniques and Their Application

Tuesday, Nov. 27 8:30AM - 12:00PM Room: S502AB

AMAPRA Category 1 Credits™: 3.50
ARRT Category A+ Credits: 4.00

Participants
Frank J. Rybicki III, MD, PhD, Ottawa, ON (Moderator) Medical Director, Imagia Cybernetics Inc
Dominik Fleischmann, MD, Stanford, CA (Moderator) Research Grant, Siemens AG

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LEARNING OBJECTIVES
1) To describe new methods that can be used to extract data from non-invasive vascular imaging. 2) To review best practices for vascular image acquisition. 3) To highlight interesting diagnoses that can be made with optimized vascular imaging protocols.

ABSTRACT
Vascular imaging continues to be a diagnostic mainstay in radiology practice. New emerging methods to derive blood flow metrics have entered the field over the last 10 years. These have been greatly emphasized in the last 2-3 years and have revitalized the field to include new diagnostic domains. This series will review these methods as well as show the spectrum of diseases commonly encountered by the vascular and cardiovascular radiologist.

Sub-Events

RC312-01 Dual-energy and Low kVp CTA

Tuesday, Nov. 27 8:30AM - 9:05AM Room: S502AB

Participants
Shuai Leng, PHD, Rochester, MN (Presenter) License agreement, Bayer AG

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LEARNING OBJECTIVES
1) Understand basic principles of dual energy CT and different implementation methods. 2) Understand dual energy processing methods commonly used in CTA exams. 3) Use various types of dual energy CT images to improve diagnosis of CTA. 4) Assess impact of low kVp on image quality and radiation dose in CTA. 5) Select appropriate kVp for CTA scans for best diagnosis at lowest radiation dose.

RC312-02 Pre-clinical CT Imaging of Aortic Aneurysm and Dissection Using a Nanoparticle Contrast Agent

Tuesday, Nov. 27 9:05AM - 9:15AM Room: S502AB

Participants
Ketan B. Ghaghada, PhD, Houston, TX (Presenter) Research Consultant, Alzeca Biosciences, LLC
Pingping Ren, Houston, TX (Abstract Co-Author) Nothing to Disclose
Zbigniew Starosolski, PhD, Houston, TX (Abstract Co-Author) Stockholder, Alzeca Biosciences, LLC
Laxman Devkota, PhD, Houston, TX (Abstract Co-Author) Nothing to Disclose
Igor Stupin, Houston, TX (Abstract Co-Author) Nothing to Disclose
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Ananth Annapragada, PhD, Houston, TX (Abstract Co-Author) Stockholder, Alzeca Biosciences, LLC Stockholder, Sensulin, LLC Stockholder, Abbott Laboratories Stockholder, Johnson & Johnson
Scott A. Lemaire, MD, Houston, TX (Abstract Co-Author) Nothing to Disclose
Ying H. Shen, MD,PhD, Houston, TX (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Non-invasive structural and functional evaluation of aortic aneurysm and dissection (AAD) can (1) improve our understanding of disease initiation and progression in pre-clinical rodent models, and (2) facilitate in the management of patients at risk for aortic expansion, dissection and rupture. In this pre-clinical study, we investigated contrast-enhanced CT (CECT) imaging of aorta in a mouse model of sporadic AAD using a long circulating liposomal-iodine (Lip-I) nanoparticle contrast agent.

METHOD AND MATERIALS
Test mice were fed high fat diet for 4 weeks followed by continuous angiotensin-II (AngII) infusion for 4 weeks via a subcutaneous osmotic pump (n=8). Control mice (n=8) were fed regular diet and saline treatment. CECT was performed on day 7 and day 28 after starting AngII infusion. Additionally, non-contrast CT scans were acquired on day 28, prior to Lip-I injection, to determine aortic wall permeability. Lip-I was administered at a dose of 1.65 g I/kg for CECT imaging. CT images were analyzed for changes in lumen diameter and for contrast agent accumulation in aortic wall. CT findings were compared with post-mortem pathological examination of excised aorta.

RESULTS

CECT using Lip-I contrast agent enabled imaging of aortic aneurysm and dissection. The long circulating property of Lip-I provided uniform vascular opacification, thereby facilitating the visualization of structural changes in the aorta. CT imaging at Day 7 and day 28 enabled functional imaging of the aortic wall. Non-contrast images on day 28 demonstrated signal enhancement in the aortic wall of test mice; none of the control mice showed wall enhancement. CECT imaging also enabled the visualization of enlarged ascending aorta; lumen diameter increased by as much as 43% compared to controls. CT results corroborated with necropsy findings of pathology in excised aortas: 75% of test mice showed evidence of aortic disease compared to none in the control group; 25% of test mice exhibited dissection in the descending aorta; large suprarenal aneurysm was seen in one mouse; 62.5% of test mice exhibited enlargement of the ascending aorta.

CONCLUSION

Contrast-enhanced CT using a liposomal-I agent enabled structural and functional imaging of aorta in a mouse model of sporadic AAD.

CLINICAL RELEVANCE/APPLICATION

Structural and functional evaluation of the aortic wall using CECT can facilitate in the stratification of patients at risk for aneurysm expansion and rupture.

RC312-03

CT Imaging Before Transcatheter Aortic Valve Implantation (TAVI)? Using One-Stop Scan for Combined CT Angiography (CTA) Of the Head, Neck, Coronary and Aortic Arteries and Its Performance for Diagnosing

Tuesday, Nov. 27 9:15AM - 9:25AM Room: S502AB

Participants
Tao Shuai, Chengdu, China (Presenter) Nothing to Disclose

PURPOSE

To evaluate the effectiveness of one-stop scan for combined CT angiography (CTA) of the head, neck, coronary and aortic arteries before TAVI on a 16cm wide-detector CT and its performance for diagnosing coronary artery disease (CAD) and craniocervical artery disease

METHOD AND MATERIALS

110 patients (73.6±9.3 years) scheduled for TAVI underwent one contrast injection, one-stop CT scan first: ECG-triggered one heartbeat axial scan for coronary CT angiography (CCTA) and aortic valve, followed immediately by the non-ECG-gated scan for craniocervical and thoracic and abdominal CTA. Patient weight-dependent contrast dose volume at 1.0ml/kg was used. We analyzed CT attenuation values of the coronary arteries, head, neck aorta, iliac and femoral arteries. The craniocervical and CCTA images quality. The presence of stenosis (>=50 %) in CCTA was also evaluated using invasive coronary angiography result as a reference standard. Radiation dose was assessed.

RESULTS

The total dose-length product for the entire examination was low at 413.11±28.53 mGy.cm, and the total contrast dose was also low at 50±3.7ml. There was adequate attenuation (greater than 400HU) in all arteries. We could evaluate the peripheral access vessels and dimensions of the ascending aorta, aortic root, and aortic annulus in all patients. The image quality of craniocervical arteries was 100% diagnostic. The one-stop CT showed sensitivity of 89.7% and negative predictive value (NPV) of 92.4 % on the per-patient analysis, and the values were 91.5% and 96.7% on the per-vessel analysis.

CONCLUSION

Using the one-stop CT scan on a 16cm wide-detector CT system before TAVI provided high sensitivity and NPV in excluding obstructive CAD, and we provided excellent image quality for analyzing craniocervical artery disease for TAVI patients before surgery

CLINICAL RELEVANCE/APPLICATION

Wide-detector one-stop CT scan for combined CTA of head, neck, coronary and aortic arteries before TAVI is feasible with diagnostic image quality and low radiation dose

RC312-04

Impact of Replacing Traditional Medical Therapy with a Novel Personalized Treatment Strategy in Patients with Initially Uncomplicated Type-B Aortic Dissections

Tuesday, Nov. 27 9:25AM - 9:35AM Room: S502AB

Participants
Anna M. Sailer, MD,PhD, West Hollywood, CA (Presenter) Nothing to Disclose
Patty Nelemans, Maastricht, Netherlands (Abstract Co-Author) Nothing to Disclose
Martin J. Willemink, MD,PhD, Menlo Park, CA (Abstract Co-Author) Speakers Bureau, Koninklijke Philips NV; Research Grant, Koninklijke Philips NV
Kai Higashigaito, MD, Stanford, CA (Abstract Co-Author) Nothing to Disclose
Lewis D. Hahn, MD, Stanford, CA (Abstract Co-Author) Nothing to Disclose
Dominik Fleischmann, MD, Stanford, CA (Abstract Co-Author) Research Grant, Siemens AG

PURPOSE
Medical treatment of initially uncomplicated acute Stanford type-B aortic dissection is associated with a high rate of late adverse events. A risk prediction model has been developed to predict individual risk of developing a complication within 5 years after diagnosis and thus identify individuals who potentially benefit from preventive endografting. The model is based on five baseline clinical and imaging parameters and has good discriminative ability with an AUC of 0.86. However, the potential clinical impact of basing clinical decisions on the model depends on the consequences of true positive (TP) versus false positive (FP) classifications. Early identification and correct treatment of patients who are at risk for an adverse event (TP) will lead to benefit, whereas unnecessary treatment of patients not at risk (FP) will cause harm.

**METHOD AND MATERIALS**

We used decision curve analysis (DCA) to assess applicability of the model in clinical practice. The net benefit of treating patients according to the prediction model is compared with the net benefit of the two alternative strategies 'treat all' and 'treat none' over a range of plausible threshold probabilities. A threshold probability reflects the relative weights that are attached to benefit versus harm, and can be different for individual doctors and patients. Data were used from 83 patients with initially uncomplicated type-B dissections who underwent follow-up with CT.

**RESULTS**

DCA showed that using a model for prediction of 1-year and 5-year risk of adverse events has higher net benefit than the strategy 'treat none' when one is not willing to treat more than 10 patients to prevent one patient with aortic dissection from having an adverse event. The strategy 'treat all' has highest net benefit only at threshold probabilities below 10%, i.e. when one is willing to treat 10 or even more patients to prevent one late adverse event from an aortic dissection.

**CONCLUSION**

Personalized risk assessment based on a prediction model to identify candidates for preventive treatment with endografting can lead to a net benefit in patient outcome when compared with the currently widely advocated wait-and-see approach.

**CLINICAL RELEVANCE/APPLICATION**

Personalized treatment based on imaging parameters and clinical parameters reduces the risk of late adverse events in patients with initially uncomplicated Type B aortic dissections.

**RC312-05  Relationship between Contrast Dose and Radiation Dose in CTA**

**Tuesday, Nov. 27 9:35AM - 10:10AM Room: S502AB**

**Participants**
Mannudeep K. Kalra, MD, Boston, MA (Presenter) Research Grant, Siemens AG; Research Grant, Canon Medical Systems Corporation

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**LEARNING OBJECTIVES**

1) How scan techniques and factors affect radiation dose and contrast enhancement in CT angiography studies. 2) How patient factors affect radiation dose and contrast enhancement in CT angiography. 3) Relationship between radiation dose and contrast media administration in CT angiography.

**RC312-06  CTA: Acquisition Artifacts and Challenges**

**Tuesday, Nov. 27 10:20AM - 10:55AM Room: S502AB**

**Participants**
Eric E. Williamson, MD, Rochester, MN (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Identify common imaging artifacts seen in CT angiography and address them, if possible. 2) Discuss techniques to address common challenges encountered in the clinical practice of vascular CT.

**RC312-08  Diagnostic Accuracy of Single-Phase CTA for Acute Aortic Syndromes**

**Tuesday, Nov. 27 11:05AM - 11:15AM Room: S502AB**

**Participants**
Matthew Thompson, MD, Orange, CA (Abstract Co-Author) Nothing to Disclose
Mayil S. Krishnam, MBBS, MRCP, Orange, CA (Abstract Co-Author) Nothing to Disclose
James Pao, MD, Orange, CA (Presenter) Nothing to Disclose

**PURPOSE**

Dual-phase CTA protocol has been the described standard protocol for evaluating acute aortic syndromes (AASs) for over 20 years without significant scrutiny over the necessity of the unenhanced scan, which is one of the highest exposure to radiation amongst CT examinations. However, with significant advances in diagnostic imaging quality and post-processing techniques available today, we sought to reevaluate the clinical utility of the unenhanced phase for AAS and hypothesize that single-phase CTA may be sufficiently accurate in the diagnosis of AAS, including intramural hematomas.

**METHOD AND MATERIALS**

We retrospectively reviewed patients who presented to our emergency department and underwent a dual-phase CTA for concern of acute aortic syndrome (AAS), within a consecutive 4 year period. Our reference standard of true positive and negative cases in our
subject population were determined by a review panel of two cardiovascular radiologists. After discovering 50 positive cases of AAS, 72 controls were selected randomly from the group of subjects negative for AAS. A study worklist was then created with both cases and control subjects (n = 122). Two radiologists, blinded to the diagnosis and the other reviewer, were asked to evaluate for an AAS by viewing only the contrast-enhanced (CTA) portions of the exams.

RESULTS

A total of 434 patients were identified as our study population. We found a total of 50 cases positive for AAS, giving a frequency of AAS to be 11.5%. Of the 50 cases positive for AAS, 13 were due to isolated intramural hematoma, 18 dissection, 6 penetrating atherosclerotic ulcer, 4 aortic rupture, and 9 a combination of IMH with dissection or PAU. The two blinded readers had perfect agreement (100%) with all cases (122/122), each designating 51 positive AAS cases and 71 negative. Each reader independently identified the same false positive case, therefore specificity was 98.6% and accuracy 99.2%. Since there were no false negatives and all true positives were identified, sensitivity was 100% for each reader.

CONCLUSION

Single-phase CTA for the diagnosis of acute aortic syndromes is highly accurate. The unenhanced portion of the dual-phase protocol could effectively be eliminated.

CLINICAL RELEVANCE/APPLICATION

Diagnosing acute aortic syndromes with single-phase CTA would significantly reduce CT radiation exposure in these patients.

RC312-09 The Value of MDCT in the Differential Diagnosis of Chronic Thromboembolic Pulmonary Hypertension Patients

Tuesday, Nov. 27 11:10AM - 11:25AM Room: S502AB

Participants
Nan Yu, MD, Xian Yang, China (Presenter) Nothing to Disclose
Haifeng Duan, Xianyang City, China (Abstract Co-Author) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (Abstract Co-Author) Nothing to Disclose
Yong Yu, Xianyang City, China (Abstract Co-Author) Nothing to Disclose
Shan Dang, Xian, China (Abstract Co-Author) Nothing to Disclose

PURPOSE

Background: Chronic thromboembolic pulmonary hypertension (CTEPH) should be differentiated from other causes of pulmonary hypertension (PH), because CTEPH is the only form of pulmonary hypertension that can be surgically treated. However, due to non-specific clinical and imaging manifestations, CTEPH remains under-diagnosed. The purpose of this study was to discern imaging findings that separate CTEPH from other causes of PE.

METHOD AND MATERIALS

Methods: A total of 56 patients diagnosed with PH were enrolled in the study, All the patients were underwent MDCT angiography. The CT images were assessed for the presence of chronic pulmonary embolism (PE). therefore, the 72 patients were divided into two groups: group1, CTEPH group (n=25); and group2, other causes of PE (pulmonary arterial hypertension n=5, PH due to left heart disease n=6, PH due to lung disease n=18, PH due to unclear or multifactorial mechanisms n=2). The symptoms, clinical signs, risk factors, blood test and radiological features were analyzed and compared in the two group.

RESULTS

There was no significant difference in the frequencies of clinical symptoms, signs, risk factors, blood test between patients with CTEPH and patients with nonthromboembolic PH, except the history of suffering from acute pulmonary embolism (APE) once (x2=5.376, p=0.029). The frequencies of direct signs signs of chronic PE, mosaic attenuation, ground glass opacity, and pulmonary artery widened were statistically significantly higher in patients with CTEPH than in patients with nonthromboembolic PH (p<0.001).

CONCLUSION

The clinical symptoms, signs and risk factors can not be dependent factors in CTEPH diagnosis due to nonspecific. However, According to MDCT angiography, most patients with CTEPH have direct signs of chronic PE. The secondary signs include mosaic attenuation, ground glass opacity, and pulmonary artery widened, which also helpful to distinguish CTEPH from other causes of PH.

CLINICAL RELEVANCE/APPLICATION

The imaging findings of MDCT is valuable in separating chronic thromboembolic pulmonary hypertension (CTEPH) from other causes of pulmonary hypertension (PH).

RC312-10 CTA: Post Processing and Workflow

Tuesday, Nov. 27 11:25AM - 12:00PM Room: S502AB

Participants
Michael L. Steigner, MD, Boston, MA (Presenter) Consultant, Canon Medical Systems Corporation

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LEARNING OBJECTIVES

1) Define post-processing principles. 2) Apply post-processing techniques. 3) Implement post-processing in the clinical workflow. 4) Emerging techniques and applications.
Emerging Technology: Dual Energy and Spectral CT Update 2018

Tuesday, Nov. 27 8:30AM - 10:00AM Room: S505AB

Participants
Savvas Nicolaou, MD, Vancouver, BC (Moderator) Institutional research agreement, Siemens AG

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LEARNING OBJECTIVES
1) Briefly review the principles of Dual Energy CT/Spectral imaging. 2) Review virtual non-contrast imaging, iodine mapping, material decomposition, and monoenergetic imaging. 3) Review cases demonstrating abdominal organ perfusion and oncologic applications in the abdomen. 4) To outline novel applications of dual energy CT in assessing bone marrow edema, gout, ligament/tendon analysis and metal artifact reduction. 5) To outline novel techniques using Dual Energy CT in pulmonary embolism, cardiac ischemia assessment. 6) Review DECT/spectral imaging applications in the brain.

Sub-Events
RC317A  Update on the Clinical Applications of Multi-Energy CT in Cardiothoracic Imaging

Participants
Prabhakar Rajiah, MD, FRCR, Dallas, TX (Presenter) Nothing to Disclose

For information about this presentation, contact:
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LEARNING OBJECTIVES
1) To describe the different implementations of multi-energy CT technology. 2) To discuss the updates on the utility of multi-energy CT in cardiothoracic imaging. 3) To review the applications of multi-energy CT in cardiothoracic imaging.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

RC317B  Novel Neuroradiology Dual Energy/Spectral CT Clinical Applications

Participants
Aaron D. Sodickson, MD,PhD, Boston, MA (Presenter) Institutional research agreement, Siemens AG; Speaker, Siemens AG; Speaker, General Electric Company

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LEARNING OBJECTIVES
1) Review Dual Energy CT fundamentals and post-processing applications. 2) Demonstrate the utility of Dual Energy CT to add value in neuro-imaging, including pathology detection, lesion characterization, diagnostic confidence, and reduced length-of-stay.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

RC317C  Dual Energy/Spectral CT of the Abdomen: What Matters Most to the Clinician

Participants
Desiree E. Morgan, MD, Birmingham, AL (Presenter) Institutional Research Grant, General Electric Company

For information about this presentation, contact:
dmorgan@uabmc.edu
LEARNING OBJECTIVES

1) Apply strategies of dual energy CT for streamlined characterization of incidentally detected intra-abdominal abnormalities such as hepatic steatosis, adrenal adenomas, and renal lesions. 2) Develop and utilize post processing techniques that improve detection and identification of clinically relevant imaging features of abdominal tumors. 3) Understand limitations and compare workflow differences among major dual/multienergy scanning systems for abdominal applications.

RC317D  Current and New Clinical Applications in Musculoskeletal Dual Energy/Spectral CT

Participants
Fabio Becce, MD, Lausanne, Switzerland (Presenter) Nothing to Disclose

For information about this presentation, contact:
fabio.becce@chuv.ch

LEARNING OBJECTIVES

1) Comprehend the basic principles and technical aspects of dual- and multi-energy CT when imaging the musculoskeletal system.
2) Apply dual-energy CT when assessing various musculoskeletal disorders, from crystal-related arthropathies to bone marrow edema. 3) Identify potential new applications of dual-energy CT in musculoskeletal imaging, such as CT arthrography and iron-related disorders.
Challenging Cases in Body Oncologic Imaging (Interactive Session)

Tuesday, Nov. 27 8:30AM - 10:00AM Room: E353A

RC318
Magnetic Resonance Imaging

Participants
Gary A. Ulaner, MD, PhD, New York, NY (Moderator) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd; Research support, Novartis AG

For information about this presentation, contact:
ulanerg@mskcc.org

LEARNING OBJECTIVES
1) Learn how to correlate CT and FDG PET findings to optimize diagnosis. 2) Identify iatrogenic effects which mimic malignancy on FDG PET/CT. 3) Learn histologies of breast cancer which may not be appreciably FDG-avid.

GENERAL INFORMATION
This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

Sub-Events
RC318A Magnetic Resonance Imaging

Participants
Alexander R. Guimaraes, MD, PhD, Portland, OR (Presenter) Consultant, Agfa-Gevaert Group

LEARNING OBJECTIVES
1) Updated understanding of soft tissue contrast mechanisms inherent in MRI including T1rho, diffusion weighted imaging, DCE-MRI. 2) Updated protocols for each organ site. 3) Potential benefits of PET/MRI in diagnosing disease.

ABSTRACT
This course is designed to update the attendee on novel MRI techniques and the benefits of MRI in diagnosing challenging cases within the abdomen and pelvis. Multiparametric MRI offers the unique ability to monitor the tumor microenvironment. Increasingly, multiparametric MRI is used for diagnosis and grading of malignancy in various organ systems (e.g. prostate cancer).

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Alexander R. Guimaraes, MD, PhD - 2018 Honored Educator

RC318B Ultrasound

Participants
Deborah J. Rubens, MD, Rochester, NY (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Understand the technical parameters to optimize to improve ultrasound diagnosis. 2) Identify discrete ultrasound features to discriminate between various pathologic entities. 3) Characterize disease processes in solid organs, vessels and soft tissues using the unique features of ultrasound and appreciate how ultrasound is complementary to CT, MRI and PET in the oncology patient.

ABSTRACT
This session will highlight a variety of disease processes in the oncology patient using grayscale, color and spectral Doppler ultrasound. Technique and potential pitfalls will be highlighted as they contribute to diagnostic acumen of the sonologist. Cases will include neoplastic, infectious and vascular processes in multiple organs. Differential diagnosis will be stressed with companion case examples, as well as when to use comparative imaging such as CT, MRI or PET/CT

RC318C PET/CT

Participants
Gary A. Ulaner, MD, PhD, New York, NY (Presenter) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd; Research support, Novartis AG

For information about this presentation, contact:
LEARNING OBJECTIVES

1) Learn where CT findings can improve FDG PET interpretation and where FDG PET findings can improve CT interpretation.

ABSTRACT

FDG PET/CT has become an indispensible modality in the treatment of cancer. While proven to be of great clinical benefit in the management of a wide array of malignancies, there are many potential pitfalls which may be detrimental if not properly identified and explained. In particular, FDG-avidity may be incorrectly ascribed to malignancy when corresponding CT findings demonstrate the FDG-avidity to be benign. In other cases, the presence of FDG avidity correctly determines the presence of malignancy despite lack of correlate findings on CT. In this presentation, challenging FDG PET/CT cases will be used to demonstrate how correlation of FDG PET and CT findings leads to optimal FDG PET/CT interpretation.
Advances in CT: Technologies, Applications, Operations-Spectral CT

Tuesday, Nov. 27 8:30AM - 10:00AM Room: E351

CT PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

Participants
Ehsan Samei, PhD, Durham, NC (Coordinator) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc
Lifeng Yu, PhD, Chicago, IL (Coordinator) Nothing to Disclose

ABSTRACT

CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

Sub-Events

RC321A  Data Acquisition and Rendition Methods

Participants
Cynthia H. McCollough, PhD, Rochester, MN (Presenter) Research Grant, Siemens AG

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LEARNING OBJECTIVES
1. Describe the various methods used to acquire multi-energy CT data. 2. Differentiate between the methods used to present the information obtained with multi-energy CT. 3. Choose the most appropriate image rendition method for a specified clinical task.

Active Handout:Cynthia H. McCollough

RC321B  Applications

Participants
Sebastian T. Schindera, MD, Aarau, Switzerland (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Describe the various clinical applications of multi-energy CT. 2) Discuss the most important challenges of multi-energy CT in clinical routine. 3) Identify future opportunities of multi-energy CT.

RC321C  Future Prospects-Photon Counting

Participants
Taly G. Schmidt, PhD, Milwaukee, WI (Presenter) Research Grant, General Electric Company

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LEARNING OBJECTIVES
1) Understand the potential benefits and current status of photon-counting detection for Spectral CT. 2) Understand the challenges of photon-counting Spectral CT.
Case-based Review of Nuclear Medicine: PET/CT Workshop-Chest and Musculoskeletal PET/CT (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Nov. 27 10:30AM - 12:00PM Room: E450B

Participants
Samuel E. Almodovar-Reteguis, MD, Orlando, FL (Director) Nothing to Disclose
Katherine A. Zukotynski, MD, Ancaster, ON (Director) Nothing to Disclose
Delphine L. Chen, MD, Saint Louis, MO (Moderator) Nothing to Disclose

Sub-Events

**MSCC32A  Chest**

Participants
David M. Naeger, MD, San Francisco, CA (Presenter) Nothing to Disclose

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david.naeger@ucsf.edu

**LEARNING OBJECTIVES**

1) Describe the classic PET/CT appearance of various types of lung cancer. 2) Compare the imaging features that are similar between different types of lung cancer.

**ABSTRACT**

The classic PET/CT appearance of various types of lung cancers will be reviewed. Similarities and differences between different types of lung cancer will be presented in an effort to help attendees interpret thoracic imaging with more confidence and be more helpful in interdisciplinary settings.

**MSCC32B  Musculoskeletal**

Participants
Gary A. Ulaner, MD, PhD, New York, NY (Presenter) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd; Research support, Novartis AG

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ulanerg@mskcc.org

**LEARNING OBJECTIVES**

1) Demonstrate how to integrate the FDG PET and CT components of an FDG PET/CT exam to distinguish benign and malignant osseous lesions. 2) Identify common benign causes of FDG-avidity in the musculoskeletal system.
**Main Event**

**Tuesday Morning Plenary Session**

Tuesday, Nov. 27 10:30AM - 12:00PM Room: E451B

**RSNA/AAPM Symposium: State of the Art in CT Imaging**

**PS31A**

Participants
Vijay M. Rao, MD, Philadelphia, PA (Presenter) Nothing to Disclose
Bruce R. Thomadsen, PhD, Madison, WI (Introduction) Nothing to Disclose

**Sub-Events**

**PS31B**

CT Technology - and Dose - in the 21st Century

Participants
Paul E. Kinahan, PhD, Seattle, WA (Moderator) Research Grant, General Electric Company; Co-founder, PET/X LLC

**PS31C**

Contemporary CT of the Indeterminate Lung Nodule: Where We Are and Why it Matters

Participants
Denise R. Aberle, MD, Los Angeles, CA (Presenter) Consultant, Siemens AG

**LEARNING OBJECTIVES**

1) Identify key technological advances in x-ray computed tomography. 2) Describe new clinical applications that have been enabled by these technology advances. 3) List important technical advances that have facilitated CT dose reduction. 4) Appreciate the continued decline in CT doses since its inception. 5) Apply caution in reducing CT doses for low-contrast detection tasks.

**For information about this presentation, contact:**

McCollough.cynthia@mayo.edu

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**LEARNING OBJECTIVES**

1) To learn the current role of CT in lung cancer screening and early detection. 2) To examine current approaches to the classification of indeterminate lung nodules. 3) To understand the basis for using an atlas to standardize semantic features of lung nodules. 4) To appreciate the potential of semantic, quantitative, and machine learning approaches in nodule classification.
PURPOSE

The aim of this study was to investigate the prognostic value of coronary artery disease-reporting and data system (CAD-RADS) scores and determine the additional risk stratification benefit of CAD-RADS scores compared to coronary artery calcium score (CACS) and coronary artery disease (CAD) extent classifications in ischemic stroke patients without cardiac symptoms.

METHOD AND MATERIALS

From January 2013 to August 2014, 615 ischemic stroke patients who had at least one risk factor for CAD without chest pain underwent coronary computed tomography angiography (CCTA) and were included for final analysis. CT images were evaluated for CACS, extent of CAD and CAD-RADS scores. The primary endpoint was major adverse cardiovascular events (MACEs) defined as cardiovascular death, nonfatal myocardial infarction, unstable angina (UA) requiring hospitalization, revascularization and recurrent ischemic stroke event. Cox regression analyses were used to identify associations between CAD-RADS results and MACEs. C-statistics were calculated to compare discriminatory values of each model.

RESULTS

During the median follow-up period of 3.11 years, there were a total of 78 MACEs. Of 615 patients, 24.7% were classified as CAD-RADS 0, 19.3% as CAD-RADS 1, 17.6% as CAD-RADS 2, 18.5% as CAD-RADS 3, 15.6% as CAD-RADS 4A, 2.1% as CAD-RADS 4B, and 2.1% as CAD-RADS 5. CACS, CAD extent classification and CAD-RADS scores independently stratified risk of future MACEs (all p < 0.05). C-statistics revealed that both CAD extent classification and CAD-RADS scores improved risk stratification beyond CACS (C-index: 0.753 vs 0.698, p < 0.001 and 0.726 vs 0.698, p = 0.041, respectively).

CONCLUSION

In ischemic stroke patients without chest pain, CAD-RADS score had prognostic value for future MACE. In addition, CAD-RADS score provide additional risk-discrimination over CACS.

CLINICAL RELEVANCE/APPLICATION

CAD-RADS score provides additional risk-discrimination over CACS for the future major adverse cardiovascular events and can be recommended in the assessment of cardiovascular risk of stroke patient without chest pain.
Machine Learning Outperforms CAD-RADS in Finding Optimal Prognostic Plaque Characteristics on Coronary CT Angiograms

Tuesday, Nov. 27 10:40AM - 10:50AM Room: S104B

Participants
Kevin M. Johnson, MD, New Haven, CT (Presenter) Nothing to Disclose
Hilary E. Johnson, Madison, CT (Abstract Co-Author) Nothing to Disclose
Yang Zhao, New Haven, CT (Abstract Co-Author) Nothing to Disclose
David A. Dow, MD, Absecon, NJ (Abstract Co-Author) Nothing to Disclose
Lawrence H. Staib, PhD, New Haven, CT (Abstract Co-Author) Nothing to Disclose

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PURPOSE
To use machine learning to find an optimal combination of coronary artery imaging features on CT angiography for the prediction of all cause mortality and coronary deaths, myocardial infarction and revascularization

METHOD AND MATERIALS
CT angiography was performed and risk factor data collected. Arteries were scored using CAD-RADS and 4 other published methods and compared to a score derived using machine learning. Causes of death were determined using the National Death Index. Myocardial infarction and revascularizations were discovered by follow-up letters. Prognostic results were compared using the area under the receiver operating characteristic curves.

RESULTS
7117 patients were imaged and followed for a mean of 9.0 years. There were 414 deaths from all causes, 79 attributed to coronary artery disease as the underlying or contributing cause, 51 myocardial infarctions (MI) and 231 revascularizations. The two best machine learning models were linear discriminant with diagonal covariance matrix and a classification neural network. Respective areas under the ROC curve were 0.76 and 0.77 for all cause mortality, 0.82 and 0.82 for coronary deaths or MI, and 0.87 and 0.88 for CHD or MI or revascularization. The corresponding CAD-RADS results were 0.71, 0.79 and 0.86.

CONCLUSION
Machine learning outperformed CAD-RADS for prediction of death and coronary events.

Development of a Deep Learning Algorithm for Predicting the Coronary Artery Calcium Score Using Retinal Images

Tuesday, Nov. 27 10:50AM - 11:00AM Room: S104B

Participants
Tyler Hyungtaek Rim, Seoul, Korea, Republic Of (Abstract Co-Author) Stockholder, Medi-whale Inc
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Seongjung Kim, Seoul, Korea, Republic Of (Abstract Co-Author) Stockholder, Mediwhale
Yoon Seong Choi, MD, Seoul, Korea, Republic Of (Presenter) Spouse, Stockholder, Medi Whale

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PURPOSE
To determine if deep learning networks could be trained to estimate coronary artery calcium score (CACS) in heart CT scan from retinal images.

METHOD AND MATERIALS
All patients who obtained both ophthalmic examination and heart CT angiography at the tertiary center. Automated extraction of an OCT and retinal images was performed and linked to clinical end points from the electronic medical records. A deep neural network was trained to categorize images as either CACS<=10 (normal) or CACS>=100 (abnormal). We used the Modified VGG 11 model. We inserted one global average pooling layer instead of 2 fully-connected layers. To avoid overfitting, we had the data augmentation. At the SoftMax layer, the image that passed over the network was shown normal or abnormal binary probability value. Accuracy and Area under the receiver operating characteristic was estimated.

RESULTS
A total of 23,177 retinal images based on 15,056 examinations from 2,419 patients, who have received heart CT angiography including CACS, were extracted. At the examination level, we achieved an area under the ROC curve of 78.43% with an accuracy of 70%. At a patient level, we achieved an area under the ROC curve of 85.53% with an accuracy of 77.9%.

CONCLUSION
Using the non-invasive retinal examination including fundus photographs and OCT, deep learning networks show an impressive ability to predict the CACS, which is one of most important marker of heart disease.

CLINICAL RELEVANCE/APPLICATION
Deep-learning based screening of fundus photographs and OCT may have potential for a surrogate marker without radiation
exposure for high-risk patients with high coronary artery calcium score.

SSG02-04  Coronary Calcium Content Extracted by Machine Learning Methods from Incidental CT Scans Improves Coronary Heart Disease Prediction Accuracy

Tuesday, Nov. 27 11:00AM - 11:10AM Room: S104B

Participants
Noam Barda, Tel Aviv, Israel (Presenter) Nothing to Disclose
Eldad Elnekave, MD, Shefayim, Israel (Abstract Co-Author) Employee, Zebra Medical Vision Ltd
Noa Dagan, MD, MPH, Tel Aviv, Israel (Abstract Co-Author) Nothing to Disclose
Orna Bregman-Amirai, BSC, Shefayim, Israel (Abstract Co-Author) Employee, Zebra Medical Vision Ltd
Ran Balicer, MD, PhD, Tel Aviv, Israel (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Despite significant reductions in the last few decades, coronary heart disease (CHD) remains a significant cause of mortality. Many risk factors for CHD can be mitigated by lifestyle changes and pharmacological interventions, making risk calculation for individuals an important part of prevention. Accordingly, quantification of risk is integrated into prevailing management guidelines. Determination of coronary calcium content has been shown to allow improvement in risk calculation, but requires specialized tests that are not often performed. We present a novel algorithmic method that allows for the extraction of coronary calcium scores from incidental chest CTs performed for other indications, and demonstrate its utility in improving prediction accuracy over the American Heart Association (AHA) 2013 pooled risk model in a retrospective cohort study.

METHOD AND MATERIALS
There were 14,866 patients aged 30-74 with no prior CHD diagnosis included. CT scans and different covariates for the model were extracted in the two years prior to the index date (1 June 2012). Patients were followed-up for five years. Prediction performance results were compared between the AHA 2013 model (base model) and the same model with the novel coronary calcium score inserted as an additional predictor (augmented model). Both were logistic regression models and were trained on the sample population to allow comparison. For measures requiring a threshold, 3.5% risk over 5 years was chosen.

RESULTS
Based on the likelihood ratio test, the augmented model was superior to the base model (p-value <0.001). Similarly, the augmented model achieved superior performance for all performance measures: sensitivity increased 0.85%, specificity increased 4.9%, area under the ROC curve increased by 2.2% and there was a 4.5% categorical net reclassification improvement.

CONCLUSION
In this study, use of a novel biomarker extracted using a machine learning algorithm from incidental CT scans improves predictive accuracy compared to the commonly used model. This improvement occurs both in theoretical and practical measurements of model utility; in actual use it would translate into better clinical decisions.

CLINICAL RELEVANCE/APPLICATION
Coronary calcium content extracted via novel machine learning methods from incidental CTs significantly improves coronary heart disease prediction.

SSG02-05  Radiomics of Coronary Artery Calcium in the Framingham Heart Study

Tuesday, Nov. 27 11:10AM - 11:20AM Room: S104B

Awards
Student Travel Stipend Award

Participants
Parastou Eslami, PhD, Boston, MA (Presenter) Nothing to Disclose
Chintan Parmar, Boston, MA (Abstract Co-Author) Nothing to Disclose
Borek Foldyna, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
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Roman Zelezniak, Boston, MA (Abstract Co-Author) Nothing to Disclose
Michael T. Lu, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Maros Ferencik, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Vasan Ramachandran, Boston, MA (Abstract Co-Author) Nothing to Disclose
Kristin Baltusaitis, Boston, MA (Abstract Co-Author) Nothing to Disclose
Joseph M. Massaro, PhD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Ralph D'Agostino, PhD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Christopher J. O'Donnell, MD, MPH, West Roxbury, MA (Abstract Co-Author) Nothing to Disclose
Hugo Aerts, PhD, Boston, MA (Abstract Co-Author) Stockholder, Sphera Inc
Udo Hoffmann, MD, Boston, MA (Abstract Co-Author) Institutional Research Grant, Kowa Company, Ltd; Institutional Research Grant, Abbott Laboratories; Institutional Research Grant, HeartFlow, Inc; Institutional Research Grant, AstraZeneca PLC

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PURPOSE
To assess whether detailed coronary artery calcium (CAC) characterization based on radiomic feature extraction followed by machine learning improves prediction of cardiovascular (CV) events.
METHOD AND MATERIALS

Participants from the Offspring and third Generation cohorts of the community-based Framingham Heart Study who underwent chest CT between 2002 and 2005 were followed over a median of 9.1 years for cardiovascular events (CV events) (myocardial infarction, stroke, or death). Of those, 624 participants who had excellent image quality and CAC (Agatston score (AS)>0) were randomly divided into discovery (n=318) and validation cohorts (n=306). CAC was segmented manually using 3DSlicer, and about 2000 radiomic features (based on intensity, shape, and texture of CAC) were extracted using pyRadiomics software. In the derivation cohort, we used an internal minimum redundancy maximum relevance algorithm (without knowledge of events) to identify the 20 highest ranked features. Finally, a random forest classifier was used to optimize decision trees for prediction for CV events. The weighted predictive probability of events for each of the 20 features was summarized into a radiomic score. The performance of this score was tested independent in the validation cohort.

RESULTS

The discovery (66.1% men, 58.1±11.1 age) and validation cohorts (61.4% men, 59.3±11.2 age) had similar CV risk profile, median AS, and CV event rates (30/318=9.7% and 29/306=9.5%, respectively). In adjusted multivariate analysis (for Framingham risk factors and AS), participants in the validation cohort, who had radiomic scores in the mid and upper tertiles had significantly higher risk for events as compared to the lower tertile (mid: HR=9.3, p=0.03, upper: HR=16.5, p=0.007). The area under the curve (AUC) was higher for AS, radiomic score (RS), and combined AS/RS were 0.73, 0.76 and 0.79; respectively in the overall population. Performance was best in the subgroup with AS <300 (n=250, Figure).

CONCLUSION

This proof-of-concept study demonstrates that detailed CAC characterization based on radiomic feature extraction predicts CV events independent of traditional risk factors and AS. Further validation is necessary to determine clinical impact.

CLINICAL RELEVANCE/APPLICATION

Artificial intelligence may identify a prognostically important radiomic signature of CAC.

HONORED EDUCATORS

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Udo Hoffmann, MD - 2015 Honored Educator

SSG02-06 Identification of Invasive and Radionuclide Imaging Markers of Plaque Vulnerability Using Computed Tomography Radiomics

Tuesday, Nov. 27 11:20AM - 11:30AM Room: S104B

Participants

Marton Kolossvary, MD, Budapest, Hungary (Presenter) Creator and Developer - Radiomics Image Analysis
Jonghanne Park, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Ji-In Bang, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jinlin Zhang, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Joo Myung Lee, MD,PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jin Chul Paeng, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Bela Merkely, MD,PhD, Budapest, Hungary (Abstract Co-Author) Speakers Bureau, Medtronic plc
Jagat Narula, MD, PhD, Orange, CA (Abstract Co-Author) Nothing to Disclose
Takashi Akasaka, MD,PhD, Wakayama, Japan (Abstract Co-Author) Nothing to Disclose
Bon-Kwon Koo, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Pal Maurovich-Horvat, MD, PhD, Pecs, Hungary (Abstract Co-Author) Nothing to Disclose

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PURPOSE

Several invasive and radionuclide imaging markers of coronary plaque vulnerability have been described. Identification of these imaging biomarkers by a single, widely available non-invasive technique may provide an opportunity to identify vulnerable plaques and vulnerable patients in daily clinical practice. Therefore, our aim was to assess the diagnostic accuracy of coronary computed tomography angiography (CTA) derived radiomic features to identify attenuated plaque using intravascular ultrasound (IVUS), thin-cap fibroatheroma per optical coherence tomography and radionuclide uptake using sodium fluoride positron emission tomography morphologic (NaF18-PET) as compared to conventional qualitative and quantitative CT metrics.

METHOD AND MATERIALS

We analyzed 44 plaques in 25 patients using IVUS, OCT, NaF18-PET and coronary CTA. We assessed 7 conventional qualitative and quantitative plaque characteristics and calculated 935 radiomic parameters. We calculated receiver operating characteristics area under the curve (AUC) values using a 5-fold cross validation with 1000 repeats to assess diagnostic accuracy. We used the Kolmogorov-Smirnov test to compare the distribution of AUC values resulting from the cross-validations.

RESULTS

Radiomics outperformed conventional metrics to identify attenuated plaque per intravascular ultrasound, thin-cap fibroatheroma by optical coherence tomography and metabolically active plaques per sodium fluoride positron emission tomography in CT images (AUC: 0.72 vs 0.59; 0.80 vs 0.66; 0.87 vs 0.65; p<0.001 all; respectively).

CONCLUSION

Computed tomography radiomics may allow the non-invasive identification of invasive and radionuclide imaging biomarkers.
Radiomics is able to identify morphologic and metabolic high-risk plaque features currently only identifiable using invasive and radionuclide imaging, which are both important components of plaque instability.

**SSG02-07  Epicardial Fat is Increased in the HIV Population and Associated to Coronary Artery Plaque Burden**

Tuesday, Nov. 27 11:30AM - 11:40AM Room: S104B

**Participants**
Manel Sadouni, MD, Montreal, QC (Presenter) Nothing to Disclose
Madeleine Durand, MD,MSc, Montreal, QC (Abstract Co-Author) Nothing to Disclose
Irina Boldeanu, Montreal, QC (Abstract Co-Author) Nothing to Disclose
Samer Mansour, Montreal, QC (Abstract Co-Author) Research Grant, Abbott Laboratories
Cecile Tremblay, MD, Montreal, QC (Abstract Co-Author) Nothing to Disclose
Carl Chartrand-Lefebvre, MD,MSc, Montreal, QC (Abstract Co-Author) Equipment support, Koninklijke Philips NV; Equipment support, Bayer AG; Research Grant, Bracco Group; Research collaboration, TeraRecon, Inc; Research collaboration, Siemens AG

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**PURPOSE**
HIV patients are exposed to a higher risk of coronary artery disease (CAD) compared to non-infected patients. The exact mechanism responsible for this increased risk is not well understood. HIV individuals are also exposed to changes in body fat distribution characterized by greater ectopic fat. These changes may play a role in promoting atherosclerosis. Epicardial fat, which is the ectopic fat related to the heart, may play a unique role because of its location near to the coronary arteries. We hypothesize that epicardial fat volume is increased in the HIV patients and correlates with total coronary plaque volume, and with low attenuation plaque volume, which is a marker of plaque vulnerability.

**METHOD AND MATERIALS**
This is a cross sectional study, nested in the Canadian HIV and Aging Cohort Study (CHACS), a large prospective cohort following more than 800 HIV+ and HIV- patients. Consecutive CHACS participants with low to intermediate cardiovascular risk without symptoms or past CAD were invited to undergo cardiac computed tomography (CT) and coronary plaque imaging with CT angiography. Volume measurement of epicardial fat, total atherosclerotic plaque and low-attenuation plaque were performed. Association between epicardial fat volume, coronary plaque volume and low attenuation plaque volume was assessed using multivariate linear regression.

**RESULTS**
A total of 246 participants underwent cardiac CT scans. 173 were HIV+ and 73 were HIV-. HIV+ patients had greater epicardial fat volume indexed to body mass index (BMI) than HIV- patients (p = 0.03). In the HIV infected group, epicardial fat volume was associated with duration of antiretroviral therapy use (β = 1.45, p = 0.004). After adjustment for traditional cardiovascular risk factors, BMI and waist circumference, epicardial fat volume was significantly associated with total plaque volume (β = 1.99, p = 0.04) and low attenuation plaque volume (β = 0.86, p = 0.01).

**CONCLUSION**
Epicardial fat volume is increased in the HIV participants. The association of epicardial fat volume with antiretroviral therapy duration and subclinical coronary artery plaque may suggest a potential mechanism that could explain the increased risk for CAD in the HIV population.

**CLINICAL RELEVANCE/APPLICATION**
Epicardial fat is increased in HIV patients and correlates with total coronary plaque volume and low attenuation plaque volume, a CT marker of plaque vulnerability.

**SSG02-08  Subclinical Coronary Atherosclerosis among Individuals with HIV on Antiretroviral Therapy**

Tuesday, Nov. 27 11:40AM - 11:50AM Room: S104B

**Participants**
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**PURPOSE**
To compare coronary plaque burden and characteristics between HIV-infected and non-HIV-infected participants

**METHOD AND MATERIALS**
This cross-sectional study nested in a large prospective cohort was approved by the local Institutional Review Board. All subjects provided written consent. Consecutive HIV+ and HIV- participants were prospectively recruited for cardiac computed tomography (CT). Eligibility criteria were males/females, no known coronary artery disease, low/intermediate 10-yr Framingham risk score (FRS, 5-20%), no CT contraindication. Coronary calcium scoring was done with non-contrast CT, and contrast-enhanced CT for plaque (calcified vs noncalcified, volume) and lumen assessment. Imaging assessors were blinded to HIV status. Analyses used multivariate multiple linear and logistic regression models.
RESULTS

A total of 246 participants (173 HIV+ (93% males), 73 HIV- (81 % males)) were included, with similar age (mean 55 yo, p=0.69) and FRS (median 11 %, p=0.53). Diabetes (10% vs 1.4 %, p=0.01) and smoking (28% vs 14 %, p=0.02) were more frequent in HIV+ than HIV- participants, and elevated LDL cholesterol less frequent in HIV+ participants (20% vs 32%, p=0.07). Median duration of HIV infection in HIV+ participants was 18 yrs. All were on antiretroviral therapy (median 15 yrs). After adjusting for diabetes, smoking and LDL cholesterol, prevalence and plaque extent was similar between HIV+ and HIV- participants (72 % vs 69 %, p= 0.37; 2.9 ± 3.0 vs 2.7 ± 3.8 plaques/participant, p = 0.53). HIV+ participants showed more frequent noncalcified and less frequent calcified plaques than HIV- participants (0.3 ± 0.7 vs 0.1 ± 0.5, p=0.01; 1.4 ± 2.4 vs 2.0 ± 2.0 plaques/participants, p=0.006). Number of mixed plaques (1.0 ± 1.4 vs 0.6 ± 1.4 plaques/participant, p = 0.27), mean calcium score (148 vs 141, p=0.81), plaque volume (273 vs 218 mm3, p=0.91) and prevalence of >= 70% stenosis (10% vs 6%, p=0.40) were similar between HIV+ and HIV- participants.

CONCLUSION

Noncalcified plaques are more frequent in asymptomatic HIV+ individuals under antiretroviral therapy, while calcified plaques are less frequent, in comparison to HIV- individuals, after adjustment of cardiovascular risk factors.

CLINICAL RELEVANCE/APPLICATION

Noncalcified plaques are usually considered more vulnerable plaques. Our findings suggest one anatomic substrate that could explain the increased risk of myocardial infarction in the HIV population.
SSG03-01  Deep Learning-Based Computer-Aided Detection System for Multiclass Multiple Lesions on Chest Radiographs: Observers' Performance Study

Tuesday, Nov. 27 10:30AM - 10:40AM Room: S504AB

Awards
Student Travel Stipend Award

Participants
Sudhakar N. Pipavath, MD, Mercer Island, WA (Moderator) Adjudicator, Gilead Sciences, Inc
Mark L. Schiebler, MD, Madison, WI (Moderator) Stockholder, Stemina Biomarker Discovery, Inc; Stockholder, HealthMyne, Inc;

Sub-Events
SSG03-01  Deep Learning-Based Computer-Aided Detection System for Multiclass Multiple Lesions on Chest Radiographs: Observers' Performance Study

Tuesday, Nov. 27 10:30AM - 10:40AM Room: S504AB

Purpose
To evaluate the added value of a deep-learning based computer-aided detection (CAD) system for multiclass multiple lesions on radiographs when radiologists read chest radiographs.

Method and Materials
We developed new CAD system using deep learning for detecting multiple lesions with 4 different patterns (nodule/mass, interstitial opacity, pleural effusion, and pneumothorax) on chest radiograph. To train the deep learning network, 17917 images were collected in two tertiary hospitals. Numbers of normal and abnormal patients are 11000 and 6917, respectively. We labeled disease type and delineate region of interests (ROI) drawn as ground truths by two thoracic radiologists with consensus. To validate the effect of the developed CAD on observer's performance, 9 observers including 7 board-certified radiologists and two radiology residents reviewed 200 chest radiographs twice with two weeks interval. 200 chest radiographs consists of 100 normal and 100 abnormal (nodule/mass: 60, interstitial opacity: 10, pleural effusion: 10, pneumothorax: 10) chest radiographs. The diagnostic performance of the developed CAD, observers with and without CAD were evaluated and compared using jackknife free-response receiver operating characteristic (JAFROC) figure of merits (FOMs) on a per-lesion basis. The reading time for review was recorded.

Results
The developed CAD showed FOMs of 0.931 for nodule/mass, 0.900 for interstitial opacity, 1 for pleural effusion, and 1 for pneumothorax. The mean FOMs of 9 observers without CAD were 0.916 for nodule/mass, 0.922 for interstitial opacity, 0.944 for pleural effusion, and 0.978 for pneumothorax. After applying the CAD, the mean FOMs of 9 observers were 0.942 for nodule/mass, 0.900 for interstitial opacity, 0.967 for pleural effusion, and 1 for pneumothorax. Except for interstitial opacity, the accuracy of three patterns with CAD increased. The mean reading time was 91.5 minutes ± 53.2 without CAD and 79.1 minutes ± 28.2 with CAD.

Conclusion
The deep-learning based CAD may help improve observer performance for reading chest radiograph as well as reducing reading time.

Clinical Relevance/Application
The deep-learning based CAD has the potential to improve observer efficiency in terms of accuracy and reading and may provide preliminary interpretation for chest radiographs.

SSG03-02  A Retrospective, Multi-Center Clinical Study for Validating Increased Lesion Detection Accuracy of Radiologists When Using Computer-Aided Detection System in Reading Digital Chest X-Ray Images

Tuesday, Nov. 27 10:30AM - 12:00PM Room: S504AB
To assess the impact of automated segmentation of pulmonary nodules by measuring the accuracy of the prediction of malignancy.

**METHOD AND MATERIALS**

Each of four participating centers in three countries retrospectively collected 150 lung cancer radiographs and 50 normal radiographs. Normal x-ray images are from healthy adults, confirmed by a CT scan taken within 14 days. Each cancer x-ray image has 1 to 3 pathologically confirmed nodule(s), whose sizes are between 1 and 3 centimeters. The estimated location of each nodule was marked on x-ray image referring to the CT scan. 12 radiologists from 4 institutions with various experiences independently analyzed a set of x-ray images and marked region of interests (ROIs) on each radiograph in suspicion of a nodule. Deep learning-based computer-aided detection (CAD) software was applied to find suspicious nodules on chest radiographs. Finally, 12 radiologists reviewed whole set of images with assistance of CAD, accepting or dismissing ROIs suggested by CAD. Sensitivity and false negative per image (FPPI) of radiologist alone, CAD alone and radiologist with CAD were statistically analyzed.

**RESULTS**

The overall sensitivity and FPPI of the CAD system were 63.75% and 0.20, which was not statistically distinct from those of radiologists. The average sensitivity of radiologists appeared to increase significantly from 65.1% to 70.3%, after aided by the CAD software (p<0.0001). The average FPPI was 0.2 and 0.18, without and with CAD, respectively. The decline of FPPI was significant (p=0.0006). On subgroup analysis, incremental effects of CAD on nodule detection sensitivity were not affected by radiologists’ experience, size, location, type (primary or metastatic) of nodules and modality of acquisition.

**CONCLUSION**

The average sensitivity and FPPI of our CAD system were not statically different from those of radiologists. When radiologists were assisted by the CAD, overall sensitivity increased significantly while FPPI seemed to decrease. Incremental effect of the CAD system was not affected by radiologist's experience, characteristics of a nodule or modality, which can support the potential general use of this software.

**CLINICAL RELEVANCE/APPLICATION**

Radiologists' performance in lung cancer nodule detection can be improved with a deep learning-based computer-aided detection (CAD) software, compared with performance of radiologist or CAD alone.
using the Brock University Cancer Prediction Model.

METHOD AND MATERIALS

Retrospective analysis was carried out of 7927 nodules (of which 314 were malignant) from 5394 patients who were scanned as part of the US NLST (mean age 62±5 years; of which 3192 were male). Following BTS guidelines, nodules <5mm in size were excluded, but all other nodules were included regardless of type, attenuation, and margin. Automatic 3D nodule segmentations were generated via a deep learned model and initiated with a single click point inside the nodule. We used the following methods for measuring nodule size: the NSLT radiologist measurements, D2D, the long axis from the automatic segmentations, D3D, and in order to characterize the nodule volumes more accurately, the volumes of the automatic segmentations, V, were converted to an equivalent linear size using the equation for a sphere. Each was tested as the size term in the standard Brock model to generate a malignancy risk and Area-Under-the-Receiver-Operating-Characteristics (AUC-ROC) curve calculated.

RESULTS

The AUC-ROC was 85.96% (95% confidence interval (CI): 84.33, 87.76) for D2D, 86.64 (95% CI: 85.04, 88.19) for D3D, and 88.17 (95% CI: 86.71, 89.82) for Dsph. The expected increase in AUC Dsph offers over D2D is 2.21 (95% CI: 1.28, 3.12).

CONCLUSION

The automatic nodule size measurements outperformed the manual radiologist measurements in predicting lung cancer as an input to the Brock model. The non-axial Dsph, which is derived from the volumetric segmentation outperforms both long axis-based methods. Assessing nodule segmentation by measuring prediction efficacy is a viable alternative to overlap measures such as DICE.

CLINICAL RELEVANCE/APPLICATION

Automatic segmentation removes the need for manual extraction of axial diameters of lung nodules. It is not subject to intra- and inter-radiologist variation thereby improving consistency.

SSG03-04 Effect of Artificial Intelligence Based Vessel Suppression and Automatic Detection of Part-Solid and Ground-Glass Nodules on Low-Dose Chest CT

Tuesday, Nov. 27 11:00AM - 11:10AM Room: S504AB

Awards

Student Travel Stipend Award

Participants

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PURPOSE

Most studies with CAD and artificial intelligence (AI) software have focused on solid lung nodules. We assessed the effect of AI-based vessel suppression (AI-VS) and automatic detection (AI-AD) on ground glass (GGN) and part-solid lung nodules (PSN) in low-dose CT (LDCT).

METHOD AND MATERIALS

Our study included 100 LDCT examinations with mixed attenuation pulmonary nodules (average diameter>5mm) identified from the National Lung Cancer Screening Trial (NLST). These exams were not used in training or validation of the AI software (ClearRead CT, Riverain Inc.). All 100 LDCT were processed to generate three image series per case - unprocessed, AI-VS, and AI-AD series with annotated lung nodules. Two thoracic radiologists (R1: 3-year experience, R2: 27-year experience) independently assessed the unprocessed images alone, then together with AI-VS series, and finally with AI-AD. For each assessment, number of all >5mm with location & size of dominant GGN and PSN were recorded. Descriptive statistics and student t tests were performed for data analysis.

RESULTS

On unprocessed images, R1 and R2 detected 278 nodules (123 PSN, 155 GGN) and 269 (117 PSN, 152 GGN), respectively (p>0.05). With addition of AI-VS images, R1 and R2 detected 299 nodules (126 PSN, 164 SSN) and 293 (132 PSN, 161 GGN), respectively, which were significantly greater than those detected without the AI-VS (p= 0.004). AI-VS aided in detection of solid component in 22 PSN which were deemed SSN by both readers. Conversely, AI-AD annotated only 75 PSN and 54 GGN (total 129 nodules). In 21 patients, AI-AD did not detect the dominant PSN or SSN; it detected 14 false positive nodules (vessels, atelectasis, anterior junctional line). Average respective sizes of 69-matched and detected PSN on unprocessed and AI-AD series were 15 ±7 mm and 13 ± 6 mm (p =0.07).

CONCLUSION

AI-VS improves detection and characterization of GGN and PSN on LDCT of the chest. Specifically, improved and easier detection of the solid component in non-solid nodules with AI-VS can avoid false down-grading of Lung-RADS category, and thus help in appropriate patient management.

CLINICAL RELEVANCE/APPLICATION

AI software can aid in improved detection and confident detection of ground-glass and part-solid lung nodules on low dose chest CT.

Honored Educators
**SSG03-05  Evaluation of Lung Nodules with FDG PET-CT: The Value of MIP Reconstructions in Conventional Thoracic CT Images During Shallow Breathing versus Images in Deep Inspiration**

Tuesday, Nov. 27 11:10AM - 11:20AM Room: S504AB

**Participants**
Montserrat Alemany, Uppsala, Sweden (Presenter) Nothing to Disclose
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**PURPOSE**
Detection of small lung nodules is important for appropriate staging of cancer. There is controversy in literature about the value of adding a separate CT of the lungs in deep inspiration. Radiation dose is no longer an issue with the use of modern equipment because only approximately 3 mSv are added to the usual dose. The purpose of this study was to assess the value of additional thoracic CT in deep inspiration and the use of maximum intensity projection (MIP) reconstructions in PET-CT of oncologic patients.

**METHOD AND MATERIALS**
186 consecutive patients (99 male and 89 female; mean age, 72 years; range: 26-93 y) underwent FDG PET-CT for one of the following indications: characterization of a new detected lung nodule/mass (n=101), staging of cancer (n=31), therapy response monitoring (n=33), suspicion of tumor relapse (n=19) and cancer of unknown origin (n=2). After PET-CT acquisition with shallow breathing, a thoracic CT in deep inspiration was performed to all patients (slide thickness: 1.25 mm). MIP of the two sets of lung images were performed. Two experienced radiologist analyzed the 4 sets of CT studies. The number of lung nodules was recorded. Lung nodule was defined as a rounded opacity smaller than 10 mm completely surrounded by lung parenchyma. The clinical relevance of the eventual discrepancies between CT studies was analyzed (i.e. upstaging).

**RESULTS**
120/186 patients presented with nodules. PET-CT with shallow breathing detected 393 nodules, and 578 when MIP images were analyzed. Thoracic CT with deep inspiration found 534 nodules and 905 when MIP was used. The number of detected nodules increased from free breathing to breathe hold CT in 42 patients. The detected number of nodules with breath hold technique compared with free breathing increased increased in 51 patients when MIP was used. The extradetected nodules were considered clinical relevant in 7/120 (6%) of patients because they influence patient management for example by increasing TNM staging.

**CONCLUSION**
According to our results the addition of deep inspiration thoracic CT with MIP reconstructions can be recommended in clinical practice because this approach yields better performance in TNM staging in oncologic patients.

**CLINICAL RELEVANCE/APPLICATION**
Addition of deep inspiration CT with MIP reconstructions to conventional FDG PET-CT in oncologic patients yields better performance in TNM staging.

**SSG03-06  Deep Learning for Rule-Out of Unnecessary Follow-Up in Patients with Incidentally Detected, Indeterminate Pulmonary Nodules: Results on an Independent Dataset**

Tuesday, Nov. 27 11:20AM - 11:30AM Room: S504AB

**Participants**
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**PURPOSE**
To assess the follow-up rule-out accuracy of a convolutional neural network (CNN) in patients with incidentally detected, indeterminate pulmonary nodules in a multi-site, heterogeneous population.
METHOD AND MATERIALS

The US National Lung Screening Trial (NLST) dataset was manually curated and used to create a training set: each reported nodule and cancer was located, contoured and diagnostically characterised (9310 benign nodule patients; 1058 cancer patients). All patients with solid and semi-solid nodules of 6mm and above, where benign nodules and cancers could be confidently identified by clinicians (5972 patients, of which 575 were cancer patients), were selected. A CNN was trained using Deep Learning and three thresholds for benign rule-out were calculated at three levels of sensitivity: 100%, 99.5% and 99%. An independent dataset of patients with incidentally detected indeterminate pulmonary nodules was retrospectively collected from a tertiary referral centre and surrounding hospitals in the UK with a heterogeneous mix of scan parameters, manufacturers and clinical indications (610 patients, 698 nodules, 5-15mm). Diagnosis was established according to British Thoracic Society guidelines (2015). The dataset contained 50 cancers from 47 patients (7% of all nodules). Performance was evaluated by measuring the specificity at the three benign rule-out thresholds; i.e. to measure the proportion of benign nodules correctly stratified while missing no or few cancers. Overall Area-Under-the-ROC-Curve analysis (AUC) was also calculated.

RESULTS

The specificity (sensitivity) was 24% (100%), 24% (100%) and 48.6% (100%) at the three thresholds respectively. AUC was 0.93 (95%CI = 0.90-0.96).

CONCLUSION

On this independent dataset, the CNN was able to correctly classify just under half of the benign nodules whilst not misclassifying any cancers.

CLINICAL RELEVANCE/APPLICATION

Our work shows the potential of CNNs in ruling out benign pulmonary nodules and therefore reducing the need for follow up scans in a large number of patients.

SSG03-07  A Decision Analysis of Follow-Up and Treatment Algorithms for Subsolid Pulmonary Nodules

Tuesday, Nov. 27 11:30AM - 11:40AM Room: S504AB

Participants
Mark M. Hammer, MD, Saint Louis, MO (Presenter) Nothing to Disclose
Lauren Palazzo, Boston, MA (Abstract Co-Author) Nothing to Disclose
Andrew Eckel, Boston, MA (Abstract Co-Author) Nothing to Disclose
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PURPOSE

To use simulation modeling based on evidence from the literature to evaluate several management strategies and treatment options for patients with ground glass nodules (GGNs).

METHOD AND MATERIALS

We developed a Monte Carlo model for patients with GGNs as they underwent follow-up per Lung-RADS for up to ten years. Nodules could grow and develop solid components over time. Rates of clinically-significant malignancy were calibrated to data from the National Lung Cancer Screening Trial. We investigated modifications to the follow-up schedule and tested different treatment strategies, specifically lobectomy, radiation therapy, and no therapy.

RESULTS

Overall, 2.3% of nodules represented clinically significant malignancies, and 6.3% of nodules were treated. Only 29.8% of Lung-RADS 4B/4X nodules were clinically-significant malignancies. We compared outcomes of patients with Lung-RADS 2 nodules followed at 1-, 2-, and 3-year intervals; overall survival at 10 years of follow-up was similar, ranging from 74.7% (annual) to 73.5% (triennial). We also evaluated 10-year outcomes from Lung-RADS 4B/4X non-solid nodules treated with different modalities; at 10 years, overall survival was highest in the radiation therapy arm, at 83.9%, and lowest in the no treatment arm, at 78.1%.

CONCLUSION

Our results suggest a conservative approach to the follow-up and treatment of GGNs. The follow-up interval for GGNs can be increased to 3 years with minimal change in outcomes. Our results also favor the use of radiation therapy when a nodule has met criteria for treatment. Prospective randomized trials are needed to evaluate thresholds for management and different treatment modalities for GGNs.

CLINICAL RELEVANCE/APPLICATION

Conservative management strategies for non-solid nodules, such as triennial follow-up for Lung-RADS 2 nodules and radiation therapy instead of lobectomy for Lung-RADS 4B/4X nodules, are preferable to more aggressive treatment.

SSG03-08  A Robust Model for Prediction of Pulmonary Nodule Malignancy with CT Scans

Tuesday, Nov. 27 11:40AM - 11:50AM Room: S504AB

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Yufeng Deng, PhD, Durham, NC (Presenter) Employee, Infervision Inc
Pulmonary nodules could be early manifestations of lung cancer, but the morphological complexity makes it difficult to differentiate benign and malignant nodules. This paper proposes two deep learning models aiming to accurately determine the malignancy of pulmonary nodules from CT images.

**RESULTS**

On Dataset 1 (LIDC-IDRI), Model-1 achieved an AUC of 0.91 in the prediction of pulmonary nodule malignancy while Model-2 achieved an AUC of 0.96. On Dataset 2, Model-1 again reached a high AUC of 0.90, which significantly outperformed the Model-2 with AUC=0.80.

**CONCLUSION**

Model-1 showed consistently high accuracy in pulmonary nodule malignancy prediction on both the LIDC dataset and CT scans collected from collaborating hospitals. Our two models achieved comparable results with NoduleX model which had got the state-of-the-art performance in LIDC dataset. The experimental results demonstrated that Model-1 showed more stable performance across datasets and had better model robustness. The strength of Model-1 may lie in its Capsule Network structure that could extract more universally informative features and the end-to-end deep learning architecture.

**CLINICAL RELEVANCE/APPLICATION**

Our proposed model can serve as a useful tool for early diagnosis of lung cancer and has the potential to be applied in clinical treatment planning.

**METHOD AND MATERIALS**

Model-1 was adapted from the winning model in Data Science Bowl 2017.. We chose ResNet as its backbone and integrated U-Net and Capsule Network architectures to enable the model to comprehensively capture multiscale features of pulmonary nodules. Model-2 took extracted features from Model-1 as input to a random forest classifier to further predict nodule malignancy, as inspired from the NoduleX model. Two datasets were adopted to validate the performance of the proposed two models. Dataset 1 contains 1061 samples (benign/malignant: 703/353) from Lung Image Database Consortium and Image Database Resource Initiative (LIDC-IDRI), and Dataset 2 consists of 1117 samples (benign/malignant: 354/763) provided by collaborating hospitals. Nodules in both datasets were biopsy or surgery proven, and pathology diagnoses were used as gold standard. We randomly selected 20% from each dataset as the testing set and used the rest 80% as the training set. We trained and tested our two models on the above two datasets respectively.

**RESULTS**

While the AUC of the model was good 0.905 [0.882-0.928]), the histogram plot showed that whether a nodule was cancer/not cancer could not be well-separate (see Figure, left). The calibration plot showed that the model tended to overestimate the probability of cancer. Following methods in Steyerberg et al (doi: 10.1002/sim.1844), the updated model achieved an AUC of 0.914 [0.892-0.936] and a better calibration (see Figure, right). Emphysema (p=0.03) and nodule spiculation (p<0.01) had a significantly different effect in the NLST cohort compared to the PanCan. Among the new covariates, only the pack-year history was found to be significant (p<0.01).
External validation is necessary to assess generalizability of a prediction model to new patients. We show how discrimination and calibration can be examined to assess how models can likely enter in clinical practice.
Spectrum of Diagnostic Errors in Cervical Spine Trauma Imaging and Their Clinical Significance

Participants:
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Sub-Events:
SSG04-01 Spectrum of Diagnostic Errors in Cervical Spine Trauma Imaging and Their Clinical Significance

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PURPOSE
The purpose of our study was to describe and categorize diagnostic errors in cervical spine CT interpretation (CsCT) performed for trauma and to assess their clinical significance.

METHOD AND MATERIALS
All CsCT studies with diagnostic errors that came to our attention based on clinical or imaging follow up from 2004 to 2017 were analyzed. Errors were categorized as extraspinal or spinal, osseous or soft tissue finding, according to anatomical site and level for each spinal finding. All images were reviewed by a musculoskeletal fellowship trained emergency radiologist and a spine surgeon. For each error, the spine surgeon assessed the need for 1) surgery, 2) immobilization and 3) MRI. Findings were considered clinically significant if the answer to any of the three questions was positive.

RESULTS
56 patients with CsCTs and reports containing diagnostic errors were reviewed. 12 patients (21.5%) had missed or misinterpreted finding in extraspinal location. 44 patients (78.5%) had errors localized to spine (28 fractures/dislocations, 15 intervertebral disc protrusions, 1 lytic bone lesion). The locations of missed/interpreted fractures were: transverse (n=8), spinous process (n=6), facet (n=4), lamina (n=2), vertebral body (n=11), C1 (n=3), occipital bone (n=1). Two dislocations were at the atlantoaxial articulation (n=2). 4 patients had missed fractures encompassing more than one anatomical location. The most common spinal fracture levels were C5 (n=7) and C7 (n=6). In 4 patients, additional contiguous (n=2) or noncontiguous (n=2) fractures were missed. Responses to the three questions were positive in 3, 25, and 16 patients, respectively. All fractures were considered clinically significant, including 3 patients who would have required surgical stabilization (2 atlantoaxial dislocations and 1 facet fracture). None of the intervertebral disc protrusions were reported to alter the management by the surgeon.

CONCLUSION
65.9% of our patients in our series with diagnostic errors localized to spine on CsCTs were considered clinically significant, potentially altering therapeutic and diagnostic management. Transverse process fractures were the most common clinically significant missed/interpreted finding.

CLINICAL RELEVANCE/APPLICATION
Radiologists should be aware of commonly missed injuries on CsCT and their clinical significance so they can adjust their search pattern and improve the accuracy of their reports.
Diagnostic Value of Prevertebral Soft Tissue Thickening on Cervical Spine CT in Acute Trauma, Using MRI as the Reference Standard

Tuesday, Nov. 27 10:40AM - 10:50AM Room: S403A

Participants
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PURPOSE
Population normal values of prevertebral soft tissue (PVST) thickness on CT have been established but there is little previously published research examining whether an abnormal PVST thickness on CT has diagnostic value as a sign of cervical spine injury. This study aims to evaluate whether an abnormal PVST on CT is a predictor of anterior column soft tissue injury on cervical spine MRI.

METHOD AND MATERIALS
The radiology information system (RIS) at a tertiary trauma centre was searched for Emergency Department patients over 18 years of age who had a CT of the cervical spine for trauma from 1st January 2017 onwards, which was followed by a cervical spine MRI within 7 days. Exclusion criteria include previous spinal surgery and intubated patients. 40 consecutive patients meeting inclusion and exclusion criteria were selected. For each CT study, PVST thickness on CT at levels C1 to C7 were measured, and the PVST thickness was categorised as normal or abnormal based on previously published normal values by Rojas et al in 2009. The corresponding MRI images and reports were reviewed for anterior column soft tissue injury (prevertebral haematoma or anterior longitudinal ligament injury). The performance of abnormal PVST thickness on CT as a predictor of MRI findings of anterior column soft tissue injury was evaluated and diagnostic odds ratio, sensitivity and specificity were calculated.

RESULTS
Prevertebral soft tissue thickening on CT is strongly associated with findings of anterior column soft tissue injury on MRI (p = 0.0002), with a diagnostic odds ratio of 32.7, specificity of 93% and sensitivity of 70%.

CONCLUSION
Prevertebral soft tissue thickness should be evaluated on cervical spine CTs as it is a useful radiological sign of anterior column soft tissue injury.

CLINICAL RELEVANCE/APPLICATION
When reporting cervical spine CTs, anterior column soft tissue injury should be strongly suspected if there is prevertebral soft tissue thickening.

Spinal Trauma in DISH: Is MRI Essential After the Detection of Vertebral Fractures on CT?

Tuesday, Nov. 27 10:50AM - 11:00AM Room: S403A

Awards
Student Travel Stipend Award

Participants
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PURPOSE
1. To assess the incidence of posterior column involvement on CT and MRI in patients with diffuse idiopathic skeletal hyperostosis (DISH) and known anterior/middle column injury on CT. 2. To evaluate the utility of performing MRI in DISH patients with isolated anterior/middle column fractures and no neurological deficit.

METHOD AND MATERIALS
Records of 177 consecutive patients older than 50 years of age admitted between 2008 and 2017 for a traumatic spinal fracture and a diagnosis of DISH were reviewed. Only fractures involving an ankylosed region of the spine were included. Patients with fractures involving a non-ankylosed spine segment and history of prior spine surgery were excluded. Age, gender, mechanism of trauma, fracture type, spine CT and MRI imaging findings, surgical intervention, neurologic deficit, complications, and in-hospital mortality were collected from the medical records.

RESULTS
26% (47/177) of patients had hyperextension injuries; overall, 59% (106/177) had either non-displaced or minimally displaced fractures. 116/177 (66%) patients had fractures isolated to the anterior/middle column. 22/177 patients had fractures isolated to the posterior column only and 39/117 patients had fractures involving both the anterior/middle and posterior columns. 97 patients in our cohort underwent MRI after a fracture was detected on CT. 75 of the 97 patients had fractures isolated to the anterior/middle column. Of these 75, 26 had disruption of the posterior ligamentous complex (PLC), and only 4 of the 26 patients had no neurologic deficit. 28 of the 97 patients had either spinal cord injury or epidural hematoma and 27/28 of these patients presented with neurologic deficit. The one patient that did not present with neurologic deficit had a tiny dorsal epidural hematoma without spinal
cord injury or disruption of the PLC and was managed conservatively.

CONCLUSION

1. 49% of patients in our cohort (87/177) had either a posterior column fracture on CT or disruption of the PLC on MRI. 2. In DISH patients with isolated anterior/middle column fractures and no neurologic deficit, MRI did not provide additional information that would change management in most cases (85%).

CLINICAL RELEVANCE/APPLICATION

In most DISH patients with anterior/middle column fractures only and no neurologic deficit, spine CT alone is sufficient for management without the additional time and money spent on MRI.

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SSG04-04 Incidence and Patterns of Cervical Spine Injuries on CT: A Study in a Level I Trauma Center

 Participants
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PURPOSE

Though spinal fractures constitute a minority of all trauma, the financial burden imposed is very significant especially cervical spine trauma. The pattern of cervical spine injuries in the setting of trauma in general population is unknown at the moment in United States with very few papers addressing the issue. We reviewed entire spectrum of cervical spine injuries and demonstrated correlation between various demographics, clinical presentation with radiological appearance of the injury.

METHOD AND MATERIALS

We performed retrospective analysis of 13,500 patients who underwent imaging for cervical spine trauma at a level I trauma center. Out of this database we selected 934 patients who had a positive CT scan. Each patient was then analyzed by reviewing the medical records and correlation was sought between demographic, clinical and imaging features.

RESULTS

In our study, the peak incidence of cervical spine trauma was in the age group of 21-30 years followed by 31-40 years with a male:female ratio of 2.1. Major cause of injury in the study population was motor vehicle accidents (66.1%), followed by fall from height of less than 8 feet (12.2%). For fractures of vertebral bodies, we identified 440 injury levels, with C1 and C2 being the most frequent fractured as compared to the subaxial spine. Incidence of C2 fractures (40.9%) was higher as compared to C1 (23.2%). Body and lateral mass fracture incidence was marginally higher as compared to odontoid fractures. C7 (11.3%) was the most fractured vertebral body in the subaxial spine followed by C6 (8%) and C5. Highest number of vertebral body fractures were due to compression injury. 924 injury levels were identified for vertebral body process with transverse process fractures (38.6%) being the most common.

CONCLUSION

Spinal trauma is on the rise and it helps to understand the frequency and pattern of injuries in cervical spine to guide us for better management of these patients.

CLINICAL RELEVANCE/APPLICATION

To understand the distribution and pattern of injuries in cervical spine to improve delivery of healthcare.

SSG04-05 The Combination of SWI and DTI in Evaluating the Severity of Traumatic Brain Injury

 Participants
Chengru Song, Zhengzhou, China (Presenter) Nothing to Disclose
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PURPOSE

To explore the diagnostic value of SWI and DTI on different severity's traumatic brain injury(TBI).

METHOD AND MATERIALS

Totally 60 TBI patients (including 20 mild TBI patients, 20 moderate TBI patients and 20 severe TBI patients) and 20 health volunteer underwent SWI, DTI and conventional MRI examination. The numbers of involving regions, numbers and areas of...
hemorrhagic lesions detected by SWI, and FA values of 37 brain regions (including knee, body, splenium of corpus callosum, cingulate bundle, et al.) were compared between each two groups. The correlation analysis between GCS scores and the number of involving regions, number of hemorrhagic lesions, areas of hemorrhagic lesions detected by SWI, and FA values of each region were performed.

RESULTS

The differences of involving regions’ number, lesions’ number, lesion’s areas detected by SWI between each two groups were statistically significant (P<0.05). Severe TBI group got the maximum number of involving regions, lesions, and the largest areas. Followed by moderate group and mild group. Among the 37 regions, totally 30 regions differ in FA values between the four groups (P<0.05). And among these 30 regions, 18 regions’ FA values, for example corpus callosum region, gradually reduce as the severity of TBI aggravate. The GCS scores are highly negatively correlated with the number of involving regions, number of lesions, areas of lesions detected by SWI, but are positively correlated with 30 regions’ FA values. The descending order of relevance is hemorrhagic lesions’ areas(r=-0.932), lesions’ number(r=-0.911), involving regions’ number(r=-0.900), FA values of right cingulum(r=0.872), right anterior limb of internal capsule(r=0.801), left cingulum (r=0.787), the splenium of corpus callosum(r=0.775), the body of corpus callosum (r=0.765), et al.

CONCLUSION

The clinical applications of SWI and DTI is valuable in diagnosing different severity’s TBI.

CLINICAL RELEVANCE/APPLICATION

SWI and DTI are effective in evaluating the severity of traumatic brain injury

SSG04-06  Iodine Maps on Follow-Up DECT: Prognostic Value in Patients with Cerebral Hemorrhagic Contusions in Moderate to Severe Head Trauma

Participants
Uttam Bodanapally, MD, Baltimore, MD (Presenter) Speakers Bureau, Siemens AG; Travel Support, Siemens AG;
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PURPOSE

We aimed to retrospectively determine if the quantitative data derived from Iodine Maps of follow-up head DECT can predict the 6-month mortality and unfavorable outcome scores in patients with cerebral contusions as derived from IMPACT model.

METHOD AND MATERIALS

This study was HIPAA compliant and institutional review board approved. Informed consent was waived. We retrospectively analyzed admission and 6-hour follow-up CT studies in 69 patients with hemorrhagic contusion(s). We incorporated the previously described powerful conventional CT outcome predictors related to the dominant lesion and new variables derived from Iodine Maps in our evaluation. After performing univariate analysis, the independent predictors were determined by using regression analysis.

RESULTS

CT variables with significance on univariate analysis were, hematoma volume at admission (Spearman's rho=0.38, p=0.03 for mortality; Spearman's rho=0.36, p=0.04 for unfavorable outcome), hematoma volume on follow-up (Spearman's rho=0.42, p=0.001 for mortality; Spearman's rho=0.38, p=0.004 for unfavorable outcome), enhancing penumbra volume (Spearman's rho=0.47, p=0.0003 for mortality; Spearman's rho=0.43, p=0.001 for unfavorable outcome), iodine concentration (Spearman's rho=0.32, p=0.02 for mortality; Spearman's rho=0.3, p=0.03 for unfavorable outcome), iodine content in penumbra (Spearman's rho=0.5, p=0.0002 for mortality; Spearman's rho=0.45, p=0.001 for unfavorable outcome), iodine content in contusion (Spearman's rho=0.5, p = 0.0002 for mortality; Spearman's rho=0.44, p=0.001 for unfavorable outcome). There was no correlation between the fractional hemorrhagic progression of contusion (%HPC) and the outcomes. Enhancing penumbra volume, and iodine content in penumbra were the independent predictors of both the outcome scores on regression analysis (B=10.9, p=0.002; B=9.22, p=0.02 for mortality; B=13.1, p=0.003; B=11.4, p=0.02 for unfavorable outcome).

CONCLUSION

Enhancing penumbra volume, and iodine content in penumbra may be more accurate for predicting outcomes in patients with cerebral contusions, than the previously identified predictor variables of hematoma volumes and %HPC.

CLINICAL RELEVANCE/APPLICATION

Quantitative iodine based CT variables derived from extravasated iodine into the contusions may improve the accuracy of the existing prediction models.

SSG04-07  Supplemening Screening Criteria Yields Increased BCVI Incidence, with Subsequent Imaging Showing Markedly Increased Risk for Ischemic Stroke

Participants
Frank Bensch, MD, PhD, Helsinki, Finland (Presenter) Nothing to Disclose
Elina Varjonen, MD, Helsinki, Finland (Abstract Co-Author) Nothing to Disclose
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Blunt cerebrovascular injuries (BCVI) are uncommon, but can have severe consequences such as ischemic stroke. Detection of BCVI requires an angiogram of the cervical arteries, commonly by CT angiography (CTA). CTA screening criteria for BCVI based on clinical findings and trauma mechanism have improved detection. Denver criteria for screening are most commonly used in absence of a clear consensus. Since clinical findings are often inconclusive, many patients do not meet any of these criteria. The aim of this study was to analyze the effect of augmented Denver criteria on BCVI incidence, as well as to determine the relative risk for ischemic stroke.

METHOD AND MATERIALS
For a single level one trauma center, Denver screening criteria for BCVI were augmented by including any high-energy trauma, cervical spine fracture, and major chest injury. All acute blunt trauma WBCT studies over a period of 38 months were reviewed retrospectively for distribution and grade of BCVI by two board-certified radiologists blinded to initial results. Non-CTA studies were excluded and any disagreements settled by consensus. Any subsequent cerebral imaging studies were reviewed for ischemic lesions appearing at a later phase.

RESULTS
1544 WBCT studies included 374 CTA (mf=271/103; mean age 41.5 years). Most common mechanisms of injury were MVA (51.5%) and fall from a height (22.3%). We found 72 BCVI in 56 patients (15.0%), with 13 (23.2%) multiple lesions. The internal carotid artery (ICA) was affected in 49 (68.1%) and the vertebral artery (VA) in 23 (31.9%) of cases. Most common injury grades were Bifi I and II in both ICA and VA, with C2 as the most common level. Gender (p=0.1482) and age (p=0.611) had no impact on BCVI incidence. Interobserver agreement was substantial (Kappa=0.674). Subsequent imaging of 215 patients revealed cerebral ischemic stroke in 19.6% of BCVI and 3.5% of the remaining cases. Fisher's exact test shows this difference to be highly significant (p=0.001) with an OR of 9.77 (95% CI; 3.3-28.7).

CONCLUSION
Augmenting Denver screening criteria yielded an almost threefold incidence for BCVI in blunt trauma than expected (15.0%), which emphasizes the need for more liberal screening protocols. The markedly elevated relative risk for ischemic stroke following BCVI with an OR of 9.77 underlines the urgency of this proposal.

CLINICAL RELEVANCE/APPLICATION
Supplementing screening criteria for BCVI might markedly improve patient outcome.

SSG04-08  Frequency of Acute Findings in Head CT Scans Performed in the Emergency Department

Tuesday, Nov. 27 11:40AM - 11:50AM Room: S403A

Participants
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PURPOSE
Head CT is the most common CT scan conducted in the ED. The aims of this study were to evaluate the frequency of acute findings on head CTs conducted in the ED in different age groups, and to analyze head CT referral indications.

METHOD AND MATERIALS
Institutional review board (IRB) approval was granted for this study. Informed consent was waived by the IRB committee. The records of one tertiary care hospital's ED were retrospectively reviewed for consecutive adult patients who underwent head CT during a time frame of 40 days from January 1st 2017. CT interpretations were obtained and checked for demographics, referral indications and CT findings. Findings were divided into three groups: acute findings, chronic findings and normal head CT. The cohort was divided into 6 groups according to age: young adults (aged 19-40), adults (aged 41-65) and elderly (over 65 years old). Associations between referral indications and acute findings were calculated.

RESULTS
During the study's time frame, 12,958 adult patients presented to our ED. 1,621 of them (12.5%) underwent a head CT (young adults 221/1621=14.4%, adults 404/1,621=26.3%, and elderly 913/1,621=59.4%). Acute findings were found in 15% of the patients (young adults 12.2%, adults 13.6%, elderly 17.2% p=0.027). Chronic findings were found in 24% of the patients (young adults 5.9%, adults 18.3%, elderly 30.6% p<0.001). The distribution of acute findings for the entire cohort was: brain hemorrhage 32.6%, brain infarct 27.6%, SOL 23.0%, fractures 8.4%, sinusitis 11.3% and hydrocephalus 9.2%. Brain hemorrhage was the most common finding in young adults (29.2%) and in the elderly (36.3%), while SOL was the most common in the adult group (36.4%). The top three referral indications were neurological signs (19.7%), trauma (15.6%) and headache (12.3%). Headache was the most common indication in young adults (25.1%) and neurological signs were the most common in the adults and elderly groups (20.6%, 20.0% respectively). Seizures were associated with acute findings (p=0.024, OR=1.917) and dizziness with absence of acute findings (p=0.022, OR=0.528).

CONCLUSION
Acute findings are found in 15% of head CT scans performed in the ED. The frequency of acute and chronic findings increases with age.

CLINICAL RELEVANCE/APPLICATION
The increasing amount of head CTs and the relatively low yield of this test, requires the implementation of decision protocols.
PURPOSE
Approximately 20-40% of ischemic strokes are caused by a cardio genetic embolic disease. Evidence of the embolic origin cannot become clearly defined. The goal of this study was the implementation of an extended stroke protocol (Big-5, see Fig. 1) for evaluation of thrombo-embolic sources, detection of pulmonary artery embolism, carotid artery stenosis and acute aortic syndrome in one initial exam.

METHOD AND MATERIALS
Imaging was performed using a high-end CT in the ER (Revolution CT, GE Healthcare). All patients (n=208) received an unenhanced brain scan for hemorrhage exclusion. Subsequently a combined ECG-gated/non-ECG-gated scan (caudo-cranial) for the assessment of heart, aortic arch, carotid arteries and brain vessels. Consecutively 40 s after CM injection another ECG-gated acquisition in diastolic phase covering the left atrial appendage and left atrium. Finally, a dynamic neuro perfusion scan was performed. All patients had no contraindication for CM or any known iodine allergy. Image quality of left atrium appendage was scaled with a 5-tier Likert-scale by 2 radiologists.

RESULTS
Excluded were 48 patients due to external causes (motion artifacts, IC, etc.). In 60/160 patients a pathological finding, in 54 (34%) patients morphological change consistent with acute stroke was detected. Cardiogenic thrombus sources could be found in 8/160 cases, 6 in the left atrial appendage and 2 on the aortic valve. One type A aortic dissection was documented. In 3/54 patients with acute stroke a cardiac source of thrombus, in 18 cases a severe stenosis or occlusion of carotid vessels and in 20 cases extensive thrombotic plaques of aortic arch or carotids and in 13 patients an intracranial arterial thrombus could be found. Image quality of left atrium appendage was significantly better in venous phase compared with CTA arterial phase (141 vs. 107 cases as good or very good, p<0.001).

CONCLUSION
Big5 provides extensional clinical information for patients with acute ischemic stroke compared to the traditional CT stroke examination protocol.

CLINICAL RELEVANCE/APPLICATION
Concomitant pathologies including pulmonary artery embolism, carotid artery stenosis and acute aortic syndrome could make the initial clinical assessment difficult and can be excluded. There is higher prevalence of pathologic findings in carotid vessels than in detection of intracardial thrombus.
SSG08

Musculoskeletal (Machine Learning and Artificial Intelligence)

Tuesday, Nov. 27 10:30AM - 12:00PM Room: S102CD

Participants
Martin Torrani, MD, Lincoln, MA (Moderator) Nothing to Disclose
Bao H. Do, MD, Stanford, CA (Moderator) Nothing to Disclose

Sub-Events

SSG08-01 SpineNet: Automated Vertebra and Disc Gradings Using Deep Learning

Tuesday, Nov. 27 10:30AM - 10:40AM Room: S102CD

Participants
Timor Kadir, Oxford, United Kingdom (Presenter) Employee, Optellum Ltd;
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Jeremy Fairbank, Oxford, United Kingdom (Abstract Co-Author) Nothing to Disclose
Amir Jamaludin, Oxford, United Kingdom (Abstract Co-Author) Nothing to Disclose
Jill Urban, Oxford, United Kingdom (Abstract Co-Author) Nothing to Disclose

PURPOSE
To assess the performance of a fully automated deep learning method in producing radiological gradings of spinal MRI in the context of management of chronic back pain

METHOD AND MATERIALS
A dataset comprising images of 12,018 individual discs from 2009 patients were retrospectively collected from 6 different referral centers in the UK, Hungary, Slovenia and Italy in a previous EU project (Genodisc). The primary selection for recruitment to Genodisc was “patients who seek secondary care for their back pain or spinal problem” and were sourced from routine clinical management. The MRI machines and protocols varied between the sites but included at least one standard T2 sagittal MRI acquisition which, for consistency, was used for all of the results reported here, though the system is capable of using the T1 and axial images also. The scans were annotated with the following radiological scores by a single experienced spinal radiologist: Pfirrmann grade, disc narrowing, endplate defects, marrow changes, spondylolisthesis and central canal stenosis. To test the radiologist’s intra-rater variability, they repeated their grading on a subset of 200 patients randomly interdispersed throughout the entire dataset. For training, the dataset was split into a 80:10:10 train:validation:test sets on a per patient basis (not per disc). This resulted in 1806 patients (10,836 discs) for training and 203 patients (1,224 discs) for testing. A multi-class Convolutional Neural Network (CNN) was trained using Deep Learning to predict all of the gradings. Accuracy was measured by comparing the output of the system to the radiologist annotations using class-balanced accuracy. Multi-way cross-validation was used to test the efficacy and repeatability of the system.

RESULTS
The average class balanced accuracy for the SpineNet system was 86.3% (+/- 0.3). This compares favourably to the radiologists intra-rater repeatability of 82.5%.

CONCLUSION
The SpineNet system can produce accurate and repeatable gradings for a range of spinal MRI radiological gradings used in chronic back-pain clinical management and research. Such gradings may be used to augment the radiologist report, improve consistency and communication with the referring physician.

CLINICAL RELEVANCE/APPLICATION
Quantitative gradings of spinal degeneration may be a useful adjunct to routine qualitative report of spinal MRI and improve communication with the referring physician.

SSG08-02 Can a Machine Diagnose an Anterior Cruciate Ligament Tear? Fully-Automated Detection System Using Deep Learning

Tuesday, Nov. 27 10:40AM - 10:50AM Room: S102CD

Participants
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Ali Guermazi, MD, PhD, Boston, MA (Abstract Co-Author) Shareholder, Boston Imaging Core Lab, LLC ; Research Consultant, Merck
PURPOSE
To investigate the use of a deep learning (DL) approach to create a fully-automated prediction model for detecting anterior cruciate ligament (ACL) tears of the knee joint.

METHOD AND MATERIALS
The proposed deep learning approach consisted of two neural networks connected in a cascaded fashion to create a fully-automated processing pipeline. The first network performed rapid segmentation of the intercondylar notch on two to three consecutive image slices, while the second classification network evaluated structural abnormalities within the segmented anatomic region. Sagittal proton density-weighted fast spin-echo (PD-FSE) and fat-suppressed T2-weighted fast spin-echo (T2-FSE) sequences were acquired using the same 3T scanner on the knees of 200 subjects (100 subjects with a torn ACL and 100 subjects with an intact ACL at subsequently performed knee arthroscopy). The DL method was trained to detect ACL tears using both the PD-FSE and T2-FSE images on 100 randomly chosen subjects and evaluated on the remaining 100 subjects. Diagnostic performance of the DL method was assessed with receiver operation characteristic (ROC) and area under curve (AUC) analysis using arthroscopy as the reference standard. The diagnostic performance of a musculoskeletal radiology fellow and an experienced fellowship-trained musculoskeletal radiologist for detecting ACL tears in the same subject population was also calculated.

RESULTS
For the fellow and radiologist, the sensitivity (95%CI) for detecting ACL tears was 94% (81%-99%) and 97% (86%-100%) respectively, while the specificity (95%CI) was 98% (92%-100%) and 98% (92%-100%) respectively. In comparison, the sensitivity (95%CI) and specificity (95%CI) for the DL method for detecting ACL tears at the optimal threshold by the Youden index was 89% (74%-97%) and 98% (92%-100%) respectively. The AUC (95%CI) for the DL method was 0.942 (0.876-0.979, p<0.001), indicating high overall diagnostic performance.

CONCLUSION
A fully-automated DL approach showed high diagnostic performance for detecting surgically confirmed ACL tears, but its sensitivity was slightly lower than human readers indicating the need for larger training datasets to maximize diagnostic performance.

CLINICAL RELEVANCE/APPLICATION
A fully-automated DL approach trained on a small image dataset shows promise for detecting ACL tears but requires further optimization to achieve diagnostic performance comparable to human readers.

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individual levels contained a fracture. Accuracy, AUC, sensitivity, specificity, PPV and NPV were 0.961, 0.956, 0.845, 0.967, 0.590, 0.991 (per-vertebrae) and 0.859, 0.836, 0.875, 0.823, 0.856, 0.963 (per-patient). Combined, serial inference for the 3D mask R-CNN followed by the 3D residual CNN required 2.19 seconds per patient on a single GPU workstation.

CONCLUSION
A custom deep learning based tool is accurate for detection of vertebral body fracture. Given the potential subtle appearance of fractures and high resolution of CT spine imaging, a two-part serial architecture was required to integrate complimentary large field-of-view (vertebral body localization) and small field-of-view (fracture detection) information needed for this task.

CLINICAL RELEVANCE/APPLICATION
A high-performing deep learning tool for CT spine fracture detection can be used for rapid triage in the acute trauma setting, optimizing radiology workflow and expediting patient care.

SSG08-04 Automatic Detection of Distal Radius Fractures in X-Ray Images using Deep Learning
Tuesday, Nov. 27 11:00AM - 11:10AM Room: S102CD

Participants
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PURPOSE
The aim of this study was to evaluate the diagnostic performance of a multi-purpose, deep-learning based image analysis software for the detection of wrist fractures.

METHOD AND MATERIALS
In this retrospective study, patients with suspected wrist fractures on X-ray imaging studies ordered by the ER department between 2016 and 2017 were included. After applying exclusion criteria (e.g. presence of osteosynthesis material), the remaining X-ray images were labeled for the presence of radius fractures. In uncertain cases, CT studies were consulted, excluding cases missing CT confirmation. The cases were randomly split into training and test set (85% and 15%, respectively). A multi-purpose image analysis software was trained for the decision whether a distal radius fracture was present on the X-ray image. Training data was augmented (e.g. by horizontal flipping, shifting, rotating, scaling). The test set was subsequently processed by the trained system. Performance was measured as area under the ROC curve (AUC) from the score the software assigned to each image. Sensitivity and specificity were calculated at the optimal threshold as indicated by Youden's index. Finally, the test set was evaluated by an attending radiologist and a radiology resident with 16 and 2 years of experience, respectively.

RESULTS
The included images featured 171 cases with fractures and 562 controls, amounting to 733 X-ray images of 277 different patients. The training and evaluation set consisted of 573 and 160 X-ray images, respectively. The diagnostic performance of the trained software on the test set of 160 X-ray images was excellent with an AUC of 0.91 (95%-CI 0.85-0.95). It therefore performed comparable to a radiology resident (AUC 0.87, p=0.25) but worse than the attending radiologist (AUC 0.98, p<0.01). Sensitivity and specificity of the software at the optimal threshold were calculated to be 88.5% and 89.9%, respectively. Heatmaps drawn as an image overlay by the software indicated areas suspicious for defects as useful visual feedback. The interreader agreement of the human readers was substantial with a Cohen's kappa of 0.71 (95%-CI 0.60-0.82).

CONCLUSION
The software was able to detect wrist fractures with high sensitivity and specificity, using only a small dataset for training. It performed on a par with the radiology resident reader.

CLINICAL RELEVANCE/APPLICATION
Deep-learning based software is useful for the detection of wrist fractures.

SSG08-05 Multi-Tissue Segmentation for Body Composition Using a Deep Convolutional Neural Network
Tuesday, Nov. 27 11:10AM - 11:20AM Room: S102CD

Awards
Student Travel Stipend Award

Participants
Benjamin Wang, MD, Boston, MA (Presenter) Nothing to Disclose
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PURPOSE
To develop and test a deep convolutional neural network (CNN) to automatically segment abdominal CT images for body composition measures. We hypothesized that a deep CNN would achieve high accuracy using a limited training dataset and data augmentation.
METHOD AND MATERIALS
We manually segmented single-slice CT images obtained at the level of L4 (80kV, 70mAs, 10mm slice thickness, 50cm field of view) in 160 subjects for determination of body composition. Manual segmentation was performed on 512x512 pixel images to label 6 classes: background, muscle, bone, bowel/solid organs, visceral and subcutaneous fat. Twenty cases were segregated for a test dataset. The remaining 140 underwent a processing pipeline of histogram equalization followed by data augmentation (N=2,000), which included random deformations, horizontal mirroring, Poisson noise, cropping and magnification. We trained our model from scratch on Keras/Tensorflow using an 80/20 training/validation split and a U-Net architecture (8 batch size, 50 epochs, dropout 0.3, initial learning rate 0.0001, softmax). Testing was performed to obtain the Dice (F1) score as a parameter to compare the similarity between manual vs. CNN-based multi-class segmentation.

RESULTS
The overall mean Dice score was 96% (median 97%, range, 94-98). Mean Dice scores for each class were: background 96% (median 98%, range, 96-99), bone 87% (86, 83-92), subcutaneous fat 94% (96, 87-98), muscle 91% (91, 84-97), bowel/solid organs 99% (90, 83-94), and visceral fat 81% (88, 45-93). Visceral fat demonstrated the broadest accuracy range, which may derive from its more variable quantity and morphology, representing an important focus to improve algorithm performance.

CONCLUSION
Our results show overall accurate automated abdominal CT segmentation for body composition using a deep CNN algorithm, trained on a limited dataset with data augmentation. While segmentation accuracy was generally high for most classes (>81%), improvement of algorithm performance will focus on strategies to increase visceral fat segmentation accuracy. This workflow may serve as a basis for future models aimed at automated segmentation of entire abdominal CT studies for body composition.

CLINICAL RELEVANCE/APPLICATION
Deep CNN algorithms for tissue segmentation are promising methods to obtain body composition measurements, and may allow efficient and automatic data extraction in opportunistic and population studies.
Of the 1,573 radiographs tested, the algorithm predicted sex correctly with 95.4% accuracy (95.2% in female and 95.7% in male).

METHOD AND MATERIALS

First, individual lumbar vertebral bodies are segmented to separate bone from soft tissue, and create reference anatomic levels for muscle analysis, via thresholding, morphologic operations, and aggregated intensity profiles. Next, muscle groups at reference vertebral levels are segmented on axial images by a holistically nested neural network through image-to-image training and classification. There are varying reference level and muscle group standards for sarcopenia determination in different medical and surgical specialties. To accommodate this, the system performs analysis for multiple muscle groups and vertebral levels. Segmentation accuracy was assessed via Dice Similarity Coefficient, a measure of overlap between manual and automated segmentations. The system was trained on contrast enhanced portal venous phase CTs of 51 patients and tested on 51 cases (average age 67 (range 59-81), 53 F, 49 M). For demonstration here, the system was designed to calculate sarcopenia via the standard cutoff value for L3 SMI (skeletal muscle index: L3 axial muscle area cm2/patient ht m2) of < 3.62 cm2/m2 for women and < 4.93 cm2/m2 for men, as proposed by international consensus of cancer cachexia.

RESULTS

The Dice coefficients for the psoas, paraspinous, and total abdominal muscle groups in the training and testing sets were 0.953 +/- 0.015 and 0.938 +/- 0.028, respectively at the level of the third lumbar vertebra. The mean normalized L3MI was 5.02 +/- 1.45 cm2/m2 for women and 6.18 +/- 1.83 cm2/m2 for men. Sarcopenia was present in 15.4% (8/52) of women and 13.3% (6/45) of men.

CONCLUSION

This fully-automated system can robustly detect, accurately segment, and generate quantitative statistics for multiple abdominal wall muscle groups at multiple lumbar vertebral levels on CT scans.

CLINICAL RELEVANCE/APPLICATION

Automated quantification of sarcopenia may guide patient management in pre-treatment risk assessment and surgical planning, and act as a platform to facilitate large scale clinical trials.

SSG08-08 Machine-Learning-Based Discovery of Sexual Dimorphism of Hand and Wrist Radiographs

Participants

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PURPOSE

Skeletal sexual dimorphism develops mostly in the pelvis during puberty. Although prior work has shown higher second-to-fourth digit ratio and smaller carpal bones in women compared to men, the distributions of these measures substantially overlap for women and men. We aim to create a machine-learning algorithm to distinguish sex from hand and wrist radiographs and evaluate its performance by comparing it to radiologists’.

METHOD AND MATERIALS

We compiled a dataset of 10,607 (5,148 male and 5,459 female) radiographs of hand and wrist from a cohort of patients, ranging from 5 years to 80 years of age. A total of 7,461 radiographs were used for training, and 1,573 images separate from the training data were randomly selected for validation. Images from the remaining 1,573 cases were reserved for testing. The images were labeled solely with the sex of the subject. We fine-tuned an ImageNet-pretrained VGG16 convolutional neural network (CNN) on our training dataset. The best CNN, selected based on the validation loss, then provided automated prediction of sex, which was compared to the sex in the medical record. To compare the performance with human radiologists, we randomly selected 50 cases for which the CNN correctly predicted sex. Two radiologists independently read the hand and wrist radiographs and predicted sex for these 50 cases. The radiologists were blinded to clinical information of the patients but were allowed to use reference such as the Greulich and Pyle atlas while reading the radiographs.

RESULTS

Of the 1,573 radiographs tested, the algorithm predicted sex correctly with 95.4% accuracy (95.2% in female and 95.7% in male).
The two radiologists showed 58% (45.8% in female and 69.2% in male) and 46% (50% in female and 57.7% in male) accuracy. The class activation maps (CAM) showed that the CNN mostly focused on 2nd and 3rd metacarpal base or 4th and 5th metacarpal head in women, and radioulnar/radiocarpal joint or 2nd, 3rd, and 4th metacarpophalangeal joints in men.

CONCLUSION

We developed an algorithm that accurately distinguishes men and women from hand and wrist radiographs in children as well as in adults.

CLINICAL RELEVANCE/APPLICATION

The current study shows the discovery of previously unrecognized radiologic features using machine learning. It could be used in screening of disorders affecting sexual development.

Participants
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PURPOSE

Utilize deep learning to obtain preoperative measurements from radiographs in patients with femoroacetabular impingement.

METHOD AND MATERIALS

A retrospective study of patients with femoroacetabular impingement was performed. 181 unique patients who underwent CT scan of the hip for preoperative measurement of alpha angle (AA), acetabular version (AV), femoral version (FV) and lateral center edge (LCE) were identified. The training set consisted of 1084 radiographs. This was made up of available preoperative false profile, Dunn, frog leg and AP radiographs (n=419) and augmented with digitally reconstructed radiographs (DRRs) generated from the CT scans at different views (n=665). A novel convolutional neural network (CNN) based on a DenseNet architecture with 54 hidden layers and a regression head was trained on 256x256 input images to predict LCE measurement. For testing AA, AV, and FV measurements, both a regression output and a binary classifier for normal and abnormal ranges were tested. Parameters were tuned based on a 20% validation group generated from the training set. The sequestered testing set consisted of 95 preoperative radiographs at various views and corresponding measurements from accompanying CT scans.

RESULTS

Overall mean absolute error (MAE) and standard deviation of the error for LCE measurement was 3.2° ± 2.3°. Performance of the network was best on false profile views of the hip (3.0° ± 2.2°) but this difference was not statistically significant. AA, AV and FV prediction performance was evaluated, however the performance of the network was not predictive in the current implementation.

CONCLUSION

Deep learning techniques applied to radiographs can be used for quantitative measurement of LCE. With further modification and additional examples, quantitative measurement of AA, AV and FV may be possible.

CLINICAL RELEVANCE/APPLICATION

An accurate, automated system designed to obtain FAI measurements from radiographs can obviate the need for CT and has the potential to decrease healthcare costs, decrease patient exposure to radiation and increase radiologist efficiency.
**Dynamic PET Perfusion Imaging (DPPI) of Esophageal Cancer to Characterize Angiogenicity: A Phase I Study to Explore this Potential Imaging Biomarker Enabled by Ultra-Fast Digital PET**

**Participants**
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**Sub-Events**

**SSG09-01 Dynamic PET Perfusion Imaging (DPPI) of Esophageal Cancer to Characterize Angiogenicity: A Phase I Study to Explore this Potential Imaging Biomarker Enabled by Ultra-Fast Digital PET**

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**PURPOSE**
While PET perfusion imaging using dynamic acquisitions has a long history, its use in clinical practice outside of cardiovascular applications remains negligible. This Phase I study assesses the feasibility of dynamic PET perfusion imaging as an alternative methodology to contrast enhanced MRI in esophageal cancer using next-generation digital PET technology with substantially improved TOF timing resolution and reduced dead time.

**METHOD AND MATERIALS**
FDG PET/CT was performed prior to radiation therapy of advanced esophageal cancer in 12 patients using a next-generation digital photon counting system (Vereos Philips, dPET). Prior phantom and preclinical experiments established the following protocol. Dynamic PET Perfusion Imaging (DPPI) was performed at the time of bolus injection of 5 mCi FDG over a volume of interest for 10 min. PET events were recorded in continuous list mode acquisition and reconstructed using frame rates from 1 sec/fr to 15 sec/fr. A count density adaptive reconstruction approach was previously developed. Data analysis were performed using Intellispace Discovery (Philips) workspace. The reconstructed dynamic PET images were assessed in blinded review by three experienced PET readers. Descriptive statistics were calculated for data analysis.

**RESULTS**
All dynamic PET acquisitions were successfully acquired and reconstructed according to protocol. Frame rates of 10 sec led to high quality uptake time curves of the well delineated esophageal cancer. Count density adaptive reconstruction was essential to minimize noise. 2mm voxel length (HD) reconstruction was found to be beneficial. The first 2 min duration of the dynamic series were found to be the most relevant and also sufficient for the perfusion assessment. Uptake time curves were found analogous to characteristic findings in DCE-MRI.

**CONCLUSION**
Dynamic PET Perfusion Imaging (DPPI) of esophageal cancer was achievable using frame rates of 10 sec with acceptable quality for quantitative and visual assessment even at the low FDG dose of 5 mCi. A short table time of 5 min appears to be sufficient combined with the dPET's low dose capabilities making clinical utilization feasible.

**CLINICAL RELEVANCE/APPLICATION**
Dynamic PET perfusion imaging has the potential to be an alternative methodology to DCE-MRI or CT for assessment of perfusion of esophageal cancer for therapy planning and response assessment.

**SSG09-02 Focal Liver Uptake on 18F-FDG PET/CT without CT Correlate: Utility of MRI Evaluation in Patients with Known Malignancy**
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PURPOSE
There is insufficient evidence to guide management of focal FDG uptake in the liver without CT correlate. This study aims to assess the utility of MRI for evaluation of focal FDG uptake on PET/CT without CT correlate in patients with known malignancy.

METHOD AND MATERIALS
In this IRB-approved, HIPAA compliant retrospective study, between 2005 and 2012, out of 1851 patients who underwent FDG-PET/CT, we identified 36 patients with known malignancy (19 women, 17 men; mean age, 56.1 years) who had focal hepatic uptake on PET/CT without CT correlate and had follow-up MRI within 100 days for assessment of the uptake. Two radiologists reviewed the PET/CT images in consensus blinded to the area of uptake noting SUVmax of the lesion and background liver. MRI images were then reviewed to look for the presence of focal lesion corresponding to the uptake. When a focal lesion was present, the size, signal intensity and enhancement characteristics and follow-up imaging were documented. Statistical analysis was performed to determine correlation between intensity of FDG uptake and presence of focal lesion.

RESULTS
A total of 50 sites of focal hepatic uptake without CT correlate were identified. Median SUVmax was 4.1 (range 2.1-10.1) and median SUVmax ratio of hepatic lesion/normal parenchyma was 1.3 (range 0.98-2.6). MRI confirmed focal lesion in 26/50 sites (52%). Median lesion size was 13 mm (range 3-30 mm). Among 26 hepatic lesions noted on MR imaging, 77% (20/26) were diagnosed as metastatic disease (6 with pathological confirmation, 14 based on follow-up image findings). Other 6 lesions were diagnosed as benign, including 3 with pathological diagnosis of nodular regenerative hyperplasia (n=2) and heterogenous hepatic steatosis (n=1). There was no significant difference in the SUVmax of hepatic lesions (3.85 vs. 4.2, p=0.5) and the SUVmax ratio (1.32 vs. 1.31, p=0.97) between the groups with and without MRI correlate.

CONCLUSION
More than half of focal areas of uptake on PET/CT without CT correlate had a focal lesion on MRI in our study, and more than three-quarters of these MRI lesions were hepatic metastases, regardless of SUVmax values.

CLINICAL RELEVANCE/APPLICATION
In patients with known malignancy, focal FDG uptake in the liver without CT correlate warrants further assessment with MRI regardless of SUVmax as it is likely to be metastasis.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Sreeharsha Tirumani, MBBS, MD - 2016 Honored EducatorNikhil H. Ramaiya, MD - 2017 Honored EducatorAtul B. Shinaagare, MD - 2017 Honored Educator

SSG09-03 Focal Colonic Tracer Uptake in 18F-FDG PET/CT Scans: Does the Combined Analysis of Morphological Changes and PET Improve Lesion Characterization?

Tuesday, Nov. 27 10:50AM - 11:00AM Room: SS05AB

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PURPOSE
To evaluate the impact of morphological information derived from contrast enhanced CT on the characterization of incidental, focal colonic uptake in 18F-fluorodesoxyglucose positron emission tomography / computed tomography (18F-FDG PET/CT) examinations.

METHOD AND MATERIALS
In this retrospective study, 125 patients (female: n=53, male: n=72, mean age 62.9y) that underwent 18F-FDG PET/CT and colonoscopy (mean time between colonoscopy and PET: 52±58d) were included. By two readers, PET/CT examinations were assessed for incidental, focal colonic tracer uptake in comparison to the background. Focal tracer uptake was correlated with morphological changes of the colonic wall such as focal thickening, polypous shape or focal contrast media uptake. Discrepancies were resolved in a consensus reading. Then, colonoscopy reports were evaluated for precancerous (oligo-tubular adenoma, serrated adenoma, sessile adenoma and tubulo-villous adenoma) and cancerous lesions verified by histopathology, serving as a reference standard. Imaging findings were then compared to the reference standard to calculate sensitivity, specificity as well as positive (PPV) and negative predictive values (NPV) for focal tracer uptake in PET alone as well as focal tracer uptake in PET and
morphological changes in contrast enhanced CT in the detection of precancerous and cancerous lesions.

RESULTS
In 38.4% (48/125) of all patients, focal tracer uptake was observed in 67 lesions. In the corresponding colonoscopy reports, a total of 10 cancerous and 26 precancerous lesions were found. In PET, two cancerous lesions and 10 precancerous lesions were missed, resulting in a sensitivity, specificity, PPV and NPV of 51%, 68%, 29% and 84% for focal tracer uptake in PET alone. By correlation focal tracer uptake with morphological changes in contrast enhanced CT, a sensitivity, specificity, PPV and NPV of 48%; 79%; 37.5%; 86% for precancerous and cancerous lesions could be observed.

CONCLUSION
Focal colonic tracer uptake has a low specificity and sensitivity for precancerous and cancerous lesions. By analyzing additional morphological changes in contrast enhanced CT imaging in 18F-FDG PET/CT examinations, the specificity can be increased without sacrificing sensitivity.

CLINICAL RELEVANCE/APPLICATION
Morphological changes in 18F-FDG-PET/CT examinations help to decide, which patients with focal tracer uptake will profit from additional colonoscopy.

SSG09-04  Clinical Workflow of PET/MR for Primary Staging of Rectal Cancer

Tuesday, Nov. 27 11:00AM - 11:10AM Room: S505AB

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PURPOSE
analyze the clinical workflow of a PET/MR for rectal cancer staging, regarding MR imaging protocol, total scan time, prevalence and distribution of metastasis.

METHOD AND MATERIALS
55 patients with rectal adenocarcinoma were submitted to whole-body PET/MR for primary staging. MR sequences and total scan time were recorded. One reader analyzed the MR (blinded to PET findings) for locoregional staging. Another reader (blinded to the high-resolution MR of the pelvis) analyzed the PET/MR according to T, N and M staging. A third blinded reader analyzed only the liver MRI. Standard of reference was biopsy when feasible or imaging follow-up.

RESULTS
PET/MR workflow consisted of a dedicated pelvic MR, including high-resolution T2w and DWI, followed by whole-body PET/MR from head to mid thigh, ending with a T2w and DWI of the liver. Any dedicated MR sequence was used for the thorax. The mean total acquisition time of PET/MR was 64 minutes, ranging from 53 to 90 minutes. The PET acquisition time was on average 17 minutes, ranging from 12 to 25 minutes and the only-MR time was 52 minutes on average, including the dedicated pelvic and the liver sequences. One patient has not completed the exam due to claustrophobia and one patient was recalled due to low imaging quality (movement artifacts). For primary lesion detection, PET and DWI were positive in 54 out of 55 patients (one patient was negative even at MR). Metastatic disease was observed by PET/MR in 21 (38.2%) patients, mainly in the liver (12/21, 57.1%) non-regional lymph node (10/21, 47.6%), lungs (7/21, 33.3%) and peritoneum (1/21, 4.8%). Liver DWI detected 64 lesions in 12 patients and PET detected 62 lesions in the same 12 patients. Any brain metastasis was found.

CONCLUSION
PET/MR for rectal cancer staging is feasible, with a tolerable scan time and showing a high incidence of synchronic metastasis. DWI of the liver and of the rectum could be omitted in a staging/detection setting. PET coverage could start from skull base instead of vertex. Optimization of MR protocol would decrease scan time and allow the inclusion of other MR sequences.

CLINICAL RELEVANCE/APPLICATION
PET/MR for rectal cancer may be used clinically as a one-stop-shop imaging tool for whole-body staging.
PURPOSE
To compare the detection rate of metastatic lesions on PET/MR versus conventional staging (pelvic MR and thoracoabdominal CT) in rectal cancer patients referred for primary staging.

METHOD AND MATERIALS
Ninety-five patients with biopsy proven rectal adenocarcinoma were submitted to whole-body PET/MR for primary staging in addition to conventional staging with pelvic MR and thoracoabdominal contrast-enhanced CT (ceCT). One reader analyzed the MR (blinded to PET findings) regarding locoregional staging. Another reader (also blinded to the high-resolution part of pelvic MR) analyzed the PET/MR about T-, N- and M-stage. A third blinded reader assessed the M-stage by ceCT. Standard of reference was biopsy when feasible or imaging follow-up. Lesions were categorized as positive, negative or indeterminate.

RESULTS
On a lesion-based analysis, PET/MR detected 24.5% more positive metastatic lesions than conventional imaging (305 vs. 254 lesions). The higher detection rate on PET/MR was observed for non-regional lymph nodes (73 vs. 37 lesions). On a patient-based, PET/MR was positive in 38 out of 95 patients (40%), while conventional staging in 24 out of 95 patients (25.3%). PET/MR was indeterminate in 7 patients (7.4%), which 1 was positive on CT (non-regional lymph nodes, later confirmed to be sarcoidosis), while conventional imaging was in 30 patients (31.6%), which 10 were positive on PET/MR, mainly for non-regional lymph nodes and liver.

CONCLUSION
For rectal cancer staging, PET/MR presents not only a higher detection rate of metastatic lesions than conventional imaging (pelvic MR and thoracoabdominal ceCT), but also clarifies the etiology indeterminate lesions.

CLINICAL RELEVANCE/APPLICATION
PET/MR might be preferred for whole-body staging of rectal cancer patients, with a higher detection rate and potential clinical impact.

SGG09-06 Diagnostic Performance of PET/MR in Identifying High-Risk Primary Rectal Cancer Patients

Tuesday, Nov. 27 11:20AM - 11:30AM Room: SS505AB

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PURPOSE
To assess the diagnostic performance of PET and MR parameters to identify high-risk rectal cancer patients.

METHOD AND MATERIALS
Fifty-three patients with biopsy proven rectal adenocarcinoma were submitted to whole-body PET/MR for primary staging. One reader analyzed the MR (blinded to PET findings) regarding T stage, mesorectal fascia involvement, extramural vascular invasion, and presence of locoregional nodal disease. Another reader (also blinded to the high-resolution part of pelvic MR) measured the semiquantitative PET parameters using a dedicated software (PETVCAR, GE Healthcare) and assessed the M stage. Standard of reference was biopsy when feasible or imaging follow-up. Mann-Whitney test was performed to compare PET parameters between high and low-risk patients. ROC analysis was also used to define the diagnostic performance of PET parameters in identifying the tumor risk.

RESULTS
PET-volumetric parameters, namely TLG and MTV, performed better than SUVmax and mean to distinguish low and high-risk patients. MTV (48.9 vs. 18.4, $p = 0.006$) and TLG (629.4 vs. 190.4, $p = 0.008$), but not SUVmax (23.4 vs. 19.2, $p = 0.306$) or SUVmean (11.7 vs. 9.9, $p = 0.285$) were significantly higher in high-risk patients. Patients with advanced T stage, positive regional node and metastatic disease also presented significantly higher MTV and TLG values. No difference was found in any PET parameters in patients according to the involvement of mesorectal fascia and presence of EMVI. The AUC to distinguish low and high-risk patients was 77.9% ($p = 0.006$) for MTV and 77.0% ($p = 0.008$) for TLG and the best cut-off value (sensitivity of 83.7% and specificity of 70%) of MTV and TLG to detect high-risk patients was 16.1 and 172.8, respectively.

CONCLUSION
In addition to MR adverse risk factors, the volumetric-based PET parameters (MTV and TLG) allow the identification of high-risk patients, which could tailor therapy management.
PET/MR Characterization of Mucinous versus Nonmucinous Components of Rectal Adenocarcinoma: A Comparison of Tumor Metabolism and Cellularity

Tuesday, Nov. 27 11:30AM - 11:40AM Room: S505AB

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Purpose
To analyze the relation of mucinous component of rectal adenocarcinoma to FDG avidity and diffusion restriction.

Method and Materials
Ninety-four patients with biopsy proven rectal adenocarcinoma were submitted to whole-body PET/MR for primary staging. One reader analyzed the MR (blinded to PET findings) regarding locoregional staging, including the presence of mucinous component. Another reader (also blinded to the high-resolution part of pelvic MR) analyzed the PET/MR according to T, N and M staging. Two different readers drawn in consensus the volume of interest (VOI) larger than 0.5 cm³ of the mucinous component (MC) and the non-mucinous component (NMC) of the primary tumor on high-resolution T2w sequence and propagated the VOI to PET, DWI and ADC. SUVmax, SUVmean, TLG, MTV, ADCmax, ADCmean and ADCmin values were recorded and compared using Mann-Whitney test.

Results
Seventeen patients (18.1%) presented MC on MRI. The SUVmax and SUVmean of the NMC were significantly higher than of the MC (16.7 vs. 7.4, p = 0.002 and 13.4 vs. 5.4, p = 0.001). Any of the ADC values was significantly different between MC and NMC groups.. Among the 17 patients with MC, 16 (94.1%) were at least mrT3b, 15 (88.2%) presented positive extramural vascular invasion, 14 (82.4%) had involvement of mesorectal fascia, 13 (76.5%) were N-positive and 8 (47.1%) presented distant metastasis, reinforcing the correlation of MC and tumor risk.

Conclusion
The MC identified on PET/MR presents lower glycolytic metabolism than the NMC and is associated with high tumor risk. Tumor cellularity was not different between MC and NMC.

Clinical Relevance/Application
PET/MR enables a conspicuous correlation of mucinous component and tumor metabolism. Imaging readers should be aware of this pattern, recognizing that both primary and metastatic disease of mucinous tumors present low FDG uptake.

Comparative Accuracy of Qualitative and Quantitative 18F-FDG PET/CT Analysis in Detection of Lymph Node Metastasis from Anal Cancer

Tuesday, Nov. 27 11:40AM - 11:50AM Room: S505AB

Awards
Student Travel Stipend Award

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Purpose
To evaluate the diagnostic performance of qualitative and quantitative FDG PET combined with CT in detection of regional and distant lymph node metastases in patients with anal cancer.

Method and Materials
In this IRB approved retrospective study between January 2000 and December 2017, a total of 29 patients (F/M: 17/12), mean age 59.9±13.7 (15-95) with anal cancer who had staging PET/CT and pathological analysis of suspicious lymph nodes were included for qualitative and quantitative analysis. For qualitative analysis, the positive lymph nodes were defined as uptake close to or higher than the liver background. For quantitative study, lymph nodes were contoured using the 3D region of interest (ROI) to determine...
the maximum standard uptake value (SUVmax) and metabolic tumor volume (MTV). Receiver operating characteristic (ROC) curves were analyzed to extract the optimal cut-off values of SUVmax, lesion to background (L/B) ratio, short axis diameter (SAD) and MTV of the lymph nodes. Histopathologic analysis was the reference standard.

RESULTS
A total of 29 lymph nodes (25 inguinal, 2 external iliac, 1 internal iliac and 1 paraaortic nodes) in 29 patients on PET/CT were included for analysis. For qualitative visual analysis, PET/CT interpreted 27 patients as positive for the presence of nodal metastases with sensitivity, specificity and accuracy of 1, 0.25 and 0.79. The optimal cut-off values of SUVmax and L/B ratio were 2.51 and 1.13 with sensitivity and specificity of 0.91, 0.75 and area under the ROC curve (AUC) of 0.863 (95%CI:0.685,0.962) for SUVmax and 0.887 (95%CI:0.714,0.974) for L/B ratio. Using a best discriminative cut-off value 1.5 cm for SAD and 3.53 cm3 for MTV, the sensitivity and specificity were 0.81 and 1 with AUC of 0.952 (95%CI:0.803,0.997) for SAD and 0.935 (95% CI:0.777,0.993) for MTV. If we used the optimal cut-off value of either SUVmax or SAD, the sensitivity will increase to 0.95 (95%CI:0.76,0.99) with a specificity of 0.75 (95%CI:0.35,0.97).

CONCLUSION
Quantitative analysis of lymph node metastases in patients with anal cancer obtained with SUVmax, L/B ratio, nodal size and MTV are more specific and accurate than those performed with qualitative analysis but slightly less sensitive.

CLINICAL RELEVANCE/APPLICATION
The presence of nodal metastasis is crucial for treatment planning. Inguinal nodes with gross nodal involvement will receive a booster dose. Distant metastasis will change the chemotherapy regimen.

SSG09-09 68Ga-DOTATATE PET/CT as a Predictive Marker for 177Lu-DOTATATE Therapy
Tuesday, Nov. 27 11:50AM - 12:00PM Room: S505AB

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PURPOSE
Lutetium-177 (177Lu)-DOTATATE has shown significant promise in patients with somatostatin receptor positive neuroendocrine tumors (NETs). Here we report our preliminary experience with the use of 68Ga-DOTATATE PET/CT as a predictive marker for outcomes with 177Lu-DOTATATE therapy.

METHOD AND MATERIALS
Fifteen patients with progressive metastatic NETs were enrolled at our institution on the Expanded Access Program for 177Lu-DOTATATE. Pre-treatment 68Ga-DOTATATE PET/CT scans were performed in all patients. A retrospective analysis of these PET/CT scans was performed for tumor burden. Indices measured include maximal SUV uptake (SUVmax) and total SUV uptake (SUVtotal), which is the sum of 68Ga-DOTATATE uptake by all the lesions in one patient’s PET scan. Tumor burden is the sum of all tumor volumes. These measurements were correlated with progression-free survival.

RESULTS
Of the 15 enrolled patients, six completed all four 177Lu-DOTATATE infusions, and 9 patients completed 3 or fewer infusions. Median progression-free survival is 80% at 12 months from the date of enrollment. The pre-treatment 68Ga-DOTATATE PET/CT demonstrated well-differentiated NETs and wide-spread metastases in all 15 patients, with liver, lymph nodes and bone being the most common sites. Our data showed a larger tumor burden (1824 ml vs. 748 ml) and higher SUVtotal (636 thousand vs. 186 thousand) in deceased patients vs. patients with stable disease, while SUVmax had the opposite trend (36.5 vs. 51.0).

CONCLUSION
It may be possible to metrics from the pre-therapy 68Ga-DOTATATE PET/CT to predict outcomes of 177Lu-DOTATATE in patients with metastatic NET. While the results are encouraging, larger cohorts are needed to establish 68Ga-DOTATATE PET/CT based predictive factors for progression-free survival.

CLINICAL RELEVANCE/APPLICATION
68Ga-DOTATATE PET/CT could serve as a clinical predictor for response to 177Lu-DOTATATE.
CONCLUSION
The CBCT scan may result in higher radiation dose, even exceeding the dose from conventional MDCT scan. Using lower x-ray tube current allowed 3.8-fold dose reduction without clinically significant degradation of image quality. The DLP method provided good estimate of patient effective dose.

Background
Hybrid imaging modalities provide anatomic and functional information improving diagnostic accuracy but also increase patient radiation dose. Combining a cone beam CT (CBCT) with SPECT may result in high radiation exposure due to lack of tube current modulation. The purpose of our investigation was to assess radiation dose for clinical CBCT protocols as part of SPECT/CT examinations and to evaluate dose reduction options.

Discussion
Effective doses calculated from the measurements were 4.21 mSv and 1.11 mSv for 20 mA and 5 mA respectively. The DLP method resulted in very similar values with the differences of 0.05% at 20 mA and 4.76% at 5 mA. With lower tube current image noise was increased by 35%. That was found acceptable for localization and attenuation correction of SPECT data.

METHOD AND MATERIALS
With IRB approval, for the calendar year of 2016, 84,683 CT exams were recorded in an in-house dose monitoring program. For each protocol using AEC, radiation dose and patient diameter was fitted to an exponential relationship. The dose value from the fitting for a patient was considered to be ideal for the given diameter. A patient with higher than 99%ile dose for his/her diameter was flagged as a dose outlier. To streamline the severity of over-dosing and thus prioritizing the investigation of outliers, a dose...
deviation index (DDI) was calculated for each outlier as the ratio of received dose and ideal dose minus one. All outliers were investigated by two senior CT technologists by carefully examining the techniques and images. The CT physicist then categorized the found reasons and tagged each outlier with all reasons applicable to that case.

RESULTS
Over 50% of the dose outliers had a DDI between 1-2. A total of 18 different reason categories were identified. Out of the 661 dose outliers, about half were due to multiple accession number grouped together due to dose values extracted from screenshot of the dose reports, a problem resolved when radiation dose structure report can be used in the dose monitoring report. Another common reason for high dose (25%) was correlated with use of high kV, rotation time, or both with extra-large patients. Wrong positioning including patients unable to raise their arms (13%) was the third common issue.

CONCLUSION
A strategy was devised to survey patient CT dose and characterize the dose outliers. The identified categories are representative reasons of high radiation dose in CT imaging, and can be used as reference reasons for the community. The tagged data set can further be used as a training set for machine learning algorithm to automatically characterize the outliers in the future.

CLINICAL RELEVANCE/APPLICATION
A strategy was devised to survey large scale patient CT dose, identifying dose outliers, and characterize the outliers. The identified categories are representative reasons of high radiation dose in CT imaging, and can be used as reference reasons for the community.

SSG12-03 A Data-Centric Strategy for Developing CT Dose and Noise Reference Levels from Clinical Patient Populations

Tuesday, Nov. 27 10:50AM - 11:00AM Room: S404CD

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PURPOSE
To develop a data-centric strategy solution for developing CT dose and noise reference levels across large clinical patient populations and in CT scanners.

METHOD AND MATERIALS
This IRB-exempt study evaluated CT abdominopelvic (AP)-related examinations performed in 2017 by 22 scanners from two vendors with 11 models in 3 site hospitals. An in-house developed informatics system automatically extracted protocol information, patient size (cross-sectional diameter), dose, and in vivo noise magnitude within images. Protocol nomenclature categorization was performed using a decision tree machine learning algorithm. Four reference patient size intervals were identified: 13-20, 20-30, 30-40, and 40-50 cm. Noise Reference Level (NRL), Noise Reference Range (NRR), Dose Reference Level (DoRL), and Dose Reference Range (DoRR) were defined for each size range as the median and interquartile interval of noise and dose, respectively.

RESULTS
60,000 CT AP studies with 64 different convolution kernels for patients ages 0-70 and sizes 13-48 cm were identified. NRLs ranged between 15.8 to 18.4 HU with NRRs for the four size ranges were the following: 13.2-24.7,12.6-22.5,12.5-23.2, and 12.1-22.8 HU. DoRLs ranged within 11.9-16.1 mGy. The four DoRRs were 9.5-21.4,7.9-17.3,9.9-21.3, and 10.8-23.2 mGy.

CONCLUSION
This study offers the first even data-crunching solution for developing CT dose and noise reference levels using clinical patient data. New reference levels and ranges simultaneously consider image noise and radiation dose information across patient populations. The new metrics enables prospective optimization of clinical practice to maximize the imaging benefit and patient safety.

CLINICAL RELEVANCE/APPLICATION
A new solution is introduced for simultaneously defining image quality and dose reference levels across different patient body habitus. The methodology enables prospective optimization of clinical practice to maximize the imaging benefit and patient safety.

SSG12-04 Does the Dose Reduction Associated with a Percentage Increase of a CT Statistical Iterative Algorithm Maintain the Detectability of Low-Contrast Details? A Phantom Study

Tuesday, Nov. 27 11:00AM - 11:10AM Room: S404CD

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Effective Dose for Computed Tomography in Large, Clinical Populations

Tuesday, Nov. 27 11:10AM - 11:20AM Room: S404CD

Awards
Student Travel Stipend Award

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PURPOSE
Effective dose can efficiently integrate multiple organ dose values into a singular scalar value of radiation dose. The effective dose can also be calculated using dose length product (DLP) to effective dose conversion coefficients. The purpose of this study was to compare the results from these two methods across a large clinical population.

METHOD AND MATERIALS
This IRB-approved study included 579 chest and 247 abdominopelvic exams from two scanners. The organ doses were estimated based on an established Monte Carlo method. Each patient was matched to an XCAT anthropomorphic phantom of the same anatomical height. Precomputed Monte Carlo data were then applied along with adjustments for tube current modulation and patient size. A bias correction factor was also applied to each organ dose to calibrate the organ doses to validated ground truth dose values. The effective dose of each exam was calculated using both dose-length-product based (EDk) and organ-dose-based (EDOD) methods. The EDk was estimated by extracting the DLP and DLP-to-effective dose conversion coefficients defined by ICRP 102. The EDOD was derived using the patient-informed organ doses from the exam using ICRP 103 weighting factors. The EDk was compared to EDOD and CTDIvol.

RESULTS
For the abdominopelvic protocol, EDk was > EDOD by 80.2±48.7% on average (min: -28%; max: 235%; median: 75%). For the chest protocol, EDk was > EDOD by 64.1±33.1% on average (min: -18%; max: 191%; median: 60%). EDk was highly influenced by mean CTDIvol (abdominopelvic: R=0.9692, chest: R=0.9557). EDk was higher than EDOD, especially for larger patients (abdominopelvic: 9.6%, 66.2%, and 115.6% higher; chest: 30.2%, 77.9%, and 116.2% higher on average for patients with 22, 30, and 35 cm water equivalent diameters, respectively). This can be attributed to the contribution of doses absorbed by remainder tissue in EDk calculations.
CONCLUSION
In this work, we compared the effective dose calculated using DLP-based methods versus those based on organ dose. The result showed that DLP methods may over-estimate effective dose, especially for larger patients.

CLINICAL RELEVANCE/APPLICATION
This clinical cohort study showed the substantial differences of effective dose estimated using DLP vs. organ-dose-based methods. This effect is more prominent for larger patients. The study indicates that radiation dose monitoring and reporting could benefit from accurate and robust organ dose estimation.

SSG12-06 Addressing Limitations of the ACR DIR Patient Size Measurement Method
Tuesday, Nov. 27 11:20AM - 11:30AM Room: S404CD

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PURPOSE
AAPM Reports 204/220 reported the relationship between patient size surrogates and normalized dose coefficients (NDC) needed for size-specific dose estimates (SSDE). When localizer radiographs are used to calculate SSDE then a magnification correction should be applied. In this study, we demonstrate a new patient-model based magnification correction on patient data. We also discuss limitations to thresholding based size measurements for bariatric and pediatric patients.

METHOD AND MATERIALS
We analyzed 573 patient scans obtained from a clinical CT system under IRB approval. There were 229 adult abdomen, 284 adult chest, 48 pediatric abdomen, and 12 pediatric chest exams. We extracted LAT and AP dimensions from CT localizers using the ACR DIR method and a connected component analysis to extract gold standard LAT and AP dimensions from axial CT images. We extracted table height from the DICOM header. We applied the model-based magnification correction to the AP and LAT dimensions from the localizers. We used the equation from AAPM Report 204 to calculate the NDC. ‘Gold’ standard NDC values were derived using effective diameter measurements from axial CT images. We plot the NDC for our model-based correction and ACR DIR method as a function of the gold standard NDC values.

RESULTS
NDC estimates for the model-based approach have excellent correlation (R2 = 0.92) with the gold standard approach. On average, effective diameter for the ACR DIR and model-based methods are 8.0% and 1.0% greater than the gold standard, respectively. Outlier cases were noted caused by patient truncation, arms down or devices on patients. ACR DIR size extraction method failed for small patients due to the CT couch being included in the size measurement and bariatric patients were underestimated as some of their anatomy was classified as belonging to the CT couch and thresholded away.

CONCLUSION
The model-based magnification method gives an accurate estimate of effective diameter needed for calculating NDC to achieve accurate SSDE. We discuss errors associated with threshold based size methods for very small and very large patients.

CLINICAL RELEVANCE/APPLICATION
We demonstrate how thresholding based size methods, like those used by the ACR DIR fail for very small and very large patients.

SSG12-07 Characterization of Radiation Risk across a Clinical CT Patient Population: Comparison across 12 Risks Metrics
Tuesday, Nov. 27 11:30AM - 11:40AM Room: S404CD

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PURPOSE
Ascertaining radiological procedure radiation burden is essential for justification, optimization, and personalization of the procedure. While the exact radiation risk for an individual exam is unknowable, various risk-related figures have been used as surrogates, e.g., device output metrics such as CTDI, DLP, SSDE, and hypothetical constructs such as Effective Dose (ED) and Risk Index (RI) that take into account specific organ risks, age, and gender factors. Purpose of this study was to compare how twelve different radiation risk metrics characterize the radiation burden across a set of clinical CT examinations differently.

METHOD AND MATERIALS
This IRB-approved study included 265 abdominopelvic exams with contrast. Organ doses were estimated using Monte Carlo methods. The following risk metrics were calculated using previously validated methods: CTDIvol, DLP, SSDE, DLP-based ED (EDk), organ-dose-based ED (EDOD), dose to a defining organ (ODD to stomach), organ-dose-based RI (Ri), and RI for a reference 20 y.o. patient (Rir). Additional metrics of ODD, O, EDk, and R were calculated for a reference patient (ICRP 110). Lastly, inspired by the ICRP, an adjusted ED (ED) was computed as the product of RIRi and EDOD. A linear regression was applied to each metric dependency to the patient water equivalent diameter (WED). Fit slopes (FS) and relative interquartile ranges (rIQR) at 30 cm reference WED were calculated and normalized to those of RI, which was assumed to be the actual patient risk closest surrogate.

RESULTS

Results showed significant differences between the metrics. EDOD exhibited closest concordance with RI, followed by ODD. Normalized FS ranged between 0.99 (ED') to 2.24 (DLP), and normalized rIQR ranged between 0.30 (DLP) to 4.03 (ED').

CONCLUSION

Different risk metrics lead to different characterization of population risk, particularly risk overestimation for large patients and underestimation for small patients. Furthermore, the risk variability across a population is underestimated for most variables except ED, which exhibits more variability and radiation risk individualization. Care should be exercised in drawing risk predictions from unrepresentative risk metrics applied to a population.

CLINICAL RELEVANCE/APPLICATION

Different risk metrics can lead to different risk predictions. There is a need to standardize risk metrology for proper justification and optimization of radiological procedures.

SSG12-08 Effect of Simulated Micro-Dose (mD) CT on the Performance of Neural Network Convolution (NNC) Deep-Learning (DL) In Radiation Dose Reduction in Chest CT

Participants

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PURPOSE

Radiation dose reduction in chest CT is highly demanded since current radiation dose is high for lung cancer screening. Our purpose was to investigate the effect of simulated mDCT images on the training and performance of our 3D NNC DL for radiation dose reduction in chest CT.

METHOD AND MATERIALS

We developed anatomy-specific (AS) NNC models employing volume-based neural network regression in a convolutional manner to convert mDCT to higher-dose (HD)-like CT. We trained 3 AS NNC models with soft-gating layers with 3 anatomic areas under two training protocols. In our first protocol, we trained our NNC with an anthropomorphic chest phantom (Kyoto Kagaku, Kyoto, Japan) by utilizing real mDCT (120kVp, 10mAs, 0.37mSv) images as input and HDCT (120kVp, 550mAs, 34.9mSv) as "teaching" images. In a second protocol, we trained our NNC with simulated mDCT and HDCT from our diagnostic CT database of 20 patients. Our mDCT simulation consisted of forward-projection of HDCT, addition of photon and electric noise to the sinogram image, filtered back-projection of the noise component, and addition of the noise image to the original HDCT. Through training, our NNC learned to convert lower-dose CT to HD-like CT, where noise and artifacts are substantially reduced; thus, term "virtual" HD (VHD) CT. To compare our NNC models under two different protocols, we collected mD (120 kVp, 5 mAs, 0.2 mSv) and full-dose (120 kVp, 50 mAs, 2.0 mSv) CT of 50 clinical cases including 30 cases with nodules.

RESULTS

Our VHD technology converted mDCT to "virtual" HDCT where noise and artifacts were reduced substantially, while anatomic structures and pathologies were preserved. Our NNCs trained with real mDCT and simulated mDCT improved the contrast-to-noise-ratio (CNR) of mDCT of clinical cases from 4.1±3.9 dB to 21.5±4.9 dB and 22.7±5.0 dB, respectively, which were higher than that of "gold-standard" full-dose CT (CNR: 13.4±5.1 dB). Difference between the 2 models was not statistically significant (t-test; P=0.1).

CONCLUSION

Our 2 NNC models, using real and simulated mDCT images for training, achieved a similar dose reduction performance of 90% and converted mDCT of 50 clinical cases to VHDCT that have higher image quality than "gold-standard" full-dose CT.

CLINICAL RELEVANCE/APPLICATION

Substantial reduction of radiation dose in CT by our new VHD technology would potentially make mDCT screening possible, and it would be beneficial to screening population.
**PURPOSE**

To compare the radiation doses from the dual-layer spectral detector CT (SDCT) and a conventional CT scanner at different patient sizes.

**METHOD AND MATERIALS**

In this retrospective IRB-approved study, consecutive patients scanned on the SDCT scanner (IQon, Philips, Cleveland, USA) with chest CT (PE protocol) and abdominal CT (routine single portal venous phase) protocols from were included. A comparison group of patients scanned using the same matched protocols in a conventional 256-slice scanner (Brilliance iCT, Philips, Cleveland, USA) was selected. The radiation doses (CTDVol) and the size (WED- Water equivalent diameter) was extracted using Radimetrics software (Bayer, Whippany NJ, USA). The radiation doses of the two scanners for these two protocols were compared by log transformation of the CTDVol and using linear regression model to measure the differences in log (CTDI) on average when interacting with WED. The percentage difference between iQon and iCT was also calculated. Each variable was estimated using Maximum likelihood method and tested against the hypothesis of being zero (no effect). P value of less than 0.05 was considered as statistically significant. SAS 9.4(SAS Institute Inc., Cary, NC) was used for all analysis.

**RESULTS**

The study included 482 abdominal CTs (mean patient size 306.4 ± 38.3 mm (182.4 - 442.2 mm)) and 215 chest CTs (296.3 ± 34.1 mm (207.4 - 388.4 mm) ) performed in IQon and 741 abdominal CTs (303.1 ± 44 mm (156.8 - 450.1 mm)) and 323 chest CT (299.6 ± 42.3 mm (205.5 - 408.2 mm)) in iCT. For the abdominal CTs, the mean CTDI for IQon was 12.0 ± 6.0 (3.1 - 50.8) and for iCT was 11.7 ± 6.7 (2.8 - 44.5). For the chest CTs, the mean CTDI for IQon was 11.7 ± 6.2 (4.0-43.1) and for iCT was 6.3 ± 3.0 (3.9-57.0). The intercept was lower for iQon than that for the conventional CT (p<.0001). However, IQon has a higher slope (p<.0001). As a result, the percent difference in CTDVol between iQon and the conventional CT increased when the patient size increased.

**CONCLUSION**

With matched abdominal and chest CT protocols, the SDCT had lower CTDVol than the conventional CT at small patient sizes, but slightly higher radiation dose than conventional CT at large patient sizes.

**CLINICAL RELEVANCE/APPLICATION**

Understanding the size-based variability of radiation dose from the SDCT will help in optimizing the dose and utilize the technique appropriately.

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Prabhakar Rajiah, MD, FRCR - 2014 Honored Educator
Imaging Arterial Vasa Vasorum Proliferation as an Early Marker of Atherosclerosis Using High Resolution Photon-Counting CT

**Purpose**

To detect vasa vasorum (VV) proliferation in arterial walls as an early marker of atherosclerosis using a whole-body photon counting detector (PCD-CT) system.

**Method and Materials**

A swine carotid model of enhanced vasa vasorum (the micro vessels in artery walls) was developed in an anesthetized animal, by injecting autologous blood into the left carotid wall in multiple locations caudal to the bifurcation to mimic early stage atherosclerosis. The right carotid artery (control) was exposed but was not injected. The animal was allowed to recover, and six weeks later re-anesthetized and scanned using the PCD-CT system. Four locations caudal to the carotid bifurcation were scanned using the ultra-high resolution (UHR) PCD-CT acquisition mode and a 40mL contrast bolus (Omnipaque) followed by a 30mL saline chaser. Axial acquisitions (140kV, 342 mAs) were performed at 20 time points (1s rotation, 3s cycle time) allowing CT number measurements in arterial lumen and wall for peak enhancement and recirculation phases. The PCD-CT energy thresholds were set to be 30 and 70 keV. PCD-CT images were reconstructed using a quantitative sharp kernel(Q65). To reduce image noise, a multi-energy non-local means denoising algorithm was applied to the PCD-CT images. Arterial lumen-wall boundaries in the 30-140 keV images were identified using half-max CT number thresholding, and wall CT number enhancement was calculated using an annular ROI placed in the segmented arterial wall. The animal model of increased VV was validated using microfil-enhanced micro-CT (μCT) of excised carotids from the same animal.

**Results**

Baseline corrected wall-lumen ratio integrated over the arterial recirculation phase showed a significantly higher value (p = 0.0036, unpaired t-test) for the left common carotid with enhanced vasa vasorum measured over a length of 22.5mm. Images from contrast-enhanced μCT showed VV proliferation in the excised left carotid, while the right carotid showed normal VV density.

**Conclusion**

We have demonstrated in vivo quantification of vasa vasorum proliferation in the carotid arteries of an animal model using contrast-enhanced PCD-CT. The findings were compared to ex vivo μCT of the carotids.

**Clinical Relevance/Application**

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Vasa vasorum proliferation precedes atherosclerosis and its detection could enable early diagnosis prior to irreversible consequences occur from vulnerable plaques, stenosis, infarction or stroke.

**SSG14-03 High-Pitch Coronary CT Angiography in Revolution CT During Free Breathing versus Breath Holding in Patients with Unlimited Heart Rates**

Tuesday, Nov. 27 10:50AM - 11:00AM Room: S405AB

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**PURPOSE**
To explore the feasibility of coronary CT angiography (CCTA) using free breathing and evaluate the image quality CCTA in free breathing patients when compared to breath holding patients.

**METHOD AND MATERIALS**
60 patients with suspected coronary heart disease were randomly divided into two groups for CCTA scans: group A (n=30) were performed during breath-holding, and the remaining 30 during free-breathing (group B). No heart rate control was performed before examination. The heart rate during planning was 57-113 bpm in group A and 48-124 bpm in group B. The basic information for the two groups was statistically the same. A coefficient of 25 mgl/kg/s was applied for all patients. CT value in Aortic sinus (AS), right coronary artery (RCA), left anterior descending (LAD), left circumflex (LCX), and pericardial fat and standard deviation (SD) in AS and fat were measured. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) for AS were calculated. We compared the differences in the heart rates during the planning and scanning period between two methods. Image quality of every coronary artery segment according to the American Heart Association 15-segment model with at least 1.0 mm diameter was evaluated using 5-point grading scales (1: non-diagnostic - 5: excellent). Two experienced Radiologists also independently reviewed image quality of each coronary artery segment.

**RESULTS**
There was no statistical difference between the demographic data of the two groups. The subjective image quality scores for coronary artery image were 4.49±0.41 (A) and 4.33±0.36 (B). With breath-holding, 91.7% of the coronary artery segments were evaluable with image quality scores of 4 and 5 compared to 89.5% with free breathing group (P>0.05). The CT Value in AS, SNR, CNR with RCA were significantly (P<0.05) lower with group B, but CT numbers in LAD, LCX, RCA, as well as CNR between the two groups were not statistically different (P>0.05). The mean difference between the heart rates before and during scanning for group A was (1.74±1.86) bpm, and group B was (1.30±1.25) bpm, the two groups were not statistically different (P>0.05).

**CONCLUSION**
Free-breathing CCTA is feasible using 256-MDCT scanner without heart rate control, and acquire high quality image.

**CLINICAL RELEVANCE/APPLICATION**
Free-breathing CCTA is feasible using 256-MDCT scanner without heart rate control, and acquire high quality image.

**SSG14-04 Early Investigation on CT Thermometry as a Tool to Monitor the Ablation Zone During Thermal Ablation Therapy**

Tuesday, Nov. 27 11:00AM - 11:10AM Room: S405AB

Participants
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**PURPOSE**
Percutaneous thermal ablation, such as microwave or radiofrequency ablation, is a clinical treatment for cancer that utilizes directed heating to induce cell death. Currently, there is no accurate way to evaluate the ablation zone, which can lead to incomplete ablation and thereby precipitate local recurrence of cancer. Since temperature affects mass density and since CT can measure changes in mass density, CT could be used to monitor the ablation zone. In this study, we test the hypothesis that a reliable, clinically significant decrease in attenuation can be seen in water heated from body temperature (36°C) to the temperature at which cell death occurs (above 55°C).

**METHOD AND MATERIALS**
Four bottles of water stacked in a 2 x 2 arrangement were heated to 75°C and then passively cooled to 30°C. The temperature within each bottle was monitored using independent thermometers (1°C accuracy). CT scans (120 kV, routine abdominal protocol) were taken after every 2°C drop until the desired temperature range was covered. A representative central slice passing through the four bottles was chosen. The mean attenuation coefficient in an 81 x 81 region-of-interest was evaluated within each bottle and plotted against temperature at time of acquisition.

**RESULTS**
At 73°C (the temperature measured during the initial CT scan), the attenuation of water was -24.6 ± 0.4 Hounsfield Units (HU). As the water cooled to 33°C (the temperature measured during the last scan), the attenuation increased to -5.0 ± 0.6 HU. The measurements were consistent across all 4 bottles. A linear model was fitted to all measurements ($R^2 = 0.98$). The model demonstrates an 11.52 HU change between 36°C and 60°C (95% confidence interval: [11.21-11.84], based on the Student distribution with 88 degrees of freedom).

CONCLUSION

Our study shows that there is a measurable decrease in CT attenuation between body temperature and 55°C, the temperature at which cell death occurs. This observed 11.5 HU change in attenuation can be clinically differentiated by radiologists at a reasonable radiation dose, indicating that parenchymal changes due to heating could be measured using CT.

CLINICAL RELEVANCE/APPLICATION

In thermal ablation, directed heating is used to treat pathology, especially malignancy. Reliable evaluation of the ablation zone using CT thermometry will allow more accurate cancer treatment.

SSG14-05  
Effectiveness of Metal Artefact Reduction Algorithm in a New Generation Spectral CT

Participants
Cheng Li, Shanghai, China (Presenter) Nothing to Disclose
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PURPOSE

The purpose of this study was to quantify the effectiveness of metal artefact reduction (MAR) algorithm in restoring the CT image quality with the new generation spectral CT scanner, and compared the results with those of an older generation CT scanner.

METHOD AND MATERIALS

We retrospectively reviewed clinical data of twelve patients with pedicle screw fixation of fractured vertebrae or degenerated intervertebral disc. Institutional review committee approval and written informed consents from patients were obtained. All patients underwent CT scan during the first hospital admission and three weeks thereafter to evaluate the position of the pedicle screws. The initial CT examination was carried out using GE Discovery CT750 HD with 80/140kVp, 0.5s rotation and 0.986 pitch. The follow-up scan was performed at 0.5s rotation and 0.992 pitch using a new generation spectral CT (Revolution CT, GE Healthcare). Virtual monochromatic images (VMIs) were reconstructed at energy levels of 63, 68, 74, 88, and 105 keV. Artefact index ($AI=(Ns-Nm)^2$) was assessed by region of interest (ROI) measurements in position of the strongest artefact (Ns) and in a muscle structure without artefact (Nm) (noise in HU units). The subjective image quality was assessed by two experienced radiologists independently. The CTDIvol and dose length product (DLP) were recorded. All quantitative analysis was based on the mean value of parameter calculated from five VMIs.

RESULTS

Metal artefact index and radiation dose was significantly reduced in the new generation spectral CT ($\text{AI} = 18.27\pm7.09$, CTDI 11.89±4.09, DLP 212.50±36.96) compared with that in older generation CT ($\text{AI} = 51.98\pm28.77$, CTDI 17.51±1.63, DLP 276.69±42.11, p<0.05 for all). There was high agreement between two radiologists ($kappa=0.682$). Subjective image quality analysis showed significantly higher score at new generation CT scanner (3.82±0.68,3.85±0.66) than older generation CT scanner (2.12±0.76), (2.00±0.74).

CONCLUSION

The MAR algorithm in the new generation spectral CT allows for a significant reduction of metal artefacts and improved subjective image quality in patients with pedicle screw.

CLINICAL RELEVANCE/APPLICATION

Pedicle screw with high atomic number are widely used in orthopedic surgery and can produce severe metal artefact. The present study demonstrated that MAR algorithm in a new generation spectral CT was effective in reducing artefacts arising from pedicle screw.

SSG14-07  
Improvement of Image quality in Low-Dose Computed Tomography Using a Deep Learning Based Denoising Algorithm

Participants
Yoon Joo Shin, MD, Seongnam, Korea, Republic Of (Presenter) Nothing to Disclose
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PURPOSE

The purpose of this study was to quantify the effectiveness of metal artefact reduction (MAR) algorithm in restoring the CT image quality with the new generation spectral CT scanner, and compared the results with those of an older generation CT scanner.

METHOD AND MATERIALS

We retrospectively reviewed clinical data of twelve patients with pedicle screw fixation of fractured vertebrae or degenerated intervertebral disc. Institutional review committee approval and written informed consents from patients were obtained. All patients underwent CT scan during the first hospital admission and three weeks thereafter to evaluate the position of the pedicle screws. The initial CT examination was carried out using GE Discovery CT750 HD with 80/140kVp, 0.5s rotation and 0.986 pitch. The follow-up scan was performed at 0.5s rotation and 0.992 pitch using a new generation spectral CT (Revolution CT, GE Healthcare). Virtual monochromatic images (VMIs) were reconstructed at energy levels of 63, 68, 74, 88, and 105 keV. Artefact index ($AI=(Ns-Nm)^2$) was assessed by region of interest (ROI) measurements in position of the strongest artefact (Ns) and in a muscle structure without artefact (Nm) (noise in HU units). The subjective image quality was assessed by two experienced radiologists independently. The CTDIvol and dose length product (DLP) were recorded. All quantitative analysis was based on the mean value of parameter calculated from five VMIs.

RESULTS

Metal artefact index and radiation dose was significantly reduced in the new generation spectral CT ($AI = 18.27\pm7.09$, CTDI 11.89±4.09, DLP 212.50±36.96) compared with that in older generation CT ($AI = 51.98\pm28.77$, CTDI 17.51±1.63, DLP 276.69±42.11, p<0.05 for all). There was high agreement between two radiologists ($kappa=0.682$). Subjective image quality analysis showed significantly higher score at new generation CT scanner (3.82±0.68,3.85±0.66) than older generation CT scanner (2.12±0.76), (2.00±0.74).

CONCLUSION

The MAR algorithm in the new generation spectral CT allows for a significant reduction of metal artefacts and improved subjective image quality in patients with pedicle screw.
SSG14-08  
**Potential Application of Photon Counting CT in Cerebrovascular Imaging**

Tuesday, Nov. 27 11:40AM - 11:50AM Room: S405AB

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**PURPOSE**

To assess the image quality of low dose (LD) computed tomography (CT) using a deep learning based denoising algorithm (DLA) compared with filtered back projection (FBP) and advanced modeled iterative reconstruction (ADMIRE).

**METHOD AND MATERIALS**

Our institutional review board approved this retrospective study. A total of 50 patients underwent routine dose (RD) abdominal CT using FBP. CT images at 50%, 25%, and 13% dose levels of RD were simulated from RD CT images and reconstructed using FBP. We trained the DLA using the simulated LD CT images as input data and the RD CT images as the ground truth. To assess the image quality, we included five patients who underwent abdominal LD CT and additionally performed CT scan for the CTP 528 module of Catphan. CT images were reconstructed using FBP and ADMIRE (LD-FBP and LD-ADMIRE images). LD-FBP images were processed using DLA (LD-DLA images). We compared the mean image noise levels of LD-DLA, LD-ADMIRE and LD-FBP images in the liver, subcutaneous fat, paraspinal muscles and aorta drawing elliptical region-of-interests. Modulation transfer function (MTF) was measured at the images of CTP 528 module to assess the spatial resolution.

**RESULTS**

Mean image noises in LD-DLA images were significantly lower than LD-FBP images (p<0.05 for all) and similar compared with LD-ADMIRE images (p>0.05 for all). MTFs (mm-1) of 10% contrast were 0.629, 0.629 and 0.635 in LD-DLA, LD-ADMIRE and LD-FBP images, respectively.

**CONCLUSION**

The LD-DLA images showed the less noise than LD-FBP images and comparable noise to LD-ADMIRE images while preserving the spatial resolution.

**CLINICAL RELEVANCE/APPLICATION**

Deep learning based denoising algorithm could improve the image quality of low dose computed tomography and be a new way to reduce radiation dose.

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**Participants**

Evan Harvey, Madison, WI (Presenter) Nothing to Disclose
Ran Zhang, PhD, Madison, WI (Abstract Co-Author) Nothing to Disclose
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Xu Ji, Madison, WI (Abstract Co-Author) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (Abstract Co-Author) Research funded, General Electric Company Research funded, Siemens AG
Ke Li, PhD, Madison, WI (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

The goal of this work was to study the potential benefit of photon counting CT (PCCT) in imaging the cerebral vasculature. The scientific rationale was that compared with the current cerebral CT angiography (CCTA) technology, PCCT could provide better performance for cerebrovascular imaging tasks due to 1) improved energy weighting scheme applied to the photon signal and 2) significantly relaxed noise-spatial resolution tradeoff offered by the photon counting detector (PCD).

**METHOD AND MATERIALS**

An in-house experimental PCCT was constructed using a 51 cm CdTe-based PCD with a native pixel size of 100 μm. A customized angiographic CT head phantom containing contrast-enhanced healthy cerebral artery models (diameters ranging from 0.5 to 4.0 mm) was scanned by both the PCCT and a clinical MDCT with a clinical CCTA protocol. Radiation dose, beam collimation (20 mm), kV (100), reconstruction pixel size (0.4 mm) and slice thickness (1.25 mm) were matched between the two systems. MIP images were generated based on the instruction of the clinical CCTA protocol. CNR was measured at both proximal and distal branches of ICA and MCA. In addition, axial- and z-MTFs were measured for the two CT systems.

**RESULTS**

The CTDIvol and effective dose of the two systems were matched at 35 mGy and 1.23 mSv, respectively. Based on the measured axial MTF of MDCT, the reconstruction kernel of PCCT was adjusted until the axial spatial resolution of the two CT systems was matched; under this condition, the CNR of the proximal arteries (diameter 4.0 mm) was 44.7±12.2 in MDCT and was 87.5±22 (p=0.0003) in PCCT. For the distal and smaller artery branches (0.5 mm) the CNR was 11.3±4.3 for CCTA and 17.3±6.1 for PCCT (p=0.013). 10% MTF along z was 1.1 lp/mm for MDCT and 2.1 lp/mm for PCCT. The MDCT MIP demonstrated artificial stenosis in a healthy angular artery due to partial volume effect; in contrast, the PCCT MIP provided more accurate and clearer rendering of all the arteries evaluated.

**CONCLUSION**

With matched dose and axial spatial resolution, PCCT provides higher vessel CNR, better z resolution, and reduced partial volume artifact, which suggests its promising application in cerebrovascular imaging.

**CLINICAL RELEVANCE/APPLICATION**

PCCT has the potential to address two major challenges in clinical CCTA: 1) limited CNR and spatial resolution of MDCT in imaging small or partially enhanced vessels; 2) distortions of true artery information due to image artifacts.
Case-based Review of Nuclear Medicine: PET/CT Workshop-Abdomen/Pelvis & Pediatrics PET/CT (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Nov. 27 1:30PM - 3:00PM Room: E450B

Participants
Samuel E. Almodovar-Reteguis, MD, Orlando, FL (Director) Nothing to Disclose
Katherine A. Zukotynski, MD, Ancaster, ON (Director) Nothing to Disclose
Terence Z. Wong, MD, PhD, Chapel Hill, NC (Moderator) Consultant, Lucerno Dynamics, LLC;

Sub-Events
MSCC33A Abdomen/Pelvis I

Participants
Don C. Yoo, MD, E Greenwich, RI (Presenter) Consultant, Endocyte, Inc

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LEARNING OBJECTIVES
1) Review Challenging and Instructive cases which will help with interpretation of PET/CT scans in the abdomen and pelvis.

ABSTRACT
For oncologic studies, F18-FDG is an outstanding tracer with wide applications. However, there are many normal variants and pitfalls which can make interpretation challenging. Appropriate clinical history can help avoid mistakes. Having patients fill out a questionnaire form can provide helpful information and if possible directly interviewing the patients for relevant pertinent clinical information can also be valuable. Discussing a complicated PET/CT scan with the referring physician can also yield valuable information and improve interpretation. This review will discuss challenging cases, physiologic variants and pitfalls seen in the abdomen and pelvis when interpreting PET/CT scans concentrating on genitourinary and gastrointestinal cases.

MSCC33B Abdomen/Pelvis II

Participants
Esma A. Akin, MD, Washington, DC (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Review the current applications of PET-CT in gynecologic disease and bladder cancer.

ABSTRACT
FDG PET-CT is an effective tool in initial assessment and treatment follow up of various genitourinary and gynecological tumors. This session aims to highlight the utility of PET-CT in genitourinary disorders as well as tumors of the bladder. An updated review of the current applications of PET-CT in gynecologic disease as well as bladder cancer will be presented. Pitfalls and variants that may challenge image interpretation will also be highlighted.

MSCC33C Pediatrics

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Helen R. Nadel, MD, Palo Alto, CA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To be able to identify optimal PET/CT imaging parameters for children. 2) To be able to describe PET/CT patterns of disease in pediatrics. 3) To be able to compare PET/CT with PET/MR imaging in children.
MSR037

Dynamic Perfusion Area-Detector CT versus Dynamic Perfusion MR Imaging versus FDG-PET/CT: Capability for Therapeutic Outcome Prediction in Small Cell Lung Cancer Patients with Limited Disease

Tuesday, Nov. 27 1:30PM - 1:40PM Room: S103CD

Participants
Meng X. Welliver, MD, Columbus, OH (Moderator) Nothing to Disclose
Tracy M. Sherertz, MD, San Francisco, CA (Moderator) Nothing to Disclose

Sub-Events

MSR037-01 Dynamic Perfusion Area-Detector CT versus Dynamic Perfusion MR Imaging versus FDG-PET/CT: Capability for Therapeutic Outcome Prediction in Small Cell Lung Cancer Patients with Limited Disease

Tuesday, Nov. 27 1:30PM - 1:40PM Room: S103CD

Participants
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PURPOSE
To directly compare the capability for therapeutic outcome prediction among dynamics contrast-enhanced (CE-) perfusion area-detector CT (ADCT) and CE-perfusion MR imaging (MRI) assessed by same mathematical method and FDG-PET/CT in small cell lung cancer (SCLC) patients assessed as limited disease (LD).

METHOD AND MATERIALS
Forty-three consecutive pathologically diagnosed SCLC patients assessed as LD (25 male, 18 female; mean age 67 year old) underwent FDG-PET/CT, dynamic CE-perfusion ADCT and MRI, chemoradiotherapy, and follow-up examination. In each patient, therapeutic outcomes were assessed as therapeutic effect based on RECIST guideline, disease free interval and overall survival. Then, all patients were divided into two groups as follows: 1) responder (CR+PR: n=33) and 2) non-responder (SD+PD: n=10) groups. In each patient, total perfusion (TP) and tumor perfusions from pulmonary (TPP) and systemic (TPS) circulations calculated by dual-input maximum slope method from dynamic CE-perfusion ADCT and MRI data and SUVmax on PET/CT were assessed at targeted lesions. Then, final values were determined as average values from all targeted lesion, and compared between two groups by Student’s t-test. To compare the capability for distinguishing two groups, all indexes as having significant difference were assessed by ROC analysis. Finally, disease free and overall survivals between responders and non-responders assessed by each index were compared by Kaplan-Meier method followed by log-rank test.

RESULTS
There were significant difference of all indexes except TPP determined by each method (p<0.05). Area under the curves (Azs) of TPS (ADCT: Az=0.92, MRI: Az=0.92) were significantly larger than that of SUVmax (Az=0.73, p<0.05). Disease free survivals of responder were significantly longer than that of non-responder by TP (ADCT: p=0.006, MRI: p=0.02) and TPS (ADCT: p=0.001, MRI: p=0.02). Overall survivals of responder were also significantly longer than that of non-responder by TP (ADCT: p<0.0001, MRI: p=0.0003, and TPS (ADCT: p=0.001, MRI: p=0.001).

CONCLUSION
Dynamic CE-perfusion ADCT and MRI have better potential for predicting therapeutic outcome than FDG-PET/CT in small cell lung cancer patients with limited disease.

CLINICAL RELEVANCE/APPLICATION
Dynamic CE-perfusion ADCT and MRI have better potential to predict therapeutic outcome than FDG-PET/CT in small cell lung cancer patients with limited disease.
**PURPOSE**

Non-small cell lung cancer (NSCLC) is one of the most common malignancies associated with brain metastases (BM) at diagnosis. Recent randomized trials have shown equivalent survival outcomes and improved neurocognitive outcomes with stereotactic radiosurgery (SRS) compared to whole brain radiation therapy (WBRT). We reviewed the NCDB to identify trends of RT for NSCLC patients with BM.

**METHOD AND MATERIALS**

11,299 NSCLC patients with BM at diagnosis and treated with palliative brain RT between 2010 and 2014 were identified in the NCDB. Patients receiving "stereotactic radiosurgery, NOS," "LINAC radiosurgery," or "gamma knife radiosurgery," or received external-beam RT with fraction size >=6 Gy were included in the SRS cohort. The WBRT cohort included all patients receiving RT to the brain in >=5 fractions. Patient characteristics were correlated with treatment received using multivariable logistic regression. Kaplan-Meier was used to compare overall survival (OS) between these two groups and Cox Proportional Hazards modeling (CPHM) to identify variables associated with OS.

**RESULTS**

9,680 (85.7%) patients were included in the WBRT group and 1,619 (14.3%) patients in the SRS group. Median dose in the WBRT was 3000 cGy and 2200 cGy in the SRS group. The frequency of SRS increased from 9.9% in 2010 to 19.6% in 2014. On MVA, variables associated with increased likelihood of receiving SRS included: increasing age (OR 1.01, 95% CI 1.01-1.02; P<0.0001), most recent year (2014) of diagnosis (OR 2.14, 1.78-2.56; P<0.0001), treatment at an academic facility (OR 3.21, 2.51-4.10; P<0.0001), private insurance (OR 2.25, 1.62-3.11), income in zip code >$63,000 (OR 1.33, 1.13-1.56; P=0.001), living >20 miles from treatment facility (OR 1.19, 1.03-1.37; P=0.016), and receipt of chemotherapy (OR: 2.48, 2.12-2.88; P<0.0001). WBRT patients had median OS of 4.1 months (95% CI, 4.0-4.3) vs. 8.9 months (8.2-9.7) for SRS patients (P<0.0001). On CPHM, factors independently associated with improved OS included receipt of SRS, chemotherapy, treatment at an academic center, and private insurance (P<0.02 for all).

**CONCLUSION**

Our analysis reveals that WBRT remains the most common palliative treatment for BM in NSCLC. SRS use is increasing and has nearly doubled between 2010 and 2014. In this study, SRS was associated with increased OS although there are biases in the selection of patients who receive SRS.

**CLINICAL RELEVANCE/APPLICATION**

SRS use for NSCLC patients with BM at the time of diagnosis is increasing, and is independently associated with improved OS.

**PURPOSE**

This study assessed the feasibility of FDG-PET/CT to quantify radiation-induced pneumonitis in ipsilateral and contralateral lungs of patients with locally advanced non-small cell lung cancer (NSCLC) who received proton, photon, or combined proton-photon radiotherapy (RT).
Participants of imaging in precision medicine. A non-invasive method from image features to predict gene mutation status correlated with NSCLC and further advancing the role of clinical relevance/application.

RESULTS

Among the 9 patients who received photon RT, there was a significant increase in PVC-GLPG of ipsilateral (p < 0.001) and in GLG of contralateral (p = 0.036) lungs. Also, in the subset of 9 patients who received combination of proton-photon RT, there was a statistically significant increase in PVC-GLPG in only the ipsilateral lung (p < 0.001). In contrast, among the 21 patients treated exclusively with proton RT, no significant increase in PVC-SUVmean (p=0.114) or in PVC-GLPG (p=0.453) were observed in ipsilateral lungs. Also, there were no significant increase in SUVmean (p=0.841) or in GLG (p=0.241) of contralateral lungs of patients who received exclusively proton RT.

CONCLUSION

We identified significant increases in PVC-SUV and PVC-GLPG in patients who received photon RT (either alone or in combination with proton RT) that were not identified in patients who received only proton RT. These observations suggest less induction of inflammatory response in both ipsilateral and contralateral lungs of patients treated with proton compared to photon or combined proton-photon RT, suggesting a mechanism by which proton therapy reduces radiation-induced pneumonitis.

METHOD AND MATERIALS

Eighty patients with stage II and III NSCLC and a confirmed EGFR mutation status (30 patients were positive and 50 were negative for EGFR mutation), who underwent PET/CT between January 2017 to December 2017, were included in this study. We extracted 514 quantitative features from PET/CT (257 for PET and 257 for CT) and 12 qualitative features from CT. Principal component analysis (PCA) was applied for feature selection. We selected principal components retaining 95% of the variability from all features. We then rebuilt the original features using the selected principal components and the original features were selected that correlated by at least 99% to the rebuilt features. Finally, 5 quantitative features, 24 quantitative features for CT as well as 10 qualitative features from PET were selected. A predictive model of EGFR mutation in terms of selected features using generalized linear regression with lasso regularization. The regularization parameter was selected through a 10-fold cross validation. All statistical analysis were performed in R software version 3.4.4.

RESULTS

With the total of 39 features selected which were significantly associated with EGFR mutation status, a predictive model for associating image features with EGFR positive/negative was built. We estimated the performance of the model using the area under the receiver operating characteristic curve (AUC). The result revealed an AUC=0.74.

CONCLUSION

By combing the PET-CT images together with first generation gene testing data, we investigate the relationship between image features and EGFR mutation status and built a radiogenomics model which can predict whether the patients have EGFR mutation or not from a certain number of qualitative features as well as quantitative features.

CLINICAL RELEVANCE/APPLICATION

A non-invasive method from image features to predict gene mutation status correlated with NSCLC and further advancing the role of imaging in precision medicine.
Lorenzo Livi, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Pierlugi Bonomo, Florence, Italy (Presenter) Nothing to Disclose
Vieri Scotti, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Marco Perna, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Luca Visani, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Gabriele Simontacchi, Florence, Italy (Abstract Co-Author) Nothing to Disclose
Vanessa Di Cataldo, Florence, Italy (Abstract Co-Author) Nothing to Disclose
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PURPOSE

By definition, centrally located lung tumors are identified as a lesion located within 2 cm or touching the zone of the proximal bronchial tree or tumors immediately adjacent to the mediastinal or pericardial pleura. In these cases, the use of stereotactic body radiotherapy (SBRT) is debated due to the potential risk of severe toxicity. Currently, no high-level evidence is available to support its use.

METHOD AND MATERIALS

Between 2010 an 2015, 40 patients were treated with SBRT for 45 centrally located lesions. SBRT was delivered through either a LINAC-based intensity modulated radiotherapy (IMRT) technique or a robotic technique with Cyberknife. The prescribed total dose varied between 26 and 60 Gy delivered in 1 or 8 fractions, respectively, with median BED10 of 69 Gy (range 37.5-105 Gy). Overall Survival (OS) and Progression Free Survival (PFS) were reported using Kaplan-Meier method. Treatment-related toxicity was evaluated according to CTCAE version 4.0

RESULTS

The median age of the cohort was 62 years (48-86). The majority of treated lesions were secondary hilar or mediastinal lymphadenopathies (31/45, 69%), while unresectable primary tumors represented the remaining 14 cases (14/45, 31%). The most commonly used technique was VMAT for 21 lesions (47%), followed by Cyberknife for 14 (31%) and step and shoot IMRT for 10 targets (22%), respectively. The predominant NSCLC histology was adenocarcinoma (32/45, 71%). The median longest tumor diameter was 31 mm (range 10-60 mm). At a median follow-up of 14.5 months, OS and PFS were 86.5%, 55.6%, 49.4% and 48.6%, 24.1% and 12% at 1, 2 and 3 years, respectively. According to RECIST 1.1 criteria, a clinical benefit was achieved for 23 patients (57.5%) with a complete or partial response or stable disease in 4 (10%), 15 (37.5%) and 4 (10%) patients, respectively. Consistent with previous experiences using the same fractionation regimens, SBRT was well tolerated, with no G3/G4 toxicities: the most severe side effect was G2 esophagitis in 5/40 patients (12.5%).

CONCLUSION

In accordance with standardized risk-dose prescriptions, the use of SBRT for centrally located NSCLC was confirmed to be a safe and effective strategy. Prospective studies are warranted to support its use with high level evidence.

CLINICAL RELEVANCE/APPLICATION

Our single-center experience adds to the limited available evidence on the feasibility and clinical benefit of SBRT for centrally located NSCLC.

MSRO37-06 Evaluation of the Tumor Response Using FDG-PET/CT Scans in Non-Small Cell Lung Cancer Patients Treated with Proton or Photon Radiotherapy

Tuesday, Nov. 27 2:20PM - 2:30PM Room: S103CD

Participants
Pegah Jahanjiri, MD, Philadelphia, PA (Presenter) Nothing to Disclose
Kamyar Pournazari, MD,MSc, Philadelphia, PA (Abstract Co-Author) Nothing to Disclose
Charles B. Simone II, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Drew A. Torigian, MD, Philadelphia, PA (Abstract Co-Author) Co-founder, Quantitative Radiology Solutions LLC
Abass Alavi, MD, Philadelphia, PA (Abstract Co-Author) Nothing to Disclose

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PURPOSE

Pancreatic cancer is one the leading causes of death worldwide. Radiation therapy (RT) is a major treatment option for lung cancer, including for unresectable locally advanced non-small cell lung cancer (LA-NSCLC). The aim of this study was to evaluate the response of the primary lung tumor to proton versus photon RT using 18F-fluorodeoxyglucose (FDG)-PET/CT in patients with LA-NSCLC.

METHOD AND MATERIALS

Thirty-nine consecutive patients who underwent FDG-PET/CT imaging pre- and post- proton or photon RT were assessed. Patients were predominantly female (53.8%) with a median age of 67 years and with predominantly stage IIIA (62%). An adaptive contrast-oriented thresholding algorithm was applied to measure metabolically active tumor volumes, uncorrected SUV, partial volume corrected SUV and total lesion glycolysis. Parameters of FDG-PET/CT scans before and after RT were compared using two-tailed paired t-tests.

RESULTS

Parameters of FDG-PET/CT scans before and after RT were compared using two-tailed paired t-tests.
Among the 9 patients who received photon RT and the 9 patients who received a combination of proton-photon RT, there was a significant decrease in PVC-TLG. Interestingly, among the 21 patients treated exclusively with proton RT, all tumor parameters including MTV, SUVmax, uncorrected SUVmean, PVC-SUVmean, uncorrected TLG, and PVC-TLG after treatment decreased significantly (all \( p < 0.001 \)). The decreases in PVC-TLG and tumor PVC-SUVmean were more obvious than non-PVC ones (\( \Delta \text{PVC-TLG} -357.26 \text{ cc versus } \Delta \text{TLG} -252.92 \text{ cc; } \Delta \text{PVC-SUVmean} -16.2 \text{ versus } \Delta \text{SUVmean} -10.19 \)).

CONCLUSION

Adaptive contrast-oriented thresholding algorithm is a promising method to quantify whole tumor glycolysis in LA-NSCLC, and our findings demonstrates that proton RT is as effective as photon RT metabolically in inducing tumor response of LA-NSCLC.

CLINICAL RELEVANCE/APPLICATION

Proton RT, which is much safer, is as effective as photon RT in treatment of LA-NSCLC.
SSJ05

Science Session with Keynote: Chest (Thoracic MRI)
Tuesday, Nov. 27 3:00PM - 4:00PM Room: S404AB

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

FDA Discussions may include off-label uses.

Participants
Jurgen Biederer, MD, Seeheim-Jugenheim, Germany (Moderator) Nothing to Disclose
Patricia J. Mergo, MD, Jacksonville, FL (Moderator) Nothing to Disclose

Sub-Events
SSJ05-01 Chest Invited Speaker: Beyond Morphology-Comprehensive Imaging of Pulmonary Disease with MRI
Tuesday, Nov. 27 3:00PM - 3:10PM Room: S404AB

Participants
Jurgen Biederer, MD, Heidelberg, Germany (Presenter) Nothing to Disclose

SSJ05-02 Combination of MR Free-Breathing 3D T1-Weighted Star VIBE and DWI for the Differentiation of Benign from Malignant Peripheral Pulmonary Lesions: A Comparative Study Using Routine-Dose CT
Tuesday, Nov. 27 3:10PM - 3:20PM Room: S404AB

Participants
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PURPOSE
The differentiation of benign pulmonary lesions from malignant pulmonary lesions is very difficult. High resolution CT is the most commonly used radiology methods for lung. While it is limited to children, child-bearing women and disorders requiring repeated examinations over prolonged periods because of its radiation dose. The result of our previous studies showed that: comparing with routine-dose CT, the MR T1-weighted 3D Star VIBE sequence was slightly lower in differentiating the peripheral pulmonary lesions (PPL) with morphological features. MR can provide not only the morphological information, but also functional information. The apparent diffusion coefficient (ADC) value was used widely in whole body, but this research of combining MR-DWI ADC value with morphological characteristics of PPL was rare. The purpose of this study was to evaluate the no radiation-dose MR (ADC value and T1-weighted 3D Star VIBE sequence) diagnostic efficiency in differentiating the malignant PPL from benign, with the routine-dose CT as a reference standard.

METHOD AND MATERIALS
Forty-seven patients (30 males and 17 females, mean age 64.1 years old; age range 48-83 years) were enrolled in this study, all the patients had undergone routine-dose CT, MR T1 Star VIBE and DWI with 3.0T MR sanner. These lesions were all diagnosed by transthoracic needle biopsy or surgery. Two radiologists observed the morphological signs of MR and CT images independently. The order of observation was MRI first, and followed by CT. Then the ADC value of lesions were measured. The logistic regression analysis was used to calculate the probability. The ROC curve was used to analyze the capabilities of morphological characteristics and DWI in distinguishing malignant PPL from benign.

RESULTS
There was significant difference of the ADC value between benign and malignant groups (p=0.001). The cut-off ADC value was 1197×10-6 mm2/s. Combined MR T1 Star VIBE with ADC value can distinguish PPL better than only routine-dose CT, ADC value and T1 Star VIBE alone.

CONCLUSION
The ADC value could differentiate the peripheral pulmonary lesions initially, but the distinguishability was better if combing MR T1 Star VIBE morphological characteristics with ADC value.

CLINICAL RELEVANCE/APPLICATION
We can use MR T1-weighted 3D Star VIBE and DWI to replace routine-dose CT to distinguish PSPLs in order to avoid radiation exposure.

SSJ05-03 18F-Fluorodeoxyglucose Positron Emission Tomography/Computed Tomography (PET/CT) and Diffusion-Weighted Magnetic Resonance Imaging (DWI-MRI) Diagnostic Performance in the
Evaluation of Pulmonary Lesions: A Systematic Review and Meta-Analysis

Tuesday, Nov. 27 3:20PM - 3:30PM Room: S404AB

Awards
Student Travel Stipend Award

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PURPOSE
To perform a systematic review and meta-analysis of the diagnostic performance of DWI-MRI and 18F-FDG PET/CT in the evaluation of pulmonary lesions.

METHOD AND MATERIALS
Databases of MEDLINE and Embase were searched through December 2017. Studies published in English were included when the diagnostic performances of 18F-FDG PET/CT or DWI in detecting malignant pulmonary lesions were clearly identified in the articles. Two reviewers evaluated the study quality of all selected articles using QUADAS-2 and only those that met a minimum quality score were included. Parameters of lesion quantification were analyzed separately for each imaging modality (e.g., lesion-to-spine ratio (LSR), and apparent diffusion coefficient (ADC) for DWI-MRI). Meta-analysis using a random-effects model were conducted to calculate the pooled sensitivities, specificities, positive and negative likelihood ratios (PLR and NLR), diagnostic odds ratios (DOR) and area under the curve (AUC) for PET/CT and DWI with 95% confidence intervals (95% CI).

RESULTS
The literature search yielded 1280 results, and the inclusion criteria were met by 37 studies (23 FDG PET/CT studies, 8 MRI studies and 6 studies including both methods), with a total of 4224 participants and 4463 lesions (malignant, n = 3090, 69.2%; benign, n=1362, 30.8%). Pooled sensitivity and specificity of SUVmax (n = 25) were 0.86 (95%CI, 0.82-0.90) and 0.73 (95%CI, 0.62-0.82), respectively. For DWI-MRI, LSR studies (n = 4) showed a sensitivity of 0.81 (0.71-0.88) and a specificity of 0.90 (0.79-0.95), whereas studies utilizing ADC (n = 12) had a sensitivity and specificity of 0.83 (0.77-0.88) and 0.86 (0.76-0.92), respectively. DWI-LSR yielded the greatest diagnostic odds ratio (DOR = 38, 95%CI 12-115) compared to DWI-ADC (DOR = 30, 95%CI 14-66) and SUVmax (DOR = 17, 95%CI 10-28).

CONCLUSION
Diagnostic performance of DWI-MRI is comparable to 18F-FDG PET/CT for the evaluation of potentially malignant pulmonary lesions.

CLINICAL RELEVANCE/APPLICATION
This is the first meta-analysis to compare the diagnostic performance of DWI-MRI and 18F-FDG PET/CT for the evaluation of pulmonary lesions. Our study demonstrated that the diagnostic performance of DWI-MRI is comparable or even superior to that of PET/CT, which supports the inclusion of MRI as a low-cost and radiation-free option to the diagnostic work-up of pulmonary lesions.

SSJ05-04 Chemical Exchange Saturation Transfer (CEST) Imaging versus Diffusion-Weighted Imaging (DWI) versus 18F-FDG PET/CT: Capability for Diagnosis of Solitary Pulmonary Nodule

Tuesday, Nov. 27 3:30PM - 3:40PM Room: S404AB

Participants
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PURPOSE
To directly and prospectively compare the capability for diagnosis of solitary pulmonary nodules (SPNs) among chemical exchange saturation transfer (CEST) imaging, diffusion-weighted imaging (DWI) and 18F-FDG PET/CT imaging.
METHOD AND MATERIALS

113 consecutive patients (69 male and 44 female; mean age 71 year old) with 122 SPNs underwent CEST imaging and DWI at a 3T MR system, FDG-PET/CT, and pathological and/or follow-up examinations. According to final diagnoses, all SPNs were divided into malignant (n=76) and benign (n=46) SPNs. In each patient, magnetization transfer ratio asymmetry (MTRasym) was calculated from z-spectra at 3.5ppm in each pixel, and MTRasym map was computationally generated from CEST data. In each lesion, MTRasym, apparent diffusion coefficient (ADC) and SUVmax were assessed by ROI measurements. To compare all indexes between two groups, Student’s t-test was performed. Then, multivariate logistic regression analyses were performed to investigate the discriminating factors of two groups. In addition, ROC analyses were performed to compare diagnostic performance among all indexes as well as combined methods. Finally, sensitivity, specificity and accuracy were compared among all methods by McNemar’s test.

RESULTS

MTRasym, ADC and SUVmax had significant difference between malignant and benign SPNs (p<0.05). Multivariate regression analyses identified MTRasym (Odds ratio [OR]: 0.54), ADC (OR: 47.6) and SUVmax (OR: 0.47) as significant differentiators (p<0.05). ROC analyses showed area under the curve (Az) of MTRasym (Az=0.77, p<0.05). Sensitivity (SE) and accuracy (AC) of MTRasym (SE: 81.6 [62/76] %, AC: 82.8 [101/122] %) and combined methods (SE: 85.5 [65/76] %, AC: 85.2 [104/122] %) were significantly higher than those of ADC (SE: 69.7 [53/76] %, p<0.05; AC: 77.9 [95/122] %, p<0.05) and SUVmax (SE: 64.5 [49/76] %, p<0.05; AC: 71.3 [87/122] %, p<0.05).

CONCLUSION

CEST imaging has a better potential and can improve diagnostic performance of SPNs, when compared with DWI and FDG-PET/CT.

CLINICAL RELEVANCE/APPLICATION

CEST imaging has a better potential and can improve diagnostic performance of SPNs, when compared with DWI and FDG-PET/CT.

RESULTS

Minimum, mean, maximum and 10th,25th,50th,90th percentile ADCs with two groups were significantly lower (all P<0.05), except for the maximum and 25th percentile ADCs in whole-volume group (P=0.128, P=0.221) in malignant lesions compared with benign ones. The 75th and 50th percentile ADCs in two ROI setting group respectively achieved the highest AUC (single-slice: whole-volume=0.891:0.894) with cutoff value of 1.57×10-3 mm²/s and 1.41×10-3 mm²/s in differentiating solitary pulmonary lesions. ICC for the whole-volume ROIs(0.76~0.97) was better the largest-slice ROIs(0.59~0.91).

CONCLUSION

Both single-slice and whole-volume ADCs are helpful for distinguishing malignant from benign lung lesions. Whole-volume ADC histogram analysis could have greater diagnostic properties and repeatability.

CLINICAL RELEVANCE/APPLICATION

In conclusion, ADC histogram is helpful for distinguishing malignant from benign lung lesions, and the 75th percentile ADC derived from 2D-ROI and 3D-VOI could provide better information in characterizing in SPLs, with no statistical difference. Moreover, placing ROIs in the largest lesion would be more suitable for clinic practice considering about saving time.

RESULTS

Minimum, mean, maximum and 10th,25th,50th,90th percentile ADCs with two groups were significantly lower (all P<0.05), except for the maximum and 25th percentile ADCs in whole-volume group (P=0.128, P=0.221) in malignant lesions compared with benign ones. The 75th and 50th percentile ADCs in two ROI setting group respectively achieved the highest AUC (single-slice: whole-volume=0.891:0.894) with cutoff value of 1.57×10-3 mm²/s and 1.41×10-3 mm²/s in differentiating solitary pulmonary lesions. ICC for the whole-volume ROIs(0.76~0.97) was better the largest-slice ROIs(0.59~0.91).

CONCLUSION

Both single-slice and whole-volume ADCs are helpful for distinguishing malignant from benign lung lesions. Whole-volume ADC histogram analysis could have greater diagnostic properties and repeatability.
PURPOSE

Iraq-Afghanistan War Lung Injury (WLI) describes new onset respiratory symptoms occurring in deployed soldiers to the Middle East that can ultimately lead to constrictive bronchiolitis. This study sought to determine if 19F MRI could identify patients with WLI.

METHOD AND MATERIALS

Three soldiers who presented to local VA clinics were evaluated for reactive airways disease, post deployment dyspnea, and decreased respiratory fitness. All subjects had a full pulmonary function evaluation. Inspiratory and expiratory imaging with HRCT was also obtained for each subject. For 19F MRI studies, each subject inhaled a gaseous mixture of 79% PFP mixed with 21% O2 mixture over the course of several minutes in a protocol consisting of three tidal breaths followed by a 6 second breath-hold at total lung capacity during which a 3D imaging of the lung airspaces was obtained. The image data was analyzed to generate regional wash-in and wash-out time constants (seconds) throughout the lung airspaces. Finally, the fraction of slow filling compartments was calculated as the number of volume elements exhibiting a wash-in time constant of > 100 seconds divided by the total number of lung airspace elements in the imaged [FVR1>100].

RESULTS

Two subjects were non-smokers and the third is a current smoker (11 pack-years). All three subjects were exposed to aerosolized contaminants during deployment in Iraq/Afghanistan. Spirometry for all subjects were normal FEV1% predicted (81, 109, 86), FEV1/FVC (72, 75, 73). Expiratory CT imaging was normal for subject 1, while the 2nd and 3rd subjects had mild basilar or lobular areas of air trapping. Imaging with 19F for each subject was as follows: FVR1>100 = 17.5%, 37.8%, and 24.5% for the three subjects respectfully. While the first subject’s FVR1>100 was close to values seen in subjects with normal lung function the second and third subjects more resembled patients diagnosed with COPD (25->60%).

CONCLUSION

19F MRI demonstrated delayed regional filling of PFP gas in two subjects with suspected WLI when compared to data from normal subjects.

CLINICAL RELEVANCE/APPLICATION

19F MRI has the potential to detect airway abnormalities at earlier time points than current techniques. This may ultimately lead to better diagnosis of challenging airway abnormalities such as WLI and perhaps a tool for evaluation of interventions.
Science Session with Keynote: Emergency Radiology (Practice Management)

Tuesday, Nov. 27 3:00PM - 4:00PM Room: S402AB

Participants
Zachary S. Delproposto, MD, Ann Arbor, MI (Moderator) Nothing to Disclose
Jennifer W. Uyeda, MD, Boston, MA (Moderator) Consultant, Allena Pharmaceuticals, Inc; Invited Speaker, Siemens AG

Sub-Events

SSJ06-01  Emergency Radiology Keynote Speaker: Dual Energy CT in the ED

Tuesday, Nov. 27 3:00PM - 3:10PM Room: S402AB

Participants
Jennifer W. Uyeda, MD, Boston, MA (Presenter) Consultant, Allena Pharmaceuticals, Inc; Invited Speaker, Siemens AG

SSJ06-02  CT Utilization Patterns in an Expanded Level 1 Trauma Center

Tuesday, Nov. 27 3:10PM - 3:20PM Room: S402AB

Awards
Student Travel Stipend Award

Participants
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PURPOSE
To investigate CT utilization patterns in a major level 1 trauma center before and after the opening of a new facility with expanded ER and critical care capacity.

METHOD AND MATERIALS
A retrospective analysis of all CT scans ordered from the emergency department of a major level 1 trauma center was performed during a 36 month period spanning the opening and transition to a new facility in May of 2016. Eligible for inclusion were CT studies performed within call hours (5pm-8am weekdays, 24 hours on weekends). Data were conducted retrospectively, using ad hoc SQL query against PACS Oracle database, and classified into one of two subcategories based upon the findings 1) Type 1: critically acute findings usually necessitating hospital admission, and 2) Type 2: negative or non-critical. The incidence of Type 1 and Type 2 findings before (January 2015-May 2016) and after (May 2016-Dec 2017) transitioning to the new facility were analyzed.

RESULTS
Comparing 16 months prior and 20 months after opening of an expanded trauma center, there was a 12% increase in overall ED patient volume. There was an associated increase in overall CT utilization of 24.6%. When weighted by number of days, there was a total of 33 CT studies per day ordered before and 41 CT studies ordered per day after opening the new hospital. However, there was no significant increase in Type 1 studies (weighted average total increase of 9.2%). The increase in CT utilization was entirely accounted for by a significant increase type 2 studies which increased by 32.3% (p<0.05). The yield for type 1 studies (defined as the ratio of Type 1 to Type 2), decreased from 0.41 to 0.33.

CONCLUSION
Increased CT utilization following the opening of an expanded level 1 trauma center was accounted for entirely by an increase in volume of non-critical (Type 2) studies. Potential contributors to this utilization pattern are explored and include overall increase in ED volume and increased proximity of CT scanners within the new emergency department.

CLINICAL RELEVANCE/APPLICATION
Hospital geography can play a role in increasing CT utilization without increasing clinical yield.
**SSJ06-03  ED CT Utilization Has Increased but What Has Increased and Who Reads Them?**

Participants
Santosh K. Selvarajan, MD, Philadelphia, PA (Presenter) Nothing to Disclose

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**PURPOSE**
The growth in CT utilization is considerable and has increased across the world. The continued growth in the ED may be partly related to increased applications with improved technology and partly from inappropriate use. Our purpose was to determine the different subcategories of CT that have increased since code bundling was used only for CT of abdomen and pelvis and secondly assess the change in Non-Radiologists interpretations of CT from 2004 to 2016.

**METHOD AND MATERIALS**
We used the Medicare Physician/Supplier Procedure Summary Master Files for 2004-2016. The codes for ER CT were selected and the procedure volumes in ED settings were calculated. We doubled the number of bundled codes, since these would have counted as 2 exams in 2010 and before. We performed a secondary analysis of the different CT examinations by categorizing them in to head, body, spine, musculoskeletal and CT vascular. The CTA of the head and neck were assigned to the head CT to help assess the utility of neuroimaging. Then used Medicare provider specialty codes to identify those exams interpreted by Radiologists and other specialties.

**RESULTS**
The utilization of CT in the EDs grew in all the categories with a more substantial increase in the utilization of CT spines (+423%), CT vascular (+306%), and CT MSK (+164%). The utilization of CT body has increased by 56%. The volume of neuroimaging has significantly increased from 1,875,263 in 2006 to 3,632,617 in 2016 (+94%). A small number of cardiac CTs are performed in the ED, which has increased from 194 in 2006 to 2430 in 2016 (+1153%). Radiologists interpret 99% of the studies in all categories. The percentage of non-Radiologists interpreting CTs in the ED have reduced in all subcategories except a mild increase in the interpretation of CT spines and CT vascular.

**CONCLUSION**
There is substantial increase in the utilization of all CTs in the ED. The growth is predominantly in CT spine, CT vascular and CT of extremities. The utilization of CT and CTA for neuroimaging has also increased markedly.

**CLINICAL RELEVANCE/APPLICATION**
These trends may be partially due to defensive medicine in ED and radiologists and ED physicians need to work together to better control utilization.

**SSJ06-04  The Effect of Advanced Age on the Utilization of CT in Trauma**

Participants
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**PURPOSE**
In the 1990s the most frequent mechanism of injury (MOI) in trauma was Road Traffic Accidents (RTA) with a mean age of 31; by 2013 falls from <2 meters were the predominant mechanism and the mean age had risen to 53.8. CT plays a major role in the management of trauma. The possibility exists for a delay in investigation and treatment in older trauma patients due to differences in MOI, mode of presentation and awareness.

**METHOD AND MATERIALS**
Trauma Audit Research Network (TARN) data from a tertiary referral urban university teaching hospital with an annual ED census of over 53,000 patients from 2012 to 2017 was analysed. Fisher's Exact test, multivariate logistic regression and Student's T Test were used for analysis in SPSS 24.

**RESULTS**
1422 trauma patients were included of whom 928 had CT. 721 were male and 701 were female. Mean age was 63 (range : SD) (3-99:22.2). Mean Injury Severity Score (ISS) was 13 (1-57 : 8.4). Fall <2m was the MOI in 61.5% and RTA in 15.3%. Trauma patients aged >65 were no more likely to require a CT than those <65 (p=0.575). Patients >65 were more likely to have a time to CT (TCT) >24 hours (p<0.001). This held true controlling for gender, ISS, date and time (p<0.01). Patients aged >65 with an ISS >15 were more likely to have a TCT >6 hours (p=0.016). Overall mean TCT was 262% longer (p<0.001) in those patients aged >65.

**CONCLUSION**
Trauma patients over 65 years of age wait longer for CT compared to those under 65.
Outcomes for older trauma patients are worse in terms of morbidity, mortality and length of stay. While the cause and effect for the impact on outcomes of the delay to CT is difficult to elucidate; maximising controllable variables has the potential to benefit the patient. With the aging population and the changing face of trauma emergency departments need to plan for a different type of patient. Older patients who suffer traumatic injuries may not be identified as early and strategies should be implemented minimise delay in access to diagnostics and implementation of treatment. Emergency and radiology departments need to be accordingly resourced for this changing practise.

Participants
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PURPOSE
The worldwide population is aging, and in proportion to this development the morbidity and mortality related to geriatric trauma, and its burden on healthcare is increasing. In this study, we aimed to analyze the imaging findings in a series of geriatric trauma patients admitted to our emergency department during the period of 2006-2011 and 2012-2017. We also investigated whether trauma induced pathologies or the need for imaging has changed over the years.

METHOD AND MATERIALS
We randomly selected two sets of 300 patients among 597 and 987 patients admitted to the emergency department during the time periods of 2006-2011(group I) and 2012-2017(group II), respectively. A comprehensive comparison was carried out between the groups regarding age, sex, reason for admission, associated comorbidities, Revised Trauma Score (RTS), Glasgow Coma Scale (GCS), radiological findings and number of radiological examinations, DLP values, duration of hospital stay, and trauma associated morbidity and mortality.

RESULTS
No statistically significant difference was observed between both groups regarding age and gender (p>0.05). Falls were the most common cause for admission in both groups, followed by traffic accidents. RTS and GCS values were similar in both groups (p>0.05). The number of patients who underwent X-ray and CT examinations in group II was higher compared to group I (89% vs. 82%, 73% vs. 44%, respectively, p=0.021). The total number of X-rays and CT scans was also higher in group II (613 vs. 310, 409 vs. 142, respectively, p=0.01). In 49% of patients in group I and 55% of patients in group II, CT scans were negative for a trauma related finding. In patients with radiological evidence of trauma, no significant difference was observed between the groups regarding major trauma related change (p=0.151). However, trauma related minor CT findings were more common in group II (p=0.031).

CONCLUSION
Increased need for radiological examinations over the years seem to occur as a consequence of the tendency to practice defensive medicine. In addition to increased radiation dose, unnecessary radiological examinations result in heavy burden on health care systems and radiologists’ workload.

CLINICAL RELEVANCE/APPLICATION
Increased need for imaging in recent years appears to be related to ‘defensive medicine’ but not to Revised Trauma Score or Glasgow Coma Scale of the patients.
METHOD AND MATERIALS

This is a retrospective HIPPA-compliant, IRB-approved study of CT and MR performed for PE evaluation in the ED from January 1, 2009 - December 31, 2017. All ED patients with an imaging order placed and not canceled during an ED encounter were identified. Patient encounters were included if (1) study type was CT or MR and (2) study description included 'PE protocol' or study information entered by the ED clinician included a PE variant (i.e. pulm* embol*, vte). Patient factors were populated via the electronic medical record (EMR); comorbidity indices were calculated from ICD 9/10 codes. Logistic regression was used to calculate odd ratios (OR) of factors associated with use of MR versus CT.

RESULTS

There were 10,986 CT and 1,448 MR patient EMRs reviewed. MR patients were younger (p<.001) and female (p<.001). CT patients had higher morbidity indices (p<.001). In the patient factor model, female sex, lower age, slightly lower comorbidity index, and history of renal disease increased odds of MR use (female OR 2.7, p<.001; age OR 0.93, p<.001; Elixhauser OR 0.97, p<.001; renal disease OR 3.5, p<.001). In a separate vital signs model, slightly lower maximum respiratory rate (RR_max) and slightly higher minimum oxygen saturation (O2_min) increased odds of MR (RR_max OR 0.97, p<.01; O2_min OR 1.04, p<.001).

CONCLUSION

ED ordering of MR occurred more often in female, younger patients with lower comorbidity and more favorable vital signs. History of renal disease also significantly increased the OR of MR.

CLINICAL RELEVANCE/APPLICATION

ED clinicians have consistently utilized MR for PE evaluation since its introduction, with selection of MR in stable patients to mitigate perceived risks of CT.
**Automated Measurement of Liver Attenuation to Identify Hepatic Steatosis from Low-Dose CT Lung Screening Scans**

**Participants**
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**Sub-Events**

**SSJ09-01** Automated Measurement of Liver Attenuation to Identify Hepatic Steatosis from Low-Dose CT Lung Screening Scans

**Participants**
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**PURPOSE**
To measure liver attenuation automatically from low-dose lung screening CT scans to identify patients with moderate-to-severe hepatic steatosis (HS) and compare the automated method to manual region of interest (ROI) based measurement.

**METHOD AND MATERIALS**
This IRB-approved, HIPAA compliant study included 251 participants with a baseline low-dose CT scan with a slice thickness of <=1 mm (111 from a lung cancer screening program and 140 from the World Trade Center (WTC) cohort). Radiologists measured the liver attenuation (Hounsfield units; HU) at the level of the portal vein in four sectors defined by the Couinaud system. In each sector, the average liver HU was measured in a 1.0 cm² circular (ROI), avoiding lesions and large vessels. The automated method samples cubic ROIs in the liver region, which is determined using a computer-based automated segmentation of the right diaphragm as the upper bound of the region, extending to 7.0 cm below the diaphragm. This region is divided into non-overlapping 1.0 cm³ cubes, and the mean intensity is computed for each cube. To account for regions that may be outside the liver or include blood vessels, cubes with mean values outside of the inner quartile range (50%) are excluded. The overall mean attenuation is computed from the remaining cubes for each CT scan. A threshold for HS was defined as the mean - 2*standard deviation from the lung screening cohort for both methods. The manual ROI measurement and automated methods were compared by using limits of agreement of average liver attenuation values and comparing the detection of HS in the WTC cohort using the established thresholds.

**RESULTS**
The overall mean and SD for the automated liver attenuation measurement was 51.52 HU ± 12.72 and for the manual measurement, 55.31 HU ± 11.21. The limits of agreement were (-14.09, 6.51). The threshold for HS was 40 HU for the manual method and 37 HU for the automated method; using these thresholds, 97.1% (136/140) of WTC participants had the same classification by both methods.

**CONCLUSION**
Automated measurement of liver attenuation from low-dose chest CT scans is feasible and shows good agreement (97%) with manual ROI based measurements for detecting HS.

**CLINICAL RELEVANCE/APPLICATION**
Automated identification of hepatic steatosis (HS) from low-dose lung screening CT scans has good agreement with radiologists, enabling physicians to identify patients at risk of liver disease.
To determine relationships between visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) index and attenuation on abdominopelvic CT examinations with one-year survival in older adults.

**METHOD AND MATERIALS**

Relationships between adipose tissue metrics and all-cause mortality were determined retrospectively in a cohort of 436 consecutive Medicare patients (52% women, mean age 75 years) who had non-contrast abdominopelvic CT exams for routine clinical indications. On CT images, VAT and SAT were segmented at the level of L3 pedicle using segmentation software (Mimics) and a threshold of -190 to -30 Hounsfield units. VAT and SAT cross-sectional area (CSA) and attenuation were measured. VAT and SAT index was determined by dividing adipose CSA by patient height in meters squared. Cox regression models were fit to determine associations between VAT and SAT metrics and one-year mortality, adjusted for age, sex, race, body mass index, smoking status, and Charlson comorbidity index.

**RESULTS**

Within one year of follow-up, 90 patients (20.6%) died. In the fully-adjusted models, higher values of VAT and SAT attenuation were associated with higher hazard ratios (HR) for mortality at 1 year. A 1 SD increase in the VAT attenuation was associated with a 75% increase in mortality (HR/SD=1.75; 95%CI=1.40-2.19; p<0.0001). A 1 SD increase in the SAT attenuation was associated with a 75% increase in mortality (HR/SD=1.75; 95%CI=1.40-2.19; p<0.0001). VAT index and SAT index were not associated with increased mortality.

**CONCLUSION**

In older adults, increased adipose tissue attenuation on abdominopelvic CT examinations was associated with increased one-year mortality, independent of other causes of death.

**CLINICAL RELEVANCE/APPLICATION**

Quantitative data mining for adipose tissue attenuation on abdominal CTs of older adults may help determine prognosis.

**SS309-03 Accuracy of CT Texture versus Mean Attenuation for Quantification of Liver Fat Content**

Participants:

- Andrew D. Smith, MD, PhD, Birmingham, AL (Presenter)
- Kristin M. Lenoir, MPH, Winston-Salem, NC
- Josh C. Tan, MS, Winston-Salem, NC
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**PURPOSE**

To develop a CT texture prediction model to accurately and reproducibly measure liver fat content.

**METHOD AND MATERIALS**

Retrospective secondary analysis of a prospective study that included 50 adult participants (23 men, 27 women; mean age 57 years; BMI 27) who underwent unenhanced single energy CT and MRI proton density fat fraction (MRI-PDFF). In separate independent reading sessions, three readers measured 110 first order CT texture parameters (before and after application of median and Gaussian filters) and liver fat content on MRI-PDFF-maps. Linear regression was used to examine the association between predictors and liver fat content per MRI-PDFF (reference standard). CT texture parameters with higher reproducibility (ICC >0.60) were moved forward into development of a multivariable model. The CT texture multivariable model was built using least absolute shrinkage and selection operator (LASSO) on those significant predictors (p<0.05). The root-mean square error (RMSE) and the coefficient of determination (R²) were used to assess the goodness of fit of the models. Using a subset of significant predictors, accuracy (AUROC), sensitivity and specificity for correctly classified patients with >5.56% liver fat content were calculated.
RESULTS
The CT texture model most strongly associated with liver fat content consisted of percent of pixels less than 40 HU on unfiltered images (ICC=0.97-0.98, p<0.001), mean after median filtration (ICC=0.98-0.99, p<0.0001), and percent of pixels less than 40 HU after Gaussian filtration (ICC=0.95-0.97, p<0.0001). The CT texture prediction model had less deviation from and higher correlation with the reference standard than mean attenuation (RMSE = 0.474 vs. 0.513; R = 0.77 vs. 0.72, respectively). The AUROC, sensitivity and specificity for detecting >5.56% liver fat content were 0.96, 86.5%, and 92.3% for the CT texture prediction model vs. 0.93, 83.8% and 92.3% for mean attenuation.

CONCLUSION
A CT texture prediction model is highly reproducible and more accurate than CT mean attenuation for estimating liver fat content.

CLINICAL RELEVANCE/APPLICATION
CT texture can be used to accurately and reproducibly quantify liver fat content in patients at risk for NAFLD.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Perry J. Pickhardt, MD - 2014 Honored EducatorPerry J. Pickhardt, MD - 2018 Honored Educator

SSJ09-04 Quantitative Evaluation of Heterogeneous Hepatic Injury with Gd-EOB-DTPA Enhanced MRI: An Initial Experimental Study

Tuesday, Nov. 27 3:30PM - 3:40PM Room: S104B

Participants
Yanyan Zhang, Shenyang, China (Presenter) Nothing to Disclose
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Jun Wang, Shenyang, China (Abstract Co-Author) Nothing to Disclose
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Liyang Xia, Shenyang, China (Abstract Co-Author) Nothing to Disclose
Chaoxu Zhang, Shenyang, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
To assess heterogeneous hepatic injury with Gd-EOB-DTPA enhanced MRI on a novel rat model.

METHOD AND MATERIALS
This study is approved by institutional review board. Seventy male Sprague-Dawley rats were randomly divided into control group (n=10) and colchicine group (n=60). The solution with 0.25% colchicine (0.4ml/kg) was injected via the splenic vein to develop a rat model of heterogeneous hepatic injury. An equal volume of normal saline was injected via the splenic vein in the control group. After the operation, at Day 3, week 1, week 2, week 4, week 8 and week 12 ten rats of the colchicine group were selected randomly for MRI examinations respectively, then they were euthanized. The ten rats of control group underwent MRI examinations at the same time points, and were euthanized at week 12 after MRI examinations. Gd-EOB-DTPA enhanced T1WI, T2WI and diffusion weighted imaging (DWI) were used to evaluate the heterogeneous hepatic injury. The quantitative data of left and right hepatic lobes, which were calculated on MRI, were compared and correlated with the pathological result of hepatic injury, which was assessed on liver sections according to the histological scoring criteria. P value of <0.05 was considered statistically significant.

RESULTS
There was obvious pathological change of rat hepatic parenchyma after colchicine injection through splenic vein, and the hepatic injury of left and right lobes was significantly difference (P <0.05). Meanwhile there were significant difference in ADC of DWI, LMR(liver-to-muscle ratio) of T2WI and ΔLMR(the difference value of LMR between pre- and post-enhanced T1WI) between left and right lobes of colchicine group at each time point respectively (P <0.05), and it is similarly between colchicine and control group (P <0.05). Besides, there were significant correlation between ADC, LMR, ΔLMR value and hepatic injury score, respectively (r = 0.682, P=0.000; r = 0.245, P=0.018; r = 0.807, P=0.000).

CONCLUSION
Gd-EOB-DTPA enhanced MRI is useful for evaluation of heterogeneous hepatic injury, which induced by injection of colchicine through splenic vein. It is necessary for the further research on clinic.

CLINICAL RELEVANCE/APPLICATION
Gd-EOB-DTPA enhanced MRI is useful for evaluation of heterogeneous hepatic injury, which is necessary for the further research on clinic.

SSJ09-05 Expanded Quantitative Ultrasound of the Liver in Healthy Adults

Tuesday, Nov. 27 3:40PM - 3:50PM Room: S104B

Participants
Andrew T. Trout, MD, Cincinnati, OH (Presenter) Author, Reed Elsevier; Research Grant, Siemens AG; Research Grant, Canon America Medical Systems Corporation; Board Member, Joint Review Committee on Educational Programs in Nuclear Medicine Technology; Travel support, Koninklijke Philips NV; Consultant, Guerbet SA

Jonathan R. Dillman, MD, Cincinnati, OH (Abstract Co-Author) Research Grant, Siemens AG; Research Grant, Guerbet SA; Travel support, Koninklijke Philips NV; Research Grant, Canon Medical Systems Corporation; Research Grant, Bracco Group

Samantha Summers, Cincinnati, OH (Abstract Co-Author) Nothing to Disclose

CONCLUSION
CT texture prediction model is highly reproducible and more accurate than CT mean attenuation for estimating liver fat content.

CLINICAL RELEVANCE/APPLICATION
CT texture can be used to accurately and reproducibly quantify liver fat content in patients at risk for NAFLD.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Perry J. Pickhardt, MD - 2014 Honored Educator Perry J. Pickhardt, MD - 2018 Honored Educator

SSJ09-04 Quantitative Evaluation of Heterogeneous Hepatic Injury with Gd-EOB-DTPA Enhanced MRI: An Initial Experimental Study

Tuesday, Nov. 27 3:30PM - 3:40PM Room: S104B

Participants
Yanyan Zhang, Shenyang, China (Presenter) Nothing to Disclose
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Chaoxu Zhang, Shenyang, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
To assess heterogeneous hepatic injury with Gd-EOB-DTPA enhanced MRI on a novel rat model.

METHOD AND MATERIALS
This study is approved by institutional review board. Seventy male Sprague-Dawley rats were randomly divided into control group (n=10) and colchicine group (n=60). The solution with 0.25% colchicine (0.4ml/kg) was injected via the splenic vein to develop a rat model of heterogeneous hepatic injury. An equal volume of normal saline was injected via the splenic vein in the control group. After the operation, at Day 3, week 1, week 2, week 4, week 8 and week 12 ten rats of the colchicine group were selected randomly for MRI examinations respectively, then they were euthanized. The ten rats of control group underwent MRI examinations at the same time points, and were euthanized at week 12 after MRI examinations. Gd-EOB-DTPA enhanced T1WI, T2WI and diffusion weighted imaging (DWI) were used to evaluate the heterogeneous hepatic injury. The quantitative data of left and right hepatic lobes, which were calculated on MRI, were compared and correlated with the pathological result of hepatic injury, which was assessed on liver sections according to the histological scoring criteria. P value of <0.05 was considered statistically significant.

RESULTS
There was obvious pathological change of rat hepatic parenchyma after colchicine injection through splenic vein, and the hepatic injury of left and right lobes was significantly difference (P <0.05). Meanwhile there were significant difference in ADC of DWI, LMR(liver-to-muscle ratio) of T2WI and ΔLMR(the difference value of LMR between pre- and post-enhanced T1WI) between left and right lobes of colchicine group at each time point respectively (P <0.05), and it is similarly between colchicine and control group (P <0.05). Besides, there were significant correlation between ADC, LMR, ΔLMR value and hepatic injury score, respectively (r = 0.682, P=0.000; r = 0.245, P=0.018; r = 0.807, P=0.000).

CONCLUSION
Gd-EOB-DTPA enhanced MRI is useful for evaluation of heterogeneous hepatic injury, which induced by injection of colchicine through splenic vein. It is necessary for the further research on clinic.

CLINICAL RELEVANCE/APPLICATION
Gd-EOB-DTPA enhanced MRI is useful for evaluation of heterogeneous hepatic injury, which is necessary for the further research on clinic.

SSJ09-05 Expanded Quantitative Ultrasound of the Liver in Healthy Adults

Tuesday, Nov. 27 3:40PM - 3:50PM Room: S104B

Participants
Andrew T. Trout, MD, Cincinnati, OH (Presenter) Author, Reed Elsevier; Research Grant, Siemens AG; Research Grant, Canon America Medical Systems Corporation; Board Member, Joint Review Committee on Educational Programs in Nuclear Medicine Technology; Travel support, Koninklijke Philips NV; Consultant, Guerbet SA

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Samantha Summers, Cincinnati, OH (Abstract Co-Author) Nothing to Disclose
Validation of Tumor-Host Interface on Pancreatic Protocol CT Scan as a Prognostic Biomarker in Patients with Pancreatic Ductal Adenocarcinoma

Tuesday, Nov. 27 3:50PM - 4:00PM Room: S104B

Stavra Xanthakos, Cincinnati, OH (Abstract Co-Author) Nothing to Disclose

PURPOSE

Imaging techniques including ultrasound are becoming increasingly quantitative. With shear wave elastography (SWE) becoming increasingly utilized clinically, ultrasound system manufacturers are developing additional methods of tissue quantification. Two such techniques are shear wave dispersion (SWD) and attenuation imaging (ATI). SWD quantifies the variation in shear wave speed (SWS) with frequency (i.e. dispersion slope in units of (m/s)/kHz) and should provide information about viscoelasticity. ATI quantifies the ultrasound attenuation coefficient in tissue and may serve as a means to quantify hepatic steatosis. The purpose of this study was to acquire SWE, SWD, and ATI data in healthy adults to demonstrate applicability of the technique and define normal values.

METHOD AND MATERIALS

Under IRB approval, 28 healthy adults without a known personal or family history of liver disease were recruited to undergo a quantitative ultrasound of the liver including SWE, SWD and ATI. Imaging was performed by a group of experienced technologists utilizing an Apio i800 (Canon Medical Systems, USA). 10 SWE and SWD measurements and 5 ATI measurements were obtained from the right lobe in each patient. Study population data were summarized utilizing descriptive statistics (means, medians, standard deviations and ranges).

RESULTS

Median age for the population was 45.2 years (range: 17.6-64 years) and 18 of 28 participants (64.2%) were female. Median body mass index was 24 kg/m2 (range: 20-29 kg/m2). Mean average (for the 10 measurements) SWS for the population was 1.37±0.11 m/sec (median: 1.34 m/sec, range: 1.17-1.6 m/sec). Mean interquartile range (IQR) was 0.17 for the population and mean IQR/median was 0.15. Mean SWD was 10.68±1.53 (m/s)/kHz (median: 10.15 (m/s)/kHz, range: 8.4-14.8 (m/s)/kHz) and mean attenuation was 0.59±0.09 dB/cm/MHz (median 0.59 dB/cm/MHz, range: 0.42-0.8 dB/cm/MHz).

CONCLUSION

Mean shear wave speed for adults without known liver disease on an Apio i800 was 1.37±0.11 m/sec. SWD and ATI provide quantitative information that is additive to SWE. Data acquired in healthy adults presented here may serve as a reference against which to compare data from patients with suspected liver disease.

CLINICAL RELEVANCE/APPLICATION

Attenuation imaging and shear wave dispersion provide quantitative measures of tissue characteristics in addition to shear wave elastography. Normative values for adult liver on the Apio i800 are provided.

SSJ09-06  Validation of Tumor-Host Interface on Pancreatic Protocol CT Scan as a Prognostic Biomarker in Patients with Pancreatic Ductal Adenocarcinoma

Tuesday, Nov. 27 3:50PM - 4:00PM Room: S104B

Ahmed M. Amer, MD, Birmingham, AL (Presenter) Nothing to Disclose
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PURPOSE

To validate a previously published pre-therapy conventional single energy multiphasic CT imaging biomarker that stratifies pancreatic ductal adenocarcinoma (PDAC) patients into different clinical groups and outcomes, using dual energy CT.

METHOD AND MATERIALS

IRB approved HIPAA compliant retrospective analysis of consecutive adult PDAC patients. Single operator recorded regions of interest (ROI) in tumor core, tumor border, pancreas border, normal pancreas using dedicated DECT server. ROIs were simultaneously populated to identical image locations on DECT 70 keV pancreatic parenchymal phase (PPP), single energy portal venous phase (PVP), and conventional unenhanced images. Imaging based classification of High Delta (HD-defined as increased enhancement difference across tumor-host tissue interface >= 40 HU on either 70 keV PPP or PVP) and Low Delta (LD- lower enhancement difference) was evaluated for resectable, borderline resectable (BRPC), locally advanced (LAPC), and metastatic PDAC groups and compared to outcomes using Cox proportional-hazards model.

RESULTS

158 subjects (79M, 79F, mean age 67.8) included: 93 advanced stage -50 locally advanced, 43 metastatic; 65 lower stage -48
158 subjects (79M, 79F, mean age 67.8) included: 93 advanced stage - 50 locally advanced, 43 metastatic; 65 lower stage - 48 resectable, 17 borderline resectable. 44 underwent Whipple. 28 received neoadjuvant therapy. Median overall survival (OS) was significantly shorter for HD tumors in both advanced stage patients (10.8 vs 18 months; HR, 2.03; 95%CI, 1.22 to 3.48; P= .0062) and in lower stage patients (13.5 vs 23.3 months; HR, 1.87; 95%CI, 1.01 to 3.53; P= .042). In lower stage patients, delta was associated with OS after accounting for age, tumor size, surgery, and neoadjuvant therapy (P= .04). In non-metastatic patients, HD was associated with shorter time to distant metastasis development (HR, 2.28; 95%CI, 1.04 to 5.25; P= .03).

CONCLUSION

Our results validate the prognostic value of CT-based classification of PDAC patients using DECT; those with tumors characterized by high delta have significantly shorter survival.

CLINICAL RELEVANCE/APPLICATION

As with conventional MDCT, Delta score is a visually apparent and quantifiable DECT imaging biomarker that can stratify distinct subtypes of tumors in PDAC patients.
Molecular Imaging (Novel Multi-Modal Applications)

SSJ14

Tuesday, Nov. 27 3:00PM - 4:00PM Room: S505AB

Participants
Ciprian Catana, MD, PhD, Charlestown, MA (Moderator) Nothing to Disclose
Sabah Servaes, MD, Philadelphia, PA (Moderator) Nothing to Disclose

Sub-Events

SSJ14-01 Multispectral Optoacoustic Tomography of Systemic Sclerosis: A Feasibility Study Using a Hybrid Approach at the Patient’s Bedside

Tuesday, Nov. 27 3:00PM - 3:10PM Room: S505AB

Participants
Anne Helfen, MD, Muenster, Germany (Presenter) Nothing to Disclose
Max Masthoff, MD, Muenster, Germany (Abstract Co-Author) Nothing to Disclose
Ulrich Gerth, MD, Muenster, Germany (Abstract Co-Author) Nothing to Disclose
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Moritz Wildgruber, MD, PhD, Munster, Germany (Abstract Co-Author) Nothing to Disclose

PURPOSE
Systemic sclerosis is an autoimmune disease with dysfunctional connective tissue repair inducing skin and internal organ fibrosis as well as vasculopathy, leading to serious complications such as digital ulcers. Microvascular dysfunction is a prognostic marker for morbidity and mortality in systemic sclerosis. However, due to a lack of functional tissue information using established imaging technologies, risk stratification remains challenging. We aimed to evaluate the clinical feasibility of a hybrid multispectral optoacoustic tomography (MSOT)/ultrasound (US) approach in systemic sclerosis.

METHOD AND MATERIALS
We used a combined handheld MSOT/US imaging system (iThera Medical, Munich) for imaging fingers D2 to D5 of systemic sclerosis patients (n=7, n=56 fingers) and healthy volunteers (n=8, n=64 fingers). In subcutaneous tissue, tissue levels of hemoglobin (deoxygenated (HbR), oxygenated (HbO2) and total (HbT)) were calculated after spectral unmixing. Furthermore, MSOT values were analyzed to stratify patients with either progressive or stable disease activity. Statistical analysis was performed using unpaired t test.

RESULTS
In systemic sclerosis, MSOT values for HbR, HbO2 and HbT were significantly lower compared with healthy volunteers. On an individual basis, all patients had - as compared to healthy volunteers - a reduced ratio (<1.0) for HbO2 (ratio 0.53, p<0.0001) and HbT (ratio 0.49, p<0.0001). Additionally, in systemic sclerosis patients with a progressive disease significantly lower MSOT values were detected than in patients with a stable disease activity (HbR: 27.31 vs. 33.03 AU, HbO2: 23.87 vs. 29.22 AU, HbT: 51.18 vs. 62.24 AU; p<0.001).

CONCLUSION
This preliminary study demonstrates the feasibility of MSOT imaging to detect and quantify microvascular dysfunction in systemic sclerosis and to distinguish between progressive and stable disease activity. Therefore, MSOT may serve as a valuable non-invasive tool for disease stratification and therapy monitoring.

CLINICAL RELEVANCE/APPLICATION
As an easy-to-use, non-invasive and contrast-free imaging technique hybrid MSOT/US may facilitate both diagnosis and monitoring of treatment response in systemic sclerosis at the patient’s bedside.

SSJ14-02 Optimization of Chest Acquisition on Whole Body PET/MRI for HCC Tumor Staging Using Non-Cartesian K Space Reconstructions

Tuesday, Nov. 27 3:10PM - 3:20PM Room: S505AB

Participants
Mathilde Vermersch, Lille, France (Presenter) Nothing to Disclose
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PURPOSE
To compare diagnostic performance and image quality for chest imaging of stack-of-stars T1 EG acquisition (STARVIBE) with non-cartesian reconstructions of k-space, and Caipirinha 3D T1 EG acquisition, during whole-body PET-MR of HCC patients.

METHOD AND MATERIALS
33 consecutive patients referred for HCC staging in PET MRI (Biograph mMR, Siemens Erlangen) were retrospectively included. All benefited from Caipirinha Dixon 3D T1 (T1EG Dixon post gadolinium) and Starvibe (post-gadolinium T1EG Dixon with radial filling of the Fournier plan). A subjective evaluation of the image quality was performed. Detection of pulmonary nodular lesions with both sequences was compared by taking the chest CT scan as the standard of reference (Exact Fisher test). The signal-to-noise ratio of lung parenchyma (SNR) and contrast-to-noise ratio (CNR) of nodules, muscles and pulmonary vessels were compared between the two sequences (Student T-test).

RESULTS
The Starvibe sequence was judged subjectively better in 42% of cases and at least equivalent to Vibe in 88% of cases. It improved SNR (375% vs 89%, p < 0.001) and CNR for muscles (53% vs 41%, p < 0.001), vessels (84% vs 73%, p < 0.001) and pulmonary nodules (34% vs 24%, p = 0.03). The detection of nodules was improved (sensitivity = 55% vs 41%) with a decrease in false positives (VPP = 92% vs 35%), without significant difference.

CONCLUSION
K space non cartesian reconstruction improves MRI's diagnostic performance at the chest stage by elevation of SNR and CNR.

CLINICAL RELEVANCE/APPLICATION
This new type of sequence without apnea could allow an improvement of the MRI diagnostic performances especially at the thoracic stage in patients followed in oncology.

SS314-03 Whole-Body Functional PET-MR for Multiple Myeloma Staging: Impact of Sequence Design on Bone Marrow Infiltration and Focal Lesion Assessment

Tuesday, Nov. 27 3:20PM - 3:30PM Room: S505AB

Participants
Robert E. Burns, MD, Creteil, France (Presenter) Nothing to Disclose
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PURPOSE
To study the impact of functional simultaneous 18FDG-PET-MR on bone marrow infiltration evaluation and focal lesion detection in initial staging of Multiple Myeloma (MM).

METHOD AND MATERIALS
25 consecutive patients referred to our centre for initial staging of a monoclonal gammopathy were included. PET-MR sequence design included whole-body T1-weighted spin-echo and T2-fat supressed Dixon weighted images (CWB-MRI) combined to whole-body Simultaneous Multi-Slice diffusion-weighted imaging (WB-DWI), 3D whole-body isotropic dynamic contrast-enhanced images (WB-DCE) and 3D-T1 weighted images combined with PET (T1-PET) acquisition using 4-5 MBq/kg of 18FDG-glucose. In the first part of the evaluation, the mean apparent diffusion coefficient (mADC), the mean enhancement (mE) and mean maximal standard uptake value (mSUV) of the bone marrow measured at the posterior part of the ischium, the lowest lumbar vertebral, and lowest thoracic vertebral possible outside of focal lesions were measured. The second part of the evaluation comprised the counting of focal lesions on CWB-MRI, CWB-MRI combined with WB-DWI, CWB-MRI combined with WB-DCE, CWB-MRI combined with PET, and PET-MR. Based on these findings, each patient was allocated a specific staging for bone marrow infiltration (BMI) and the number of focal lesions.

RESULTS
Functional imaging significantly impacted assessment of BMI; Compared to CWB-MRI, WB-DWI upstaged 7 and down staged 8 patients, WB-DCE upstaged 17 and down-staged 5 patients, PET upstaged 6 and down-staged 4 patients. Correlation between functional imaging and percentage of plasma cell infiltration were \[r=0.7635, p<0.001\], \[r=0.549 p<0.005\], \[r=0.678, p=0.0001\] for mADC, mE, and mSUV. Compared to CWB-MRI, PET-MRI detected 30 additional focal lesions among 8 patients and upstaged 6 of them. 4 patients were upstaged from MGUS to stage 1 Multiple Myeloma (MM), 1 patient from stage 1 to stage 2 MM, and 1 patient from stage 1 to stage 3 MM. The detection of additional focal lesions did not modify staging for 2 patients.

CONCLUSION
PET-MRI modifies initial staging of patients with a monoclonal gammopathy. Further studies are necessary to improve medullary infiltration evaluation as well as prospective longitudinal studies to evaluate the prognostic value of these modifications.

**CLINICAL RELEVANCE/APPLICATION**

Functional PET-MRI significantly impacts initial staging of patients with suspected MM.

**SSJ14-04** Multispectral Optoacoustic Tomography of Vascular Malformations

**Tuesday, Nov. 27 3:30PM - 3:40PM Room: S505AB**

**Participants**
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**PURPOSE**

Differential diagnosis and treatment of congenital vascular anomalies is challenging and misdiagnosis is frequent. A novel non-invasive imaging approach combining not only visualization of anatomical features but also quantitative assessment of molecular tissue biomarkers would aid both diagnosis and monitoring of treatment response of vascular anomalies. We aimed to evaluate the feasibility of hybrid ultrasound (US) and multispectral optoacoustic tomography (MSOT) for non-invasive, real-time imaging of vascular malformations.

**METHOD AND MATERIALS**

In this pilot study 6 patients with arteriovenous (AVM) and 6 patients with venous (VM) malformations were investigated with a clinical hybrid MSOT/US system before and after either endovascular embolization (AVM) or percutaneous sclerotherapy (VM). All patients were diagnosed with AVM or VM according to the classification system of the International Society for the Study of Vascular Anomalies (ISSVA). Region of interest analysis of the lesion and contralateral healthy tissue revealed quantitative values for oxygenated (HbO2) and deoxygenated hemoglobin (HbR). Ratios of HbO2 over HbR were calculated for all vascular malformations and healthy tissue before and after treatment.

**RESULTS**

HbO2/HbR ratio was significantly higher for AVM versus VM and compared with healthy tissue (1.82±0.08 vs. 1.12±0.04 vs. 0.89±0.03, all p-values<0.001). Therefore MSOT provided intrinsic biomarker patterns to distinguish arteriovenous from venous malformations. After therapy the HbO2/HbR ratio decreased in correlation to treatment success validated by MRI and angiography.

**CONCLUSION**

Different types of vascular malformations are clearly distinguished by MSOT-based, non-invasive assessment of hemoglobin levels in vascular malformations. Therapy effects could be instantly visualized and quantified.

**CLINICAL RELEVANCE/APPLICATION**

As an easy-to-use, non-invasive and contrast-free imaging technique hybrid MSOT/US may facilitate both diagnosis and monitoring of treatment response of vascular malformations at the patient's bedside.

**SSJ14-05** Ultra-Fast Whole-body PET/CT Enabled by Digital Photon Counting PET Detector Technology: Findings from a Phase II Clinical Trial

**Tuesday, Nov. 27 3:40PM - 3:50PM Room: S505AB**

**Participants**
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**PURPOSE**

To assess in a Phase II study the clinical feasibility of ultrafast whole body PET imaging using the new generation digital photon counting PET and to compare by intraindividual comparison the diagnostic and quantitative findings to current clinical whole body PET acquisition.

**METHOD AND MATERIALS**

52 patients scheduled for FDG whole body PET/CT were imaged using three separate acquisitions as part of an intra-individual comparison study to compare a new generation digital system, dPET/CT (Vereos) with a current generation conventional system, cPET/CT (Gemini). Standard PET imaging was performed at ~75 min p.i. of 13mCi FDG with investigational dPET imaged at ~55 min p.i. The first dPET acquisition was performed using 90s/bed position, immediately followed by a 9s/bed position acquisition lead to average table times of ~15 and ~2 min and compared with 90s/bed position cPET ~20 min. The 9s/bed dPET were reconstructed using a previously optimized methodology. All other aspects of image acquisition were kept identical. Three blinded reviewers...
evaluated the data sets regarding visual characteristics, diagnostic confidence and semi-quantitative readouts.

RESULTS
All ultrafast scans were classified to be assessible. As expected, visual assessment scores were significant higher for 90s/bed dPET whole body (p<.01), while no significant between the ultra-fast wholebody and the cPET scans were reported. The ultra-fast scan presented with slightly increased background noise levels. The ultra-fast scans also presented with substantially less motion artefacts including bowl movements. A county density regularized reconstruction approach is essential to achieve the acceptable image quality on a consistent basis.

CONCLUSION
Next generation digital photon counting detector technology enabled consistent acceptable image quality even for ultra-fast wholebody imaging with a whole body acquisition time of 2 min. The concept of ultra-fast whole-body acquisition is feasible, however requires count density adaptive, regularized reconstruction, New PET workflow concepts, improved patient comfort, minimized patient motion and whole-body pseudo dynamic imaging of tracer were demonstrated as feasible.

CLINICAL RELEVANCE/APPLICATION
Ultra-Fast Wholebody PET/CT with 2 min acquisition time was shown to be feasible using a new generation digital photon counting PET/CT system.
Purpose
To evaluate the diagnostic performance of a dual-energy computed tomography (CT) virtual non-calcium (VNCa) technique for the detection of bone marrow edema in patients with acute knee trauma.

Method and Materials
Data from 41 patients with acute knee trauma who had presented to a level 1 trauma center emergency department were retrospectively included. Subjects had undergone clinically indicated third-generation dual-source dual-energy CT and 3-T magnetic resonance imaging (MRI) of the knee within 7 days between January 2017 and March 2018. Six blinded radiologists independently evaluated conventional grayscale dual-energy CT series for the presence of fractures; after 8 weeks, readers reevaluated all cases using color-coded dual-energy CT VNCa reconstructions for the presence of bone marrow edema for six femoral and six tibial regions. Quantitative analysis of CT numbers on VNCa reconstructions was performed by a seventh blinded radiologist. Results from MRI evaluated by two separate blinded experienced radiologists (20 and 32 years of experience in musculoskeletal imaging) served as standard of reference. Diagnostic performance was calculated taking into account clustering.

Results
MRI revealed a total of 136 areas with focal posttraumatic bone marrow edema in 492 regions (61/246 femoral, 75/246 tibial). Fractures were present in 12 patients. In the subjective analysis, VNCa showed high overall sensitivity (95.6%), specificity (96.6%), positive predictive value (PPV, 91.5%) and negative predictive value (NPV, 98.3%) for the detection of bone marrow edema. Area under the curve was 0.959 (femur) and 0.962 (tibia). Inter-reader agreement was excellent (κ=0.91). CT numbers obtained from VNCa were significantly different in areas with or without edema (p<0.001). A cut-off value of -35 HU provided a sensitivity of 92.3%, specificity of 93.1%, PPV of 87.3% and NPV of 95.2% for the differentiation of bone marrow edema.

Conclusion
Dual-energy CT VNCa reconstructions yield excellent diagnostic performance for the detection of posttraumatic bone marrow edema compared to MRI in patients with acute knee trauma by enabling direct color-coded visualization.

Clinical Relevance/Application
Presence and extent of bone marrow edema may be visualized during dual-energy CT performed for detection of fracture in patients with acute knee trauma by using color-coded VNCa reconstructions, potentially replacing MRI in patients with contraindications.
Participants
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PURPOSE
To evaluate the diagnostic accuracy of dual-energy Computed Tomography (DECT) and virtual non calcium (VNC) techniques to identify bone marrow edema of the ankle and foot

METHOD AND MATERIALS
This prospective institutional review board-approved study included 38 consecutive patients (21 males and 17 females; mean age of 62.3, range 26-79 years) studied between January 2017 and January 2018. All patients underwent DECT (80 kV and tin filter 150 kV) and MRI with Short Tau Inversion Recovery images (STIR) within 7 days. DECT data were postprocessed on a dedicated offline workstation (SyngoVia® VB20; Siemens, Erlangen, Germany) by using a three-material decomposition algorithm for generating noncalcium images of the ankle and foot. Two radiologists, blinded to clinical and MRI data (25 and 11 years of experience, respectively) evaluated the presence of abnormal attenuation of each ankle on dedicated color-coded maps and on grey scale images. STIR images served as standard of reference. Diagnostic accuracy values of the DECT maps and of the CT numbers (quantitative assessment) by using receiver operator curves (ROC) and relative area under the curve (AUC) were calculated. Inter-observer and intra-observer agreement were calculated with k-statistics. Continuous and categorical variables were evaluated by using t test and x2 or Fisher exact test, as appropriate. A value of p<0.05 was considered statistically significant

RESULTS
MRI revealed the presence of bone marrow edema in 25/38 cases (65.8%). DECT numbers were significantly different between positive (mean -12.6 ± 29.6 HU) and negative cases (mean -64.2 ± 34.5 HU) with a p value <0.001. The ROC curve analysis revealed an AUC of 0.896 (95% confidence interval: 0.764-0.942). By using -20HU cutoff to identify bone marrow edema, the sensitivity, specificity, PPV and NPV and accuracy of DECT were 88.0, 92.3, 95.6, 80.0 and 89.5%, respectively. The interobserver and intra-observer agreement were near perfect (k=0.88 and k=0.91, respectively)

CONCLUSION
DECT represents a reliable imaging tool for demonstration of bone marrow edema of the ankle and foot

Clinical Relevance/Application
DECT represents a fast and reliable imaging tool for demonstration of bone marrow edema of the ankle and foot and could be proposed as an alternative imaging modality in patients with contraindications for MRI

SS515-03 Sub-Milisievert Ultralow-Dose CT of the Cervical Spine: A Feasibility Study in Human Cadavers

Participants
Julius M. Weinrich, Hamburg, Germany (Presenter) Nothing to Disclose
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Azien Laqmani, Hamburg, Germany (Abstract Co-Author) Nothing to Disclose

PURPOSE
To compare radiation dose and image quality of a standard-dose (SD) and four different reduced-dose (RD) computed tomography (CT) protocols of the cervical spine using filtered back-projection (FBP) and iterative reconstruction (IR) in human cadaver specimen.

METHOD AND MATERIALS
The cervical spine of 29 human cadavers (15 male) was examined using different RDCT protocols (P) with decreasing reference tube currents (P1:70; P2:50; P3:30; P4:10 mAs) at a tube voltage of 140 kV while a clinical SDCT protocol (120 kV, 160 mAs) served as reference. Raw data was reconstructed using FBP and two increasing levels of IR (4&6). Two radiologists assessed image quality for the upper (C1-4) and lower (C5-7) cervical spine. Images were evaluated for overall image quality and visibility of three separate anatomical structures according to a 5-point Likert scale. Additionally, diagnostic acceptability was evaluated. Results were compared using a linear mixed-effects regression model. This study was HIPAA compliant and was approved by our institutional review board, the need for informed consent was waived.

RESULTS
Image quality did not significantly differ between SDCT and RDCT P1-4 using IR 4&6 (p>0.05). Subjective image quality of the upper cervical spine was diagnostic for SDCT and all four RDCT protocols using FBP and IR except for only two cadavers in RDCT P4 using...
FBP. Image quality of the lower cervical spine was rated as non-diagnostic in RDCT P3 (n=8/29) and RDCT P4 (n=22/29) reconstructed with FBP and in RDCT P4 (n=10/29) reconstructed with IR 4&6. Compared with the SDCT all RDCT protocols resulted in a significant effective dose reduction (SDCT:1.5±0.7 mSv; RDCT P1:1±0.6 mSv; P2:0.7±0.4 mSv; P3:0.4±0.2 mSv; P4:0.2±0.1 mSv; p<0.001).

**CONCLUSION**

Diagnostic acceptable sub-milisievert CT of the cervical spine is feasible with a reference mAs of 30 at 140 kV with iterative reconstruction.

**CLINICAL RELEVANCE/APPLICATION**

RDCT of the cervical spine with an effective dose of 0.4 mSv is feasible and should be implemented in clinical routine. Further dose reduction is possible, but IR seems not to compensate for image quality loss at the lower cervical spine.

**SSJ15-04**  
**Bone Marrow Imaging Using Dual Energy CT for the Evaluation of Diffuse Infiltrative Lesions of Multiple Myeloma: Correlation with the Severity of Marrow Infiltration Assessed by MRI**

Tuesday, Nov. 27 3:30PM - 3:40PM Room: E350

Participants
Qin Wang, MD, Beijing, China (Presenter) Nothing to Disclose
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Zhao Yong Sun, Beijing, China (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

To assess the feasibility of using dual-energy CT (DECT) with virtual non-calcium (VNCa) technique for the evaluation of the severity of diffuse marrow infiltration of multiple myeloma, using MRI as reference standard.

**METHOD AND MATERIALS**

22 consecutive patients with plasma disorders were recruited prospectively, including active MM (n=12), MM in complete remission (n=2), MGUS (n=4) and systemic amyloidosis (n=4). All patients underwent whole-body DECT scan (80kV/Sn150kV) and MRI evaluation, including T1-weighted sequence, short TI inversion recovery sequence and fat fraction (FF) map quantified by six-echo volume interpolated breath-hold gradient echo Dixon sequence. VNCa CT numbers, regular CT numbers and FF of vertebral bone marrow were measured. The severity of marrow infiltration was graded as “normal”, “moderate” and “severe”, according to marrow signal intensities on T1-weighted images. The relationship between VNCa and severity of marrow infiltration was evaluated by Spearman correlation. ROC analysis was performed for the diagnosis of diffuse infiltration.

**RESULTS**

A total number of 173 vertebrae were measured. VNCa CT numbers were significantly positive correlated with the severity of marrow infiltration (r=0.580, P=0.000) and significantly negative correlated with FF of bone marrow (r=-0.546, P=0.000). The AUCs of VNCa (0.958) were significantly higher than that of regular CT numbers (0.472) for the diagnose of marrow infiltration. With the cut-off value of -34HU, the sensitivity and specificity of VNCa was 97.2% and 85.4%, respectively.

**CONCLUSION**

VNCa based on DECT is feasible for the evaluation of diffuse marrow infiltration of MM. A significant correlation was observed between VNCa and the severity of marrow infiltration assessed by MRI.

**CLINICAL RELEVANCE/APPLICATION**

VNCa technique based on DECT may severe as an alternative method for the evaluation of the severity of marrow infiltration in MM patients.

**SSJ15-05**  
**Diagnostic Accuracy Values of Dual-Energy CT and Virtual Non-Calcium Techniques to Evaluate Bone Marrow Edema in Vertebral Compression Fractures**

Tuesday, Nov. 27 3:40PM - 3:50PM Room: E350

Participants
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**PURPOSE**

To evaluate the ability of dual-energy Computed Tomography (DECT) to identify bone marrow edema in vertebral compression fractures of thoracic and lumbar spine

**METHOD AND MATERIALS**

This prospective institutional review board-approved study included 76 consecutive patients (29 males and 47 females; mean age of 62.3, range 51-82 years) studied between February 2017 and February 2018. All patients underwent DECT (80 kV and tin filter 150 kV) and MRI with Short Tau Inversion Recovery images (STIR) within 7 days. DECT data were postprocessed on a dedicated workstation (SyngoVia® VB20; Siemens) by using a three-material decomposition algorithm for generating noncalcium images of
vertebral bodies. Two radiologists blinded to clinical data (25 and 11 years of experience, respectively) evaluated the presence of abnormal attenuation of each vertebral body on dedicated color-coded maps. STIR images served as standard of reference. Diagnostic accuracy values of the DECT maps (qualitative assessment) and of the CT numbers (quantitative assessment) by using receiver operator curves (ROC) and relative area under the curve (AUC) were calculated. Inter-observer and intra-observer agreement were calculated with k-statistics. Continuous and categorical variables were evaluated by using t test and x2 or Fisher exact test, as appropriate. A value of p<0.05 was considered statistically significant.

RESULTS

MRI revealed 61/774 (7.9%) edematous vertebrae and 52/774 (6.7%) collapsed non edematous vertebrae. The sensitivity, specificity, PPV and NPV and accuracy of the DECT maps were 88.6, 92.3, 93.1, 87.3 and 90.3%, respectively. DECT numbers were significantly different between positive (mean -23 HU, range -189, 29 HU) and negative cases (mean -126 HU, range -321, -66 HU) with p<0.001. The ROC curve analysis revealed an AUC of 0.886 (95% confidence interval: 0.722-0.913). By using -50HU cutoff to identify vertebral edema, the sensitivity, specificity, PPV and NPV and accuracy of DECT were and 91.8, 90.4, 91.6, 90.4 and 91.1%, respectively. The interobserver and intraobserver agreement were near perfect (k=0.87 and k=0.83).

CONCLUSION

DECT represents a reliable imaging tool for demonstration of bone marrow edema in vertebral compression fracture.

CLINICAL RELEVANCE/APPLICATION

DECT could be proposed as an alternative imaging modality in the suspect of vertebral compression fracture in patients with contraindications for MRI.

PURPOSE

Cinematic rendering (CR) is a recently launched, FDA-approved 3D reconstruction technique which converts conventional CT images into almost photorealistic 3D reconstructions using a unique lightning model. The purpose of this study is to compare CR and volume rendering technique (VRT) in complex lower extremity fractures and to evaluate the value of CR for traumatologists to improve preoperative planning.

METHOD AND MATERIALS

In this retrospective, IRB approved study, 41 consecutive patients (female: n=13; male: n=28; mean age: 52.3±17.9y) with complex lower extremity fractures (calcaneus: n=16, tibial pilon: n=19, acetabulum: n=6) were included. All datasets were acquired using a 128-row dual-source CT. CR and VRT images were reconstructed on a dedicated workstation. Two experienced board-certified traumatologists trained in special lower extremity trauma surgery reviewed VRT and CR images in independent sessions. Image quality, anatomical accuracy and fracture visualization were rated using a 6-point Likert scale (1=non-diagnostic to 6=perfect visualization). Furthermore, the additional value of CR in comparison to conventional VRT images on preoperative planning was assessed. For each score, median values between both readers were calculated. A Wilcoxon-Ranksum test was performed to compare both reconstruction methods. p<0.05 indicated statistical significance.

RESULTS

In comparison to VRT, CR had a higher image quality (VRT: 2.5; CR: 6.0; p<0.001), a higher anatomical accuracy (VRT: 3.5; CR: 5.5; p<0.001) and provided a more detailed visualization of the fracture (VRT: 2.5; CR: 6.0; p<0.001). Furthermore, both readers reported an additional value of CR images for preoperative planning in 65.9% (27/41) of all patients in comparison to VRT.

CONCLUSION

CR provides a more detailed visualization of complex lower extremity fractures compared with VRT. Additionally, CR is a useful tool for traumatologists to improve preoperative planning.

CLINICAL RELEVANCE/APPLICATION

Cinematic rendering is superior to volume rendering technique in the preoperative evaluation of complex lower extremity fractures.
SS17
Science Session with Keynote: Nuclear Medicine (Chest/Breast Oncology Nuclear Imaging)
Tuesday, Nov. 27 3:00PM - 4:00PM Room: S504CD

Participants
Peter S. Conti, MD, PhD, Los Angeles, CA (Moderator) Nothing to Disclose
Andrew C. Homb, MD, Rochester, MN (Moderator) Nothing to Disclose

Sub-Events
SSJ17-01 Nuclear Medicine Keynote Speaker: Radiomics in Lung Cancer
Tuesday, Nov. 27 3:00PM - 3:10PM Room: S504CD

Participants
Lawrence H. Schwartz, MD, New York, NY (Presenter) Committee member, Celgene Corporation Committee member, Novartis AG Committee member, ICON plc Committee member, Bioclinica, Inc

SSJ17-02 An Updated and Validated PET/CT Volumetric Prognostic Index for Non-Small Cell Lung Cancer
Tuesday, Nov. 27 3:10PM - 3:20PM Room: S504CD

Participants
Joshua H. Finkle, MD, Chicago, IL (Presenter) Nothing to Disclose
Bill C. Penney, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose
Yonglin Pu, MD, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

PURPOSE
Whole-body metabolic tumor volume (MTVWB) and TNM staging are independent prognostic factors for overall survival (OS) in non-small cell lung cancer (NSCLC). We aimed to update and validate the PET/CT volumetric prognostic index (PVP index) using the new 8th edition TNM staging system to evaluate its prognostic power versus TNM staging and MTVWB alone.

METHOD AND MATERIALS
This study was a retrospective analysis of 949 non-small cell lung cancer (NSCLC) patients diagnosed between 2004 and 2014. Clinical TNM stage, MTVWB, age and gender, tumor histology type at the initial staging PET/CT exam, as well as treatment history and long-term survival data were obtained. Patients were randomly assigned to modeling or validation group. Univariate and multivariate Cox regression analyses were performed to compare PVP index, TNM stage, and MTVWB in the validation group.

RESULTS
The updated PVP index included the 3 variables TNM stage, and MTVWB and age. Univariate Cox models showed significant association of PVP index with overall survival (OS) in patients with NSCLC (with Hazard ratio HR= 2.88 in the validation group, p<0.001). The C-statistic of the PVP index (C-statistic = 0.71 in the validation group) was significantly greater than that of 8th edition TNM staging (C-statistic = 0.68, p=0.029 ), MTVWB (C-statistic = 0.68, p=0.001), and patient age (C-statistic = 0.53, p<0.001). Multivariate Cox regression analyses demonstrated significant association of PVP index with OS (with HR= 2.80, p<0.001) after adjusting patient’s gender and tumor histology.

CONCLUSION
The updated PVP index provides a quantitative risk assessment for NSCLC patients using 8th edition TNM staging, MTVWB, and age. The index provides a simple and practical way for the care team to incorporate the independent prognostic value of both the TNM stage and MTVWB. This approach can further improve the accuracy of overall survival prognostic.

CLINICAL RELEVANCE/APPLICATION
The PVP index combines the prognostic power of the TNM stage, whole-body metabolic tumor volume and age, offering prognostic accuracy superior to whole-body metabolic tumor volume or TNM stage alone.

SSJ17-03 Prospective Comparison of 18F-FDG PET/MRI and 18F-FDG PET/CT for Thoracic Staging of Non-Small Cell Lung Cancer
Tuesday, Nov. 27 3:20PM - 3:30PM Room: S504CD

Participants
Lino Sawicki, MD, Dusseldorf, Germany (Abstract Co-Author) Nothing to Disclose
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Benedikt M. Schaarschmidt, MD, Essen, Germany (Abstract Co-Author) Stockholder, Bayer AG; Stockholder, General Electric Company; Stockholder, Siemens AG; Stockholder, Teva Pharmaceutical Industries Ltd
Ken Herrmann, Essen, Germany (Abstract Co-Author) Co-founder, SurgicEye GmbH; Stockholder, SurgicEye GmbH; Consultant, Sofie
**PURPOSE**

To compare the diagnostic performance of 18F-FDG PET/MRI and 18F-FDG PET/CT for primary and locoregional lymph node staging in non-small cell lung cancer (NSCLC).

**METHOD AND MATERIALS**

In this prospective study a total of 84 patients (51 men, 33 women, mean age 62.5 ± 9.1 years) with histopathologically confirmed NSCLC underwent 18F-FDG PET/CT followed by 18F-FDG PET/MRI in a single injection protocol. Two readers independently assessed T and N staging in separate sessions according to the seventh edition of the American Joint Committee on Cancer staging manual for 18F-FDG PET/CT and 18F-FDG PET/MRI, respectively. Histopathology as reference standard was available for N staging in all 84 patients and for T staging in 39 patients. Differences in staging accuracy were assessed by McNemars chi2 test. The maximum standardized uptake value (SUVmax) and longitudinal diameters of primary tumors were correlated using Pearson's coefficients.

**RESULTS**

T stage was categorized concordantly in 18F-FDG PET/MRI and 18F-FDG PET/CT in 38 of 39 (97.4%) patients. Herein, 18F-FDG PET/CT and 18F-FDG PET/MRI correctly determined the T-stage in 92.3% and 89.7% of patients, respectively. N-stage was categorized concordantly in 83 of 84 patients (98.8%). 18F-FDG PET/CT correctly determined the N stage in 78 of 84 patients (92.9%), while 18F-FDG PET/MRI correctly determined the N stage in 77 of 84 patients (91.7%). Differences between 18F-FDG PET/CT and 18F-FDG PET/MRI in T and N staging accuracy were not statistically significant (p > 0.5, each). Tumor size and SUVmax measurements derived from both imaging modalities exhibited excellent correlation (r=0.963 and r=0.901, respectively).

**CONCLUSION**

18F-FDG PET/MRI and 18F-FDG PET/CT showed an equivalently high diagnostic performance for T and N staging in patients suffering from NSCLC.

**CLINICAL RELEVANCE/APPLICATION**

PET/MRI as a dose-saving alternative to PET/CT proved coequal to the current gold standard for thoracic staging of NSCLC. Thus, clinicians might use PET/MRI instead of PET/CT for this purpose. However, considering the longer examination times and higher expenses of PET/MRI, a general recommendation in favor of PET/MRI cannot be drawn from this study.

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**SSJ17-04** The Relationship Between PET/CT Imaging Features and Pathological Types and Gene Mutations of Primary Lung Cancer: A Study of 213 Untreated Lung Cancer Patients with Bone Metastases

**Tuesday, Nov. 27 3:30PM - 3:40PM Room: S504CD**

Participants
Xiaomeng Li, MD, Beijing, China (Presenter) Nothing to Disclose
Ning Wu, MD, Beijing, China (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To evaluate the relationship between 18F-FDG PET/CT image characteristics and pathological types and gene mutations of primary lung cancer in untreated lung cancer patients with bone metastases.

**METHOD AND MATERIALS**

A total of 213 untreated lung cancer patients with bone metastases were enrolled in this study. All patients underwent 18F-FDG PET/CT examination, pathological and gene mutation examination of primary lung cancer. Spearman's correlation test was performed to evaluate the association between primary tumors and bone metastases. Single factor analysis of variance was used to compare groups.

**RESULTS**

(1) A total of 213 cases were evaluated. The mean SUVmax of primary lung cancer was 7.9±4.7; that of bone metastases was 8.2±4.3. The SUVmax of primary lesions had a significantly positive correlation with the SUVmax of bone metastases (r = 0.622; p = 0.000). Osteolytic metastasis was the most common type. (2) The SUVmax of primary lung lesions with different pathological types were statistically different (all P < 0.000): squamous cell carcinoma > small cell carcinoma > adenocarcinoma. Their SUVmax were 11.7±4.3, 9.3±4.1, and 6.7±4.6, respectively. (3) In non-small cell lung cancer (NSCLC), the gene mutation rates of epidermal growth factor receptor (EGFR), K-ras, and anaplastic lymphoma kinase (ALK) were 35.7%, 10.1%, and 3.8%, respectively. There was no statistical difference in SUVmax of primary lung cancer between gene mutation type and wild type (P>0.05).

**CONCLUSION**

The SUVmax of primary lung lesions with different pathological types were statistically different. Squamous cell carcinoma was the highest, and adenocarcinoma was the lowest. The SUVmax of primary lung cancer had a significantly positive correlation with the SUVmax of bone metastases. In NSCLC, the mutation rate of EGFR is the highest. There was no statistical difference in SUVmax of primary lung cancer between gene mutation type and wild type.

**CLINICAL RELEVANCE/APPLICATION**

The SUVmax of primary lung cancer is suggestive of its pathological type. But the SUVmax of primary lung cancer is not helpful to predict the gene mutations in NSCLC.
Comparison between PET and MRI-pCM showed moderate to strong correlation for the comparison of all radiomic features ($-0.66 < \rho < 0.54$). Correlation of radiomic features of both modalities to hormone receptor status is shown in Table 1. Selected radiomic features of MRI-pCM showed moderate correlation to T-stage ($-0.64 < \rho < 0.57$) and to N-stage ($-0.52 < \rho < 0.54$). Correlation of radiomic features of both modalities to hormone receptor status is shown in Table 1.

RESULTS

Association of features between the different modalities was compared (Spearman "$\rho$").

METHOD AND MATERIALS

A total of 38 patients (37 females and one male, mean age 57 ± 10 years; range 31-78 years) with newly diagnosed, histopathologically proven breast cancer were prospectively enrolled in this trial. All PET/MRI examinations were assessed for local tumor burden and metastatic spread in two separate reading sessions: (1) One-step algorithm comprising supine whole-body 18F-FDG PET/MRI, (2) Two-step algorithm comprising a dedicated prone 18F-FDG breast PET/MRI and supine whole-body 18F-FDG PET/MRI.

RESULTS

On a patient based analysis the two-step algorithm correctly identified 37 out of 38 patients with breast carcinoma (97%), while 5 patients were missed by the one-step 18F-FDG PET/MRI algorithm (33/38; 87% correct identification; $p=0.37$). On a lesion-based analysis 56 breast cancer lesions were detected in the two-step algorithm and 44 breast cancer lesions could be correctly identified in the one-step 18F-FDG PET/MRI (79%), resulting in statistically significant differences between the two algorithms ($p=0.0015$). For axillary lymph node evaluation sensitivity, specificity and accuracy was 93%, 95 % and 94%, respectively. Furthermore, distant metastases could be detected in 7 patients with both modalities.

CONCLUSION

The results demonstrate the necessity and superiority of a two-step 18F-FDG PET/MI algorithm, comprising dedicated prone breast imaging and supine whole-body imaging, when compared to the one-step algorithm for local and whole-body staging in breast cancer patients.

CLINICAL RELEVANCE/APPLICATION

Two-step 18F-FDG PET/MI comprising dedicated breast and whole-body imaging enables high-quality local and whole-body staging in patients with breast cancer.

SS317-06 Multimodal Radiomic Imaging: Comparison of PET and MRI-pCM Heterogeneity in Breast Cancer

Participants

Bert-Ram Sah, MD, London, United Kingdom (Presenter) Nothing to Disclose

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Stephanie Tanadini-Lang, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose

Patrick Veit-Halbach, MD, Zurich, Switzerland (Abstract Co-Author) Research Grant, Bayer AG Research Grant, F. Hoffmann-La Roche Ltd Research Grant, General Electric Company

METHOD AND MATERIALS

This study investigated the value of pre-treatment F-18-Fluorodeoxyglucose (FDG)-positron-emission-tomography (PET) radiomics in comparison to T1-weighted-post-contrast-magnetic-resonance-imaging (MRI-pCM) radiomics in patients with breast cancer.

RESULTS

Selected radiomic features of PET showed moderate correlation to T-stage ($-0.52 < p < 0.54$) and weak correlation to N-Stage ($-0.35 < p < 0.38$). Selected radiomic features of MRI-pCM showed moderate correlation to T-stage ($-0.64 < p < 0.57$) and to N-stage ($-0.52 < p < 0.54$). Correlation of radiomic features of both modalities to hormone receptor status is shown in Table 1. Comparison between PET and MRI-pCM showed moderate to strong correlation for the comparison of all radiomic features ($-0.66 <$
p < 0.68) (Figure 1), whereas the correlation for the comparison of a respective radiomic parameter was only weak to moderate (0.22 < p < 0.56) (1st diagonal in Figure 1).

CONCLUSION
Radiomics in a multimodality approach might be a complementary tool for non-invasive pre-therapeutic characterization of breast cancer.

CLINICAL RELEVANCE/APPLICATION
Combining radiomic features from different imaging modalities may help in non-invasive specification of breast cancer.
Recent theoretical and experimental studies about CT number accuracy in low dose CT have shown that filtered backprojection (FBP) and conventional model based iterative reconstruction (MBIR) methods are biased by an amount that is dose and contrast dependent. This work validates that the data weighting scheme in the MBIR framework is the culprit for both these biases and that a more optimal weighting scheme has been found to eliminate bias across all dose and contrast levels.

**METHOD AND MATERIALS**

Raw CT data was acquired for two phantoms on a benchtop CT system using a photon counting detector (XC-HYDRA FX50, XCounter AB, Sweden). The Catphan phantom (Catphan 600, Phantom Laboratory, Salem, New York) was scanned at several dose levels in the range 69-367 mAs, with 50 repeated scans for each dose level. A customized head phantom was also scanned in the range 40-400 mAs, with 30 repeated scans for each dose level. Reference images for each phantom were obtained by averaging the pre-log projections for the highest dose level across all repetitions, and then performing FBP reconstruction. These references served as the experimental ground truth. For each dose level and reconstruction method (FBP, MBIR, proposed MBIR), bias images were calculated by subtracting the reference image from the mean of the reconstructions of each repeated scan. Bias images of the Catphan and head phantoms were also assessed across the image field of view (FOV).

**RESULTS**

There are three main results: 1) The theoretical relationship bias=±a/mAs*(1+ßΔHU) was validated experimentally for both FBP (positive polarity) and conventional MBIR (negative polarity). 2) The proposed MBIR method, which uses a modified weighting scheme, eliminates bias for each contrast and dose level in the Catphan phantom. 3) The proposed MBIR method demonstrates promising preliminary results for reducing bias across the FOV in a more complex anthropomorphic head phantom.

**CONCLUSION**

The proposed MBIR method maintains CT number accuracy of varying contrast across dose levels by using a theoretically based modified data weighting scheme.

**CLINICAL RELEVANCE/APPLICATION**

Certain tasks, e.g. detection of acute cerebral venous sinus thrombosis (CVST), rely on CT number estimation. It is critical the CT reconstruction method maintains accurate HU values.
**PURPOSE**

Acquiring low-count PET and undersampled MR can shorten PET/MR scan time, which, however, may also lead to noisy PET images and MR images with artifacts. The goal of this report is to evaluate whether deep learning method can reconstruct high-quality PET/MR images from its low-quality counterpart, potentially enabling shorter scan time in PET/MR. We also compared the proposed model with single modality models to investigate whether the resulting image quality can benefit from sharing features of the two modalities in the network.

**METHOD AND MATERIALS**

We developed a fully convolutional encoder-decoder network to predict high quality PET and MR images from low-count PET and undersampled MR. Concatenate skip connections and strategy of residual learning is adopted to restore high resolution details. Brain PET/MR data are acquired from a simultaneous PET/MR system (uPMR790, United Imaging Healthcare) from 50 patients who received 0.12 mCi/kg FDG. To generate low-count PET, the PET list-mode data was randomly undersampled for 10% events. Both standard-count and low-count PET images were reconstructed with OSEM (4 iterations, 20 subsets). Undersampled T1 weight MR is generated using radial sampling in k-space with sampling rate equal to 10%. Standard-count PET and fully sampled MR were taken as ground-truth in network training.

**RESULTS**

Models were trained on 40 patients and evaluated on the other 10 patients. The proposed joint model gains 4.5/7.9dB in peak signal-to-noise ratio (PSNR) and 0.036/0.42 in structural similarity index (SSIM) compared with low-count PET/undersampled MR. When compared with the single modality model of PET/MR, results shows that our joint model has an improvement of 0.97/0.15dB in PSNR and 0.006/0.0012 in SSIM.

**CONCLUSION**

Using a deep learning algorithm, we can estimate high-quality PET and MR images from low-count PET and undersampled MR images. Results also showed that joint reconstruction of PET and MR by sharing features in network can improve image quality of two modalities compared with single modality model.

**CLINICAL RELEVANCE/APPLICATION**

This method was demonstrated promising in greatly reducing the scan time in PET/MR imaging by up to 90%.

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**SS322-03**  
Implementation of a CT Reference Library Containing Manufacturer-Neutral Projection Data, Images, and Clinical Metadata

**Tuesday, Nov. 27 3:20PM - 3:30PM Room: N227B**

**Participants**

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**PURPOSE**

A manufacturer-neutral CT projection data (PD) format (DICOM-CT-PD) has been previously developed and used to allow access to CT PD and the scanner information required for image reconstruction. Access to such data was not previously possible, limiting the ability of reconstruction scientists to work with patient data. In this work, we aim to construct a reference DICOM-CT-PD library containing patient PD with corresponding images and clinically relevant metadata, and to publish this library for public access.

**METHOD AND MATERIALS**

CT images and PD were acquired from three different manufacturers for three clinical scanners at routine dose levels for head, chest and abdomen exams. The PD were converted to the DICOM-CT-PD format and a lower dose exam was simulated for each PD set using a validated noise-insertion method. Radiologists reviewed each case and marked lesion locations and diagnosis. Reference truth was obtained from the patient medical record, either from histology or subsequent imaging. Metadata such as lesion location, diagnosis, and source of truth were acquired for each case and formatted into a reference report. Each case was anonymized to remove protected health information for transfer to an NCI-hosted public data archive, The Cancer Imaging Archive (TCIA).

**RESULTS**

450 total cases from Siemens (n=150), GE (n=150), and Philips (n=150) scanners were obtained, including both negative and positive patient cases. PD are available for two dose levels, routine full dose and simulated low dose (25% of routine dose for head and abdomen cases and 10% of routine dose for chest cases). Routine dose image series are available for all of the cases, and reduced dose images are additionally available for exams acquired on a Siemens scanner. Clinical metadata are organized in an easy to use spreadsheet. The assembled projection, image and clinical data provide a rich data library with which CT image reconstruction scientists can validate their algorithms.
**CONCLUSION**
A large patient library containing manufacturer-neutral PD, the corresponding full dose images, and clinical reference information has been developed and is being made available through the TCIA.

**CLINICAL RELEVANCE/APPLICATION**
The successful implementation of this library will provide open source CT PD with correlated images and clinical information to investigators for reconstruction research and development.

**SS22-04  Motion Compensation in Liver SPECT using Simultaneous X-Ray and Nuclear Imaging**

Tuesday, Nov. 27 3:30PM - 3:40PM Room: N227B

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**PURPOSE**
Quantitative accuracy of liver SPECT/CT is crucial for e.g. dosimetry in radioembolization, but due to respiratory motion limited in precision. Motion can be compensated for in the reconstruction, but in clinical practice this requires an external device for the tracking of the motion signal and a prior motion vector field estimate to link the motion signal to organ movements, complicating the acquisition. A device under development, which simultaneously measures x-ray and nuclear projections, could be used to retrieve both measures intrinsically. Such a data-driven approach eliminates the need for external devices and provides a real-time vector field. The purpose of this work is to evaluate the performance of the proposed motion compensation technique using simulations.

**METHOD AND MATERIALS**
Nuclear and x-ray projections of a realistic digital phantom with respiratory motion were generated using Monte Carlo simulations for several breathing patterns. X-ray projections were sampled at 1 to 5 Hz; nuclear projections were acquired continuously. Total x-ray imaging dose was varied from 1 to 1000 µGy. The motion signal was extracted from x-ray projections by calculation of the center of mass and then used to bin the projections into gates. The x-ray gates were individually reconstructed and registered onto each other, resulting in the vector field to be included in the nuclear reconstruction.

**RESULTS**
The respiratory motion signal was accurately extracted from the x-ray projections, provided the x-ray sampling rate was greater than 2 Hz and the motion was stable in amplitude. The total minimally required dose for x-ray sampling was 10 µGy for a 5 minute scan. The inclusion of motion correction into the SPECT reconstruction improved contrast-to-noise ratio, in comparison with no motion correction, from 11.9 ± 0.5 to 19.1 ± 0.7.

**CONCLUSION**
The proposed motion compensation technique has the potential to improve quantitative SPECT reconstructions. Additionally, the need for external devices and a prior vector field estimate are eliminated. Only a limited amount of dose is required to obtain significantly improved results, paving the way for clinical use.

**CLINICAL RELEVANCE/APPLICATION**
Liver radioembolization requires quantitative SPECT to study the activity distribution. In order to improve accuracy and personalize dosimetry, motion should be accounted for in reconstructions.

**SS22-05  Motion Compensated Reconstruction of the Aortic Valve for Non-Gated Helical CT Scans**

Tuesday, Nov. 27 3:40PM - 3:50PM Room: N227B

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**PURPOSE**
Precise CT imaging is prerequisite for reliable planning of transcatheter aortic valve implantation (TAVI). Especially in non-gated CT scans, cardiac motion leads to severe artifacts in the reconstructed CT images. Blurring of the valve and the neighboring vascular anatomy potentially result in incorrect device sizing. A second pass motion correction method for non-gated helical CT scans with a pitch <1 is introduced here.

**METHOD AND MATERIALS**
The new post-processing method was applied to five non-gated clinical datasets acquired with a 256-slice CT scanner (Brilliance iCT, Philips Healthcare). Redundancy in the helical projection data was used to generate three image volumes at identical spatial positions, but different time points. During each reconstruction a subset of detector rows was selected which may be either overlapping or fully separated depending on the pitch size. The 3D edge-filtering scheme included Gaussian smoothing for noise reduction, gradient calculation for edge enhancement, non-maximum-suppression and hysteresis thresholding for reduction of incoherent edges. The sparse filter results were taken as input for an elastic registration to estimate the displacement of each
voxel between the given time points. Reconstructed datasets were evaluated with a TAVI planning software (IntelliSpace Portal, Philips Healthcare) by two blinded readers.

RESULTS
The method achieved significant motion artifact reduction in CT aortic valve reconstructions. A removal of doubled structures at the aortic boundaries could be observed, as well as reduced blurring compared to the uncompensated reconstructions.

CONCLUSION
Motion compensated reconstruction is feasible for non-gated helical CT scans using edge filtering and image based registration for motion estimation. Reconstructed CT image datasets may improve planning and device selection for TAVI procedures.

CLINICAL RELEVANCE/APPLICATION
Motion compensated reconstruction yields reduced artifact levels at the aortic valve in non-gated helical CT scans with a pitch <1.

Multi-Channel GAN: A Machine Learning Approach to Parallel MRI Reconstruction

Participants
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PURPOSE
Magnetic resonance imaging (MRI) has a low imaging speed. MRI acceleration relies on undersampling that may introduce aliasing artifacts in image reconstruction. Here we propose a machine learning approach that can automatically learn parallel MRI mechanisms underlying multi-channel k-space data and reconstruct high-quality MR images from undersampled data.

METHOD AND MATERIALS
Parallel MRI is a standard approach to imaging acceleration on clinical MRI scanners. This approach can effectively suppress aliasing artifacts associated with undersampling, but requires an additional calibration procedure that limits the overall imaging speed. Here a deep learning based neural network model, multi-channel generative adversarial network (multi-channel GAN), is developed to process multi-channel raw MRI data. This model can learn parallel MRI reconstruction mechanisms underlying a large amount of multi-channel k-space data. The trained model can be used to reconstruct images from undersampled data without calibration, thereby providing a higher imaging speed than conventional parallel MRI. In our approach, the basic unit of multi-channel GAN has two sub-networks: a generator network which learns the relationship between undersampled and fully-sampled data and a discriminator network which justifies if the generated data are real. The whole model consists of the same number of basic unit networks as that of radiofrequency channels on the MRI scanner for parallel MRI reconstruction. The training process uses a stochastic gradient descent and back-propagation algorithm. The trained multi-channel generator network is used to perform image reconstruction.

RESULTS
We evaluate the proposed method with a total of 170 sets of 2D multi-channel brain MRI images. Figure 1 shows an example of reconstruction results with an undersampling factor of 5. It is found that the machine learning method outperforms other state-of-the-art parallel MRI reconstruction methods.

CONCLUSION
We demonstrate a machine learning approach to parallel MRI reconstruction. This approach can generate high-quality images from undersampled data without calibration, providing a higher imaging speed than conventional parallel MRI.

CLINICAL RELEVANCE/APPLICATION
The machine learning approach to parallel MRI reconstruction can enhance diagnostic MRI quality, shorten clinical MRI procedures and improve clinical MRI throughput.
SSJ23

Physics (CT: Cone-Beam CT in Imaging and Radiation Therapy)

Tuesday, Nov. 27 3:00PM - 4:00PM Room: N226

CT PH RO

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

FDA Discussions may include off-label uses.

Participants
Joseph W. Stayman, PhD, Baltimore, MD (Moderator) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc; Research Grant, Elekta AB; Research collaboration, Fischer Medical; Research Grant, Medtronic plc; Research collaboration, Koninklijke Philips NV; Research Grant, Siemens AG
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Sub-Events
SSJ23-01 Quantitative Extremity Cone-Beam CT Using Model-Based Polynenergetic Reconstruction

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PURPOSE
Quantitative evaluation of bone mineral density (BMD) using cone-beam CT (CBCT) is challenged by a high level of artifacts typically associated with CBCT. We apply a polynenergetic model-based iterative reconstruction (MBIR) with a material mixing model to obtain accurate and reproducible density estimates in extremity CBCT.

METHOD AND MATERIALS
An ideal solution model was used in polynenergetic MBIR (MBIR-poly, Elbakri PMB 2003) to account for mixing of Ca and marrow in bone. The model was calibrated using BMD inserts of known concentration (Gammex 467, 472). Scans were acquired at 90 kVp on a test-bench emulating the geometry of extremity CBCT. Monte Carlo scatter estimates obtained from water-corrected FBP were subtracted from projection data. Artifact reduction and quantitative accuracy were evaluated in water phantoms with muscle, adipose and BMD inserts (from 20 mg/cc to 500 mg/cc Ca). MBIR-poly reconstructs the density map of the object and thus the reconstructed voxel values were compared with measured physical densities of the inserts. To assess robustness to imaging conditions (essential in longitudinal studies), we compared density estimates in cortical and trabecular regions-of-interest (ROI) of a cadaveric ankle imaged in the following configurations: ankle alone (C1), ankle+water+2 BMD inserts (C2), ankle+water+2 BMD inserts+2 cm shift (C3).

RESULTS
With MBIR, the error in density was <0.009 g/cc across all BMD inserts. The magnitude of streak artifacts (departure from uniformity in a water region) was reduced by 96% compared to FBP with water-correction only. The spread (standard deviation) of mean cortical and trabecular density across configurations C1-C3 was reduced by 78% and 51%, respectively. The estimates of physical BMD insert density remained accurate when imaged in the presence of the ankle (configurations C2 and C3), with errors<0.015 g/cc.

CONCLUSION
MBIR-poly with an ideal solution mixture model yielded correction of beam hardening artifacts and provided quantitatively accurate estimates of object density in extremity CBCT. The density estimates were reproducible across a variety of imaging conditions.

CLINICAL RELEVANCE/APPLICATION
A polynenergetic model-based reconstruction algorithm yields accurate and reproducible estimates of tissue density in extremity CBCT, enabling quantitative studies of bone mineralization.

SSJ23-02 Two-Dimensional Anti-scatter Grids for CBCT: Transmission Properties of High Grid Ratio 2D Grid
**Prototypes**

Tuesday, Nov. 27 3:10PM - 3:20PM Room: N226

Participants
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**PURPOSE**

CT number accuracy and low contrast resolution can be poor in CBCT images due to high levels of scattered radiation. To reduce scatter, we have been investigating the utility of 2D antiscatter grids for flat panel detector based CBCT. In this study, we developed two prototypes, and characterized their scatter and primary transmission performance in a CBCT system for image guided radiation therapy.

**METHOD AND MATERIALS**

Two prototypes with grid ratio of 12 (R12) and 16 (R16) were developed and fabricated by using direct metal laser sintering process. Both grids have 2 mm grid pitch, and 0.1 mm septal thickness, and their grid cells were focused towards the x-ray source, in offset detector CBCT geometry. Prototypes were integrated with the flat panel detector in a clinical CBCT system. Primary and scatter transmission properties were measured using PMMA phantoms and beam-stops, at tube voltages of 80, 125, and 140 kVp. To benchmark the performance of prototypes, a fluoroscopic 1D antiscatter grid with a grid ratio of 21 (R21) was also evaluated under identical imaging conditions.

**RESULTS**

At 140 kVp, scatter-to-primary ratio (SPR) at 40 cm phantom thickness was 10.1 without a grid. SPR was reduced to 0.36 and 0.29 with our R12 and R16 prototypes, whereas SPR was 1.47 with the 1D grid. Scatter transmission fraction (Ts) with R12 and R16 prototypes were 3.1% and 2.4%, and Ts for 1D grid was 10.8%. When tube voltage increased for 80 to 140 kVp, Ts values increased by 13% for both 2D grids, whereas Ts increased by 31% for the 1D grid. Similar trends were observed for all grids when phantom thickness was varied between 10 and 40 cm. Average primary transmission fraction of R12, R16 prototypes, and 1D grid were 83%, 71%, and 70%, respectively.

**CONCLUSION**

Scatter transmission of our 2D grids were up to factor of 4.5 lower than a conventional antiscatter grid, while providing higher primary transmission. Thus, lower scatter transmission provided by 2D grids may lead to higher CT number accuracy and improved contrast resolution in CBCT. Lower scatter transmission may also play an important in the context of dual-energy CBCT, where highly accurate projection images are required.

**CLINICAL RELEVANCE/APPLICATION**

Scattered radiation is one of the leading causes of image quality degradation in CBCT imaging, limiting the utility of CBCT in a range of clinical applications. Our research on 2D antiscatter grid development aims to address this problem.

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**Deep Scatter Estimation (DSE) for Truncated Cone-Beam CT (CBCT)**

Tuesday, Nov. 27 3:20PM - 3:30PM Room: N226

Participants
Joscha Maier, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

To correct for x-ray scatter in truncated CBCT in real time.

**METHOD AND MATERIALS**

Cone-beam CT (CBCT) acquisitions suffer from scatter artifacts. To correct for these artifacts, we recently developed the deep scatter estimation (DSE) that trains a deep convolutional neural network to reproduce Monte Carlo (MC) scatter estimates. Once trained, DSE combines both real-time capability and high accuracy. Applied to non-truncated data, DSE turned out to be equivalent to MC while outperforming known scatter estimation approaches. In the present work, however, we deal with truncated data as they occur in interventionally C-arm CBCT or dental CBCT. In this case MC simulations are not possible because the object, which is needed as input to the MC simulation, cannot be fully reconstructed. To overcome this drawback, we developed the truncated DSE which uses a U-net architecture to reproduce the outcome of MC simulations from non-truncated objects given only the truncated projection data as input. Here, DSE is trained on 10800 simulated truncated projection images (pelvis, abdomen, and thorax). The training is performed on a GeForce GTX 1080 for 100 epochs using an Adam optimizer and the mean absolute error between the output and the MC scatter distribution as loss function. The performance of DSE was evaluated for simulated and measured testing data of a truncated CBCT system and compared against a kernel based scatter estimation (KSE).

**RESULTS**

Considering simulated data, the accuracy of KSE and DSE scatter estimates was quantified by calculating the mean absolute error (MAE) with respect to the simulated ground truth scatter distribution. Here, we observe a MAE of 19.2 % (KSE) and 1.8 % (DSE).
To quantify the performance for measured data, a slit scan measurement was performed as reference. Compared to the slit scan, CT reconstructions that were corrected using DSE show an almost similar CT value distribution while there are discrepancies of up to 150 HU using KSE.

CONCLUSION

DSE is able to derive highly accurate scatter estimates very close to MC simulations. Compared to conventional scatter estimation approaches DSE shows a superior performance while requiring similar processing time (20 ms / projection).

CLINICAL RELEVANCE/APPLICATION

Scatter correction is crucial to maintain the diagnostic value of CBCT examinations. DSE can overcome the drawbacks of existing approaches that are optimized for performance at the cost of accuracy.

SSJ23-04  Daily Edge Deformation Prediction Using a Conventional Neural-Network Regression for Low Dose Prior Contour Based Total Variation CBCT Reconstruction (PCTV-CNN)

Tuesday, Nov. 27 3:30PM - 3:40PM Room: N226

Participants
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PURPOSE

Previously we developed a PCTV reconstruction method to enhance the edge sharpness of low-dose CBCT. PCTV deforms the edge map from planning CT to on-board volumes to obtain the on-board edge information for enhancement in TV reconstruction. However, the deformable registration used for deforming the edge is time consuming and prone to errors due to the low quality of CBCT. This study aims to develop a novel method for predicting daily on-board edge deformation using deep conventional neural networks (CNN) to bypass deformable registration to improve the PCTV reconstruction efficiency.

METHOD AND MATERIALS

The new method uses patch-based CNN deformation prediction and PCTV reconstruction. Deformation vector field (DVF) registered from CT to full-sampling CBCTs and retrospectively under-sampled low-dose CBCT are obtained on the first day to train the model, which is then updated with following days' data. The model predicts DVF for low-dose CBCT acquired on the following day to generate on-board contours for PCTV reconstruction. Specifically, 3D patches are extracted from the same location in the planning-CT and low-dose CBCT as the inputs. Only DVF and voxels at the edge regions of planning-CT are selected for the prediction model. The CNN model is developed in MATLAB using 4 convolutional layers interleaved with pooling layers to directly learn the mapping from the input image patch pair. The method is evaluated using lung SBRT patient data. The first n-1 day's CBCTs are used for CNN training to predict nth day edge information (n=2, 3, 4, 5). 45 half-fan projections covering 360° from nth day CBCT is used for reconstruction. Results from Edge-preserving (EPTV), PCTV and PCTV-CNN are compared.

RESULTS

The cross-correlations between predicted and reference edge maps are 0.9734, 0.9706, 0.9624 and 0.9477, for day 2-5 respectively. PCTV-CNN enhanced bone edges in CBCT compared to EPTV and achieved comparable image quality as PCTV while avoiding time-consuming deformable registration process.

CONCLUSION

Preliminary results demonstrated the feasibility to use CNN to predict daily deformation of on-board edge information for PCTV based low-dose CBCT reconstruction.

CLINICAL RELEVANCE/APPLICATION

PCTV-CNN has a great potential for enhancing the edge sharpness with high efficiency for low dose 3D CBCT or 4D CBCT to improve the precision of on-board target localization and adaptive radiotherapy.

SSJ23-05  A Robust Fully Automatic Method for Intrinsic Respiratory and Cardiac Gating for Cone-Beam CT Scans of the Thorax Region

Tuesday, Nov. 27 3:40PM - 3:50PM Room: N226

Participants
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PURPOSE

To automatically extract a respiratory and a cardiac signal from cone-beam CT (CBCT) rawdata.

METHOD AND MATERIALS

Due to the relatively slow acquisition speed of CBCT systems, patient respiration and cardiac motion lead to motion blurring. This can be compensated using motion-compensated image reconstruction in 4D and in 5D [Brehm et al., MedPhys 42(4)] which requires accurate motion information. Without an external signal, motion surrogates have to be retrieved intrinsically from the rawdata. While there are several methods for respiratory gating, only few are dedicated to cardiac gating but are not very robust. We propose a robust method that is able to retrieve a respiratory and a cardiac signal fully automatically. The respiratory signal is retrieved by analyzing the mean signal over the whole detector as a function of the projection angle. The cardiac signal starts from...
50×50×50 uniformly distributed grid points in the field of measurement to which x-y-circles of radius r are attached. We iterate over radii between 3 cm and 5 cm in steps of 2 mm and compute the intersection of the x-ray that runs through the tangent of each circle with the detector. The intersection points are centers of rectangular ROIs of about 8 cm by 4 cm whose mean value serves as a surrogate for the cardiac motion phase. The most regular signal after band pass filtering is selected as the cardiac surrogate. The method was tested on 10 patient thorax scans acquired with a Varian True Beam system and compared to the AS method [Van Herk et al., ICCR 07] (M1) and the method of reference [Hahn et al., SPIE Medical Imaging 2016] (M2).

RESULTS
The proposed method, M1 and M2 determined the correct number of respiratory peaks. While the proposed method showed good results for the cardiac gating with a maximum error of 1 heart beat, M2 showed good results for 6 patients (max. error 1), it did not perform well for 4 patients (max. error 23). M1 cannot detect cardiac motion.

CONCLUSION
The proposed method is able to acquire a respiratory and cardiac surrogate in a fully automatic way for CBCT scans of the thorax region and outperformed M2 in terms of robustness.

CLINICAL RELEVANCE/APPLICATION
Clinically, intrinsic gating will be useful in cases where no gating signals are available, such as it is the case in many interventional imaging scenarios. With intrinsic gating those cases can benefit from motion-compensated reconstruction and thus from better image quality.

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PURPOSE
we proposed automatic segmentation method on four facial structures including hard tissues, maxillary sinus, mandible, and mandibular canals using 3D U-Net with convolutional neural net (CNN) in CBCT.

METHOD AND MATERIALS
We obtained 100 data sets of i-Cat CBCT scans (Imaging Science International, Hatfield, PA, USA). The training and validation dataset of hard tissues, maxillary sinus and mandible consists of 7 and 4 cases, 20 and 4 cases, and 20 and 4 cases, respectively. The training, and validation dataset of mandibular canals consist of 40 and 15 cases, respectively. Each test dataset was used in the same 7 patients. Depending on the structures, the segmentation result as gold standard was made differently. The hard tissues and mandibular canals were manually drawn by an expert and confirmed by an expert dentist. The initial mandible and maxillary sinus mask was created by in-house software with conventional image processing techniques including 3D sculpting and thresholding. These masks were filled per slice, and manually corrected by experts. Before training, we pre-processed images to change brightness (window level = 450) and contrast (window width = 5000). Also, the number of each dataset was augmented by flip and rotation. We used the 3D U-Net, one of the most widely used CNN architectures for image segmentation.

RESULTS
For the evaluation metrics, the Dice similarity coefficient (DSC), Jaccard similarity coefficient (JSC), mean surface distance (MSD) and Hausdorff surface distance (HSD) were 82.60±0.04%, 70.47±0.06%, in hard tissues, 86.60±0.01%, and 92.80±0.01%, and 82.00±0.07%, 0.35±0.29 mm, 0.49±0.09 mm in maxillary sinus, 90.00±0.04 %, 0.89±0.66 %, 11.29±10.21 mm, 3.21±2.56 mm and 18.42±19.72 mm, in mandible, respectively. In the mandibular canals, mean error distances were 0.89±0.40 mm.

CONCLUSION
In this study, we proposed an automatic 3D segmentation method, demonstrated very fast segmentation results with reasonable accuracies of multi-facial structures in CBCT including hard tissues, maxillary sinus, mandibular, and mandibular canals.

CLINICAL RELEVANCE/APPLICATION
This study could be used to the planning of dental implant and orthognathic surgeries.
**Case-based Review of Nuclear Medicine: PET/CT Workshop-Advances in PET (In Conjunction with SNMMI)**

(Interactive Session)

Tuesday, Nov. 27 3:30PM - 5:00PM Room: E450B

BQ CT NM

AMA PRA Category 1 Credits ™: 1.50  
ABRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

**Participants**

Samuel E. Almodovar-Reteguis, MD, Orlando, FL (Director) Nothing to Disclose  
Katherine A. Zukotynski, MD, Ancaster, ON (Director) Nothing to Disclose  
Chadwick L. Wright, MD,PhD, Lewis Center, OH (Moderator) Nothing to Disclose

**Sub-Events**

**MSCC34A  Somatostatin Receptor PET & Therapy**

Participants  
Thomas A. Hope, MD, San Francisco, CA (Presenter) Research support, General Electric Company

For information about this presentation, contact:  
thomas.hope@ucsf.edu

**LEARNING OBJECTIVES**

1) Define the role of somatostatin receptor (SSTR) PET in patients with neuroendocrine tumors (NETs).  
2) Compare the use of conventional imaging and SSTR PET in staging NETs.  
3) Explain the mechanism of SSTR based peptide receptor radionuclide therapy (PRRT).

**ABSTRACT**

Neuroendocrine tumors (NET) are unique in that they overexpress the somatostatin receptor (SSTR). This can be leveraged in imaging by labelling somatostatin analogs with radiation to image the location of tumors. DOTATATE is a SSTR analog, that when labeled with Gallium-68 can be used to image neuroendocrine tumors with very high sensitivity and specificity. It is important to remember that although SSTR PET using Ga68 DOTATATE is very effective, conventional imaging using either CT or MRI will remain the most common imaging modality for NET patients over time. Beyond imaging, SSTR analogs can be labeled with beta emitters than can be used therapeutically. Most commonly DOTATATE is labeled with Lutetium-177. This was studied prospectively in a randomized controlled trial (NETTER-1 trial), which demonstrated significant improvement in radiographic progression free survival. These results led to the FDA approval of this therapy in 2018.

**MSCC34B  Fluciclovine/PSMA PET**

Participants  
Andrei Iagaru, MD, Emerald Hills, CA (Presenter) Research Grant, General Electric Company

**LEARNING OBJECTIVES**

1) List some of the molecular imaging targets that are used in prostate cancer.  
2) Understand underlying biology and mechanism of action for some of the new PET radiopharmaceuticals in prostate cancer.  
3) Discuss patterns of prostate cancer appearance when using some of the new PET radiopharmaceuticals.

**ABSTRACT**

Data from the American Cancer Society suggests that prostate cancer will continue to be the leading cancer diagnosis in men with 164,690 estimated new cases and will have the second highest mortality (after lung cancer) with 29,430 estimated deaths for 2018 in the United States. Initial and subsequent treatment of prostate cancer may involve surgery, radiation therapy, hormonal therapy, chemotherapy, or a combination of these. Additional molecular pathways in prostate cancer lead to the identification of new targets that may be amenable to diagnostic and therapeutic intervention with novel agents. Areas of interest for the Nuclear Medicine and Molecular Imaging community include mainly aminoacid analogues (Fluciclovine) and the prostate specific membrane antigen (PSMA), but also gastrin releasing peptide receptors (GRPR).

**MSCC34C  Response Assessment**

Participants  
David A. Mankoff, MD, PhD, Philadelphia, PA (Presenter) Speaker, Koninklijke Philips NV; Consultant, General Electric Company; Advisory Board, RefleXion Medical Inc; Consultant, Blue Earth Diagnostics Ltd; Research Funded, Siemens AG; Advisory Board, ImaginAb, Inc; Spouse, Owner, Trevarx

For information about this presentation, contact:  
david.mankoff@uphs.upenn.edu
LEARNING OBJECTIVES

1) List applications of molecular imaging as a cancer biomarker. 2) Describe clinical setting for which molecular imaging response approaches are applicable. 3) Discuss investigational agents being investigated for response assessment and early results.

ABSTRACT

This talk will review molecular imaging approaches for cancer, considering molecular imaging as a cancer biomarker to guide treatment decisions and evaluate therapeutic response. Examples from recent or ongoing multi-center trials will be presented as examples of possible future clinical role for molecular imaging cancer biomarkers.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ David A. Mankoff, MD, PhD - 2013 Honored EducatorDavid A. Mankoff, MD, PhD - 2018 Honored Educator
Participants
Cristopher A. Meyer, MD, Madison, WI (Moderator) Investor, Elucent Medical; Consultant, NIOSH Certified B-reader
For information about this presentation, contact:
cmeyer2@uwhealth.org

LEARNING OBJECTIVES
1) State the radiographic and CT findings of silicosis, CWP, and asbestos-related lung disease. 2) Always consider beryllium exposure when faced with an interstitial lung disease with features of sarcoidosis. 3) Describe the importance of expiratory imaging in the identification of small airway disease. 4) Identify clues to exposure history when interpreting HRCTs for interstitial lung disease.

ABSTRACT
Despite increased safety measures, workers remain at risk for occupational exposures. Silicosis, coal workers' pneumoconiosis, and asbestos-related lung disease continue to affect workers because of ongoing exposures in the workplace, long latency between exposure and disease, and changes in mining techniques. Immune-mediated diseases such as chronic hypersensitivity pneumonitis and chronic beryllium disease may also result from workplace exposure. Airway-centered occupational lung diseases are often the subtlest and may required expiratory imaging for recognition. This session will review these categories of occupational lung disease and conclude with a case-based session that emphasizes specific findings that may alert the interpreting radiologist to the possibility of occupational lung disease when faced with an unknown HRCT for interstitial lung disease.

Sub-Events
RC401A Classic Dusts: Asbestos, Silica, and Coal
Participants
Jeffrey P. Kanne, MD, Madison, WI (Presenter) Research Consultant, PAREXEL International Corporation;
For information about this presentation, contact:
 jkanne@uwhealth.org

LEARNING OBJECTIVES
View learning objectives under main course title.

Honored Educators
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RC401B Occupational Lung Disease: The Other Guys (Beryllium, Hard Metal, Aluminum, Siderosis)
Participants
Sudhakar N. Pipavath, MD, Mercer Island, WA (Presenter) Adjudicator, Gilead Sciences, Inc

LEARNING OBJECTIVES
View learning objectives under main course title.

Honored Educators
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RC401C Airway Related Interstitial Lung Disease and Emerging Occupational Lung Disease
Participants
Christian W. Cox, MD, Rochester, MN (Presenter) Nothing to Disclose
RC401D  HRCT Patterns of Occupational Lung Disease: Case-Based

Participants
Cristopher A. Meyer, MD, Madison, WI (Presenter) Investor, Elucent Medical; Consultant, NIOSH Certified B-reader

LEARNING OBJECTIVES
View learning objectives under main course title.
Participants
Judy Yee, MD, Bronx, NY (Moderator) Research Grant, EchoPixel, Inc; Research Grant, Koninklijke Philips NV;

LEARNING OBJECTIVES
1) Apply the results of recent research to the performance of CT colonography. 2) Improve basic knowledge and skills relative to the performance of CT colonography. 3) Assess the potential of technical advancements to improve the performance of CT colonography. 4) To understand the target lesion for colorectal cancer screening using CT Colonography and what should be reported. 5) To identify common and uncommon pitfalls on 2D and 3D CT Colonography images. 6) To review the serrated pathway to the development of colorectal cancer and how the use of oral contrast can help to identify sessile serrated polyps on CT Colonography. 7) Review briefly MRI Technique and Anatomy. 8) Highlight Structured Reporting Template for MRI of rectal cancer. 9) Discuss essential features to be included in MRI report. 10) Highlight Structured Reporting Template for MRI of anorectal fistula. 11) Discuss essential features to be included in MRI report.

Sub-Events
RC409A CT Colonography Technique Update
Participants
Courtney C. Moreno, MD, Suwanee, GA (Presenter) Researcher, General Electric Company;

For information about this presentation, contact:
courtney.moreno@emoryhealthcare.org

LEARNING OBJECTIVES
1) Apply the results of recent research to the performance of CT colonography. 2) Improve basic knowledge and skills relative to the performance of CT colonography. 3) Assess the potential of technical advancements to improve the performance of CT colonography.

Honored Educators
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RC409B CT Colonography: Strategies for Success
Participants
Judy Yee, MD, Bronx, NY (Presenter) Research Grant, EchoPixel, Inc; Research Grant, Koninklijke Philips NV;

LEARNING OBJECTIVES
1) To understand the target lesion for colorectal cancer screening using CT Colonography and what should be reported. 2) To identify common and uncommon pitfalls on 2D and 3D CT Colonography images. 3) To review the serrated pathway to the development of colorectal cancer and how the use of oral contrast can help to identify sessile serrated polyps on CT Colonography.

RC409C MRI Rectal Cancer Including Structured Reporting
Participants
Kartik S. Jhaveri, MD, Toronto, ON (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Review briefly MRI Technique and Anatomy. 2) Highlight Structured Reporting Template for MRI of rectal cancer. 3) Discuss essential features to be included in MRI report.

RC409D MRI Anorectal Fistulas Including Structured Reporting
Participants
Mukesh G. Harisinghani, MD, Boston, MA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Review briefly MRI Technique and Anatomy. 2) Highlight Structured Reporting Template for MRI of anorectal fistula. 3) Discuss essential features to be included in MRI report.
PET/CT and SPECT/CT in Movement Disorders, Epilepsy, and Dementia

Tuesday, Nov. 27 4:30PM - 6:00PM Room: S504CD

AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credit: 1.75

FDA

Discussions may include off-label uses.

Sub-Events

RC411A Dopamine Transporter Scans and Movement Disorders

Participants
Vani Vijayakumar, MD, Ridgeland, MS (Presenter) Nothing to Disclose

For information about this presentation, contact:
vvijayakumar@umc.edu

LEARNING OBJECTIVES

1) Apply basic knowledge and skills relevant to clinical practice of Movement Disorders. 2) Assess the potential of emerging technological innovations and advances to enhance clinical practice and problem-solving. 3) Develop new ideas from experts and peers in the nuclear imaging sciences. 4) Differentiate Essential Tremor and Presynaptic Parkinson Diseases on DATscans. 5) Compare different image findings for interpretation of Movement Disorders.

ABSTRACT

Introduction: Parkinson Disease (PD) is the most common movement disorder affecting 1-2% of the general population over the age of 65 years and the second most common neurodegenerative disorder after Alzheimer’s disease (AD) PD presents with 3 most common symptoms. 1. Resting tremor: Most common first symptom, usually asymmetric and most evident in one hand with the arm at rest. 2. Bradykinesia: Difficulty with daily activities such as writing, shaving, using a knife and fork, and opening buttons; decreased blinking, masked facies, slowed chewing and swallowing. 3. Rigidity: Muscle tone increased in both flexor and extensor muscles providing a constant resistance to passive movements of the joints; stooped posture, anteroflexed head, and flexed knees and elbows. Nuclear Imaging Diagnosis: DAT Scan: (123I-ioflupane) Patient preparation: Thyroid blockade with Lugols- 3 drops one hour before Stop medicines that bind to the dopamine transporter 7 days prior to study, e.g. SSRIs, amphetamine, benzotropine, cocaine, mazindol,methylphenidate and phentermine and sertraline Radiopharmaceutical: (123I-ioflupane) is a molecular imaging agent 3-5 mCi IV and Brain SPECT in 3 hours Used to demonstrate the location and concentration of dopamine transporters (DaTs) in the synapses of striatal dopaminergic neurons. Interpretation: Normal: comma shaped striatum Abnormal: dot, asymmetric caudate or putamen, high background Summary: A highly sensitive marker for accurate assessment of striatal dopaminergic function to differentiate Essential Tremor from PD Early diagnosis of presynaptic Parkinsonian syndromes Differentiation of presynaptic Parkinsonian syndromes from parkinsonism without presynaptic dopaminergic loss, such as drug-induced parkinsonism or psychogenic parkinsonism A straightforward one-day protocol An objective adjunct to the differentiation of PD syndromes from ET in clinically uncertain patients A diagnostic tool helping differentiate between probable DLB and AD Visualizing DaT distribution is useful as a novel diagnostic adjunct in movement disorders and dementia

RC411B Imaging for Epilepsy

Participants
an L. Thaggard, MD, Jackson, MS (Presenter) Nothing to Disclose

For information about this presentation, contact:
athaggard@umc.edu

LEARNING OBJECTIVES

1) Define the components of a multidisciplinary evaluation for the surgical treatment of epilepsy. 2) Compare brain SPECT with FDG PET for evaluation of an epileptogenic focus. 3) Discuss barriers to the use of ictal SPECT imaging and functional MRI. 4) Appraise the added value of fusion imaging in epilepsy evaluation.

ABSTRACT

Medically refractory epilepsy is now often treated surgically. A holistic multidisciplinary review of the patient preoperatively helps to optimize outcome. FDG PET and perfusion SPECT imaging are an integral part of the evaluation. Both imaging techniques are reviewed in context of the multidisciplinary evaluation. Imaging findings, pearls, and pitfalls of each are reviewed using case examples.

URL


Active Handout: Anson Lee Thaggard

Participants
Phillip Kuo, MD, PhD, Tucson, AZ (Presenter) Author, MD Training at Home; Research Grant, Astellas Group; Consultant, Endocyte, Inc; Consultant, General Electric Company; Education Grant, General Electric Company; Speakers Bureau, Eli Lilly and Company; Consultant, inviCRO, LLC; Consultant, Imaging Endpoints; Consultant, Progenics Pharmaceuticals, Inc

LEARNING OBJECTIVES
1) Understand the basic pathophysiology of Alzheimer's dementia. 2) Distinguish the different roles of PET imaging with FDG, amyloid, and tau tracers for evaluating dementia.

ABSTRACT
Alzheimer's disease is the most common form of dementia affecting the aging population, and is currently the 6th leading cause of death. Clinical diagnosis is difficult, and there is currently no cure. Functional imaging biomarkers may detect early stages of disease prior to the onset of symptoms, and may improve diagnostic accuracy. This in turn may improve evaluation of therapeutic interventions and provide a roadmap toward developing a cure.
Peripheral Artery Disease: CTA and MRA

Tuesday, Nov. 27 4:30PM - 6:00PM Room: N230B

Participants
Constantino S. Pena, MD, Miami, FL (Moderator) Speakers Bureau, Cook Group Incorporated; Speakers Bureau, Medtronic plc; Speakers Bureau, W. L. Gore & Associates, Inc; Speakers Bureau, Penumbra, Inc; Speakers Bureau, Terumo Corporation; Speakers Bureau, Merit Medical Systems, Inc; Advisory Board, C. R. Bard, Inc; Advisory Board, Boston Scientific Corporation; Konstantin Nikolaou, MD, Tuebingen, Germany (Moderator) Advisory Panel, Siemens AG; Speakers Bureau, Siemens AG; Speaker Bureau, Bayer AG

For information about this presentation, contact:
konstantin.nikolaou@med.uni-tuebingen.de

LEARNING OBJECTIVES
1) Understand the value of peripheral CTA and MRA. 2) Discuss the benefits of CTA in comparison to MRA in the treatment of PAD. 3) Comprehend the importance of MRA sequences to highlight particular details in peripheral MRA. 4) Understand the importance of image reconstruction for peripheral CTA and MRA.

Peripheral CTA

Participants
Konstantin Nikolaou, MD, Tuebingen, Germany (Presenter) Advisory Panel, Siemens AG; Speakers Bureau, Siemens AG; Speaker Bureau, Bayer AG

For information about this presentation, contact:
konstantin.nikolaou@med.uni-tuebingen.de

LEARNING OBJECTIVES
1) Describe techniques for acquisition, reconstruction, and image interpretation of peripheral CTA 2) Discuss available data and evidence-based results for peripheral CTA, and expected impact on patient care 3) Compare advantages and drawbacks of lower extremity CTA in comparison to other imaging modalities and diagnostic tools for arterial occlusive disease.

Peripheral MR Angiography

Participants
James C. Carr, MD, Chicago, IL (Presenter) Research Grant, Astellas Group; Research support, Siemens AG; Speaker, Siemens AG; Advisory Board, Guerbet SA

Interventional Complications: Role for CTA and MRA

Participants
Charles Y. Kim, MD, Durham, NC (Presenter) Consultant, Merit Medical Systems, Inc; Consultant, Cook Group Incorporated

For information about this presentation, contact:
charles.kim@duke.edu

LEARNING OBJECTIVES
1) Understand endovascular aneurysm repair with endografts 2) Describe types of endoleaks and associated implications 3) Discuss current methods for optimal detection endoleaks with CTA and MRA, with understanding of advantages and disadvantages

ABSTRACT
Imaging of endoleaks has evolved over the past two decades, to include a multitude of techniques with CTA and MRA. While national guidelines for post-EVAR surveillance are relatively unidimensional, it is important for the practicing radiologist to understand the spectrum of available CT and MR techniques for detection of endoleaks, along with the advantages and disadvantages to each approach.
Tips, Tricks and Pitfalls in Body Oncological Imaging: Experts Tell All

Tuesday, Nov. 27 4:30PM - 6:00PM Room: N229

AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credit: 1.75

LEARNING OBJECTIVES

1) Identify ultrasound features that differentiate between benign and malignant disease, particularly in the female pelvis. 2) Recommend specific scanning techniques and protocols for difficult cases, including use of ultrasound contrast. 3) Develop imaging strategies to enable the radiologist to make a diagnosis with ultrasound and ultrasound only. 4) To discuss newer MRI techniques that are now applied for body oncologic imaging that allows faster, better, or more accurate disease diagnosis. 5) To highlight the applications and pitfalls of diffusion-weighted imaging for assessing upper abdominal cancers, peritoneal involvement, pelvic disease and bone marrow involvement (whole body MRI). 6) To survey the applications and limitations of motion insensitive radial-acquisition MR techniques for dynamic contrast enhanced imaging for cancer evaluation. 7) To discuss newer MRI techniques that are now applied for body oncologic imaging that allows faster, better, or more accurate disease diagnosis. 8) To discuss newer MRI techniques that are now applied for body oncologic imaging that allows faster, better, or more accurate disease diagnosis. 9) To highlight the applications and pitfalls of diffusion-weighted imaging for assessing upper abdominal cancers, peritoneal involvement, pelvic disease and bone marrow involvement (whole body MRI). 10) To discuss newer MRI techniques that are now applied for body oncologic imaging that allows faster, better, or more accurate disease diagnosis. 11) To highlight the applications and pitfalls of diffusion-weighted imaging for assessing upper abdominal cancers, peritoneal involvement, pelvic disease and bone marrow involvement (whole body MRI). 12) To review the statistics and incidence of common cancers in USA. 13) To discuss the role of CT in oncology practice and value of following optimal oral and IV contrast media protocols. 14) To offer pearls and solutions to overcome the limitations of CT and emerging role of new CT technology.

Sub-Events

Participants
Roya Sohaey, MD, Portland, OR (Moderator) Nothing to Disclose

LEARNING OBJECTIVES

1) Identify ultrasound features that differentiate between benign and malignant disease, particularly in the female pelvis. 2) Recommend specific scanning techniques and protocols for difficult cases, including the use of ultrasound contrast. 3) Develop imaging workup strategies for specific clinical situations in the abdomen and pelvis. 4) Review specific diagnosis strategies for imaging of non-obstetrical pathology in the pregnant patient.

ABSTRACT

The course will focus on benign and malignant masses that mimic each other, particularly in the area of gynecology but also involving the abdomen. Emphasis is placed on the importance of knowing patient history and using good ultrasound technique, including contrast, in order to make accurate diagnoses with ultrasound. However, at times, further imaging and tissue sampling is necessary. The participant will be encouraged to 'push the envelope' with ultrasound-guided diagnosis rather than use ultrasound as a 'screening tool', particularly in the female pelvis. In addition, we will review non-obstetrical diagnoses in pregnant patients. The radiologist is often called upon by maternal-fetal-medicine providers to guide imaging in this vulnerable population.

Active Handout: Roya Sohaey

Participants
Helen C. Addley, MRCP, FRCR, Cambridge, United Kingdom (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) Explore the integral roles of CT in oncology from routine staging and follow up to problem solving tool. 2) Highlight the radiological reporting features that set apart a specialist report from a standard report. 3) Discuss challenging cases from the gynecological tumor board of cancer center.

Honored Educators

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Participants
Dow-Mu Koh, MD, FRCR, Sutton, United Kingdom (Presenter) Nothing to Disclose
LEARNING OBJECTIVES

1) To discuss newer MRI techniques that are now applied for body oncologic imaging that allows faster, better or more accurate disease diagnosis. 2) To highlight the applications and pitfalls of diffusion-weighted imaging for assessing upper abdominal cancers, peritoneal involvement, pelvic disease and bone marrow involvement (whole body MRI). 3) To survey the applications and limitations of motion insensitive radial-acquisition MR techniques for dynamic contrast enhanced imaging for cancer evaluation.
ABSTRACT

CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

LEARNING OBJECTIVES

1) Understand how to evaluate signal properties in CT; 2) Understand how to evaluate noise properties in CT; 3) Understand how to evaluate image quality by combining signal and noise properties in CT.

Participants

Yakun Zhang, MS, Durham, NC (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the current standard for CT performance evaluation oriented towards operational performance. 2) Understand the measurement methods for task-based assessment of CT including resolution, noise, and detectability. 3) Understand the use of operational characteristics to monitor and optimize CT performance.

Participants

Justin B. Solomon, PhD, Durham, NC (Presenter) License agreement, Sun Nuclear Corporation; License agreement, 12 Sigma Technologies

LEARNING OBJECTIVES

1) To understand the principle of optimization in targeting specific levels of quality while constraining the mitigating factors. 2) To understand how imaging science and physics enables prospective optimization of imaging exams using phantoms and models. 3) To understand how retrospective analysis of patient image quality and dose can affirm and inform the optimization quality and process.
**RC422**

**Dual Energy CT for Radiotherapy Applications**

Tuesday, Nov. 27 4:30PM - 6:00PM Room: S104A

**LEARNING OBJECTIVES**

1) Learn about calibration of Hounsfield Units for determination of relative stopping power for proton therapy planning. 2) Discuss potential sources of error in stopping power determination. 3) Describe treatment planning strategies to mitigate range uncertainties in proton therapy planning.

**ABSTRACT**

With dual-energy computed tomography (DECT), an additional measurement is obtained, allowing for the reconstruction of supplementary information, such as relative electron density and effective atomic number information. The additional information gained through DECT has potential to aid in several aspects of the radiation therapy process, including improving dose calculation accuracy for proton therapy. This course will discuss the basic principles of DECT and compare different vendor solutions for acquisition of DECT images.

**Participants**

Kristy K. Brock, PhD, Houston, TX (Moderator) License agreement, RaySearch Laboratories AB

**Sub-Events**

**RC422A**  Clinical Need for Dual Energy CT in Proton Radiotherapy

Participants

Jon J. Kruse, PhD, Rochester, MN (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Explain basic dual-energy CT principles. 2) Compare current dual-energy CT techniques and associated limitations.

**ABSTRACT**

With dual-energy computed tomography (DECT), an additional measurement is obtained, allowing for the reconstruction of supplementary information, such as relative electron density and effective atomic number information. The additional information gained through DECT has potential to aid in several aspects of the radiation therapy process, including improving dose calculation accuracy for proton therapy. This course will discuss the basic principles of DECT and compare different vendor solutions for acquisition of DECT images.

**RC422B**  State of the Art in Dual Energy CT Technology

Participants

Jessica Miller, PhD, Madison, WI (Presenter) Research Grant, Siemens AG

**LEARNING OBJECTIVES**

1) Explain basic dual-energy CT principles. 2) Compare current dual-energy CT techniques and associated limitations.

**ABSTRACT**

With dual-energy computed tomography (DECT), an additional measurement is obtained, allowing for the reconstruction of supplementary information, such as relative electron density and effective atomic number information. The additional information gained through DECT has potential to aid in several aspects of the radiation therapy process, including improving dose calculation accuracy for proton therapy. This course will discuss the basic principles of DECT and compare different vendor solutions for acquisition of DECT images.

**RC422C**  Technical Challenges in the Integration of Dual Energy CT into Radiotherapy Treatment Planning

Participants

Jon J. Kruse, PhD, Rochester, MN (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Compare range uncertainty to other sources of dosimetric error in proton therapy. 2) Observe clinical examples of range variation in proton therapy.
Sub-Events

MSES41A  Aortic Valvular Disease

Participants
John P. Lichtenberger III, MD, Bethesda, MD (Presenter) Nothing to Disclose

For information about this presentation, contact: jlichtenberger@mfa.gwu.edu

LEARNING OBJECTIVES
1) Describe the detailed imaging anatomy of the aortic valve, including congenital variants and malformations. 2) List incidental and known aortic valvular diseases detectable on radiography, CT, and MRI and organize that list based on epidemiology. 3) Select the best imaging modality to evaluate a given aortic valvular disease. 4) Adjust imaging protocols to optimize the evaluation of common aortic valvular diseases.

ABSTRACT
The increasing temporal and spatial resolution of imaging technology, the advancing functional data obtainable by imaging modalities, and the ever-broadening knowledge of aortic valvular disease present a challenge to both general and subspecialized imagers. This lecture will focus on the most common and most important diseases of the aortic valve encountered in clinical practice, whether those diseases are discovered incidentally or are known and must be comprehensively characterized. Emphasis will be placed on avoiding pitfalls and on obtaining and providing clinically useful information.

MSES41B  Cardiac Devices: Appearance on Imaging

Participants
Karin E. Dill, MD, Worcester, MA (Presenter) Nothing to Disclose

For information about this presentation, contact: skligerman@ucsd.edu

LEARNING OBJECTIVES
1) Learn about the early and late complications of myocardial infarction. 2) Understand how each of these manifestations appear on cross-sectional imaging. 3) Discuss medical and surgical treatment options.

ABSTRACT
Acute myocardial infarction is a leading cause of mortality in the United States. However, even if a patient survives the initial insult, myocardial damage can lead to both early and late complications including left ventricular free wall rupture, ventricular septal rupture, papillary muscle rupture, pericarditis, and aneurysm formation. Some of these are life-threatening complications that require immediate diagnosis. The purpose of this talk is the review the various pathologies that involve the myocardium and pericardium, review their imaging findings, and discuss treatment options.

MSES41C  Imaging Complications of Myocardial Infarction and CABG

Participants
Seth J. Kligerman, MD, Denver, CO (Presenter) Nothing to Disclose

For information about this presentation, contact: skligerman@ucsd.edu

LEARNING OBJECTIVES
1) Learn about the early and late complications of myocardial infarction. 2) Understand how each of these manifestations appear on cross-sectional imaging. 3) Discuss medical and surgical treatment options.

ABSTRACT
Acute myocardial infarction is a leading cause of mortality in the United States. However, even if a patient survives the initial insult, myocardial damage can lead to both early and late complications including left ventricular free wall rupture, ventricular septal rupture, papillary muscle rupture, pericarditis, and aneurysm formation. Some of these are life-threatening complications that require immediate diagnosis. The purpose of this talk is the review the various pathologies that involve the myocardium and pericardium, review their imaging findings, and discuss treatment options.

MSES41D  Cardiac CT in Acute Chest Pain

Participants
Christian Loewe, MD, Vienna, Austria (Presenter) Speaker, Bracco Group; Speaker, General Electric Company; Speaker, Siemens AG

For information about this presentation, contact: Christian.loewe@meduniwien.ac.at

LEARNING OBJECTIVES
1) To learn about the current and possible future role of Cardiac CT in the management of patients suffering from acute chest pain. 2) To become familiar with the most important imaging biomarkers in acute coronary syndromes. 3) To discuss possible algorithms for the management of patients with acute chest pain.

ABSTRACT
Three potentially life-threatening disorders can become clinically evident by the unspecific symptom of "acute chest pain", and in two out of them including pulmonary embolism and acute aortic syndrome CT angiography was established as the first diagnostic modality of choice. Given the high evidence for the value of Cardiac CT in ruling out relevant coronary artery disease in stable patients and facing still existing challenges to safely triage patients in chest pain units, the possible role of Cardiac CT in this clinical scenario is under evaluation and discussion. It is proven that CT can be used to safely rule out acute coronary syndromes with a very high negative predictive value and that CT can help to early discharge patients from the chest pain unit. However, the possible role in the positive diagnosis of an acute coronary syndrome is not as clear. Within this presentation, an overview about the technical possibilities of using CT in the management of acute chest pain patients will be provided. Furthermore, the most important differential diagnoses will be addressed with the most relevant imaging findings in the acute setting. The main focus of the presentation, however, will be on the existing challenges and possible solutions of using Cardiac CT in patients with acute coronary syndromes. New CT techniques, including CT derived FFR as well as CT perfusion will be introduced and their potential in the emergency setting should be outlined.
RC501

Lung Cancer Screening Diagnosis Live (Interactive Session)

Wednesday, Nov. 28 8:30AM - 10:00AM Room: E353C

CH  CT

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Caroline Chiles, MD, Winston-Salem, NC (Moderator) Advisory Board, ImBio, LLC

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LEARNING OBJECTIVES
1) Confirm compliance with screening guidelines, including patient eligibility, scanning protocols, radiation dose, CMS requirements and National Lung Screening Registry. 2) Incorporate shared decision making and smoking cessation in the lung screening visit. 3) Assign Lung-RADS categories to nodules encountered at baseline and annual screening CT. 4) Evaluate atypical screening findings. 5) Manage incidental findings, including COPD, coronary artery calcification, and potential extrapulmonary malignancies.

GENERAL INFORMATION
This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

Sub-Events

RC501A  Logistics of Screening

Participants
Jared D. Christensen, MD, Durham, NC (Presenter) Advisory Board, Riverain Technologies, LLC

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LEARNING OBJECTIVES
1) Confirm compliance with screening guidelines, including patient eligibility, scanning protocols, radiation dose, CMS requirements, and National Lung Screening Registry.

RC501B  Shared Decision Making and Smoking Cessation

Participants
Robert Volk, PhD, Houston, TX (Presenter) Nothing to Disclose

RC501C  Nodule Assessment and Lung-RADS Categories

Participants
Mylene T. Truong, MD, Houston, TX (Presenter) Nothing to Disclose

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Mylene T. Truong, MD - 2015 Honored EducatorMylene T. Truong, MD - 2018 Honored Educator

RC501D  Interesting Cases Encountered in a Screening Program

Participants
Brett M. Elicker, MD, San Francisco, CA (Presenter) Nothing to Disclose

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brett.elicker@ucsf.edu

LEARNING OBJECTIVES
1) Describe the role of imaging in the multi-disciplinary approach to suspected lung cancer. 2) Compare the different management options in suspected lung nodules detected on lung cancer screening CT. 3) Summarize how to appropriately use Lung-RADS when interpreting lung cancer screening CTs.
Incidental Findings on the Low-Dose CT

Carol C. Wu, MD, Bellaire, TX (Presenter) Author, Reed Elsevier

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LEARNING OBJECTIVES

1) To discuss the prevalence and significance of incidental findings on LDCT. 2) To review the latest evidence-based management recommendations for various incidental findings on LDCT.
RC505

Neuroradiology Series: Stroke

Wednesday, Nov. 28 8:30AM - 12:00PM Room: E450A

**PURPOSE**

The benefit that endovascular thrombectomy (EVT) offers to stroke patients with large vessel occlusions depends strongly on reperfusion grade as defined by the eTICI (extended Thrombolysis in Cerebral Infarction) scale. Our aim was to determine the lifetime quality of life and cost consequences of reperfusion for patients, healthcare systems, and society.

**METHOD AND MATERIALS**

A Markov model estimated lifetime quality-adjusted life years (QALY) of EVT-treated patients and associated costs based on eTICI...
grades (model structure in Figure 1). The analysis was performed from a United States perspective with two cost frameworks: 1) healthcare costs and 2) societal costs, which include productivity losses and costs of informal care given by family members. Input parameters were based on best available evidence (Table 1), including patient data from the 7-trial HERMES collaboration (ESCAPE, EXTEND-IA, MR CLEAN, REVASCAT, SWIFT PRIME, PISTE, THRACE; Figure 2). The lead analysis was conducted for stroke onset at 65 years. Probabilistic sensitivity analysis was performed using Monte Carlo simulations.

RESULTS

Lifetime QALYs increased for every grade of improved reperfusion (Figure 3A). On average, eTICI 3 resulted in 6.50 QALYs over the patients’ lifetimes, eTICI 2c (90-99%) in 5.89 QALYs, eTICI 2b (67-89%) in 5.79 QALYs, eTICI 2b (50-66%) in 4.80 QALYs, eTICI 2a in 3.55 QALYs, and eTICI 1 or 0 in 2.57 QALYs. In contrast, the healthcare and societal costs of each QALY yielded by EVT decreased for every grade of improved reperfusion (Figure 3B). The advantage of achieving eTICI 3 over eTICI 2b (50-66%) reperfusion results in average cost-savings of about $15,000/QALY per patient incurred by the healthcare system and $20,000/QALY per patient incurred by the society.

CONCLUSION

Every grade of improved reperfusion grants stroke patients additional QALYs and substantially reduces healthcare and societal costs per QALY.

CLINICAL RELEVANCE/APPLICATION

Procedural strategies to achieve complete reperfusion (eTICI 3) should be assessed for safety and feasibility, even when initial reperfusion seems to be adequate (eTICI 2b).

Participants

Liu Jie, Zheng Zhou, China (Presenter) Nothing to Disclose
Wanshi Zhang, MD, Beijing, China (Abstract Co-Author) Nothing to Disclose
Cheng Jing Liang, Henan, China (Abstract Co-Author) Nothing to Disclose
Long Qian, Beijing, China (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To investigate how the cerebral blood perfusion changes in pilots with hypoxic exposure through the measurement of resting cerebral blood flow (CBF) using a 3D pcASL technique

METHOD AND MATERIALS

35 healthy male pilots (mean age 30 years, mean total flight time 1328 h) were included in this study. In order to investigate the change of CBF of the brain in the condition of hypoxic exposure, the low oxygen mixed gas inhaled by participants through a breathing mask was approximate to the air composition at the altitude of 3000 m with the oxygen concentration of 14.5%. Pulse oximetry was applied to monitor in real-time the immediate pulse and oxygenation saturation of each subject pre- and post-hypoxic exposure. Then, 3D pcASL images were acquired at both pre- (pre-OI) and post-low oxygen mixed gas inhalation (post-OI) using 3D-FSPGR BRAVO sequence on a 3.0T scanner (GE MR750, WI, US) with the scanning parameters: TR/TE = 4632ms/10.5ms; FOV=24cm2; slice thickness = 4.0mm; bandwidth=62.5KHz; flip angle=111°. Thereafter, CBF maps could be calculated from the acquired 3D pcASL images using an automatic software in the AW workstation of GE. To enhance the spatial normalization, T1 axial anatomical image were also acquired. CBF maps were preprocessed and analyzed by FSL and SPM8.

RESULTS

After hypoxic exposure, the pulse was (63.97±10.43) beats/min, the oxygen saturation was (92.46±3.64) %, it’s significant lower than initiate examination ((71.46±10.63) beats/ min, (96.31±1.23) %). 3D pcASL scan for pilots after hypoxic exposure showed lower CBF values in various regions, including bilateral superior temporal gyrus (STG), middle temporal gyrus (MTG), lingual gyrus, left inferior temporal gyrus (ITG), right middle occipital gyrus (MOG), inferior occipital gyrus (IOG), fusiform gyrus, cuneus and cerebellum (P<0.05), as shown in Tab.1 and Fig. 1.

CONCLUSION

3D pseudo-continuous arterial spin-labeling technique could monitor CBF changes in pilots with hypoxic exposure, and the cerebral blood perfusion after hypoxic exposure was decreased mainly in the temporal and right occipital lobes.

CLINICAL RELEVANCE/APPLICATION

For the first time, in this study we mimicked hypoxic environment equal to 3000m altitude and obtained the CBF of the subjects before and after hypoxic exposure using 3D pcASL, and then fixed the corresponding brain areas.

Participants

Daniel Puhr-Westerheide, MD, Munich, Germany (Presenter) Nothing to Disclose
Steffen Tiedt, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Lukas Rotkopf, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Moritz Herzberg, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Paul Reidler, MD, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Wolfgang G. Kunz, MD, Munich, Germany (Abstract Co-Author) Grant, Medtronic plc
PURPOSE

Large vessel occlusion (LVO) stroke leads to highly variable infarction growth before hospital admission as demonstrated by DAWN and DEFUSE 3. Our aim was to identify the clinical and imaging parameters affecting pre-hospital infarction growth in patients undergoing subsequent thrombectomy.

METHOD AND MATERIALS

We selected patients with documented times from symptom onset (TFSO) and CT perfusion (CTP) imaging on admission out of 226 consecutive patients treated with thrombectomy for anterior circulation LVO stroke. Two independent, blinded readers evaluated imaging. Ischemic core volume (ICV) was determined based on CTP using automated thresholds. Pre-hospital infarction growth was defined as ICV divided by TFSO, assuming linear progression during the time from symptom onset to admission. For collateral assessment, the regional leptomeningeal collateral score (rLMC) was assessed. Clinical data including the National Institutes of Health Stroke Scale (NIHSS) score on admission were obtained. Regression analysis was performed to adjust for confounders.

RESULTS

In the total 94 patients included in this study, the median pre-hospital infarction growth was 0.34 mL/min. In regression analysis including age, sex, stroke side, NIHSS, clot burden score, Alberta Stroke Program Early CT Score, rLMC scores and systemic blood pressure on admission, only rLMC scores showed an independent association with pre-hospital infarction growth (b=-0.31, p=0.042). Trichotomizing patients by rLMC score yielded 31 patients with good (rLMC >16; 33%), 28 with intermediate (rLMC 13-16; 30%) and 35 with poor collaterals (rLMC <13; 37%). The pre-hospital infarction growth was 0.22 mL/min in patients with good, 0.35 mL/min in patients with intermediate and 0.58 mL/min in patients with poor collateral scores. The unadjusted data of ICV and TFSO are plotted by collateral grade in Figure 1.

CONCLUSION

Pre-hospital infarction growth strongly depends on collateral flow and may be a useful parameter to triage slow and fast stroke progressors. In contrast, clinical or other imaging parameters contained no relevant information on the individual stroke dynamics.

CLINICAL RELEVANCE/APPLICATION

In primary stroke centers, pre-hospital infarction growth may be interpolated to estimate the stroke progression during transfer times to thrombectomy centers and provide decision support on which patients to transfer.
CONCLUSION
Our fully-automatic pipeline for stroke segmentation demonstrate the potential for deep learning-based tools to automate ischemic stroke volumetrics.

CLINICAL RELEVANCE/APPLICATION
Automatic localization and calculation of volume of ischemic stroke on diffusion-weighted imaging may bypass the need for manual segmentation, assist with timely decision making for clinical management, and hence, reduce the risk of adverse patient outcomes.

RC505-06  Fast Stroke Triage: CT and MR Protocols
Wednesday, Nov. 28 9:40AM - 10:10AM Room: E450A

Participants
Howard A. Rowley, MD, Madison, WI (Presenter) Research Consultant, Bracco Group; Research Consultant, Guerbet SA; Research Consultant, General Electric Company; Consultant, W.L. Gore & Associates, Inc.; ; ; ; ; ;

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LEARNING OBJECTIVES
1) List the key goals of imaging triage in acute ischemic stroke. 2) Streamline workflow in CT and MRI to facilitate rapid and accurate treatment selection. 3) Describe the practice and pitfalls of perfusion methods in acute stroke triage. 4) Build fast and effective CT and MR protocols for stroke triage in your practice.

Honored Educators
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RC505-07  When to Swing at the Curveball: Treating Stroke Patients Who Don’t Quite Match the Clinical Trials
Wednesday, Nov. 28 10:20AM - 10:50AM Room: E450A

Participants
Steven W. Hetts, MD, San Francisco, CA (Presenter) Royalties, Penumbra, Inc; Stockholder, ThrombX Inc; Researcher, Stryker Corporation; Researcher, Terumo Corporation; Researcher, Siemens AG

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LEARNING OBJECTIVES
1) Describe groups of patients suffering acute ischemic strokes who fall outside the inclusion criteria for recent randomized controlled trials who, nevertheless, may benefit from acute endovascular therapy. 2) Develop an approach to trauma patients at risk for ischemic stroke. 3) Evaluate the treatment of patients outside the age ranges subjected to clinical trials to date.

RC505-08  Texture Analysis to Identify Early Thrombus in Stroke Patients with Cerebral Artery Occlusion: A High-resolution MRI Study
Wednesday, Nov. 28 10:50AM - 11:00AM Room: E450A

Participants
Jinhao Lyu, Beijing, China (Presenter) Nothing to Disclose
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Huabing Li, Jincheng, China (Abstract Co-Author) Nothing to Disclose
Jilong Jin, Jincheng, China (Abstract Co-Author) Nothing to Disclose
Xiaoxiao Ma, Beijing, China (Abstract Co-Author) Nothing to Disclose
Lan Lin, Beijing, China (Abstract Co-Author) Nothing to Disclose
Yina Lan, Beijing, China (Abstract Co-Author) Nothing to Disclose
Jianfeng He, Beijing, China (Abstract Co-Author) Nothing to Disclose
Lin Ma, MD, Beijing, China (Abstract Co-Author) Nothing to Disclose
Xin Lou, MD, PhD, Beijing, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
In the present study, we aimed to identify the features of early thrombus by qualitative evaluation and by quantitatively texture analysis based on thrombus imaging from High-resolution vessel wall imaging (HRVWI).

METHOD AND MATERIALS
The prospective study recruited patients with cerebrovascular occlusion from January 2017 to January 2018. Three-dimensional black blood T1WI HRVWI was performed in a 3.0T scanner (Skyra, Siemens) with a voxel size of 0.6mm. Thrombus was identified when visible embolization of intraluminal material downstream was present. Early thrombus was defined as symptomatic culprit thrombus within 24 hours after symptom onset, previous confirmed thrombus and asymptomatic thrombus. Signal intensity patterns and vascular involvement patterns of thrombus on black blood T1WI HRVWI were categorized into patterns as illustrated in Figure. Regions of interest (ROIs) were manually outlined on the optimal 2D multiple planar reconstructions of the thrombus. Each ROI was decimated to 64 gray-levels. A gray-level co-occurrence matrix was calculated for each ROI. Comparisons between patients with early thrombus and with
late to chronic thrombus were performed. ROC was performed to measure the area under the curve (AUC) for the diagnostic efficiency estimation.

RESULTS
Totally 19 patients with 23 occlusive vessels were recruited in the current study. Four occlusive vessels were confirmed to have early thrombus and 19 occlusive vessels were confirmed to have late to chronic thrombus. For thrombus qualitative analysis, the proportion of each signal intensity pattern and vascular involvement pattern of early thrombus and late to chronic thrombus on black blood T1WI HRVWI showed no significant differences. In texture analysis, ‘correlate’ was significantly different between early thrombus and late to chronic thrombus. AUC of ‘correlate’ to differentiate early thrombus from late to chronic thrombus was 0.908(P<0.001). A threshold of <= 0.330 was with a sensitivity of 100% and specificity of 78.95%.

CONCLUSION
Textural feature may be an effective imaging marker to identify early thrombus. Further studies are warranted to verify the finding.

CLINICAL RELEVANCE/APPLICATION
The textural analysis is helpful to identify early thrombus in patients with ischemic stroke and thus to support the therapy decision making.

PURPOSE
Multiphase CT angiography (MP-CTA) is a quick and easy-to-use imaging tool for assessing collateral circulation in patients with acute ischemic stroke (AIS). Pial arterial filling in the ischemic territory of the AIS patients is assessment by comparing it to similar arteries in the unaffected hemisphere. However, no method has been established for identifying the ischemic core territory which is an indication of mechanical thrombectomy. We developed a novel method to assess ischemic core of brain tissue using MP-CTA images. The purpose of this study is to verify the usefulness of a novel method (phase ratio map; PR map) compared with MP-CTA images in assess of AIS patients.

METHOD AND MATERIALS
The AIS patients was scanned using an area detector CT scanner (Aquilion ONE Groval Standard Edition; Toshiba Medical). CT images were acquired at 80 kV and 80 mA. CTP source images (CTP-SI) were obtained at 1-s intervals using dynamic multiphase imaging. PR map was constructed using CTP-SI. An early-phase image (EPI) was generated by computing the average of CTP-SI for 5 s in the vicinity of the peak enhancement curve of the normal hemisphere. Similarly, a late-phase image (LPI) was generated by computing the average of CTP-SI for 5 s immediately after the early phase. Subsequently EPI and LPI were denoised of images and was subtracted by mask image. Finally, The PR map was created by dividing the EPI by the LPI. The pixel value of the PR map is determined by the filling degree of the contrast medium. The ischemic core without filling shows 0, the ischemic region with a slow filling shows 1 or less. MP-CTA produced slab MIP images with a thickness of 24 mm using EPI and LPI. Pial arterial filling of MP-CTA was scored from the best 5 points to the worst 0 point ordinal scale. Twenty three patients (14 men, 9 women; mean age: 66.8 years) with AIS underwent CTP. To investigate the validity of the PR map, the ischemic core territory and the MP-CTA scoring were compared.

RESULTS
The ischemic core size of PR map was consistent with the score of MP-CTA (score 4: 0 ml, score 3: 2.7 ± 2.2 ml, score 2: 8.6 ± 5.4 ml). In addition, PR map visually showed clear ischemic core territory.

CONCLUSION
The results suggested that the PR map would provide more robust information than MP-CTA in the diagnosis of AIS patients.
CONCLUSION

Validation.

constructed, using these four networks as features, which classified aphasia deficits with 75% accuracy (leave-one-out cross-

found to differentiate between initial aphasia deficits (p < 0.05, Kruskal-Wallis Analysis of Variance). A naive bayesian classifier was

increased in spelling treatment, and five increased in naming treatment (p < 0.05, Wilcoxon Signed Rank Test). Four networks were

Of twenty networks, three were observed to increase in activity across sentence comprehension and production treatment, four

METHOD AND MATERIALS

S20 internal carotid artery (ICA) and middle cerebral artery (MCA) stroke patients were included in the study, with 3-month mRS as

the goal of prediction. 24 initial features such as age, gender, Alberta stroke program early CT score (ASPECTS), and infarct volume

cT2 and CT angiograms at patient's admission were used for prediction. Gradient Boosting Tree model (GBT) and Extreme

Gradient Boosting Machine (xgboost) were constructed for binary prediction of mRS ('good': 0~2, 'bad': 3~6) and full multiclass

prediction (mRS 0~6). Final features were curated from the 24 initial features through a stochastic feature selection algorithm. Hyperparameters were optimized for minimized mean square error (MSE) of regression task. 5-fold cross validation was applied to estimate model performance.

RESULTS

Feature curation shows that xgboost can accurately predict the mRS using only 5 features: ASPECTS, age, hyperdense middle

cerebral artery sign, NIH stroke score at 24 hours, and left-sided North American Symptomatic Carotid Endarterectomy Trial score. Binary xgboost produced an Area-under-curve (AUC) of 0.884 with selected features and an AUC of 0.873 without feature selection. Binary GBT achieved a slightly lower AUC of 0.876 with selected features, and 0.849 without feature selection. For multiclass prediction, xgboost achieved Mean Squared Error (MSE) of 1.6 and 85.2% predictions are within +/- 1 categories. GBT achieved also a MSE of 1.6 while only 68.2% predictions are within +/- 1 categories.

CONCLUSION

Using information available at diagnosis, machine learning models can accurately predict the recovery outcome at 3 months. An xgboost algorithm using curated clinical and imaging-based features achieves the best performance.

CLINICAL RELEVANCE/APPLICATION

Using machine learning, an acute stroke patient's 3-month outcome can be accurately predicted with data available at admission, improving treatment planning and recovery evaluation.

HONORED EDUCATORS

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RC505-11 Stroke Aphasia Treatment Strengthens Functional Network Activity

Wednesday, Nov. 28 11:20AM - 11:30AM Room: E450A

Participants

Michael Iorga, Chicago, IL (Presenter) Nothing to Disclose

James Higgins, BA, Chicago, IL (Abstract Co-Author) Nothing to Disclose

Todd Parrish, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

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PURPOSE

Aphasia is a common and debilitating complication of stroke, for which treatment is unrefined and responses are highly variable. However, functional magnetic resonance imaging (fMRI) is not used in the assessment of stroke aphasia. By monitoring changes in resting networks which occur with deficits and treatment, treatment-responsive patterns may be identified. Once the relationship of aphasia therapy and functional imaging is better defined, there is potential to predict which therapy a given patient will benefit most from, and how to modify existing treatments to maximize outcomes.

METHOD AND MATERIALS

We followed 60 right-handed subjects with past left hemisphere strokes from three institutions who participated in one of three aphasia therapies (sentence comprehension & production, naming, spelling). Each subject had a resting-state fMRI at baseline, and following three months of treatment. Group independent component analysis (GICA) was used to decompose all scans into 20 primary networks. The fractional amplitude of low-frequency fluctuations (fALFF) was measured for each network’s time series, and compared in subjects before and after treatment.

RESULTS

Of twenty networks, three were observed to increase in activity across sentence comprehension and production treatment, four increased in spelling treatment, and five increased in naming treatment (p < 0.05, Wilcoxon Signed Rank Test). Four networks were found to differentiate between initial aphasia deficits (p < 0.05, Kruskal-Wallis Analysis of Variance). A naive bayesian classifier was constructed, using these four networks as features, which classified aphasia deficits with 75% accuracy (leave-one-out cross-validation).

CONCLUSION

Acute stroke patients' recovery are usually evaluated using mRS, ranging from 0 for no symptoms to 6 for deceased. Early estimation of future mRS has high clinical utility as it represents recovery outcome, with mRS <=2 considered as a good recovery. We demonstrate that by applying machine learning techniques to a mix of clinical and imaging-derived data, we can accurately predict 3-month outcome in acute stroke patients.
Stroke aphasia treatment for sentence comprehension & production, naming, and spelling each alter patterns of activity in resting-state functional networks. Networks are typically treatment-specific, with the exception of one component which was elevated across treatments. Most components were more pronounced in the right hemisphere. Component specificity was observed at baseline across deficits, suggesting potential utility for fMRI in aphasia assessment.

**CLINICAL RELEVANCE/APPLICATION**

Treatment outcomes for stroke aphasia have high variability, suggesting treatment requires further optimization. Changes in resting fMRI networks may provide insight to treatment effects.

**RC505-12 Carotid Plaque Imaging**

Wednesday, Nov. 28 11:30AM - 12:00PM Room: E450A

Participants
J. Kevin Demarco, MD, Bethesda, MD (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Define the CT and MR appearance of three vulnerable carotid plaque features. 2) Describe how these three vulnerable plaque features are associated with improved risk assessment compared with simple carotid stenosis measurements. 3) Assess the ability of MR to depict the individual patient’s response to new medical therapy by measuring the change in these three vulnerable carotid plaque features.
## Essentials of Temporal Bone Imaging

**Wednesday, Nov. 28 8:30AM - 10:00AM Room: E451A**

<table>
<thead>
<tr>
<th>Event Code</th>
<th>Title</th>
<th>Presenters</th>
<th>Nothing to Disclose</th>
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<tbody>
<tr>
<td>RC506A</td>
<td>Optimizing Temporal Bone CT and MR Imaging</td>
<td>Joseph M. Hoxworth, MD, Scottsdale, AZ</td>
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<tr>
<td>RC506B</td>
<td>Cholesteatoma and Non-cholesteatomatous Inflammatory Disease</td>
<td>Amy F. Juliano, MD, BOSTON, MA</td>
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<tr>
<td>RC506C</td>
<td>Temporal Bone Tumors</td>
<td>Nikdokht Farid, MD, San Diego, CA</td>
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<tr>
<td>RC506D</td>
<td>Imaging of the Post-operative Temporal Bone</td>
<td>Gul Moonis, MD, New York, NY</td>
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**LEARNING OBJECTIVES**

1) Appraise the adequacy of CT and MR protocols for temporal bone imaging. 2) Modify temporal bone CT and MR protocols based on specific clinical indications.

1) Be familiar with the inflammatory disease entities that occur in the temporal bone. 2) Understand the pathophysiology of cholesteatoma and other inflammatory processes. 3) Recognize the imaging appearance of these diseases on CT and MR imaging. 4) Know the differential diagnoses, versus when certain imaging characteristics may be pathognomonic for one particular entity.

1) To become familiar with the different types of tumors which arise in the temporal bone by considering the differential for masses in specific regions of the temporal bone—i.e. internal auditory canal, jugular fossa region, middle ear, and petrous apex. 2) To recognize key imaging features of the various types of tumors arising in the temporal bone in order to provide accurate and useful differential diagnoses to our clinical colleagues.

1) Review surgical options for otomastoiditis and cholesteatoma. 2) Learn to differentiate between canal wall up and down mastoidectomy. 3) Discuss the complications pertaining to temporal bone surgeries. 4) Illustrate imaging findings of cochlear implants.

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[For more information about this presentation, contact:](shatzkes@hotmail.com)

**AMA PRA Category 1 Credit™: 1.50**

**ARRT Category A+ Credit: 1.75**

**FDA**

Discussions may include off-label uses.
### PURPOSE

Determine which CT findings are predictive of arterial injury and need for intervention in the setting of hepatic trauma.

### METHOD AND MATERIALS

From June 2011 to April 2017, 42 trauma patients (30 male, 12 female; mean age 36.1; age range 16-82) underwent contrast-enhanced CT angiography (CTA) and subsequent conventional hepatic angiography within 24 hours at two level 1 trauma centers. Hepatic injuries on CTA were graded based on the American Association for the Surgery of Trauma (AAST) liver injury scale. Scans were assessed for the presence and extent of contrast extravasation, hemoperitoneum, and lacerations. Hepatic angiograms were reviewed for evidence of arterial injury, including contrast extravasation and pseudoaneurysm. The chi-squared test was used to evaluate the univariate association between the tested parameters. A p value of less than 0.05 was considered to be statistically significant.

### RESULTS

There were 3 (7%) AAST grade 1, 9 (21%) grade 2, 15 (36%) grade 3, 14 (34%) grade 4, and 1 (2%) grade 5 injuries. Twenty one (50%) patients had arterial extravasation, 41 (98%) had parenchymal laceration, and 39 (93%) had hemoperitoneum on CT. The AAST liver injury scale was significantly associated with angiographic evidence of arterial injury ($\chi^2 = 10.8, p=0.029$); 46.7% (7/15) of grade 3 injuries and 57.1% (8/14) of grade 4 injuries demonstrated this finding. High AAST grade liver injuries (3-5) were also significantly associated with angiographic evidence of arterial injury when compared with low grade injuries (1-2); 0% (0/12) of low grade and 50% (15/30) of high grade injuries demonstrated arterial injury on angiography ($\chi^2 = 9.3, p=0.002$). In addition, extravasation > 1 cm on CTA demonstrated a significant association with arterial injury on angiography; 57.1% (8/14) versus 25% (7/28) when CTA extravasation > 1 cm was not present ($\chi^2 = 4.2, p=0.040$).
CONCLUSION
High grade injuries per the AAST liver injury scale and presence of contrast extravasation > 1 cm on CTA are associated with positive angiographic findings in the setting of hepatic trauma. This study also suggests that low grade injuries (1-2) have a very low likelihood of arterial injury on angiography.

CLINICAL RELEVANCE/APPLICATION
CT based predictors of arterial injury in the setting of hepatic trauma would help clinicians manage patients and diagnostic radiologists make appropriate recommendations.

RC508-03  The Role of CEUS in the Detection and Grading of Renal Injuries in Blunt Abdominal Trauma

Wednesday, Nov. 28 9:10AM - 9:20AM Room: S406B

Participants
Deepak Ravichandran, MD, New Delhi, India (Presenter) Nothing to Disclose
Atin Kumar, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Raju Sharma, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Ashu S. Bhalla, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Shivanand R. Gamanagatti, MBBS, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Contrast Enhanced CT (CECT) is the gold standard for the detection of renal injuries in blunt abdominal trauma (BAT). However its disadvantages include radiation exposure and the risks associated with iodinated contrast media. Contrast enhanced ultrasound (CEUS) provides an alternative tool for the detection and grading of renal injuries. This study was done to find the sensitivity of detection of renal injuries and to compare the AAST grading on CECT and CEUS

METHOD AND MATERIALS
Consecutive hemodynamically stable patients with BAT with CECT showing solid abdominal organ injuries were recruited in this ethically approved study. These patients underwent CEUS by a radiologist blinded to the findings of CECT and the injuries were identified and graded on both CECT and CEUS using the American Association for the Surgery of Trauma (AAST) scales. The sensitivity and specificity of detection on CEUS was obtained with CECT as the gold standard and the agreement between the grading on CECT and CEUS was analysed using kappa statistics. The injuries were further classified as high grade (AAST grades IV & above) and low grade (AAST grades I to III) and agreement between grading on CECT and CEUS was analysed

RESULTS
Among the 105 patients included as a part of a larger study, there were 22 renal injuries in the 210 kidneys assessed. CEUS detected 19 out of the 22 injuries and these injuries were graded on AAST scales and compared. The sensitivity, specificity, PPV and NPV of detection of renal injuries on CEUS using CECT as the gold standard was 86.4%, 100%, 100% and 98.4% respectively. On comparing the grading on CEUS and CECT, there was no significant agreement with a kappa value of 0.46 (>0.75 significant). On combining the grades as low grade and high grade injuries on both modalities, there is poor agreement between the grading with a kappa value of 0.46. The reason for the discrepancy is because US contrast agents are purely intravascular and do not get excreted through the renal pelvicalyceal system. Hence, the patients with PCS injuries were downgraded as grade III on CEUS

CONCLUSION
Though CEUS has a reasonable accuracy for detection of renal injuries but is poor for grading them and hence cannot be used to triage management.

CLINICAL RELEVANCE/APPLICATION
While CEUS is accurate in detecting renal injuries, it is unreliable as an alternative modality to CECT in grading renal injuries and in suggesting further management.

RC508-04  Liver Trauma: Vascular Injury on Computed Tomography as a Predictor of Patient Outcome

Wednesday, Nov. 28 9:20AM - 9:30AM Room: S406B

Awards
Student Travel Stipend Award

Participants
Nicholas Wilson, MD , Boston, MA (Presenter) Nothing to Disclose
Avneesh Gupta, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Stephan W. Anderson, MD, Cambridge, MA (Abstract Co-Author) Nothing to Disclose
Diana Dinh, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
John M. Campbell, Brookline, MA (Abstract Co-Author) Nothing to Disclose
Daniel Adran, Boston, MA (Abstract Co-Author) Nothing to Disclose
Alec Maggi, Rossmoor, CA (Abstract Co-Author) Nothing to Disclose
Jasmine Gandhi, Boston, MA (Abstract Co-Author) Nothing to Disclose
Muhammad M. Qureshi, MBBS, MPH, Boston, MA (Abstract Co-Author) Nothing to Disclose
Heidi Wing, Boston, MA (Abstract Co-Author) Nothing to Disclose
Robert W. Schulze, MD, MBA, Boston, MA (Abstract Co-Author) Nothing to Disclose
Christina A. LeBedis, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
nicholas.wilson@bmc.org
**PURPOSE**

To assess the utility of MDCT findings in predicting patient outcomes after liver injury.

**METHOD AND MATERIALS**

This retrospective study was IRB approved and HIPAA compliant. Informed consent was waived. Patients >= 16 years old who sustained blunt or penetrating trauma and found to have liver laceration from 5/1/2005 - 2/28/2017 were included. During this interval, 169 patients met inclusion criteria (123 male, 46 female; mean age of 34; age range 16-80 years old; 61 blunt trauma, 108 penetrating trauma). Liver injury was graded in blinded, consensus fashion by two abdominal fellowship trained radiologists (9 and 13 years-experience) using the AAST liver injury scale. Additional CT variables recorded in blinded fashion were contained vascular injury and active extravasation. Length of stay, treatment (interventional radiology or operative), and peri-operative transfusion were recorded from the electronic medical record. Multivariate linear regression was performed to determine crude and adjusted parameter estimate for length of stay. Logistic regression models were run and crude and adjusted odds ratio were calculated to estimate association between categorical variables.

**RESULTS**

41/128 (24.3%) patients who sustained hepatic injury have concomitant hepatic vascular injury; 23/61 (38%) in the setting of penetrating trauma and 18/108 (17%) in the setting of blunt trauma. Hospital length of stay was increased by 9.0 days for hepatic vascular injury regardless of mechanism, and by 6.0 days for those with high AAST grade (grades 4-6) as compared to referents. Patients with high grade AAST liver lacerations (grades 4-6) and patients with hepatic vascular injuries were more likely to require treatment (interventional radiology or operative) compared to referents, OR 4.74, 95% CI 2.21-10.16, p<0.0001 and OR 7.0, 95% CI 2.96-16.54, p<0.0001, respectively.

**CONCLUSION**

There is a high incidence of hepatic vascular injury in patients with liver laceration (24.3%). High grade hepatic laceration and the presence of hepatic vascular injury is predictive of longer lengths of stay and need for treatment.

**CLINICAL RELEVANCE/APPLICATION**

Hepatic vascular injury in patients who sustained blunt or penetrating liver trauma is predictive of patient outcomes.

**HONORED EDUCATORS**

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**RC508-05 Pitfalls in Abdominal Trauma CT**

*Wednesday, Nov. 28 9:30AM - 10:00AM Room: S406B*

Participants
Michael N. Patlas, MD,FRCPC, Hamilton, ON (Presenter) Nothing to Disclose

For information about this presentation, contact:
patlas@hhsc.ca

**LEARNING OBJECTIVES**

1) To discuss the impact of suboptimal trauma MDCT protocols. 2) To review common and uncommon pitfalls in interpretation of abdominal trauma MDCT examinations. 3) To suggest strategies to improve detection of easily missed injuries.

**RC508-06 Correlation between CT-Based Liver Injury Severity Scoring, Contrast Extravasation and Subsequent Management**

*Wednesday, Nov. 28 10:00AM - 10:10AM Room: S406B*

**AWARDS**

**Student Travel Stipend Award**

Participants
Martin Reim, MD, Tartu, Estonia (Presenter) Nothing to Disclose
Pilvi Ilves, Tartu, Estonia (Abstract Co-Author) Nothing to Disclose
Andrus Lomp, BA,Msc, Tartu, Estonia (Abstract Co-Author) Nothing to Disclose
Vladislav Mihnovits, MD, Tartu, Estonia (Abstract Co-Author) Nothing to Disclose
Urmas Lepner, PhD, Tartu, Estonia (Abstract Co-Author) Nothing to Disclose
Peep Talving, PhD, Tartu, Estonia (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
reimmartin@gmail.com

**PURPOSE**

The liver is the second most commonly injured abdominal solid organ. The aim of the study was to elucidate the correlation between CT-based liver injury severity scoring, contrast extravasation and subsequent management.

**METHOD AND MATERIALS**

Data on consecutive trauma admissions to two major national trauma facilities with liver injuries between 1/2009 and 12/2013 were retrospectively reviewed using ICD-10 codes (S36.10). The images were accrued from the population-based Picture Archive (PACS). CT scoring per American Association for the Surgery of Trauma organ injury scale was utilized to stratify liver injuries into
minor/moderate (grades I-III) vs. severe (grades IV-V) injuries. The primary outcomes were operative management and in-hospital mortality.

RESULTS

A total of 81 cases were included. The mean age of the cohort was 31.5 ± 12.2 years and 26.9% were female. Overall, grade I-III injuries in 86.4% (n=70) and grade IV-V injuries in 13.6% (n=11) were observed. The most common associated injuries involved chest wall (n=44; 54.4%), lung (n=42; 51.8%), lower ribs (n=32; 39.5%). Overall, 17.3 % (n=14) and 82.7% (n=67) were subjected to operative and non-operative management, respectively. There was no correlation between CT scoring of liver injuries and surgical management (p=0.196). CT signs of active bleeding was noted in 20 patients (25%) and 30% (n=6) of these patients underwent operative treatment. The remaining 10% (n=2) of patients with active bleeding were embolized per interventional radiology (IR). One patient had IR intervention for a concomitant abdominal injury and one was treated surgically for a splenic injury. A total of 8 cases (13%) without CT-verified active bleeding (n=60) required surgery. There was no statistically relevant correlation between CT-based active liver hemorrhage and subsequent operative treatment (p=0,102). The overall mortality of the study population was 2.5% (n=2).

CONCLUSION

The majority of the population-based liver injuries were minor or moderate and CT-scoring of liver injuries did not determine subsequent surgical management. There was no correlation between CT signs of active bleeding and operative treatment decision. Further prospective studies are warranted.

CLINICAL RELEVANCE/APPLICATION

To improve our clinical practices we need to analyze our previous performance using existing injury scoring criteria and imaging characteristics regarding clinical outcome and decision making.

RCS08-07 Treatment Decisions in Blunt Splenic Trauma: Insights from a UK Trauma Centre

Wednesday, Nov. 28 10:10AM - 10:20AM Room: S406B

Awards
Student Travel Stipend Award

Participants
Jim Zhong, Leeds, United Kingdom (Presenter) Nothing to Disclose
Fathallah Islam, Leeds, United Kingdom (Abstract Co-Author) Nothing to Disclose
James Denton, Wakefield, United Kingdom (Abstract Co-Author) Nothing to Disclose
Simon J. McPherson, MBBS, North Yorkshire, United Kingdom (Abstract Co-Author) Nothing to Disclose
Jai Patel, MD, FRCR, Leeds, United Kingdom (Abstract Co-Author) Nothing to Disclose
Jonathan Jones, Leeds, United Kingdom (Abstract Co-Author) Nothing to Disclose
Karen Flood, BMedSc, MBBS, Leeds, United Kingdom (Abstract Co-Author) Nothing to Disclose

PURPOSE

To review the imaging findings and clinical outcomes in blunt splenic trauma (BST) and identify common themes that help stratify management and determine the role of interventional radiology (IR), specifically splenic embolization (SE).

METHOD AND MATERIALS

Retrospective study. All patients admitted with BST from 01/01/2010 to 01/01/2018 included. Data collected included demographics, injury severity, haemodynamic stability, treatment type (Non-operative, IR or surgery), complications and follow-up. 4 Attending IRs reviewed the admission CT imaging whilst blinded to the original report or outcomes. Based on the CT findings and haemodynamic stability of the patient they were asked to recommend non-operative, SE (proximal or distal) or surgery for each case. The inter-observer agreement was calculated using Fleiss Kappa on SPSS for the CT findings and management plan.

RESULTS

257 patients included. Median age 27(3-90). 178 were male and 49 female. 15 patients had isolated splenic injuries and 212 had >2 organ system injuries. 220 had a CT scan on presentation. CT findings included splenic contrast extravasation(n=44), pseudoaneurysms(n=24), splenic lacerations(n=196, 30 full thickness and 23 involved the splenic hilum), perisplenic haematoma(n=105) and haemoperitoneum(n=65). For initial treatment, 17 had splenectomy, 32 had SE and 178 were managed conservatively. S had delayed SE following failure of conservative management. A total of 12 patients had proximal SE and 25 had distal SE. The 4 Attendings were in most agreement on the presence of active bleeding on CT (89%), Fleiss' Kappa 0.696. For chosen method of treatment, the overall inter-observer agreement was 84% (range 83-93%) and Fleiss' Kappa was 0.614. For haemodynamically stable patients with active bleeding on CT with either perisplenic haematoma or haemoperitoneum, all Attending IRs opted for SE with a view to distal embolization for splenic preservation.

CONCLUSION

Both clinical and imaging findings are invaluable in guiding management of blunt splenic trauma. In the presence of splenic injury and active bleeding on CT imaging even with a stable patient, splenic artery angiogram with a view to embolization is recommended.

CLINICAL RELEVANCE/APPLICATION

In the presence of splenic injury and active bleeding on CT imaging even with a stable patient, splenic artery angiogram with a view to embolization is recommended.

RCS08-08 Uncommon Sites of Abdominal Trauma

Wednesday, Nov. 28 10:30AM - 11:00AM Room: S406B

Participants
Felipe Munera, MD, Key Biscayne, FL (Presenter) Nothing to Disclose
RC508-09  
Segmented Pelvic Hematoma Volumes, Intravenous Contrast Extravasation Volumes, and Extravasation Rate Are All Independently Predictive of Major Arterial Injury After Pelvic Fracture: Analysis of a Prospective Cohort

Participants
David Dreizin, MD, Baltimore, MD (Presenter) Research Grant, Siemens AG ;
Matthew P. Dattwyler, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Alexis R. Boscak, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Christina A. LeBedis, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Nikki Tirada, MD, Baltimore, MD (Abstract Co-Author) Spouse, Research Grant, Siemens AG
Stephan W. Anderson, MD, Cambridge, MA (Abstract Co-Author) Nothing to Disclose
Nemil Shah, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Uttam Bodanapally, MD, Baltimore, MD (Abstract Co-Author) Speakers Bureau, Siemens AG; Travel Support, Siemens AG;

PURPOSE
The predictive value of hematoma volumes for major arterial injury after pelvic fractures is known. Area measurements of contrast extravasation (CE) and area rate of change between phases are also important. A model using hematoma volume and contrast extravasation volume on multiphasic CT is derived.

METHOD AND MATERIALS
Patients with CT in the trauma bay were screened prospectively for pelvic ring disruptions between July 2016-Oct 2017. Patients were excluded if CT was performed: after a) laparotomy or angiography, b) at another institution, or c) without IV contrast. Hematoma volumes (HMVs) were measured in all remaining patients. Patients with HMV < 50 mL were not considered at risk for arterial injury requiring intervention and were excluded a priori. Included patients were additionally assessed for: binder, Tile grade, comminution, fracture gap (> 5 mm), obturator/greater sciatic fracture, atherosclerosis, multiple/bilateral foci of arterial blush, art and PVP CE volume, and difference in CE volume between phases (bleeding rate). Variables with p<0.05 on univariate analysis (tests for proportions, Chi squared test for trend, comparison of means) were included in logistic regression with backward elimination to determine independent predictors and derive a parsimonious predictive model.

RESULTS
241 patients had pelvic ring disruptions on CT. 121 had non-negligible hematoma volumes (>50 mL). 19 patients underwent catheter embolization for pelvic arterial bleeding. In univariate analysis, predictor variables included hematoma vol (p < 0.0001), Tile grade (p = 0.002), multiple/bilateral foci of extravasation (p = 0.049), arterial blush vol (p < 0.0001), PVP blush vol (p = 0.004), and bleeding rate: PVP-art (p = 0.001). In logistic regression, hematoma vol (OR 1.007 Δ per mL), arterial CE vol (OR 194.3 Δ per mL), PV CE vol (OR 0.015 Δ per mL), bleeding rate (OR 61.7 Δ per mL), and Tile C vertical instability (OR 6.2) remained as independent predictors.

CONCLUSION
Hematoma vol, CE vol on art and PV phase, and bleeding rate between phases are independent predictors of major arterial hemorrhage after pelvic fracture. The generalizability of the model is under evaluation using a dataset from a second high-volume level I trauma center.

CLINICAL RELEVANCE/APPLICATION
Volumetric measurements of hematoma, arterial and PV CE, and rate of change of CE between phases can potentially improve prediction of major arterial injury after pelvic fractures.

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**LEARNING OBJECTIVES**

1) Describe common imaging findings of tracheobronchial injury. 2) Classify parenchymal injuries of the lung. 3) Discuss rib fracture patterns and pre-operative planning for chest reconstructive surgery.

**RC508-11  A 2018 International Survey to Assess Use of Intraluminal Contrast in CT Protocols for Penetrating Torso Trauma**

Wednesday, Nov. 28 11:40AM - 11:50AM Room: S406B

**Awards**

**Student Travel Stipend Award**

**Participants**

Cory J. Ozimok, BSC, MD, Ottawa, ON (Presenter) Nothing to Disclose  
Vincent M. Mellnick, MD, Saint Louis, MO (Abstract Co-Author) Nothing to Disclose  
Michael N. Patlas, MD,FRCP, Hamilton, ON (Abstract Co-Author) Nothing to Disclose

**For information about this presentation, contact:**  
patlas@hhsc.ca

**PURPOSE**

There is controversy regarding the administration of oral and rectal contrast in CT protocols to detect bowel injury in the context of penetrating torso trauma. Given the lack of published societal guidelines, our goal was to survey trauma radiologists across North America and abroad to determine consensus on CT protocols for penetrating trauma.

**METHOD AND MATERIALS**

With IRB approval, an anonymous 10-question online survey was distributed via email to 589 radiologists in the American Society of Emergency Radiology (ASER) member database. The survey was open for a 4-week period in February 2018. A commercially available website that allows subscribers to create and analyze survey results was used for analysis.

**RESULTS**

We received 124 responses (21% response rate) with majority from U.S. institutions (82%), followed by Europe (7%), Canada (6%), Asia (3%) and Australia/New Zealand (2%). Seventy-four percent of respondents indicated they do not routinely administer oral contrast in penetrating trauma and 68% do not administer rectal contrast. The decision to administer intraluminal contrast is made by the referring physician at 52% of institutions, the attending radiologist at 18% and a resident or fellow at 20%. Most centers do not use software to assess trajectory of penetrating trauma (90%). There is in-house attending level coverage at 54% of institutions. When asked if trauma scans are reviewed before removing the patient from the table, 41% of respondents answered ‘No’ and of those who answered ‘Yes,’ 12% said they are reviewed by an attending, 33% by a resident, and 4% by a fellow.

**CONCLUSION**

The majority of major trauma centers do not routinely administer oral or rectal contrast in cases of penetrating torso trauma and the decision is often made by the referring physician.

**CLINICAL RELEVANCE/APPLICATION**

There is international consensus that the added benefit of intraluminal contrast to detect bowel injury in CT protocols for penetrating trauma is outweighed by the delay in patient management.

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Vincent M. Mellnick, MD - 2016 Honored Educator  
Vincent M. Mellnick, MD - 2018 Honored Educator

**RC508-12  Imaging and Clinical Predictors of Outcomes in Torso Trauma**

Wednesday, Nov. 28 11:50AM - 12:00PM Room: S406B

**Awards**

**Student Travel Stipend Award**

**Participants**

Pedro V. Staziaki, MD, Boston, MA (Presenter) Nothing to Disclose  
Aaron Maybury, Jamaica Plain, MA (Abstract Co-Author) Nothing to Disclose  
Neha Gangasani, Boston, MA (Abstract Co-Author) Nothing to Disclose  
Michael J. Hsu, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose  
Mustafa Qureshi, Boston, MA (Abstract Co-Author) Nothing to Disclose  
Christina A. LeBedis, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose  
Jorge A. Soto, MD, Boston, MA (Abstract Co-Author) Royalties, Reed Elsevier  
Stephan W. Anderson, MD, Cambridge, MA (Abstract Co-Author) Nothing to Disclose

**PURPOSE**

To assess the utility of CT findings with clinical parameters to predict clinical outcomes in trauma.
To assess the utility of CT findings with clinical parameters to predict clinical outcomes in trauma.

**METHOD AND MATERIALS**

IRB-approved retrospective study of all adults who sustained blunt/penetrating trauma in a Level 1 trauma center in 2015. Clinical parameters: admission blood pressure (SBP), heart rate, Glasgow Coma Scale (GCS), hemoglobin, hematocrit (HCT) and lactate. A blinded radiologist assessed CT for colon, kidney, liver, spleen, bony pelvic ring, lung parenchyma, and/or rib injuries. Outcomes: admission to ICU, length of stay (LOS) in the ICU, life-saving procedures (conventional angiography/intervention, surgery) and total LOS in the hospital. Multivariate linear and logistic regression models were employed and covariate-adjusted parameter estimates and odds ratios (OR) with 95% confidence intervals (CI) were computed.

**RESULTS**

Among 723 patients, 162 were excluded due to missing lab data, resulting in 561 patients (72% males, age 39 ± 18 years). 168 patients were admitted to the ICU. Liver (OR 15.9 [4.8-52.5]), spleen (OR 15.9 [4.8-62.8]), pelvis (OR 3.4 [1.5-7.5]), lung (OR 3.3 [1.5-7.1]) and rib (OR 4.1 [2.4-7.3]) injuries in addition to age, GCS and lactate predicted admission to the ICU. Among these, the LOS in the ICU was 6 (3-11) days. Only pelvic injury (2.4, p < 0.05) was associated with longer LOS in the ICU. 31 patients had life-saving procedure. Colon (OR 37.3 [7.4-189.3]), liver (OR 3.9 [1.2-12.3]), spleen (OR 8.5 [2.3-31.0]) and pelvis (OR 4.8 [1.7-13.7]) injuries, in addition to lactate, predicted undergoing procedures. Total LOS in the hospital was 2 (1-5) days. Kidney (3.6, p = 0.02), liver (2.9, p = 0.03), spleen (3.5, p = 0.02), pelvis (7.2, p < 0.01), lung (3.8, p < 0.01) and rib (2.2, p < 0.01) injuries in addition to age, GCS, HCT and lactate were associated with longer LOS.

**CONCLUSION**

Liver, spleen, pelvis, lung and rib injuries are predictive of ICU admission, among which only pelvic injury predicts longer LOS in the ICU. Colon, liver, spleen and pelvis injuries are predictive of life-saving procedure. Kidney, liver, spleen, pelvis, lung and rib are predictive of increased LOS in the hospital. These are independent of age, SBP, GCS, HCT or lactate.

**CLINICAL RELEVANCE/APPLICATION**

Radiologists can demonstrate value by developing strong predictive models of interest to clinicians and administrators alike.

**Honored Educators**

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**RC511**

**Head and Neck PET/CT: Clinical Approach**

Wednesday, Nov. 28 8:30AM - 10:00AM Room: S504CD

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AMA PRA Category 1 Credit™: 1.50
ARRT Category A+ Credit: 1.75

**Sub-Events**

**RC511A**  **Oropharyngeal Cancer: Evolving Challenges—Clinician’s Perspective**

Participants
Bhishamjit Chera, MD, Chapel Hill, NC *(Presenter)* Nothing to Disclose

**LEARNING OBJECTIVES**

1) To understand how radiological interpretation of pre-treatment and post-treatment imaging studies influences the management of patients with head and neck cancer.

**RC511B**  **CT and MRI Anatomy and Interpretation**

Participants
Valerie L. Jewells, DO, Chapel Hill, NC *(Presenter)* Nothing to Disclose

For information about this presentation, contact:
jewells@med.unc.edu

**LEARNING OBJECTIVES**

1) Provide radiologists with the tools to access CT and MRI imaging for head and neck cancer. 2) Teach attendees how to address the images in a manner that will assist the ENT surgeon for staging and surgical planning. 3) Address the principles for critical thinking and analysis as well as preparation and skill development for a head and neck tumor board.

**ABSTRACT**


**RC511C**  **FDG-PET/CT: Applications and Interpretation**

Participants
Terence Z. Wong, MD, PhD, Chapel Hill, NC *(Presenter)* Consultant, Lucerno Dynamics, LLC;

**LEARNING OBJECTIVES**

1) Describe applications for FDG-PET/CT for initial evaluation and follow up of patients with head and neck cancer. 2) Learn the value of combining metabolic findings on FDG-PET findings with morphology on CT and endoscopic appearance. 3) Understand potential etiologies of false positive and false negative studies.

**ABSTRACT**

Optimal evaluation of patients with head and neck malignancies requires a multidisciplinary approach. Correlation of FDG-PET, CT, direct visualization, and clinical examination is important to provide the best management of these patients.

**RC511D**  **Panel Discussion: Q&A**

Participants
Bhishamjit Chera, MD, Chapel Hill, NC *(Presenter)* Nothing to Disclose
Valerie L. Jewells, DO, Chapel Hill, NC *(Presenter)* Nothing to Disclose
Terence Z. Wong, MD, PhD, Chapel Hill, NC *(Presenter)* Consultant, Lucerno Dynamics, LLC;

**LEARNING OBJECTIVES**

Case examples which highlight the value of multidisciplinary approaches for managing patients with head and neck cancer.
LEARNING OBJECTIVES

1) Comprehend the principles of CT Perfusion imaging in stroke and cancer applications. 2) Apply the principles to discern errors that may occur in perfusion calculation. 3) Design scanning protocols for CT Perfusion imaging of stroke and cancer. 4) Apply dose saving techniques to reduce radiation dose. 5) Discuss the application of CT Perfusion imaging in stroke and cancer with examples.

6) Comprehend the theoretical basis and pitfalls of each myocardial CTP method (qualitative, semi-quantitative and quantitative).
7) Assess the sources and solutions of various image artifacts in myocardial CTP.
8) Evaluate the effectiveness of radiation dose reduction methods for low dose quantitative myocardial CTP.
9) Develop the optimal myocardial CTP protocol for assessing high-risk coronary artery disease.
10) Assess the recent advances in quantitative CTP for imaging myocardial edema and scar and their potential applications to guide therapy in post infarction settings.

ABSTRACT

CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

Sub-Events

RC521A  Contrast Administration for Cardiovascular Imaging and Beyond

Participants
Dominik Fleischmann, MD, Stanford, CA (Presenter) Research Grant, Siemens AG

RC521B  Perfusion Techniques and Applications-Stroke and Cancer

Participants
Ting-Yim Lee, MSc, PhD, London, ON (Presenter) License agreement, General Electric Company

RC521C  Perfusion Techniques and Applications-Cardiac

Participants
Aaron So, PhD, London, ON (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) Comprehend the theoretical basis and pitfalls of each myocardial CTP method (qualitative, semi-quantitative and quantitative).
2) Assess the sources and solutions of various image artifacts in myocardial CTP.
3) Evaluate the effectiveness of radiation dose reduction methods for low dose quantitative myocardial CTP.
4) Develop the optimal myocardial CTP protocol for assessing high-risk coronary artery disease.
5) Assess the recent advances in quantitative CTP for imaging myocardial edema and scar and their potential applications to guide therapy in post infarction settings.
Optimization and Technology in Interventional Radiology

Wednesday, Nov. 28 8:30AM - 10:00AM Room: S403B

Participants
William F. Sensakovic, PhD, Scottsdale, AZ (Coordinator)
Speaker, Bayer AG; Research Grant, Mazor Robotics Ltd; Founder, Telerad Physics Teaching, LLC
Thaddeus A. Wilson, PhD, Madison, WI (Coordinator) Nothing to Disclose

LEARNING OBJECTIVES
1) Apply techniques to optimize dose in the interventional setting. 2) Identify opportunities where ionizing radiation can be replaced by ultrasound to guide interventional procedures. 3) Understand new CT interventional techniques that will open new fields of CT intervention for percutaneous and intravascular interventions. 4) Describe a 500X dose reduced CT fluoroscopy mode. 5) Describe a method for quantitative high frame rate CTA that provides vascular velocity and flow information to help plan and evaluate CT vascular interventions.

Sub-Events

RC523A Dose Optimization in the Interventional Suite

Participants
Robert G. Dixon, MD, Chapel Hill, NC (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1. Review the importance of dose optimization in the angiography suite. 2. Discuss basic concepts that will help to build a culture of safety at your institution. 3. Identify simple, practical steps that operators can take to protect patients, staff and themselves in the IR suite.

RC523B Using Ultrasound in Place of CT and Fluoroscopy in the Interventional Suite

Participants
Patrick Warren, MD, Columbus, OH (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Discuss skills, techniques, and pitfalls of invasive sonography. 2) Discuss basic skills involved in utilizing ultrasound guidance in lieu of CT fluoroscopy or conventional fluoroscopy during minimally invasive percutaneous procedures in order to minimize radiation exposure to patients and healthcare providers. 3) Incorporate these component skill sets into further life-long learning for expansion of competency and implementation into clinical interventional practice.

RC523C Advances in Interventional Use of CT

Participants
Charles A. Mistretta, PhD, Madison, WI (Presenter) Founder, Mistretta Medical Intellectual Property Licensing Activities; Research, Siemens AG; Co-Founder, LiteRay Medical LLC

LEARNING OBJECTIVES
1) To familiarize attendees with new CT interventional techniques that will open new fields of CT intervention for percutaneous and intravascular interventions. 2) To describe a 500X dose reduced CT fluoroscopy mode. 3) To describe a method for quantitative high frame rate CTA that provides vascular velocity and flow information to help plan and evaluate CT vascular interventions.

ABSTRACT
We will summarize recent developments in C-Arm 4D DSA that have now been extended to conventional CT. These include a 500X dose reduced CT fluoroscopy mode and 4D CT DSA that provides quantitative velocity and flow information from 30 CTA volumes
per second. These modes in combination, promise to provide new opportunities for ultra low dose artifact-free percutaneous needle placement and CT vascular intervention including real time intra-luminal views.
LEARNING OBJECTIVES

1) Better understand 'routine' CT imaging performed in a cancer center. 2) How this particular cancer center approaches abdominal CT imaging without IV contrast. 3) Appreciate scan options for CT imaging of very large patients. 4) Comprehend implementation of dual-energy CT for oncology.

ABSTRACT

The management of CT radiation exposure for cancer patients presents a difficult dilemma. We know that each exposure has a small probability of inducing radiation damage, but we must weigh that knowledge against the fact that the patient already has cancer, and may have a reduced life expectancy as a result. Patient management decisions often hinge on a detailed appreciation of the patient's present condition, and CT can provide critical information in this respect. In our practice, the concern for short-term survival typically supersedes the long term and complex risk associated with CT dose. The concept of what is 'routine' CT imaging at our oncology center will be explored, with a focus on our most frequently performed exams and typical scan parameters. CT dose metrics will be reviewed and compared to national benchmarks for several routine CT exams. Our approach to abdominal CT protocols designed for use without IV contrast will be covered, as well as several options for imaging our very large cancer patients. How we have implemented dual-energy CT, and its benefits, will also be illustrated.
MSRO42

BOOST: Lymphoma-Oncology Anatomy and Case-based Multidisciplinary Review (Interactive Session)

Wednesday, Nov. 28 10:30AM - 12:00PM Room: S103CD

CT  MR  NM  OI  RO

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

Participants
Chelsea C. Pinnix, MD, PhD, Houston, TX (Moderator) Research Grant, Merck & Co, Inc; Consultant, Global One Inc; Speaker, International Journal of Radiation Oncology, Biology & Physics
Jurgen Rademaker, MD, New York, NY (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Case-based review of staging and treatment response in lymphoma (CT, PET, MRI).
**PURPOSE**

To determine the sensitivity, specificity, and predictive value of cardiac CT angiography (cCTA), cardiac MR (CMR), and transthoracic echocardiography (TTE) for stroke recurrence in patients with suspected cardioembolic stroke.

**METHOD AND MATERIALS**

163 patients (55% men, 61.9±16.9 years) with suspected cardioembolic stroke who underwent TTE, CMR, or cCTA between January 2013 and May 2017 were retrospectively analyzed. The presence of left atrial thrombus, left ventricular thrombus, complex aortic plaque, cardiac tumors, and valvular vegetation was evaluated. The patient electronic medical records were used to determine if the patient suffered a recurrent stroke. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each imaging modality and the diagnostic accuracy was compared using receiver operating characteristic analysis.

**RESULTS**

cCTA was performed in 82 patients, CMR in 81 patients, and TTE in 151 patients. 28 recurrent strokes occurred (cCTA- n=14; CMR- n=14; TTE- n=26). The sensitivity, specificity, PPV and NPV were: 14%, 79%, 12.5%, and 81.5% for CMR; 28.5%, 88.2%, 33.3%, and 85.7% for cCTA; and 11.5%, 88.8%, 17.6%, and 82.8% for TTE. There was no significant difference in diagnostic accuracy between CMR (0.53, 95% CI [0.42, 0.64]), cCTA (0.56, 95% CI [0.43, 0.69]), and TTE (0.50, 95% CI [0.43, 0.57]).

**CONCLUSION**

cCTA, CMR, and TTE demonstrated comparably high specificity and NPV for the exclusion of cardioembolic stroke recurrence.

**CLINICAL RELEVANCE/APPLICATION**

The comparable performance of cCTA, CMR, and TTE in predicting recurrent cardioembolic stroke allows physicians to choose a preferred imaging modality for patients with suspected cardioembolic stroke.
The median ECV was 33.4% (IQR, 30.1-37.4) for the SECT approach and 34.9% (IQR, 31.2-39.2) for the DECT approach (p =

RESULTS

METHOD AND MATERIALS

METHOD AND MATERIALS

RESULTS

Mean ECV in normal and infarcted myocardium were 0.27±0.11 and 0.52±0.11 respectively. The corresponding mean ECDV calculated from the dynamic images covered up to 3 min post contrast injection were 0.28±0.07 ml/g and 0.60±0.10 ml/g respectively. Infarcted myocardium exhibited a higher percentage increase in ECDV from normal myocardium (114%) compared to ECV (93%).

CONCLUSION

ECDV may be a more sensitive marker of myocardial viability compared to ECV due to the larger difference exhibited between the normal and infarcted tissues, and can be measured with only 1/3 of the time required for ECV (3 min vs. 10 min post contrast injection).

CLINICAL RELEVANCE/APPLICATION

With bolus contrast injection, ECDV measurement could provide a faster and more reliable assessment of myocardial viability after acute myocardial infarction compared to conventional ECV measurement.

SSK03-03 Feasibility of Myocardial Extracellular Volume Fraction Quantification Using Dual-Energy CT

Wednesday, Nov. 28 10:50AM - 11:00AM Room: S102CD

Participants

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PURPOSE

To assess the feasibility of Dual Energy CT (DECT) to derive myocardial extracellular volume (ECV) and detect ECV differences without the need for a true non-contrast scan compared to Single Energy CT (SECT) results.

METHOD AND MATERIALS

A total of 35 patients were included in this IRB-approved, HIPAA-compliant study; 8 control patients, 17 infarct patients (focal fibrosis), and 10 cardiomyopathy patients (diffuse fibrosis). All scans were acquired using a 2nd or 3rd generation dual source CT system. A true non-contrast and delayed acquisition were used to calculate SECT-ECV, while only the delayed acquisition in dual energy mode and derived virtual non-contrast images were used to calculate DECT-ECV. In the control and diffuse fibrotic groups, a region of interest (ROI) encompassing the entire left ventricular myocardium was used to calculate ECV. Two ROIs were placed in the focal fibrotic group; one in normal myocardium and one in fibrotic myocardium.

RESULTS

The median ECV was 33.4% (IQR, 30.1-37.4) for the SECT approach and 34.9% (IQR, 31.2-39.2) for the DECT approach (p =
0.401). For both SECT-ECV and DECT-ECV, focal fibrotic and diffuse fibrotic tissue had significantly higher ECV values compared to normal myocardium (all p < 0.021). No systematic bias was observed between SECT and DECT measurements, with limits of agreement calculated at ± 9.4% (p = 0.348). The DECT acquisition had a lower radiation dose than the SECT scan by 1.1 mSv (p < 0.001), which was likely caused by the absence of the true non-contrast acquisition in the DECT approach.

CONCLUSION

Measurement of ECV with only a delayed acquisition is feasible using the DECT approach. The DECT approach provides similar results at a lower radiation dose compared to a SECT protocol.

CLINICAL RELEVANCE/APPLICATION

This study demonstrates the feasibility of DECT for myocardial ECV measurements using only a delayed acquisition, thus eliminating the need for a true non-contrast scan and consequently reducing radiation dose.

SSK03-04  Accuracy of Myocardial Blood Flow Quantification with Dual-source CT: Validation in Human Using 15O-Water PET

Participants
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PURPOSE

Myocardial CT perfusion has emerged as a potential method for absolute quantification of myocardial blood flow (MBF). However, there is no standardized technique for CT MBF quantification, and dual-source CT MBF values have never been compared against positron emission tomography (PET), which is an established technique for non-invasive quantification of MBF. The aim of this study was to assess the accuracy and usefulness of absolute MBF values quantified with dual-source CT by comparing them with those quantified with 15O-water PET.

METHOD AND MATERIALS

Dynamic CT perfusion and 15O-water PET were performed in 26 patients (70+/-9 years, 22 male) with known/suspected coronary artery disease with a median interval of 48 days (interquartile range: 29-73 days). Hyperemic MBF in AHA 16 segments were quantified with a dual-source CT and its dedicated software (Force/VPCT body, Siemens). For the quantification of hyperemic MBF using 15O-water PET, non-commercial software (Carimas) was used. Comparison of hyperemic MBF quantified by CT and PET was performed on segment (n=377), vessel (n=77), and patient (n=26) levels after exclusion of 7 segments out of FOV and 32 segments with transmural myocardial infarction.

RESULTS

CT results showed excellent linear correlation with PET results at segment (r=0.87, p<0.0001), vessel (r=0.91, p<0.0001), and patient level (r=0.93, p<0.0001). Area under the receiver-operating characteristics curve for detecting reduced MBF (<2.3 mL/min/g) on 15O-water PET was 0.88, 0.91, and 0.92 at segment, vessel, and patient level, respectively. Although CT demonstrated significantly lower hyperemic MBF than PET (1.16 ± 0.29 mL/min/g vs 2.46 ± 1.56 mL/min/g, p<0.0001), there was good per-vessel sensitivity (79.5%), specificity (92.1%), negative predictive value (81.4%) and positive predictive value (91.2%) for diagnosing reduced PET-derived MBF with a CT-derived MBF cutoff value of 1.09 mL/min/g.

CONCLUSION

Hyperemic MBF quantified by CT demonstrated excellent correlation with MBF estimated by 15O-water PET, and yielded high diagnostic accuracy for detecting abnormal perfusion.

CLINICAL RELEVANCE/APPLICATION

CT MBF quantification has potential to provide objective assessment of perfusion abnormality in patients with known or suspected CAD with high accuracy comparable to 15O-water PET.

SSK03-05  Relationship Between Epicardial Adipose Tissue and Coronary Vascular Function in Patients with Normal Myocardial Perfusion by 82Rb PET/TC

Participants
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PURPOSE
We assessed the relationship between epicardial adipose tissue (EAT) and coronary flow reserve (CFR) in patients with suspected or known coronary artery disease (CAD) and normal myocardial perfusion imaging (MPI).

METHOD AND MATERIALS
The overall population consisted of 272 subjects referred for the evaluation of suspected or known CAD to stress-rest 82Rb PET/CT and showing normal MPI. CAC score was measured according to the Agatston method. Using unenhanced CT images for CAC, EAT volume was measured (cm3). The ln(CAC+1) score and lnEAT transformation were used to reduce heteroscedasticity. Myocardial perfusion was assessed using standardized segmentation of 17 myocardial regions. The summed stress, summed rest and summed difference scores were automatically calculated. Myocardial perfusion was considered normal when the summed stress score was <3. Absolute myocardial blood flow (MBF) was computed (in milliliters per minute per gram) from the dynamic rest and stress imaging series. CFR was defined as the ratio of hyperemic to baseline MBF; CFR 2 was considered reduced.

RESULTS
In the overall population, 95 (35%) patients showed reduced and 177 (65%) normal CFR. Compared to patients with normal CFR, those with reduced CFR were older (60±11 vs. 67±9, P<0.05) and showed higher values of ln(CAC+1) (3.9±3 vs. 4.7±3, P<0.05) and lnEAT volume (4.5±1 vs. 4.7±1, P<0.05). At univariable logistic regression analysis age, ln(CAC+1) and lnEAT resulted significant predictors of reduced CFR. At multivariable analysis, only age and lnEAT volume were independently associated with reduced CFR (hazard ratio 1.05 and 1.89 and 95% confidence interval 1.02-1.08 and 1.01-3.54, P<0.005). The addition of lnEAT to clinical data significantly increased the global chi-square of the model (from 23.8 to 28.6, P<0.05) in predicting reduced CFR.

CONCLUSION
In patients with suspected and known CAD and normal myocardial perfusion, age and EAT are strongly associated with reduced CFR confirming that visceral fat depot may directly influence coronary vascular function. Thus, EAT evaluation may play a major role in the identification of coronary vascular dysfunction in patients with normal perfusion.

CLINICAL RELEVANCE/APPLICATION
In patients with suspected and known CAD and normal myocardial perfusion, age and EAT are associated with impaired CFR confirming that visceral fat may directly influence coronary vascular function.
information that is used in clinical decision making for patients with angina

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Frank J. Rybicki III, MD, PhD - 2016 Honored Educator

**SSK03-07  Feasibility of Coronary Flow and Velocity Measurement using 4D CTA Reconstruction**

**PURPOSE**

Commercially available CT scanners can achieve gantry rotation times of 0.3 s (~3 frames per second). However, the temporal resolution might not be sufficient to calculate blood flow and velocity in the coronary arteries, which are important for the diagnosis of coronary artery disease (CAD). Currently, ~1000 projection images are acquired during each gantry rotation. The purpose of this study was to determine the feasibility of a new reconstruction technique called 4D CTA, which calculates a 3D time frame for each projection image and therefore provides high temporal resolution for flow calculations in the coronary arteries.

**METHOD AND MATERIALS**

The previously described 4D DSA technique (Davis, 2013) was extended for the time-resolved 3D reconstruction of coronary arteries (CA). A pig study was retrospectively analyzed, where continuous axial CT acquisitions (64 slices) were performed with a 0.4 s gantry rotation time over a period of 50 s during intravenous contrast injection. A 3D image of the vasculature was reconstructed using a short scan (235 degrees) during diastole and the CA were manually segemented. A constrained back-projection was then performed for each projection image to create a 3D time frame. The reconstructed time attenuation curves were used to calculate the blood flow and velocity in the CA based on the mean transit time. The velocity and flow values were compared to values from literature and the flow conservation was determined.

**RESULTS**

In the first order branches, the average diameter, velocity and flow were 4.12 mm (3.28 mm), 110.43 mm/s (128 mm/s), and 1.44 ml/s (1.07 ml/s) respectively. The same measurements for the second order branches were 1.31 mm (1.70 mm), 63.34 mm/s (46.10 mm/s) and, 0.32 ml/s (0.10 ml/s) respectively. Values given in brackets are from literature as reported in Kassab et al. (1997) The flow conservation in the measured branches of the CA was 96.71 %.

**CONCLUSION**

Calculated coronary arterial velocity and flow correlated well with previously reported values from the literature suggesting that flow determination from 4D CTA is feasible. Additionally, the high flow conservation shows that the calculated values are consistent.

**CLINICAL RELEVANCE/APPLICATION**

The presented technique could provide both anatomical and functional information in diagnostic settings as well as cath labs using existing CT systems to detect pathologies of the coronary arteries.

**SSK03-08  Deep Learning Reconstruction of Non-Contrast Magnetic Resonance Coronary Angiography at 3T Machine**

**PURPOSE**

Dedicated T2 preparation pulse have enabled non-contrast magnetic resonance coronary angiography (MRCA) at 3T system; however, the vascular contrast-to-noise ratio (CNR) is still inadequate for clinical use. The deep learning reconstruction (DLR) is a novel technique to improve the image quality. The purpose of this study was to investigate the effects of DLR on the image quality of 3T non-contrast MRCA.

**METHOD AND MATERIALS**
We enrolled 10 volunteers (2 female, mean age 48 years) with no known coronary artery disease. Non-contrast MRCA was performed on a 3T MR scanner (Galan 3T ZGO, Canon medical) with following parameters: 3D fast FE, TR/TE =5.3/1.9ms, flip angle = 12°, slice thickness = 1.7mm with ECG trigger and real time motion correction. DLR images at moderate level and high level were generated by using dedicated workstation. In the quantitative evaluation, we measured signal-to-noise ratio of 3 coronary vessels (proximal and distal segments). In the qualitative evaluation, the 2 observers graded the vessel visualization and artifacts on a 4-point scale (worst, 1; best, 4).

RESULTS
The CNR (original MRCA) was 31 ± 7 and 16 ± 5 in the proximal and distal vessel, respectively. The corresponding CNR (moderate-level DLR) was 46 ± 9 and 24 ± 10; and the CNR (high-level DLR) was 85 ± 20 and 45 ± 14. The visual scores for overall image quality and image noise were significantly better in DLR images than original images. The vessel sharpness scores were comparable among 3 reconstructions (3.4, 3.8, and 3.8 for original, moderate DLR, and high DLR, respectively). The visual scores for image noise/graininess was significantly better in DLR (2.4, 3.8, and 4.0 for original, moderate DLR, and high DLR, respectively).

CONCLUSION
Non-contrast MRCA at 3T using DLR provides higher CNR without degrading the vessel sharpness.

CLINICAL RELEVANCE/APPLICATION
The deep learning reconstruction technique contributes in improved visualization of coronary arteries in non-contrast MR coronary angiography, enabling noninvasive scrutiny of the heart.

PURPOSE
Currently, transthoracic echocardiography (TTE) remains the most commonly used technique for the identification of LV thrombi. However, not all thrombi are visualized with TTE. Therefore, the purpose of our study was to identify predictors of unsuccessful TTE thrombus visualization and to develop a risk score to stratify which patients may benefit from cardiac magnetic resonance (CMR) to reliably detect or exclude LV thrombus.

METHOD AND MATERIALS
We performed a retrospective search of our CMR database including 10300 patients and identified 118 patients with LV thrombus and a time interval between CMR and TTE of <72h. Univariate logistic regression analysis was used to assess the association between baseline characteristics and TTE parameters with the primary endpoint (i.e. unsuccessful LV thrombus visualization on TTE). Variables with P<0.10 at univariate analysis were included as covariates in the multivariate logistic regression analysis. Receiver-operating characteristic (ROC) curve analysis was performed to examine differences in performance of each variable for prediction of the primary endpoint. A two-sided P-value<0.05 was considered to represent a significant difference.

RESULTS
In multivariate analysis, body mass index (BMI), LV end-diastolic diameter (LVEDD), and mitral valve regurgitation (MVR) were identified as significant predictors of unsuccessful LV thrombus visualization by TTE (all P<0.001). ROC analysis showed BMI >26.9 kg/m², LVEDD >52 mm, and MVR >2/4 to be the optimal cutoff points for prediction of the primary endpoint. The combination of the independent predictors allowed generation of a gradient response risk score of unsuccessful LV thrombus visualization by TTE (0/3 present: 0% missed; 1/3 present: 33.3% missed; 2/3 present: 79.5% missed; 3/3 present: 100% missed) (P<0.001).

CONCLUSION
Individual clinical and TTE parameters can predict the sensitivity of TTE for the successful detection of LV thrombus in heart disease. By using the presented risk score, a cost-effective strategy may be implemented by selectively referring patients to CMR when these risk factors are present.

CLINICAL RELEVANCE/APPLICATION
Clinical and TTE parameters can predict unsuccessful detection of LV thrombus in heart disease. These findings may lead to a cost-effective referral of certain patients to CMR to rule out LV thrombus.
**Purpose**
Aortic stenosis (AS) have a quite proportion of low-flow, low-gradient (LF/LG) AS, defined as small aortic valve area (AVA < 1.0 cm²) but a low mean pressure gradient (PG < 40 mmHg) and low flow (stroke volume < 35 ml/m²). Diagnosis of AS has been based on a valve area, mean PG and a peak flow velocity measured on echocardiography. However, there was a discrepancy between the measured AVA on cardiac CT and degree of AS on echocardiography. The purpose of this study was to evaluate the discrepancy between CT and echocardiography, and show the role of CT to detect LF/LG AS.

### Method and Materials
Between June 2011 and Mar 2016, 465 patients with AS underwent CT for preoperative evaluation of aortic valve replacement. On CT, aortic annulus, AVA and aortic root size were measured. Clinical information including echocardiography findings was retrospectively collected. On echocardiography, severe AS was defined as peak velocity > 4 m/s or mean PG < 40 mmHg. On CT, severe AS was defined as AVA < 1.0 cm². Patients were classified into four groups: Group 1) severe AS on both CT and echocardiography (n = 282); Group 2) Severe AS on CT alone (n = 49); Group 3) Severe AS on echocardiography alone (n = 99); and Group 4) non-severe AS on both CT and echocardiography (n = 35). Echocardiography and CT findings were compared among the groups.

### Results
AVA in both group 1 and 2 were similar (0.8 and 0.8 cm², respectively, P = 0.99). However, in group 2, left ventricular ejection fraction (LVEF) (59.3 vs. 54.1%, P = 0.02) and mean PG (28.5 vs. 28.5 mmHg, P < 0.001) were significantly low compared to those in group 1, suggests LF/LG severe AS. Peak velocity was also smaller in group 2 (5.2 vs. 3.1 m/s, P < 0.001). LV mass index and B-type natriuretic peptide were no significant difference among the four groups.

### Conclusion
In 32% of patients who required AVR due to AS, there was a discrepancy between the measured AVA on CT and degree of AS on echocardiography. Patients who showed peak velocity < 4 m/s or mean PG < 40 mmHg on echocardiography and AVA < 1.0 cm² on CT show significantly lower EF, peak velocity, and mean PG, which suggests characters of LF/LG AS. CT may be useful to detect LF/LG AS.

### Clinical Relevance/Application
Since echocardiography is useful for functional evaluation of LV and CT can accurately measure the AVA, we can accurately evaluate the characteristics of AS using both modalities. The use of two modalities may help to risk stratify AS patients and to make therapeutic decision.
Purpose

To evaluate post-transcatheter aortic valve replacement (TAVR) findings such as thrombosis and leaflet dysfunction using cardiac computed tomography.

Method and Materials

Among 397 post-TAVR patients, 133 patients underwent cardiac CT. After excluding immediate post-TAVR CT, 49 patients (23 CoreValve, 23 Sapien XT, and 3 Sapien 3) with CT obtained more than one month after TAVR were retrospectively reviewed.

Leaflet opening limitation, bioprosthesis thrombosis, leaflet degeneration, and stent eccentricity were analyzed. Baseline immediate and follow-up echocardiography parameters were collected and analyzed.

Results

Median intervals between TAVR and CT was 13 months (range: 9.4 - 24.5 months). Minimal subvalvular rim-like soft tissue thickening (n= 27, 55%) and mild thickening of leaflets (n=2, 4%) are detected, but the patients are asymptomatic without hemodynamic disturbance. Leaflet opening limitation is noted in 11 (22%, 7 mild, 3 moderate, and 1 severe reduction) patients, however, there was no correlation with echocardiography parameters. TAV thrombosis is noted in 9 (18%) patients. In the patients with TAV thrombosis, transvalvular peak velocity (2.9 vs. 2.5 m/sec) and pressure gradient (20.7 vs. 13.6 m/sec) are higher than the others, but without statistical significance (P<0.05). One patient who showed highest peak velocity and pressure gradient on echocardiography (5.4 m/sec and 71 mmHg) had extensive subvalvular and valvular soft tissue thickening on CT even though she have managed with intense anticoagulation. One infective endocarditis is occur. The smaller the size of the stent lumen at the valve level, the more the peak velocity and pressure gradient increases (r=-0.4, P=0.008).

Conclusion

Leaflet thrombosis, subvalvular soft tissue thickening and leaflet opening limitation following TAVR is not uncommon findings in patients who performed cardiac CT. Cardiac CT can demonstrate post-TAVR findings such as subvalvular soft tissue, valve thrombosis, leaflet opening limitation and stent lumen size.

Clinical Relevance/Application

Although the majority of patients who present leaflet thrombosis, subvalvular soft tissue thickening or leaflet opening limitation following TAVR show subclinical conditions without hemodynamic disturbance on echocardiography, follow-up cardiac CT may help to detect early complications of TAVR.
Mitrval annular dimensions were significantly higher in the PMR group, followed by FMR and control groups, with circumference (144±11 vs. 131±14 vs. 117±48mm), PSA (153±247 vs. 1229±45 vs. 1005±142mm2), A-P diameter (38±4 vs. 35±5 vs. 32±2mm), and AL-PM diameter (47±4 vs 41±4 vs. 39±3mm) (all p<0.001). Notably, different patterns were observed among the three groups regarding the change in annular dimensions across cardiac phases, with FMR maintaining relatively similar size while control and PMR both had substantial size changes, but with maximal and minimal sizes at different cardiac phases. However, no statistically significant difference was demonstrated for annular ellipticity among control versus pathological groups (p>0.01).

CONCLUSION

Multiphase cardiac CT affords assessment of mitral annular dynamicity in response to various types of MV disease. The dramatic variability in annular dimensions across the cardiac cycle demonstrates the significance of obtaining multiphasic 3D measurements.

CLINICAL RELEVANCE/APPLICATION

Multiphase ECG-gated cardiac CT offers dynamic, pre-procedural evaluation of complex 3D mitral valve geometry for catheter-guided prostheses in patients with various types of mitral valve disease.

SSK04-04 Differentiation of Pannus From Other Prosthetic Valve Abnormalities Using Computed Tomography Texture Analysis

Wednesday, Nov. 28 11:00AM - 11:10AM Room: S103AB

Participants
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PURPOSE

The purpose of this study was to determine whether quantitative computed tomography (CT) texture analysis features can differentiate the cause of prosthetic valve obstruction (PVO) in patients who had undergone prosthetic valve replacement.

METHOD AND MATERIALS

We retrospectively included 46 subprosthetic masses in 39 patients who were clinically suspected prosthetic valve dysfunction and underwent cardiac CT scan from March 2010 to December 2017. The cause of PVO was assessed by redo-surgery and follow-up imaging findings as standard reference, and classified as pannus, thrombus or vegetation. CT texture analysis was performed with drawing region-of-interests of subprosthetic mass using an in-house texture analysis software and features such as first-order statistics, size and volume, and gray-level co-occurrence matrix (GLCM) features were extracted. Features on texture analysis were compared between two groups (pannus vs. thrombus or vegetation) using Mann-Whitney U test. Logistic regression analysis was performed to investigate association between quantitative CT features and pannus formation.

RESULTS

Of 46 subprosthetic masses, there were 19 cases with pannus, 14 cases with thrombus, and 13 cases with vegetation. Patients with pannus tended to be female, and had higher mean and standard deviation of CT attenuation, percentile value of the cumulative histogram (Perc25, 50, 75, 90, 95), and GLCM features (moments and contrast), and smaller volume, with statistical significance (P<0.05). On multivariate logistic regression analysis, mean CT attenuation (OR: 5.71; 95% CI: 0.48, 68.43; p=0.1691), volume (OR: 5.52; 95% CI: 0.88, 34.99; p=0.068), GLCM moments and GLCM contrast (OR: 6.00; 95% CI: 0.72, 50.40; p=0.0987) and OR: 12.07; 95% CI: 1.31, 110.90; p=0.0277) of subprosthetic mass were significantly associated with pannus.

CONCLUSION

Quantitative features on CT texture analysis may help differentiating pannus from thrombus or vegetation in patients with suspected PVO.

CLINICAL RELEVANCE/APPLICATION

Quantitative CT texture analysis can differentiate pannus from other causes of prosthetic valve obstruction and may diminish the subjectivity of visual analysis.

SSK04-05 CT Virtual Endoscopic Findings of Bicuspid Aortic Valve in Patients with Severe Aortic Stenosis: Comparison with Surgical Diagnosis

Wednesday, Nov. 28 11:10AM - 11:20AM Room: S103AB

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PURPOSE

CT has been known to have high diagnostic accuracy for bicuspid aortic valve (BAV). However, CT findings of BAV remain unclear.
The aim of our study was to evaluate diagnostic characteristics of CT findings for BAV compared with surgical diagnosis as the reference standard.

METHOD AND MATERIALS

This retrospective study included 112 consecutive patients with severe aortic stenosis who underwent preoperative cardiac CT, followed by surgical aortic valve replacement (57% woman, mean age, 70 years [range, 27-92]). All CT images were acquired using retrospective ECG-gated helical scan, from the aortic arch to the heart. Optimal stationary systolic and diastolic phase images were reconstructed at the slice thickness of 0.5 mm, and surgical-view virtual endoscopic images were reconstructed on a workstation. CT findings included shape of orifice (oval or the letter ‘Y’) and the number of leaflet (2 or 3) on systolic images, and balance of leaflet size (central angle of => 150° or 120-149° in the largest leaflet) and the number of commissure (2 or 3) on diastolic images. For each CT findings, oval orifice, 2 leaflets, central angle of >= 150° or 2 commissures were defined as BAV.

RESULTS

BAV was surgically found in 37% (41/112) of patients. Accuracy, sensitivity, specificity and area under the curve (AUC) (95% confidence interval) for the detection of BAV were as follows; number of leaflets, 0.86 (0.80-0.87), 0.98 (0.91-1.00), 0.79 (0.69-0.83) and 0.88 (0.82-0.93); orifice shape, 0.93 (0.87-0.96), 0.93 (0.82-1.00) 0.93 (0.87-0.99) and 0.93 (0.86-0.96); central angle, 0.92 (0.86-0.95), 0.76 (0.59-0.88), 0.98 (0.95-1.00) and 0.87 (0.79-0.93); and number of commissures, 0.87 (0.81-0.87), 0.63 (0.46-0.78), 1.00 (1.00-1.00) and 0.82 (0.73-0.88), respectively. Although there was no difference in accuracy (p = 0.147 by Cochran’s Q test), sensitivity of the number of commissure or specificity of number of leaflet were the lowest among the CT findings (adjusted p < 0.05 for all by post-hoc Dunn’s test with Bonferroni correction, respectively). AUC of number of commissure was lower than orifice shape and central angle (p < 0.05 for both by DeLong’s test).

CONCLUSION

Although CT findings have high accuracy for detection of BAV, number of commissure showed lower sensitivity and AUC, and number of leaflet showed lower specificity.

CLINICAL RELEVANCE/APPLICATION

Knowledge of morphological CT characteristics of BAV may help diagnosis in patients with severe aortic valve stenosis.

SSK04-06 3D Printing of the Aortic Annulus Based on Cardiovascular Computed Tomography: Preliminary Experience in Pre-Procedural Planning for Aortic Valve Sizing

Wednesday, Nov. 28 11:20AM - 11:30AM Room: S103AB

Participants

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PURPOSE

To determine reliability and reproducibility of measurements of aortic annulus in 3D models printed from cardiovascular computed tomography (CCT) images.

METHOD AND MATERIALS

Retrospective study on the records of 20 patients who underwent aortic valve replacement (AVR) with pre-surgery annulus assessment by CCT and intra-operative sizing by Hengar dilators (IOS). 3D models were fabricated by fused depositions modelling of thermoplastic polyurethane filaments. For each patient, two 3D models were independently segmented, modelled and printed by two blinded "manufacturers": a radiologist and a radiology technician. Two blinded cardiac surgeons performed the annulus diameter measurements by Hegar dilators on the two sets of models. Matched data from different measurements were analyzed with Wilcoxon test, Bland-Altmann plot and within-subject ANOVA.

RESULTS

No significant differences were found among the measurements made by each cardiac surgeon on the same 3D model (p=0.48) or on the 3D models printed by different manufacturers (p=0.25); also, no intraobserver variability (p=0.46). The annulus diameter measured on 3D models showed good agreement with the reference CCT measurement (p=0.68) and IOH sizing (p=0.11). Time and cost per model were: model creation 10–15 min; printing time 60 min; post-processing 5min; material cost 1 euro.

CONCLUSION

3D printing of aortic annulus can offer reliable, not expensive patient-specific information to be used in the pre-operative planning of AVR or TAVI.

CLINICAL RELEVANCE/APPLICATION

3D models of aortic annulus printed from CCT may offer a reliable, not expensive, patient-specific pre-operative planning opportunity: they provide the final user with a unique interactive platform for both visual and tactile experiences, which are critical
for simulation of the procedure, but are not available in imaging data per se.

**SSK04-07  Improving the Diagnostic Performance of 18F-FDG PET/CT in Prosthetic Heart Valve Endocarditis**

**Wednesday, Nov. 28 11:30AM - 11:40AM Room: S103AB**

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**PURPOSE**

18F-Fluorodeoxyglucose (FDG) Positron-Emission Tomography/Computed Tomography (PET/CT) was recently introduced as a new tool for the diagnosis of prosthetic heart valve (PV) endocarditis (PVE). Previous studies reporting a modest diagnostic accuracy may have been hampered by unstandardized image acquisition and assessment, as well as several confounders. The aim of this study was to improve the diagnostic performance of FDG PET/CT in patients suspected of PVE by identifying and eliminating possible confounders, using both visual and standardized quantitative assessments.

**METHOD AND MATERIALS**

In this multicentre study, 160 patients with a PV who underwent FDG PET/CT for suspicion of PVE, as well as 77 patients with a PV who underwent FDG PET/CT for other indications (negative control group), were included. Their scans were reassessed by two independent observers blinded to all clinical data, both visually and quantitatively on EARL reconstructions. Confounders were identified using a binomial regression model, and subsequently eliminated.

**RESULTS**

Visual assessment of FDG PET/CT had a sensitivity/specificity/PPV/NPV for PVE of 74%/91%/89%/78%, respectively. Low inflammatory activity (CRP <40mg/L) at the time of imaging and use of surgical adhesives during PV implantation were significant confounders, while recent valve implantation was not. After elimination of significant confounders, diagnostic performance values of the visual assessment increased to 91%/95%/95%/91%. As a semi-quantitative measure of FDG uptake, an EARL-standardized SUVratio of >=2.0 was a 100% sensitive and 91% specific predictor of PVE.

**CONCLUSION**

Both visual and quantitative assessment of FDG PET/CT have a high diagnostic accuracy in patients suspected of PVE. FDG PET/CT should be implemented early in the diagnostic work-up to prevent negative confounding effects of low inflammatory activity (e.g. due to prolonged antibiotic therapy). As a quantitative measure of FDG uptake, an EARL-standardized SUVratio of >=2.0 is a 14 100% sensitive and 91% specific predictor of PVE. Recent valve implantation was not a significant predictor of false positive interpretations, but surgical adhesives used during implantation were.

**CLINICAL RELEVANCE/APPLICATION**

FDG PET/CT should be implemented early in the diagnostic work-up to prevent negative confounding effects of low inflammatory activity.

**SSK04-08  Aortic Regurgitation in Hypertrophic Cardiomyopathy: A Cardiac Magnetic Resonance Study**

**Wednesday, Nov. 28 11:40AM - 11:50AM Room: S103AB**

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**PURPOSE**

We sought to investigate the prevalence, mechanism and risk factors of AR in patients with HCM by cardiac magnetic resonance(CMR).
METHOD AND MATERIALS
This is a retrospective study of 105 consecutive patients (49±16 years, 70% male) with HCM who underwent CMR between April to November, 2017. Cardiac morphological, functional parameters and AR were evaluated by multi-plane cine images and velocity-encoded phase contrast images. Patients were divided into 2 groups by AR. The clinical and CMR characteristics were compared between the 2 groups, and predictors of AR assessed on multivariable logistic regression analysis.

RESULTS
AR was identified in 38 (36%) HCM patients including 25 (66%) with left ventricle outflow tract obstruction (LVOTO). AR was also more prevalent in obstruction group than that in non-obstruction group (52% vs. 23%, \( p=0.002 \)). Patients with AR showed older age (58± 11 vs. 45±16 years, \( p<0.001 \)), the higher prevalence of hypertension, mitral regurgitation (MR) and aortic valve thickening (55% vs. 33%, \( p=0.03 \); 90% vs. 61%, \( p=0.006 \) and 40% vs. 9%, \( p<0.001 \), respectively). The distance of interventricular septum that protruded into the LVOT (D1), anterior mitral leaflet (AML) and left atrial diameter were greater and LVOT effective width (D3) were shorter in patients with AR than without it (13.5± 4.4 vs. 10.6±4.0 mm, \( p=0.001 \); 25.5± 3.6 vs. 23.5±4.1mm, \( p=0.013 \) and 43.6± 8.6 vs. 39.1± 8.4mm, \( p=0.01 \); 10.2±5.3 vs. 13.7±5.9mm, \( p=0.003 \), respectively). On multivariable logistic regression analysis, the independent risk factors of AR were LVOTO and age.

CONCLUSION
This study has demonstrated that AR is not an uncommon consequence secondary to HCM. Age and LVOTO are the most probably risk factors of this pathophysiology consequence.

CLINICAL RELEVANCE/APPLICATION
(AR is a quite common comorbidity of HCM especially in patients with LVOTO. An earlier and better control of blood pressure and relieving LVOTO are required as early as possible to delay the progress of aortic valvular degeneration.)

SSK04-09 T1 Mapping as a Predictor for Persisting Valvular Cardiomyopathy in Patients with Chronic Aortic Regurgitation After Aortic Valve Repair
Wednesday, Nov. 28 11:50AM - 12:00PM Room: S103AB

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PURPOSE
Left ventricular (LV) dysfunction is associated with poor prognosis in patients presenting with chronic aortic regurgitation. Unfortunately, LV-dysfunction often persists even after successful aortic valve (AV) repair. We aimed to evaluate the value of native T1 mapping by cardiac MRI as a predictor of valvular cardiomyopathy in patients with severe aortic regurgitation.

METHOD AND MATERIALS
31 consecutive patients (mean age 49.5±11.5 years, 52% men) with severe bicuspid (n=18) or tricuspid (n=13) aortic valve regurgitation and without previous history of coronary artery disease underwent 1.5 Tesla cardiac MR imaging. Native T1 mapping was performed using a modified Look-Locker inversion-recovery (MOLLI) sequence for quantification of diffuse interstitial myocardial fibrosis prior to AV repair and correlated with echocardiographic LV parameters before and after surgery.

RESULTS
Mean native T1 relaxation time of myocardium was 1025±44 ms (range: 898-1109 ms). There was no significant correlation between native T1 and preoperative LVEF (\( r=-0.1, \ p=0.6 \)), LVEDD (\( r=-0.2, \ p=0.4 \)), LVEDV (\( r=-0.03, \ p=0.9 \)) and regurgitation fraction (\( r=-0.17, \ p=0.6 \)). Fourteen patients (45%) had a postoperative decrease in LVEF more than 10% as compared to preoperative LVEF values. These fourteen patients showed significantly longer preoperative native T1 as compared to native T1 of patients with preserved postoperative LVEF (1056 ± 32 ms vs. 1019 ± 40 ms, \( p=0.03 \)).

CONCLUSION
Native T1 mapping might be a promising predictor of postoperative LVEF decrease after AV repair for chronic severe aortic regurgitation.

CLINICAL RELEVANCE/APPLICATION
T1 mapping before aortic valve repair may guide and optimize aortic valve repair surgery in the future.
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Sub-Events

SSK06-01  Gastrointestinal Keynote Speaker: Rectal Cancer Imaging

Participants
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SSK06-02  Feasibility Study of Dual-Energy Spectral CT for Differentiating Rectal Cancers with and Without Vascular Invasion

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PURPOSE
The purpose of this study was to investigate the potential value of dual-energy CT (DECT) in differentiating vascular invasion rectal cancer from non-vascular invasion rectal cancer.

METHOD AND MATERIALS
90 consecutive untreated patients (56 men, 34 women; mean age, 62.95 years) were enrolled and underwent DECT before biopsy. DECT image metrics including iodine (water) concentration (IC) and effective atomic number (eff-Z) were measured. Data were analyzed statistically by the independent-samples t test and were correlated with pathological findings. The receiver operating characteristics (ROC) analysis was also carried to evaluate the efficacy of these parameters for differentiating rectal cancers with or without vascular invasion.

RESULTS
Pathological results showed that there were 41 vascular invasion rectal cancer and 49 non-vascular invasion rectal cancer. The IC values of the vascular invasion rectal cancer in the venous phase were 2.42±0.55mg/ml, significantly higher than that of the non-vascular invasion rectal cancer with 2.13±0.52mg/ml (P<0.05). The eff-Z of the vascular invasion rectal cancer in the venous phase was 17.85±3.731, which was also higher than that of the non-vascular invasion rectal cancer with 16.19±3.638 (P<0.05). However, there were no significant differences in those parameters in the arterial phase (P>0.05). Based on the ROC curves, the optimal cut off value for the IC was 2.25mg/ml which yielded a sensitivity of 70.7% and a specificity of 67.3% for differentiating rectal cancers with or without vascular invasion.

CONCLUSION
It is feasible to differentiate a vascular invasion rectal cancer from the non-vascular invasion rectal cancer using dual energy CT, especially the iodine concentration measurement in the venous phase.

CLINICAL RELEVANCE/APPLICATION
Dual energy CT appears to be an efficient CT technique for a possible method to evaluate vascular or non-vascular invasion of rectal cancer.

SSK06-03  Low Anterior Resection Syndrome (LARS): Imaging Characteristics of Rectal Cancer and Anorectal Anatomy
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PURPOSE
To identify risk factors associated with LARS severity based on the imaging characteristics of rectal cancer and anorectal anatomy defined by magnetic resonance imaging (MRI) pre-operation.

METHOD AND MATERIALS
Between August 2016 and August 2017, patients who had pathological-proved rectal cancer and underwent low anterior resection (LAR) were collected in this retrospective study. Patients need to be followed-up at least 9 months after operative. All patients were divided into non-major LARS group and major LARS group based on LARS score. The tumor morphological characteristics were measured and recorded as the following: the distance between tumor and anal margin, the distance between tumor and puborectal muscle, the length of tumor involvement, the tumor stage, the lymph nodes stage, and circumferential resection margin. In addition, morphological characteristics of rectal-anal canal were measured and recorded, including ano-rectal angle (ARA), levato- anal angle (LAA), levator plate angle, thickness of internal anal sphincter, thickness of rectal wall (mm), thickness of obturator internus (mm), thickness of external anal sphincter (mm), thickness of internal anal sphincter (mm), thickness of puborectal muscle (mm), and thickness of iliolumbar muscle (mm). The differences of measurement between non-major and major LARS groups were analyzed by t-test and x2-test.

RESULTS
Thirty-three patients were enrolled in the final cohort including 22 patients (66.7%) with non-major LARS (score 0-20) and 11 patients (33.3%) with major LARS (score 30-42, n=11). The distances of tumor and anal margin and the distance of tumor and puborectal muscle of patients with major LARS was significantly lower than patients with non-major LARS (<= 7 cm, P = 0.017 and <= 5 cm P=0.009). The LAA and the ARA of patients with major LARS were larger than patient with non-major LARS and significances were seen (>=100°, P=0.049 and >=125°, P=0.025).

CONCLUSION
The lower tumor, larger ARA and LAA was identified as risk factors may be associated with major LARS for patients with rectal cancer after Low Anterior Resection.

CLINICAL RELEVANCE/APPLICATION
Identification of risk factors associated with LARS severity based on the imaging characteristics of rectal cancer and anorectal anatomy defined by MRI pre-operation may help surgeons change the strategy of operation to avoid LARS and, therefore, the life quality of patients may be improve after surgery.

SSK06-04 Preoperative Staging for Rectal Cancer: Comparison of Whole Body MR-PET and Standard Protocol

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PURPOSE
To measure the concordance of rectal cancer clinical staging between whole body MR-PET including dedicated liver and rectal MRI (WB MR-PET) and the current standard care protocol (chest/abdominopelvic CT and rectal MRI).

METHOD AND MATERIALS
This IRB-approved prospective study enrolled 71 patients (M:F = 43:28, mean age 60.9 years) with newly diagnosed mid to lower rectal cancer. Clinical staging and effective dose were compared between standard protocol and WB MR-PET protocol according to AJCC 7th staging. In addition, incidence of further study recommendation and incidental findings were recorded.

RESULTS
Regarding with the presence of metastasis, two protocols were consistent in 67.6% (48/71), and discordant in 4.2% (3/71). In the remaining 28.2% (20/71), standard protocol did not conclude presence or absence of metastasis or extent of metastasis (IVA or IVb) due to indeterminate lesions in lung, liver, or retroperitoneal lymph nodes. In these patients, standard protocol recommended followings for lesion characterization: chest CT follow up in 20% (4/20), liver MRI in 20% (4/20), PET-CT in 45% (9/20) and liver MRI with chest CT follow up for multiple indeterminate lesions in 15% (3/20). In these 20 patients, WB MR-PET protocol suggested presence or absence of metastasis in 25% (5/20) and 75% (15/20), respectively. Compared with clinical follow-up results within 6 months, 14 of 15 patients with WB MR-PET negative findings did not show metastasis. In 5 patients with WB MR-PET positive
findings, all liver lesions were correctly classified, but one false positive and one false negative cases for lung nodules were observed. There were 13 cases with incidental findings including incidentally detected tonsillar cancer with neck lymph node metastasis (n=1) and incidentally detected Warthin's tumor in the parotid gland (n=1). Effective dose was significantly lower in WB MR-PET than standard protocol (6.18±1.06 mSv vs. 10.70±5.45 mSv, P<0.0001).

**CONCLUSION**

WB MR-PET protocol showed low discrepancy rate with the standard protocol for metastasis evaluation in patients with rectal cancer and it served as problem-solving modality for indeterminate lesions.

**CLINICAL RELEVANCE/APPLICATION**

Compared with the standard protocol, WB MR-PET with dedicated rectal and liver MRI may facilitate the staging work-up with less inconvenience in a short period.

**SSK06-05 Application of Dynamic Dual-Energy CT Imaging In Colorectal Cancer for Assessing the Correlation Between Blood Perfusion and Iodine Uptake on 320-Row Multidetector CT**

Wednesday, Nov. 28 11:10AM - 11:20AM Room: S502AB

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**PURPOSE**

To evaluate the characteristics of blood perfusion and iodine uptake in colorectal cancer using dynamic dual-energy imaging on 320-row CT.

**METHOD AND MATERIALS**

29 patients with colonic adenocarcinoma diagnosed by colonoscopy were enrolled. Each patient was scanned for 10 dual-emerge acquisition phases, with 3-second intervals for 1 to 7 phases, 5-second intervals for 8 to 10 phases, and total scanning time was 53s. Iodine map and perfusion map were generated, and iodine uptake peak (IUP), arterial flow (AF, ml/min/100ml), blood volume (BV, ml/100ml) and permeability (ml/min/100ml) of tumor were measured.

**RESULTS**

The IUP, AF, BV and permeability of tumor were 71.46±2.19, 158.26±80.40, 17.33±17.80, 60.14±20.59, respectively. The IUP of tumor was significantly associated with the AF (r=0.440, P<0.05) and BV (r=0.382, P<0.05) There was no significant correlation between IUP and permeability(P>0.05). The average DLP of dynamic dual-energy CT imaging was 1104 mGy•cm with an effective radiation dose of 16.56 mSv.

**CONCLUSION**

Dynamic dual-energy CT imaging can generate dynamic iodine map and perfusion map at the same time. The correlations of iodine uptake peak and perfusion parameters AF and BV of colorectal cancer are significant.

**CLINICAL RELEVANCE/APPLICATION**

Dynamic dual-energy CT imaging of colorectal cancer provides iodine uptake and perfusion data in just one scan. It can be used to evaluate the hemodynamic characteristics of colorectal cancer and provide more diagnostic information for the clinical doctors.

**SSK06-06 Predictors of Surgical Outcome, DFS and OS in Mid and Low Rectal Cancer Undergoing Laparoscopic Resection After Neoadjuvant Chemoradiation Therapy: Impact of Pretreatment and Re Staging MRI**

Wednesday, Nov. 28 11:20AM - 11:30AM Room: S502AB

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**PURPOSE**

To assess (1) the impact of restaging MRI as a predictor of surgical difficulties and survival and (2) the diagnostic accuracy of re-staging MRI against final pathological assessment.
METHOD AND MATERIALS

Between 1/2010 and 1/2016, patients with histologically proven locally advanced (AJCC stages I to IIIc) rectal cancer of the mid or lower third of the rectum, who underwent MRI including DWI before (pre-treatment MRI) and after neo-adjuvant chemoradiotherapy (re-staging MRI) followed by either elective laparoscopic anterior resection (LAR) with total mesorectal excision or laparoscopic abdominoperineal (L-APR) resection were included. Pelvimetry was performed on pre-treatment MRI providing transverse, sagittal, angles and surface measures. On pre and post-treatment MRI, T stage, N stage and EMVI status were assessed. On re-staging MRI, the MR tumor regression grade score (mrTRG) was determined. Sensitivity, specificity, PPV and NPV of restaging MRI for mrTRG prediction were assessed. Binary, multimodal, or linear regression analyses were performed to assess predictors of surgical difficulties (i.e., estimated on operative time, blood loss, and conversion rate) and surgical success (i.e., postoperative complications and successful resection rate).

RESULTS

170 patients (mean age 59±13) were included. Tumor volume and tumor height on re-staging MRI were associated respectively with operative time and blood loss. Conversion was predicted by tumor volume, interischial distance and pubic tubercle height. A circumferential resection margin> 2 mm was found as a protector of postoperative complications and unsuccessful resection. The quality of the surgical resection was found as a predictor of overall and disease-free survival. On re-staging MRI, the PPV of ymrT for ypT0 stage, ypT1/T2 stages, and ypT3/T4 staging was 83%, 55.7% and 68.8% respectively. The PPV of ymrN for ypNO and ypN+ staging was 87.7% and 62.5% respectively. The specificity, PPV, and NPV of ymrEMVI was respectively 68.4%, 78.8%, 28.8% and 95.2%. The sensitivity and specificity of tumor regression grade (mrTRG) 1 to identify pathologic complete response was 76.9% and 89.3%, respectively, with a PPV of 68.2% and NPV of 92.8%.

CONCLUSION

Pelvimetry and re-staging MRI can predict outcome in rectal cancer.

CLINICAL RELEVANCE/APPLICATION

Pelvimetry and re-staging MRI may be useful to predict surgical difficulties and surgical outcomes.

SSKG0-07 The Tram Track Sign and the Railroad to Complete Response after Neoadjuvant Therapy in Rectal Cancer

Wednesday, Nov. 28 11:30AM - 11:40AM Room: S502AB

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PURPOSE

To measure the diagnostic performance of the tram track sign for the identification of sustained complete response (SCR) after neoadjuvant therapy on re-staging magnetic resonance (MR) T2-weighted imaging (T2-WI) in patients with locally advanced rectal cancer.

METHOD AND MATERIALS

 Institutional review board approval was obtained for this retrospective study and patient informed consent requirement was waived. Fifty-eight consecutive patients with locally advanced rectal cancer who underwent neoadjuvant therapy on re-staging pelvic MRs and analyzed 3 features: a distinct morphologic pattern of tumour response - the tram track sign (TTS) - characterized by the presence of 2 hypointense rims at previous tumour location separated by a variable amount of homogeneously intermediate or high signal intensity on T2-WI; the relative proportion of intermediate signal intensity on T2-WI; and the relative proportion of high signal intensity on high b-value diffusion-weighted images (DWI). Endoscopic response grading from the same timepoint was retrieved. Chi-Square test was employed in search for any associations between SCR and TTS, T2-WI, DWI or endoscopy. Interrater agreement of MR parameters was estimated using Cohen’s Kappa statistic (k).

RESULTS

TTS was significantly associated with SCR, with specificity=0.97/0.97, sensitivity=0.52/0.64, PPV=0.93/0.94, NPV=0.73/0.78 and AuROC=0.78/0.83, for observers 1/2, respectively. DWI was significantly associated with SCR for observer 2, with specificity=0.76, sensitivity=0.60, PPV=0.65, NPV=0.71 and AuROC=0.69. No significant differences were found for T2-WI or endoscopy. Interobserver agreement was substantial for TTS (k=0.69), moderate for DWI (k=0.46) and poor for T2-WI (k=0.17).

CONCLUSION

The tram track sign is a specific and reliable tool for the early identification of SCR after neoadjuvant therapy in rectal cancer. Its diagnostic performance exceeds that of endoscopy and conventional T2-WI and DWI assessment.

CLINICAL RELEVANCE/APPLICATION

The tram track sign may outperform standard T2-WI, DWI and endoscopic assessment in the early identification of sustained complete response after neoadjuvant therapy in rectal cancer.

SSKG0-08 Diffusion-Weighted MR-Volumetry and High-Resolution MR-Volumetry Association with Lymphovascular Invasion and N-Stages in Resectable Rectal Cancer

Wednesday, Nov. 28 11:40AM - 11:50AM Room: S502AB
Participants
Hao Liu, Chengdu, China (Abstract Co-Author) Nothing to Disclose
Hang Li, Chengdu, China (Abstract Co-Author) Nothing to Disclose
Xiao-Li Chen, Chengdu, China (Abstract Co-Author) Nothing to Disclose
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Purpose: To determine whether diffusion-weighted imaging (DWI)-volumetry and high-resolution T2-weighted imaging (T2WI) MR-volumetry could predict lymphovascular invasion (LVI) and N-stages in resectable rectal cancer.

Method and Materials
Materials & Methods: 50 consecutive patients with rectal cancer who underwent radical surgery in 1-week after DWI and high-resolution T2WI were retrospectively identified. Gross tumor volume (GTV) was evaluated on DWI and high-resolution T2WI. Univariate and multivariate analyses were performed to determine whether GTV could predict LVI and lymph node metastasis (LNM). Mann-Whitney U test was performed to compare GTV among N-stages. Cutoffs of GTV were investigated using area under the receiver operating characteristic curve (AUC) analysis for predicting LVI and N-stages.

Results
Results: DWI-GTV and T2WI-GTV increased with LVI (r=0.750 and 0.710, P<0.0001, respectively) and increasing of N stage (r=0.780 and 0.755, P<0.0001, respectively). Univariate analysis showed DWI-GTV and T2WI-GTV could predict LVI (P<0.0001). Multivariate analyses indicated only DWI-GTV as an independent risk factor of LVI (P=0.005, odds ratio=1.207) and LNM (P=0.005, odds ratio=1.420). The Mann-Whitney U test showed DWI-GTV and T2WI-GTV could distinguish N0 from N1, N0 from N1-2, N0-1 from N2 (P<0.0001). DWI-GTV could predict LVI (cutoff, 11.05 cm³; AUC, 0.899), and distinguish N0 from N1 (cutoff, 10.86 cm³; AUC, 0.865), N0 from N1-2 (cutoff, 10.46 cm³; AUC, 0.934), N0-1 from N2 (cutoff, 17.7 cm³; AUC, 0.932). T2WI-GTV could predict LVI (cutoff, 13.74 cm³; AUC, 0.877), and distinguish N0 from N1 (cutoff, 12.25 cm³; AUC, 0.827), N0 from N1-2 (cutoff, 13.36 cm³; AUC, 0.911), N0-1 from N2 (cutoff, 20.43 cm³; AUC, 0.927).

Conclusion
Conclusion: High-resolution T2WI-GTV and DWI-GTV of resectable rectal cancer were correlated well with the LVI and LNM, but the latter is a potentially more promising non-invasive technique that can help predict the preoperative LVI and distinguishing N-stages.

Clinical Relevance/Application
Diffusion-weighted MR-volumetry of resectable rectal cancer are correlated well with the lymphovascular invasion and lymph node metastasis, and is recommended as a potentially more promising non-invasive technique for predicting the preoperative lymphovascular invasion and distinguishing N-stages.

SSK06-09 Comparison of Polyp Surface Tagging Performance of Barium plus Diatrizoate Meglumine/Diatrizoate Sodium Solution versus Barium plus Iohexol during CT Colonography

Method and Materials
Purpose: To determine whether diffusion-weighted imaging (DWI)-volumetry and high-resolution T2-weighted imaging (T2WI) MR-volumetry could predict lymphovascular invasion (LVI) and N-stages in resectable rectal cancer. The purpose of this study is to investigate differences in surface tagging performance of barium when combined with either diatrizoate meglumine/diatrizoate sodium solution (DM-DS) versus iohexol.

Method and Materials
A retrospective review was conducted of 338 polyps detected at CTC with two different tagging regimens: barium plus either DM-DS or iohexol. The degree of coating of each polyp was graded on a 0-4 scale (no coating to heavy coating) and correlated to polyp histologic subtype and tagging agent. Polyp histology was classified into: hyperplastic, sessile serrated or non-serrated adenoma. Performance of coating scores were analyzed with univariate logistic regression and Wilcoxon rank sum tests.

Results
338 polyps were included, 255 tagged with DM-DS and 83 with iohexol. Across all polyps, coating score of SSA (3/2) was significantly higher than in NSA (1±3) (p<0.0001). However, the coating score was only significantly higher for SSA compared with NSA within the DM-DS group (3±2 versus 1±4) (p<0.0001). No statistical difference was seen for the iohexol group (3±1 versus 1±3) (p=0.0603). Using all polyps (and in sub-analysis of DM-DS and iohexol groups) there was a statistically significant difference in tagging of SSA (N=70) versus benign HP (N=71) (p<0.0001). Of note, there is a significantly higher percentage of serrated adenomas compared with all adenomas (30.8%, 61/198) detected in the DM-DS group compared with iohexol group (15.3%, 9/59).
CONCLUSION

CT colonography using both an iodine and barium oral tagging regimen allows for detection of polyps by the presence of surface tagging. We demonstrated that DM-DS demonstrates a significantly higher coating score of serrated adenomas when compared with non-serrated adenomas. Although a similar difference was seen for iohexol, it was not statistically significant. Of concern, there is a significantly higher percentage of serrated adenomas (as compared to all adenomas) detected in the DM-DS group. This may suggest a lower sensitivity for serrated adenomas with iohexol.

CLINICAL RELEVANCE/APPLICATION

Combined with barium, DM-DS results in greater surface tagging of serrated compared with nonserrated adenomas. Although no difference in tagging was seen, Iohexol resulted in lower SSA detection.

Honored Educators

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**Gastrointestinal (Dual-Energy CT Techniques)**

Wednesday, Nov. 28 10:30AM - 12:00PM Room: S404CD

**SSK08-01** Application of Dual-Energy Spectral CT in the Quantitative Study of Blood Flow in Cirrhotic and Healthy Livers

**Participants**
- Bhavik N. Patel, MD, MBA, Stanford, CA (Moderator) Nothing to Disclose
- Lakshri Ananthakrishnan, MD, Irving, TX (Moderator) Nothing to Disclose
- Priya R. Bhosale, MD, Bellaire, TX (Moderator) Nothing to Disclose

**Method and Materials**
30 patients with liver cirrhosis diagnosed clinically were enrolled as the study group while 30 abdominal patients whose liver and portal vein enhancement examination were normal as a control group. All patients underwent Spectral CT imaging and iodine-based material decomposition (MD) images were reconstructed. The iodine concentration (IC) was measured in five liver lobes (Caudate, left lateral, left inner, right anterior and right posterior) in both the arterial phase (AP) and portal venous phase (VP) on the iodine-based MD images. The average and total iodine concentrations of the liver were calculated, as well as the arterial iodine fraction (AIF = ICAP/ICVP) and the portal venous iodine concentration (PVIC = ICVP - ICAP). These parameters between the two groups were statistically compared by using independent sample t test.

**Results**
The iodine concentrations in the five liver lobes in patients with liver cirrhosis were the same in AP (P > 0.05), but the iodine concentrations of study group in portal venous phase were statistically lower than those of the control group (P < 0.05). The average IC (6.02±2.12mg/ml) and total IC (33.74±10.84mg/ml) in the liver parenchyma in AP of liver cirrhosis were statistically the same as those in the control group (5.85±1.79 and 33.04±9.28mg/ml) (P > 0.05); while the average IC (19.42±3.28mg/ml) and the total IC (99.83±16.65mg/ml) in VP of liver cirrhosis were lower than those in the control group (22.82±3.83 and 117.27±19.45mg/ml) (P < 0.05) (Table 1). The AIF values were the same for the two groups, while the portal venous iodine concentrations in liver cirrhosis were lower than the control group (P < 0.05) (Table 2).

**Conclusion**
The material decomposition technology in Spectral CT can be used to assess the change and difference of blood flow between liver cirrhosis and healthy liver.

**Clinical Relevance/Application**
The material decomposition technology in Spectral CT may be used to provide more evidence for early diagnosis of liver cirrhosis.

**SSK08-02** Influence of Radiation Dose on Quantitative Tumor Measurements Using a Dual-Source, Single-Energy CT Acquisition

**Participants**
- Mathias Meyer, Durham, NC (Presenter) Researcher, Siemens AG; Researcher, Bracco Group
- Federica Vernuccio, MD, Palermo, Italy (Abstract Co-Author) Research support, Siemens AG
- Fernando Gonzalez, Santiago, Chile (Abstract Co-Author) Nothing to Disclose
- Hans-Christoph R. Becker, MD, PhD, Stanford, CA (Abstract Co-Author) Nothing to Disclose
- Bhavik N. Patel, MD, MBA, Stanford, CA (Abstract Co-Author) Nothing to Disclose
- Rendon C. Nelson, MD, Durham, NC (Abstract Co-Author) Research Consultant, General Electric Company; Research Consultant, Nemoto Kyorindo Co, Ltd; Consultant, VoxelMetrix, LLC; Co-owner, VoxelMetrix, LLC; Advisory Board, Bracco Group; Advisory Board,
To determine the effect of different dose levels on quantitative tumour measurements from one dual-source, single-energy CT (DSCT) acquisition.

METHOD AND MATERIALS

A total of 23 patients with 39 metastatic liver lesions were enrolled in this HIPAA-compliant and IRB approved study. Patient underwent a clinically indicated DSCT of the abdomen with reconstruction of seven radiation dose levels (25%, 37.5%, 50%, 63.5%, 75%, 88.5% as well as a 100% corresponding to a diagnostic CT dose level scan [mean CTDIvol 10.4mGy]) by using different combination of projection data of the two tubes from a single DSCT acquisition. CT data were reconstructed using a second-generation iterative reconstruction algorithm. For each dose level, unidimensional measurements of tumor size according to RECIST 1.1 criteria were obtained by four independent and blinded readers using a conventional manual approach, as well as a semi-automated approach using two commercially available lesion segmentation tools (Syngo.Via, Siemens Healthineers and Mint lesion, Mint Medical GmbH). All readers repeated lesion measurements after 4 weeks for measurement of intra-reader variability. The measurements obtained at 100% dose served as the reference standard for each reader.

RESULTS

There was an excellent intra-reader correlation of $r^2=0.93$ (range: 0.93 - 0.94 for all readers) with an intra-reader measurement error of 7.2% 7.9% (range 4.9%-8.6%). For the 25% dose level datasets the inter-reader measurement error was statistically significantly higher compared to the 75% datasets, for both the readers and semi-automated software algorithms ($p<0.0252$). Of note, the overall intra-reader measurement error (7.2% 7.9%) was significantly higher than the overall measurement error for different dose levels (6.3% 6.3%) ($p=0.001$).

CONCLUSION

Our data suggest that reductions in radiation dose up to 72.5% may not significantly affect manual and semi-automated unidimensional measurements of tumor size. Intra- and inter-reader variability affected unidimensional measurements of tumor size statistically significantly more than a decrease radiation dose.

CLINICAL RELEVANCE/APPLICATION

CT scans with a dose level of 37.5% allow for a high reproducible and accuracy of quantitative tumour measurements, potentially reducing cumulative radiation exposure of oncological staging CTs.

SSK08-05 Virtual Monoenergetic Images from Spectral Detector CT for Visualization of Hypodense Liver Lesions: Contrast Blooming Vice Versa-Proof of Concept in a 3D-Printed Phantom and Evaluation in Patients

Wednesday, Nov. 28 11:10AM - 11:20AM Room: S404CD

Awards

Student Travel Stipend Award

Participants
Nil Grosse Hokamp, MD, Cleveland, OH (Presenter) Nothing to Disclose
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PURPOSE

There is a well-known boost of iodine associated-attenuation in low keV virtual monoenergetic images (VMI_low) which is frequently used to improve visualization of lesions and structures that take up contrast media (e.g. hemangiomas, hypervascular metastases or vessels in CT-angiography). This study aimed to evaluate this contrast vice versa: Does improved attenuation of the liver parenchyma allow for improved visualization of little or none-enhancing lesions?

METHOD AND MATERIALS

For the phantom portion a 3D-printed phantom mimicking the shape of a human liver exhibiting a lesion in its center was designed and printed. Both, parenchyma- and lesion-mimic were filled with iodine-solutions of different concentrations exhibiting an attenuation of 80, 100, 120 HU for parenchyma- and 0, 40, 60 HU for lesion-mimics. Further, a total of 75 patients with MRI or follow-up proven cysts and/or hypodense metastases was included. Imaging was performed on a spectral detector CT scanner (SDCT) and VMI of 40-120 keV as well as conventional images (CI) were reconstructed. Regions of interest were placed in lesion, parenchyma (-mimics) on CI and transferred to VMI. Signal-to-attenuation ratio (S/ATT), Signal-to-attenuation ratio (S/CNR) and signal-to-attenuation ratio (S/CNR) were calculated. Data was statistically assessed using ANOVA with Tukey’s posthoc to adjust for multiple comparisons.

RESULTS

In phantoms, S/CNR was significantly higher in VMI_low. A cyst (0HU lesion mimic) in highly attenuating liver parenchyma (120HU) on CI yielded a CNR of 6.4±0.8; using 40keV images, mildly hypodense lesions in poorly attenuating liver parenchyma exhibited a similar CNR (5.8±0.9; $p<0.05$). The same tendency was observed in patients, again cysts in CI yielded similar values as metastases in VMIMN (4.4±1.2 and 3.9±1.8, respectively, $p<0.05$).
The improved attenuation of the liver outweighs increasing in attenuation of the lesion itself. Hence, VMI_low from SDCT allow for an improved visualization of hypodense focal liver lesions exploiting the concept of contrast blooming vice versa.

**CLINICAL RELEVANCE/APPLICATION**

Low keV VMI should be considered when screening after focal liver lesions, irrespective of the expected imaging characteristic.

**CONCLUSION**

The improved attenuation of the liver outweighs increasing in attenuation of the lesion itself. Hence, VMI_low from SDCT allow for an improved visualization of hypodense focal liver lesions exploiting the concept of contrast blooming vice versa.

**CLINICAL RELEVANCE/APPLICATION**

Low keV VMI should be considered when screening after focal liver lesions, irrespective of the expected imaging characteristic.

**Honored Educators**

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**PURPOSE**

Our first goal was to build in vitro liver-iron model in order to provide a phantom for iron content quantification in study. The second goal was to evaluate the feasibility and accuracy of using spectral imaging and material decomposition techniques for iron density quantification to provide a basis for the precise iron quantification in clinical use.

**METHOD AND MATERIALS**

Liver-iron mixture samples were prepared as described. A total of six homogeneous liver-iron mixed samples with a iron content of 0, 3.125, 6.25, 12.5, 25, 50 mg/mL. All samples were scanned on a GE Revolution CT scanner using GSI mode with rapid tube voltage switching between 80-140 kVp, and with tube current 200mA, 320mA, 485mA respectively. After the CT scan reconstructed imaging data were processed with GSI imaging analysis software package for material decomposition and characterization. Iron concentration (on iron-water bases, Unit: mg/mL) was measured. The difference of measured iron concentration (VIC) between 3 groups of tube currents was analyzed by one-way ANOVA. A linear regression was performed to analyze the relationship between the VIC and the actual iron concentration.

**RESULTS**

(1) We had successfully developed models in vitro for iron content quantification. (2) There was no significant difference in VIC between 3 tube current groups, P=0.999, F=0.001. (3) The model showed good linear relationship between the measured iron concentration and actual iron concentration. And the linear correlation equation was y=2.177x-2.820, R² = 0.995, P<0.001, F=3186.883.

**CONCLUSION**

(1) Spectral imaging and material decomposition techniques were demonstrated to provide accurate and reliable measurement of iron content for liver-iron model, which will contribute to the development of clinical iron content quantification assays. (2) The quantification of the liver-iron fraction was not affected by radiation dose.

**CLINICAL RELEVANCE/APPLICATION**

This study demonstrated the feasibility of using CT spectral imaging and material decomposition techniques to precisely quantify the iron concentrations. The advantages of this quantitative method are non-invasive, high accuracy, without additional scanning, and the technique can be used to guide the treatment of relieving iron overload in hereditary hemochromatosis and acquired hemochromatosis, and assist the diagnosis of canceration of liver cirrhosis nodules.

**PURPOSE**

Our first goal was to build in vitro liver iron-fat deposition model in order to provide a phantom for iron content quantification in study. The second goal was to evaluate the feasibility and accuracy of using spectral imaging and material decomposition techniques for iron density quantification under the condition of simultaneous fat deposition and iron deposition in the liver.

**METHOD AND MATERIALS**

Liver-iron-fat mixture samples were prepared as described. A total of 18 samples (3 groups) of homogeneous liver-iron mixed samples with iron concentration gradient of 0, 10, 20, 30, 40, 50 mg/mL were prepared (group A, B and C), group A, B and C added fat with volume percentage of 10%, 30% and 60% respectively. All samples were scanned on a GE Revolution CT scanner using GSI mode with rapid tube voltage switching between 80-140 kVp, tube current 485mA. After the CT scan reconstructed imaging data were processed with GSI imaging analysis software package for material decomposition and characterization. Iron concentration (on iron-fat bases) measured with consistent regions of interest (ROIs) and statistical analysis. A linear regression was performed to analyze the relationship between the measured iron concentration and the actual iron concentration.
(1) We had successfully developed liver iron-fat models in vitro. The designed iron concentration range covered clinical iron content in liver, and the fat volume ratio of 10%, 30% and 60% simulated the mild, moderate and severe fatty liver respectively.

(2) The model showed good linear relationship between the measured iron concentration and actual iron concentration. And the linear correlation equation were $y_A=0.575x+11.22$, ($R^2=0.927$, $p=0.005$, $F=52.038$), $y_B=0.848x-2.303$ ($R^2=0.884$, $p=0.011$, $F=31.481$), $y_C=0.788x+9.998$ ($R^2=0.949$, $p=0.003$, $F=76.068$).

CONCLUSION

(1) Spectral imaging and material decomposition techniques were demonstrated to provide accurate and reliable measurement of iron content for liver-iron-fat model. (2) Fat affect the results of measured iron concentration.

CLINICAL RELEVANCE/APPLICATION

This study demonstrated the feasibility of using CT spectral imaging and material decomposition techniques to precisely quantify the iron concentrations under the condition of simultaneous fat deposition and iron deposition, and can be used to guide the treatment of relieving iron overload in hereditary hemochromatosis and acquired hemochromatosis.

SSK08-08 Dual Energy CT Iodine Maps for Response Assessment in Colorectal Liver Metastases (CLM) Treated With a Multikinase Inhibitor (MKI) with Anti-Angiogenic Activity

Wednesday, Nov. 28 11:40AM - 12:00PM Room: S404CD

Participants

Uday Patel, London, United Kingdom (Presenter) Nothing to Disclose
Khurum Khan, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Ed McDonagh, MSc, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
David Cunningham, MD, MRCP, Sutton, United Kingdom (Abstract Co-Author) Nothing to Disclose
Dow-Mu Koh, MD,FRCR, Sutton, United Kingdom (Abstract Co-Author) Nothing to Disclose
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PURPOSE

To assess changes in quantitative CT iodine maps in patients with CLM treated with a MKI with known anti-angiogenic activity and to assess their relationships with treatment outcomes.

METHOD AND MATERIALS

After IRB approval, 28 patients with CLM were prospectively consented and underwent dual energy CT studies on a Siemens SOMATOM CT scanner before and at 8 weeks after treatment. Iodine maps were generated from 3 mm dual energy CT images acquired in the arterial and portovenous phases. In each patient, regions of interest were drawn around a target hepatic metastasis to record the average iodine uptake before and after treatment, as well as the absolute and percentage change in iodine uptake after treatment. Results were compared between responders and non-responders, defined by RECIST 1.1 and clinical criteria. The diagnostic performance of CT iodine uptake for identifying responders was assessed by ROC analysis, and the relationship to overall survival (OS) was evaluated by Kaplan-Meier analysis.

RESULTS

Of the 28 patients, 16 patients were responders and 12 non-responders. Across the entire cohort, a significant decrease in the median averaged iodine uptake after treatment in arterial (17.06 vs. 7.86, $p=0.0002$) and portovenous phases (20.34 vs. 14.06, $p<0.0001$) was observed. However, there was no significant difference in the mean absolute or percentage decrease in iodine uptake on arterial (-6 vs -4.5, $p=0.82$ and -65 vs -38, $p=0.22$) or portovenous (-8.4 vs -6.1, $p=0.10$ and -41 vs -28, $p=0.17$) phase between the two groups. A -33.6% reduction in iodine uptake showed 68.8% sensitivity and 81.8% specificity for identifying responders, but this threshold showed no relationship with OS (36 vs. 29 weeks, $p=0.3278$).

CONCLUSION

A significant decrease in iodine uptake was observed across the study cohort on arterial and portovenous phase CT after anti-angiogenic therapy. Notwithstanding with small numbers, a significant difference in CT iodine uptake between responders and non-responder was not observed thus the technique cannot be used to inform treatment decisions at this stage.

CLINICAL RELEVANCE/APPLICATION

Dual energy CT iodine maps can not yet be used for response assessment in colorectal liver metastases treated with anti-angiogenic agents.

SSK08-09 How Reliable are CT-Based Measurements of Iodine Concentration? A Comparison of the Minimum Detectable Concentration Difference Among Single-Source and Dual-Source Dual-Energy CT

Wednesday, Nov. 28 11:50AM - 12:00PM Room: S404CD

Participants

Andre Euler, MD, Durham, NC (Presenter) Fellowship funded, General Electric Company
Justin B. Solomon, PhD, Durham, NC (Abstract Co-Author) License agreement, Sun Nuclear Corporation; License agreement, 12 Sigma Technologies
Maciej A. Mazurowski, MS, PhD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (Abstract Co-Author) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc
Rendon C. Nelson, MD, Durham, NC (Abstract Co-Author) Research Consultant, General Electric Company; Research Consultant, Nemoto Kyorindo Co, Ltd; Consultant, VoxelMetrix, LLC; Co-owner, VoxelMetrix, LLC; Advisory Board, Bracco Group; Advisory Board, Guerbet SA; Research Grant, Nemoto Kyorindo Co, Ltd; Speakers Bureau, Bracco Group; Royalties, Wolters Kluwer nv

For information about this presentation, contact:
PURPOSE
To assess the impact of scan- and patient-related factors on the error and the minimum detectable difference in iodine concentration among a wide range of different imaging conditions for second- and third-generation single-source fast kV-switching and dual-source dual-energy CT (DECT).

METHOD AND MATERIALS
Lesions of nine iodine concentrations (0.2 - 4 mgI/mL) were emulated in a 3D-printed phantom of medium and large size. Each combination of concentration and size was scanned in dual-energy mode on four different second- and third-generation single-source (SS) fast-kV switching and dual-source (DS) DECTs. Radiation doses were 7, 10 mGy (medium size) and 10, 13, 16 mGy (large size). Iodine maps were reconstructed with FBP and vendor-specific iterative reconstruction algorithms. ROI measurements of iodine concentration were made from each reconstructed iodine map with an automated script (243,000 total measurements). Absolute error of iodine quantification (E) was calculated. Multivariate regression models determined the influence of CT scanner condition, iodine concentration, phantom size, radiation dose, and reconstruction algorithm on E. Minimum detectable difference in iodine concentration, Dmin, was estimated for each pair of imaging conditions (including inter- and intra-condition comparisons). For a given pair of imaging conditions, Dmin was defined as the minimum difference in iodine concentration in which measured differences corresponded to true differences 95% of the time.

RESULTS
The iodine quantification error E was significantly lower in third-generation compared to second-generation DECT platforms (P<0.001). E significantly increased with increasing phantom size and decreasing radiation dose for all CT scanner conditions (P<0.001). Iodine concentration only significantly affected E for SS DECT (P<0.001). The minimum intra- and interconditional detectable difference in iodine concentration depended on patient- and scan-related factors and ranged from 0.4 mgI/mL to 1.5 mgI/mL.

CONCLUSION
Patient- and scan-related factors have a significant impact on the error and minimum detectable difference in iodine concentration within and among second- and third-generation SS fast kV-switching and DS DECT.

CLINICAL RELEVANCE/APPLICATION
To inform radiologists about the impact of patient- and scan-related factors and the high error range of DECT-based iodine quantification when patients are imaged under different conditions.
SSK09

Genitourinary (Renal Masses)

Wednesday, Nov. 28 10:30AM - 12:00PM Room: N226

CT GU MR OI

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Atul B. Shinagare, MD, Boston, MA (Moderator) Advisory Board, Arog Pharmaceuticals, Inc; Research Grant, GTx, Inc
Erick M. Remer, MD, Cleveland, OH (Moderator) Travel support, Bracco Group

Sub-Events

SSK09-01 Application of Deep-Learning Neural Network Model in Differentiation of Clear Cell Renal Carcinoma from Benign Oncocytoma Lesions

Participants
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PURPOSE

To use feature representations based on deep convolutional neural network in differentiating Clear Cell Renal Cell Carcinoma (ccRCC) from Oncocytoma lesions on MRI T2-weighted images.

METHOD AND MATERIALS

94 ccRCCs from 31 patients (12 males, 19 females) and 37 Oncocytoma lesions from 9 patients (6 males, 3 females) were identified from an institutional urologic oncology database. Weighted-T2 MR images taken within 6 months prior to surgery were selected for analysis. Lesions were segmented on every slice. Local square ROIs around each lesion were extracted and resized to 224x224 as neural network inputs. Deep residual network ResNet-101 pre-trained on ImageNet dataset was then used as feature extractor without fine-tuning. Using feature representations from ResNet, the corresponding lesion slices were then classified into either ccRCC or Oncocytoma using Support Vector Machine. Performance was reported based on five-fold cross-validation classification results. Accuracy at the lesion level was calculated based on the majority (> 50%) of correctly predicted class for all the slices in one lesion. If the number of correctly predicted slices is equal to the number of incorrectly predicted slices, then the entire lesion is considered to be incorrectly classified.

RESULTS

Out of a total of 407 slices, our model showed an overall accuracy of 78.62% in detecting Oncocytoma from Clear Cell RCCs. At the lesion level, 80 out of 94 (85%) ccRCC lesions and 23 out of 37 (62%) of oncocytoma lesions were correctly identified. The model showed an overall accuracy of 78.63%.

CONCLUSION

Deep Learning with CNN showed promising diagnostic performance in differentiation of Oncocytoma lesions from Clear Cell RCC. The model showed an overall accuracy of 78.63%.

CLINICAL RELEVANCE/APPLICATION

Our training model can be used as support information in the differential diagnosis between Oncocytoma and Clear Cell.

SSK09-02 Semantic Modeling of Fat Poor Angiomyolipoma (fp-AML) on Multiphase Contrast-Enhanced CTs

Participants
Yaqin Zhang, MD, PhD, Zhuhai, China (Presenter) Nothing to Disclose
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Hong Shan, PhD, MD, Zhuhai, China (Abstract Co-Author) Nothing to Disclose
To investigate the efficacy of noninvasive models in which clinical and radiographic descriptors were fused to differentiate the fp-AMLs from clear cell renal cell carcinoma (ccRCCs) in multiphase contrast-enhanced CT images.

METHOD AND MATERIALS

With IRB approval, we retrospectively collected patients at two academic hospitals (A and B) from Jan. 2006 to Dec. 2015 in Guangdong, China. All patients were clinically diagnosed with one suspicious ccRCC on multiphase contrast-enhanced CT acquired at least 30 days before surgical resection. Histopathologic data was served as ground truth. For model selection, we collected 118 cases (13 of 20 fpAMLs diameter <= 4cm and 46 of 98 ccRCCs diameter <= 4cm) at hospital A. An experienced radiologist identified the locations of lesions by examining all available information including the CTs and clinical reports, and provided descriptors of the lesion shapes, gray-level information as well as lesion margins. Twenty-four features including 5 clinical (gender, age, red blood cell in urine, white blood cell in urine, and symptom) and 19 radiographic descriptors were used. LASSO was used for feature selection and fp-AML prediction. To evaluate the efficacy of the developed fp-AML model, an independent set of 63 cases including 15cases (13 diameter <= 4cm) fp-AMLs and 48 (22 diameter <= 4cm) ccRCCs were collected from hospital B. Four additional radiologists independently provided the radiographic descriptors on multiphase CTs as well as the binary diagnostic decision of each lesion for baseline comparison.

RESULTS

On test set, the diagnosis accuracies of four readers were 0.74, 0.73, 0.71 and 0.90 while the models’ achieved 0.81, 0.83, 0.87 and 0.92, respectively. Comparing to baselines, the improvements with models were 9.5%, 13.7%, 22.5% and 2.2%, respectively. For small lesions (diameter <= 4cm), the readers’ accuracies were 0.57, 0.60, 0.57 and 0.89 while the models’ were 0.74, 0.71, 0.83 and 0.91, correspondingly. The improvements were 29.8%, 18.3%, 45.6% and 2.2%, respectively.

CONCLUSION

Multiple reader study found that the semantic model improved the diagnostic accuracies of fp-AMLs and the higher improvement were observed for small lesion.

CLINICAL RELEVANCE/APPLICATION

The noninvasive diagnosis of fp-AMLs from ccRCCs is a challenging task in clinical practice. The semantic modeling has the potential to improve the diagnostic accuracy of fp-AMLs.

SSK09-03 Comparison of Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Contrast-Enhanced Ultrasound (CEUS) in the Evaluation of Unclear Renal Lesions: A 10-Year Single Center Experience

Wednesday, Nov. 28 10:50AM - 11:00AM Room: N226

Participants
Johannes Ruebenthaler, MD, Munich, Germany (Presenter) Nothing to Disclose
Dirk-André Clevert, MD, Muenchen, Germany (Abstract Co-Author) Speaker, Siemens AG; Speaker, Koninklijke Philips NV; Speaker, Bracco Group; Speaker, Samsung Electronics Co, Ltd;

PURPOSE

To compare the sensitivity and specificity of contrast-enhanced ultrasound (CEUS), computed tomography (CT) and magnetic resonance imaging (MRI) in the evaluation of unclear renal lesions to the histopathological outcome.

METHOD AND MATERIALS

A total of 255 patients with a single unclear renal mass with initial imaging studies between 2005 and 2015 were included. Patient ages ranged from 18 to 86 with (mean age 62 years; SD ± 13). CEUS (255 patients), CT (88 out of 255 patients; 34.5%) and MRI (36 out of 255 patients; 14.1%) were used for determining malignancy or benignancy and initial findings were correlated with the histopathologica outcome. Out of the 255 renal masses a total of 212 lesions were malignant (83.1%) and 43 were benign (16.9%). Diagnostic accuracy was tested by using histopathology as the gold standard.

RESULTS

CEUS showed a sensitivity of 99.1% (95% confidence interval (CI): 96.7%, 99.9%), a specificity of 80.5% (95% CI: 65.1%, 91.2%), a positive predictive value (PPV) of 96.4% (95% CI: 93.0%, 98.4%) and a negative predictive value (NPV) of 94.3% (95% CI: 80.8%, 99.3%). CT showed a sensitivity of 97.1% (95% CI: 89.9%, 99.6%), a specificity of 47.4% (95% CI: 24.4%, 71.1%), PPV of 87.0% (95% CI: 77.4%, 93.6%) and a NPV of 81.8% (95% CI: 48.2%, 97.7%). MRI showed a sensitivity of 96.4% (95% CI: 81.7%, 99.9%), a specificity of 75.0% (95% CI: 34.9%, 96.8%), a PPV of 93.1% (95% CI: 77.2%, 99.2%) and a NPV of 85.7% (95% CI: 42.1%, 99.6%). Out of 212 malignant lesions 130 clear cell renal carcinomas, 59 papillary renal cell carcinomas, 7 chromophobe renal cell carcinomas, 4 combined clear cell and papillary renal cell carcinomas and 12 other malignant lesions were diagnosed. Out of 43 benign lesions 10 angiomylipomas, 3 oncocytomas, 8 benign cysts and 22 other benign lesions were diagnosed. Using CEUS, 10 lesions were falsely identified as malignant or benign: 8 lesions were false positive and 2 lesions false negative. The 8 false-positive lesions included 5 oncocytomas or angiomylipomas and 3 Bosniak category III cystic lesions.

CONCLUSION

CEUS is an useful method which can be additionally used to clinically differentiate between malignant and benign renal lesions. CEUS shows a comparable sensitivity, specificity, PPV and NPV to CT and MRI.

CLINICAL RELEVANCE/APPLICATION

CEUS can be easily performed during clinical routine for the evaluation of unclear renal lesions as a complementary imaging method.
Accurately Differentiate High Grade from Low Grade Disease to Better Guide Management?

Wednesday, Nov. 28 11:00AM - 11:10AM Room: N226

Awards
Student Travel Stipend Award

Participants
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PURPOSE
Multi-parametric (mp) MRI is accurate to diagnose clear cell renal cell carcinoma (cc-RCC). T1a cc-RCC is typically treated radically; however, low-grade tumors may be candidates for active surveillance. Fuhrman nuclear grading (FNG) of cc-RCC with biopsy is not accurate and this study evaluated mp-MRI to differentiate low from high-grade cc-RCC.

METHOD AND MATERIALS
42 consecutive solid <4cm cc-RCC with mp-MRI before nephrectomy between 2013 and 2017 (low-grade=FNG 1 [N=4] or 2 [N=27] and high-grade=FNG 3 [N=11]) were identified. Size, apparent diffusion coefficient (ADC), enhancement wash-in and wash-out (WI/WO) ratios and, chemical-shift signal-intensity index (SI-index) were measured. Subjectively, two blinded radiologists assessed for: 1) intracellular lipid (SI drop on opposed-phase MRI), 2) hemorrhage and 3) homogeneity. Discrepancies were resolved by consensus. Comparisons were performed using logistic regression and Chi-square and accuracy assessed using ROC.

RESULTS
Mean lesion size was 24 ± 7 (13-39) mm with no difference by FNG (p=0.45). 35.5% (11/31) low-grade tumors showed intracellular lipid compared to 9.1% (1/11) high-grade tumors (p=0.009). Agreement was moderate (K=0.65). SI-index was higher in low grade tumors (9.8 ± 34.4 versus 5.2 ± 19.9), p=0.283. Hemorrhage and homogeneity did not differ between groups (p>0.05). Mean ADC was higher in low-grade tumors (0.860 ± 0.142 versus 0.787 ± 0.229 mm2/sec) with significant differences observed for 10th centile ADC (p<0.001). WI index was higher in low-grade tumors for corticomedullary (p=0.019) and nephrographic phase (p=0.027) with no differences in WO. Presence of lipid was specific for diagnosis of low-grade disease (90.9% [58.7-98.8]) with low sensitivity (35.5% [19.2-54.6]). Logistic regression model combining presence of intracellular lipid, SIindex, ADC and WI yielded area under curve=0.79 (CI 0.62-0.96) with better accuracy (p=0.007, improved sensitivity=75.0% but lowered specificity=73.7%) compared to subjective assessment of lipid content alone.

CONCLUSION
Intracellular lipid in T1a clear cell RCC on MRI is highly specific for low-grade disease but with low sensitivity. Combining presence of lipid with ADC, SI-index and enhancement features improved accuracy of diagnosis.

CLINICAL RELEVANCE/APPLICATION
Multi-parametric MRI is accurate to differentiate low-grade and high-grade solid T1a clear cell tumors which may better inform management decisions.
Four images dataset, including Dixon fat and water images, dynamic contrast enhancement (DCE) from MR imaging and standard uptake value (SUV) from PET, were coregistered, and then radiomic imaging features were extracted from the pre-defined ROIs. Associations between these radiomic features, SUV, and 12 key selected genetic expressions of ccRCC were analyzed using sparse canonical correlation analysis.

RESULTS

Our study highlighted that combined structural and functional information from MRI and PET provides significant moderate to strong correlations between radiomic features and 8 of the selected genetic expressions, including FBP-1, BAP1, VHL, MUC4, PECAM1, PBRM1, TSC1, and MUC1 (P = 0.041). PET provides the highest loadings for the explanations of the radiomic correlations of expressions of PECAM1, while DCE in expressions of FBP-1, VHL, and PBRM1, and Dixon images in expressions of BAP1, MUC4, and TSC1.

CONCLUSION

Our study revealed the associations between PET/MR image features and regional variation of relevant biological features, underscoring the potential utility of PET/MR for discerning regional genetic variability in ccRCC.

CLINICAL RELEVANCE/APPLICATION

PET/MR identifies associations between radiomic features and genetic expressions. Knowledge on radiogenomic associations facilitates non-invasive mapping of tumor heterogeneity and selection of personalized treatments.

SSK09-06 Radiologically-Defined Tumor Necrosis in Clear Cell Renal Cell Carcinoma as a Surrogate of Pathologically-Defined Tumor Necrosis, Staging, and as a Size-Independent Prognostic Biomarker

Wednesday, Nov. 28 11:20AM - 11:30AM Room: N226

Participants

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PURPOSE

Pathologically defined tumor necrosis (PDTN) in clear cell renal cell carcinoma (ccRCC) has been considered as a prognostic factor. We aimed to measure radiologically-defined tumor necrosis (RDTN) of ccRCC and explore its association with PDTN, stage/grade, and with survival outcomes in a multi-institutional cohort.

METHOD AND MATERIALS

183 patients with ccRCC form The Cancer Genome Atlas (TCGA) with available contrast enhanced CT imaging were included in this study. Quantitative imaging methods were used to measure the volume of non-enhancing component of ccRCC (representing necrotic volume) based on the change of attenuation values of each tumor pixel between pre-contrast and postcontrast imaging. The percent of tumor necrosis ((necrotic volume/whole ccRCC volume) x 100) was used as a size-independent variable to represent RDTN. Associations of RDTN with pathological stage/grade were tested using Wilcoxon signed-rank test and with survival outcomes using Kaplan-Meier's curves and Cox regression analyses.

RESULTS

Median RDTN was 8% (interquartile range 3% - 17%) in this cohort. RDTN was higher in ccRCC with PDTN than those without (11% versus 7%; p-value = 0.042). There was no significant association between RDTN and pathological grading (p-value = 0.057). However, RDTN was higher in patients with AJCC pathological stage II, III, and IV in comparison with stage I (11% versus 5%; p-value < 0.001). Patients with higher RDTN (>=median) had higher incidence of cancer recurrence after resection (Log-rank test p-value < 0.001) and higher incidence of cancer-specific mortality (Log-rank test p-value < 0.001). Controlling for age at diagnosis and stage of disease in a multivariable Cox-regression model, patients with higher RDTN continued to have higher cancer recurrence and worse cancer-specific survival (Odds Ratios = 4.6 and 2.8; p-values = 0.003 and 0.020).

CONCLUSION

RDTN in ccRCC can be a surrogate to pathologically defined TN. Additionally, RDTN is associated with pathological staging and an important independent prognosticator.

CLINICAL RELEVANCE/APPLICATION

Radiologically-defined tumor necrosis in clear cell renal cell carcinoma conveys additional clinically-relevant information regarding tumor stage and prognosis.
PURPOSE

Imaging biomarkers of metabolism such as tumor glucose uptake, patient muscle mass, and patient visceral fat have the ability to predict outcomes in cancer patients. Recent evidence has demonstrated sex differences in these metabolic measurements both on the imaging and the molecular levels. We wanted to determine if muscle mass and visceral fat measured by CT and molecular profiling of tumor glycolytic metabolism could be combined to develop a multiparametric sex-specific stratification system for RCC patients.

METHOD AND MATERIALS

This study included 222 patients with clear cell RCC included within The Cancer Genome Atlas (TCGA) and Cancer Imaging Archive (TCIA). The abdominal fat and glycolytic subtyping of patients were performed and used as published previously [PMID: 29558292] and combined with muscle quantification in this study. Abdominal fat was segmented into visceral, subcutaneous, and total fat areas as well as the normalized relative visceral fat area (visceral fat/total fat ratio, or rVFA). Glycolytic gene expression profiling of the tumors using TCGA data was used to metabolically classify the tumors. CT-based muscle mass and density measurements of the psoas muscle at L3 were performed. Biomarker optimization analyses were conducted to identify imaging metric thresholds that maximally stratified the patients based upon overall survival (OS).

RESULTS

The average psoas muscle area measured more in men than women (1171 vs 679.5 mm²) [p<0.0001]. The average psoas muscle density also measured more in men than women (41.1 vs 38.5 HU) [p=0.045]. Increased muscle area (>442 mm² for women and >784 mm² for men) was associated with increased OS (men p=0.002, women p=0.001). However, increased psoas density (>48.1 HU) was prognostic only for women; in this cohort, only 1/11 women died compared to the <48.1 HU group that experienced 29/66 deaths [p=0.02]. Combining rVFA, glycolysis and muscle area resulted in the identification of three sex-specific survival groups (Figure 1). Although all three variables contributed to female stratification (p=0.0001), male stratification was driven by glycolysis and muscle area (p=0.001).

CONCLUSION

Abdominal CT measurement of muscle and fat in tandem with molecular features of tumors predicts sex-specific outcomes in RCC patients.

CLINICAL RELEVANCE/APPLICATION

Sex differences in patient and tumor metabolism may provide a new risk-stratification system for patients with clear cell RCC.

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Vincent M. Mellnick, MD - 2016 Honored EducatorVincent M. Mellnick, MD - 2018 Honored Educator

SSK09-08 Baseline CT Texture Feature of Metastatic Clear Cell Renal Cell Carcinoma Correlates with Sunitinib Therapy Response

Wednesday, Nov. 28 11:40AM - 11:50AM Room: N226

Participants
Yichen Wang, MD, Beijing, China (Presenter) Nothing to Disclose
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Fei Xu, Beijing, China (Abstract Co-Author) Nothing to Disclose

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PURPOSE

Our study aimed to analyze tumor's baseline CT texture features and evaluate the correlation with first-line Sunitinib therapy response in metastatic clear cell renal cell carcinoma patients.

METHOD AND MATERIALS

Jan 2013 to July 2016, 48 metastatic RCC patients who received first line Sunitinib undertook abdominal CT scan before treatment. Forty-two patients were included. Clinical information (age, gender, surgery, MSKCC score and Heng's score, metastasis) and pathological information (tumor diameter, Fuhrmann grade, tumor thrombus) were collected. We collected 30 unenhanced CT images, 30 corticomedullary phase CT images and 36 nephrographic phase CT images from these patients. 2D CT texture parameters were generated from the image with the largest tumor diameter using histogram analysis and spatial gray-level dependence matrices (GLCM and RLM), respectively. Patients were divided into respond group (CR+PR) and non-respond group (SD+PD) according to RECIST criteria. We compared the CT texture feature, clinical and pathological parameters between two groups. We further assess the CT texture parameters with progression-free survival (PFS) using Kaplan-Meier analysis and Cox regression model.

RESULTS

Age, gender, tumor diameter and clinical prognostic scores (MSKCC and Heng's score) had no difference between respond and non-
Age, gender, tumor diameter and clinical prognostic scores (MSKCC and Heng’s score) had no difference between respond and non-respond group. Gray-level nonuniformity (GLN) from unenhanced and corticomedullary phase CT in respond group was significantly smaller than non-respond group (p<0.05). Logistic regression showed that GLN from unenhanced (p<0.05, OR 0.98(0.97, 0.99)) and corticomedullary phase CT (p<0.05, OR 0.96(0.94, 0.99)) independently associated with therapy response. GLN from unenhanced CT had AUC of 0.77 (P<0.05, sensitivity 73.7%, specificity 73.7%). Cox regression model showed that both GLN from unenhanced (p<0.05, HR 1.008(1.003,1.013)) and corticomedullary phase CT(p<0.05, HR 1.012(1.002,1.022)) had significant correlation with PFS.

CONCLUSION
For metastatic patients who received Sunitinib therapy, baseline CT texture parameter Gray-length nonuniformity reflecting tumor heterogeneity correlate with therapy response and PFS.

CLINICAL RELEVANCE/APPLICATION
CT texture parameter reflecting tumor heterogeneity has the potential to predict targeted therapy response before treatment in metastatic clear cell renal cell carcinoma.

SSK09-09 Role of Non-Target Disease and New Lesions as Defined by RECIST 1.1 in Determining Radiological Progression in Renal Cell Carcinoma

Wednesday, Nov. 28 11:50AM - 12:00PM Room: N226

Participants
Heidi Coy, Los Angeles, CA (Presenter) Nothing to Disclose
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PURPOSE
Progression free survival (PFS) based on RECIST 1.1 (R1.1) is still the most accepted primary end point for Phase III trials in renal cell carcinoma. Guidelines to assess tumor response based on changes in target lesions (TG) are quantifiable and established. However, guidelines to assess tumor response based on non-target (NT) or new lesions (NL) are qualitative and subject to inter-observer variation. The purpose of our study was to retrospectively assess the most common criteria for determination of progressive disease (PD) assessed using R1.1 and how these progression events impact PFS.

METHOD AND MATERIALS
We conducted a secondary analysis of a cohort of patients enrolled in a Phase III global multi-center open label trial who were randomized 1:1 to open label anti-VEGFR tyrosine kinase inhibitor (TKI) therapies. All patients had previously progressed after having received prior VEGFR therapy and had measurable disease at screening (SCR). A chest CT, and either a CT or MRI of the abdomen and pelvis were acquired at SCR and every 8 weeks and interpreted at an imaging core laboratory for PD using R1.1. Kaplan-Meier plots, Holm's multiple comparisons and log-rank tests were performed to compare the median PFS for each R1.1 measurement assessment.

RESULTS
We analyzed 395 subjects with a mean age of 60.7 years (SD ± 10.0). The mean number of follow-up visits was 4.9 (SD ± 1.8) with a mean of 6.59 (SD ± 3.70) months enrolled. PD was determined by growth of target (TG) lesions in 126 (32%) subjects (median PFS (mPFS) 5.44 months, IQR 3.87) appearance of a new lesion (NL) in 105 (27%) subjects (mPFS 3.61 months, IQR 3.60), and unequivocal progression of a non-target (NT) lesion in 73(18%) subjects (mPFS 2.79 months, IQR 3.54). The remaining subjects had PD determined by a combination of assessments: 33 (8%) by TG+NT (mPFS 3.54 months, IQR 3.70), 27(7%) by NT +NL (mPFS 3.74 months, IQR 2.48), 23(6%) by TG +NL (mPFS 3.64 months, IQR 5.38), and 8(2%) by TG+NT+NL (mPFS 4.52 months, IQR 4.98).

CONCLUSION
TG disease contributed to PD determination in less than 50% of patients and NT and NL were the most common criteria that defined PD, with a significant decrease in PFS compared to those patients who had PD determine by TG alone.

CLINICAL RELEVANCE/APPLICATION
In R1.1 assessment of metastatic RCC, both NT and NL alone, or in combination, are the dominant contributors to PD and may need updated R1.1 guidelines for NT and NL progression.
SSK14

Nuclear Medicine (Lymphoma, Sarcoma and Melanoma)

Wednesday, Nov. 28 10:30AM - 12:00PM Room: S505AB

BQ CT NM

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
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Matthew S. Robertson, MD, Cleveland, OH (Moderator) Nothing to Disclose

Sub-Events
SSK14-01 Incremental Value of Interim 18F-FDG PET/CT over CT-Scan for Early Response Evaluation in Patients with Hodgkin Lymphoma Treated with Immune Checkpoint Inhibitors

Participants
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Laurent Dercle, MD, New York, NY (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Anti-Programmed Death 1 (anti-PD1) antibody triggers new patterns of response and progression in patients with Hodgkin lymphoma (HL). We aimed to evaluate the incremental value of interim 18F-FDG PET/CT over CT scans in patients treated by anti-PD1.

METHOD AND MATERIALS
We retrospectively analyzed patients treated by anti-PD1 from 2013 to 2017. Concomitant 18F-FDG PET/CT and CT scans were acquired at baseline and upon treatment. A pair of radiologists classified blindly and independently patients as immune-responding or immune-refractory based on the first evaluation, using the International Harmonisation Project Cheson 2014 criteria and the Lymphoma Response to Immunomodulatory therapy Criteria (LYRIC) (2016 revised criteria).

RESULTS
Forty-four consecutive HL patients were included. Forty-four interim 18F-FDG PET/CT and CT scans were acquired at a median time of 3.7 months after anti-PD1 initiation. Radiologists classified patients as immune-responding or immune-refractory on both 18F-FDG PET/CT and CT-scan in 55.7% and 35.2% of cases, respectively. Radiologists experienced a significant incremental value of 18F-FDG PET/CT in 8.0% (95%CI: 3.3%-15.7%) of patients, whom were reclassified as immune-refractory (2.3%) or immune-responding (5.7%). Additionally, 18.2% (95%CI: 10.8%-27.8%) of patients were reclassified from PR on CT-scan to CR on PET.

CONCLUSION
CT-scan alone can reliably be used for response assessment in patients with HL treated with anti-PD1: radiologists correctly classified patients as immune-responding or immune-refractory in 92% of cases. However, interim 18F-FDG PET/CT showed clear incremental value to reclassify immune-responding patients from partial response to complete response, which is crucial for risk-adapted strategies.

CLINICAL RELEVANCE/APPLICATION
Interim 18F-FDG-PET/CT in HL patients treated with anti-PD1 supplied incremental value over CT-scan by reclassifying patients to immune-responding or complete response. This concept is crucial for risk-adapted therapeutic strategy.

SSK14-02 Impact of FDG-PET/CT on the Staging, Management and Outcomes of Patients with Presumed Limited Stage Hodgkin's Lymphoma and Aggressive Non-Hodgkin's Lymphoma

Participants
Ur Metser, MD, FRCP, Toronto, ON (Presenter) Nothing to Disclose
Anca Prica, Toronto, ON (Abstract Co-Author) Nothing to Disclose
To determine the impact of positron-emission tomography/computed tomography (PET/CT) on the staging, management and outcomes of patients with apparent limited-stage (LS) Hodgkin’s lymphoma (HL) or aggressive non-Hodgkin’s lymphoma (aNHL) being treated with curative intent.

METHOD AND MATERIALS

This single arm, prospective multicenter registry included patients with apparent LS HL or aNHL based on clinical data and CT, or with equivocal CT findings for advanced stage, being considered for curative-intent therapy. Pre-PET/CT treatment plan was compared to actual treatment received. Outcomes at 1 year post first line therapy included survival and second-line therapy initiation. These were compared to a historical control pool staged with CT alone. Administrative data sources were used to obtain and control for baseline characteristics using propensity score matching and regression adjustment. Outcomes were assessed using adjusted Cox proportional hazards regression and propensity score matching.

RESULTS

PET/CT upstaged 58/330 (17.6%) patients with HL and 92/520 (17.7%) patients with aNHL. Change in planned mode of therapy was seen in 119/266 (44.7%) patients with HL and 131/334 (39.2%) with aNHL (p<0.00001 for both). There was a lower 1-year mortality for aNHL patients with LS on PET compared to those with LS on CT (for propensity score matched cohort: HR, 0.34; 95% CI: 0.15, 0.74; p=0.0072). For patients with HL, no significant difference was found in survival or second-line therapy initiation at 1 year.

CONCLUSION

PET/CT upstaged >17% of patients with presumed LS aggressive lymphoma to advanced stage and planned management was altered in a significant proportion of patients. Patients with confirmed LS aNHL after PET/CT treated with curative intent had significantly better survival compared to the cohort of LS determined by CT.

CLINICAL RELEVANCE/APPLICATION

1. PET has a significant impact on the management of patients with HL and aNHL. 2. Patients with presumed limited stage aNHL on PET/CT treated with curative intent had a significantly better survival at one year compared to patients with presumed limited stage as determined by CT. 3. These results support the recent recommendation of the International Conference on Malignant Lymphoma in Lugano for the utilization of PET in the staging of patients with aggressive lymphoma.

SSK14-03 Altered Liver FDG Uptake in Lymphoma Patients with Chemotherapy Associated Hepatic Steatosis on PET/CT

Wednesday, Nov. 28 10:50AM - 11:00AM Room: SS05AB

Participants

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PURPOSE

To evaluate the prevalence of hepatic steatosis in lymphoma patients after chemotherapy; to reveal whether lymphoma patient with chemotherapy associated hepatic steatosis (CAHS) will change liver FDG uptake on PET/CT, compared to their baseline and to further study the relation between liver FDG uptake and severity of fatty liver.

METHOD AND MATERIALS

88 of 1647 lymphoma patients had been diagnosed fatty liver during or after chemotherapy from December 1, 2014, to June 30, 2017. 176 FDG PET/CT scans of the 88 lymphoma patients were reviewed retrospectively. These 88 lymphoma patients all had a normal liver before chemotherapy and then got hepatic steatosis after chemotherapy. Each patient had performed two PET/CT scans: baseline and post-chemotherapy. Paired t test was used to compare BMI, blood glucose (BG), liver SUVmax (SUVmax-l), liver average SUV (SUVave-l), liver SULmax (SULmax-l), aorta SUVmax (SUVmax-a), aorta average SUV (SUVave-a) and aorta SULmax (SULmax-a) between baseline and post-chemotherapy. CAHS was divided into three groups: mild-grade, moderate-grade, and severe-grade. The relationship within or between groups was assessed.
RESULTS

The prevalence of CAHS in lymphoma patients of our hospital was about 88/1647 (5.3%). After chemotherapy, 28 of 88 (31.8%) patients had increased liver SUVs, whereas 60 of 88 (68.2%) patients showed decreased liver SUVs. There were significant differences of mean liver SUVs between baseline and CAHS (baseline versus CAHS; SUVmax-l, 2.84±0.57 vs 2.57±0.64, P<0.00; SUVave-l, 2.17±0.43 vs 1.95±0.51, P=0.001; SUVmax-l, 2.24±0.40 vs 2.04±0.41, P<0.001). BG had a slight decrease after chemotherapy (baseline versus CAHS, 5.5±1.2 vs 5.2±1.0, P=0.01). No difference was identified when the mean aorta SUVs and BMI for baseline were compared with those for CAHS (P>0.05). The patients with severe-grade of CAHS had significant lower liver SUV values, compared to those with mild-grade (P<0.05). And BMI showed no difference among the three groups of CAHS.

CONCLUSION

Increase of liver FDG uptake coexists with decrease. The severer the fatty liver is, the more likely the liver FDG uptake declines. The altered liver SUV due to CAHS might affect the response assessment and prognostic evaluation for lymphoma patients.

CLINICAL RELEVANCE/APPLICATION

(dealing with 18F-FDG PET/CT) 18F-FDG PET/CT is a powerful imaging technique and has become the standard for staging and response assessment of FDG-avid lymphomas.

SSK14-04 Is Dual-Time Point 18F-FDG PET/CT Valuable for Differentiating Goitrous Hashimoto's Thyroiditis from Primary Thyroid Lymphoma?

Wednesday, Nov. 28 11:00AM - 11:10AM Room: SS505AB

Participants
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PURPOSE

Goitrous Hashimoto's thyroiditis (HT) occasionally shows diffusely increased F-18 fluorodeoxyglucose (FDG) uptake in the thyroid that it mimics primary thyroid lymphoma (PTL) on FDG-PET/CT iImages. The aim of the study was to determine whether delayed imaging of FDG-PET/CT was valuable in differentiating PTL from HT.

METHOD AND MATERIALS

53 patients with HT, who were suspected of PTL due to enlarging goiter, underwent dual-time-point (60 ± 5min and 120± 10min after FDG injection ) PET/CT scan using FDG combined with neck ultrasound (US) and US-guided core needle biopsy. Specimen of core needle biopsy was subjected to immunohistochemical staining (CD20,CD3,CD79a, Ki-67, etc.) along with H-E staining. Rearrangement of igH was also analyzed by PCR. In addition to visual assessment based on 5-point scale from The Lugano classification, the maximum standardized uptake value for the thyroid at the early image (SUV-E) and that at the delayed image (SUV-D) for the thyroid were determined. In addition, SUV increment (ΔSUV) was calculated by subtracting SUV-E from SUV-D.

RESULTS

Pathological diagnosis was PTL in 36 (MALT lymphoma 31, DLBCL 5) and was HT in 17. 11 patients with PTL was excluded from analysis because they had either nodular FDG uptake in the thyroid or abnormal uptake in extrathyroidal area. The remaining 25 patients with PTL and all patients with HT showed diffusely increased thyroid FDG uptake on both the early and the delayed PET/CT images. There was no statistically significant difference between PTL and HT in S-PS (early 4.4 vs. 4.2, delayed 4.1 vs. 4.0 ) as well as SUV-E and SUV-D (9.02 vs. 7.51, 8.28 vs. 6.54 ). 7 of 25 patients (28%) with PTL had plus values of ΔSUV while none but one (6%) with HT had plus value of ΔSUV. When plus value of ASUV was considered as a sign for PTL, PPV, NPV, and accuracy for PTL was 88%, 47%, and 55%, respectively.

CONCLUSION

Neither visual nor semi-quantitative analysis of dual time-point FDG-PET/CT was helpful in differentiation HT from PTL among enlarging goiter. Needle biopsy may be the best strategy in differential diagnosis of HT with enlarging goiter.

CLINICAL RELEVANCE/APPLICATION

Addition of delayed imaging does not improve diagnostic performance of FDG-PET/CT in diffusely increased thyroidal uptake in enlarging goiter.

SSK14-05 Utility of Integrated 18F-FDG PET/MRI for Response Assessment of Isolated Limp Perfusion in Patients with Soft-Tissue Sarcomas

Wednesday, Nov. 28 11:10AM - 11:20AM Room: SS505AB

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To evaluate the diagnostic potential of simultaneously obtained PET- and MR-datasets for therapy response assessment of isolated limb perfusion with TNF-alpha and melphalan (TM-ILP) in patients with soft-tissue sarcomas.

A total of 32 patients with histopathological confirmation of a soft-tissue sarcoma were prospectively enrolled for an integrated 18F-FDG PET/MRI examination before (1st scan) and after (2nd scan) neoadjuvant TM-ILP. In each examination morphological (tumor size) and metabolic (SUVmax, SUVpeak) parameters of the tumors were determined. Two readers analysed the datasets and assessed treatment response based on RECIST 1.1 and PERCIST criteria. Results from subsequent tumor resection served as reference standard and therapy response was determined based on the tumor regression grading scale of Salzer-Kuntschik.

RESULTS
Based on the reference standard, a total of 25 patients were classified as partial responder (PR) and 7 patients as stable disease (SD). Calculated mean values of the maximum tumor diameter, SUVmax and SUVpeak in patients with stable disease amounted to 62.4 ± 42.4 mm, 11.1 ± 7.9 and 9.1 ± 6.2 before and 59.5 ± 50.3 mm, 8.4 ± 5.3 and 6.7 ± 5.1 after treatment. The respective values in the responder group were 78.1 ± 65.6 mm, 11.9 ± 7.4 and 9.6 ± 6.1, before and 71.1 ± 65.9 mm, 5.1 ± 3.1 and 3.9 ± 2.4 after treatment. Based on RECIST criteria, 25 patients were classified as SD and 6 patients as PR, whereas 1 patient showed progressive disease (PD). PERCIST criteria categorized 11 patients as SD, 20 patients as PR and one patient as PD. In accordance with PERCIST, a significantly higher number of patients (n = 23, 71.9%) could be correctly categorized as SD/PR, when compared to RECIST (n = 9, 28.1%; p < 0.005).

CONCLUSION
Our results demonstrate the significant discrepancy in morphological and metabolic response and underline the diagnostic superiority of 18F-FDG PET data over MRI for response assessment of neoadjuvant ILP in sarcoma patients.

18F-FDG PET/MRI might enable more accurate therapy response assessment of isolated limb perfusion in patients with soft-tissue sarcomas when compared to MRI alone.

SSK14-06 Evaluation of 18F-FDG-PET/CT for Response Assessment in Patients with Advanced Melanoma Treated with Immune Checkpoint Inhibitors

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PURPOSE
Treatment with immune checkpoint inhibitors (ICI) have improved outcomes for patients with advanced melanoma. The aim of this retrospective study was to characterize the findings on 18F-FDG PET/CT that predict response in these patients.

METHOD AND MATERIALS
Ninety-seven patients with advanced melanoma treated with ICI were identified, with 70 having baseline (PET0) and interim 18F-FDG PET/CT studies (PET1, median 84 and range 19 to 181 days after cycle 1). Of these, 34 were treated with ipilimumab alone (N=17) or combined with nivolumab (N=17, analyzed together as the ipi cohort) and 36 with pembrolizumab (pembro cohort) alone. AutoPERCIST software was used to determine the SULpeak and SUVmax of the hottest lesion on each scan. Clinical assessment at the last office visit determined responders (R: partial response, stable, or no disease) and nonresponders (NR: progression) at a median 9.5 (range 0 to 61) months after PET1 for the ipi cohort and 5.5 months (range 0 to 20) for the pembro cohort. Repeated measures analysis of variance (SigmaPlot 12.5, Systat Software, Inc.) determined differences between PET0 and PET1 metrics among response categories by cohort. The Mann-Whitney rank sum test assessed for differences in the % change in each metric between response categories.

RESULTS
Thirteen R and 21 NR were identified in the ipi cohort and 26 R and 10 NR in the pembro cohort. Within the ipi R cohort, SULpeak (PET0 6.8±5.1, PET1 1.2±2.4, p=0.002) and SUVmax (PET0 9.9±7.0, PET1 2.0±4.3, p=0.002), were significantly different. The PET1 SULpeak (13±12, p=0.007) and SUVmax (19±19, p=0.006) of the NR was also significantly different from the R PET1 values. For the pembro NR cohort, SULpeak (PET0 6.2±5.3, PET1 10±4.8, p=0.017) and SUVmax (PET0 9.5±9.1, PET1 14±12, p=0.033) were significantly different, and the pembro R PET1 SULpeak (2.0±3.6, p<0.001) and SUVmax (3.4±6.0, p=0.001) were also significantly different from NR PET1 values. The % change in all metrics was significantly different between R and NR in both treatment cohorts.

CONCLUSION
Changes in the SULpeak and SUVmax of the hottest lesion on interim 18F-FDG PET/CT studies may be useful in predicting responders to ICI.
CLINICAL RELEVANCE/APPLICATION

Higher SULpeak and SUVmax values and lower % decrease in these parameters on interim 18F-FDG PET/CT scans during ICI treatment are predictors of poor treatment response.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

Richard L. Wahl, MD - 2013 Honored Educator

SSK14-07 Is 18F-FDG PET/MR Including DWI an Alternative to Sentinel Lymph Node Biopsy in Initial N-Staging in Patients with Malignant Melanoma?

Wednesday, Nov. 28 11:30AM - 11:40AM Room: S505AB

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PURPOSE

To compare 18F-fluorodeoxyglucose positron emission tomography / computed tomography (18F-FDG PET/CT), 18F-FDG PET / magnetic resonance (18F-FDG PET/MR) as well as 18F-FDG PET/MR and diffusion weighted imaging (DWI) with sentinel lymph node biopsy (SLNB) in initial lymph node staging in patients with malignant melanoma.

METHOD AND MATERIALS

In this retrospective study, 52 patients with malignant melanoma (female: n=30, male: n=22, mean age 50.5y) that underwent 18F-FDG PET/CT and consecutive 18F-FDG PET/MR including DWI prior to lymphoscintigraphy with single photon emission computed tomography / CT (SPECT/CT) and consecutive SLNB were included. By two readers, the status of the sentinel lymph nodes detected by SPECT/CT (benign/malignant) was assessed on 18F-FDG PET/CT, 18F-FDG PET/MR as well as 18F-FDG PET/MR and DWI images. In all modalities, increased tracer uptake in comparison to the background was considered as a sign of malignancy. In PET/MR, morphological criteria were considered as additional signs of malignancy. In 18F-FDG PET/MR and DWI, all of the aforementioned criteria and diffusion restriction were considered as signs of malignancy. Discrepancies were resolved in a consensus reading. Histopathologic results served as a reference standard to calculate sensitivity, specificity as well as positive (PPV) and negative predictive values (NPV).

RESULTS

In all patients, a total of 87 sentinel lymph nodes were detected by lymphoscintigraphy and SPECT/CT. According to histopathology, lymph nodes were metastatic. We found a sensitivity, specificity, PPV and NPV of 17.7%, 95.6%, 50.0% and 82.3% for PET/CT and of 23.5%, 96.9%, 66.7% and 82.3% for PET/MR. Additional DWI was available in 56 lymph nodes and led to two additional false positive findings, thus decreasing specificity of PET/MR and DWI.

CONCLUSION

Due to its low sensitivity and specificity, 18F-FDG PET/MR cannot be considered an alternative to SLNB in initial N-Staging in patients with malignant melanoma even if additional DWI is performed.

CLINICAL RELEVANCE/APPLICATION

18F-FDG PET/MR is inferior to SLNB in N-Staging in patients with malignant melanoma. Therefore, neither 18F-FDG PET/MR nor 18F-FDG PET/MR and DWI will be able to replace SLNB in clinical routine.

Skr14-08 Prognostic Value of 18F-FDG PET/CT in Intralesional Interleukin-2 Therapy for Cutaneous Metastatic Melanoma

Wednesday, Nov. 28 11:40AM - 11:50AM Room: S505AB

Participants

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PURPOSE

Intralesional interleukin-2 (IL-2) therapy is an effective treatment for cutaneous metastatic melanoma even in cases refractory to multiple treatment modalities. 18F-FDG PET/CT is a valuable tool for diagnosis, staging and surveillance of melanoma, but its role in therapy assessment is unclear given the strong local inflammatory response in injected sites. This study investigates the prognostic value of 18F-FDG PET/CT for assessment of intralesional IL-2 in cutaneous metastatic melanoma.

METHOD AND MATERIALS

13 patients (10M/3F, 23 - 96 years) with Stage IIIIC/IV cutaneous metastatic melanoma or stage IIB disease not amenable to surgical intervention had a total of 31 PET/CT scans performed at baseline, interim and completion time points while receiving variable injections of intralesional IL-2 (range, 1 - 20; mean 7.8) at variable doses (range 5 - 22 million units; mode 7). PET/CT scans were evaluated using maximum SUV (SUV max) and a 5 point scale (5PS): 1, no uptake; 2, uptake <= mediastinum; 3, uptake > mediastinum <= liver; 4, uptake moderately < liver; 5, uptake markedly > than liver. The 5PS was dichotomized to
negative (score 1, 2, and 3) or positive (score 4 and 5). The Kaplan-Meier (KM) method with log-rank test and Cox-regression analysis were performed.

RESULTS
Of the 31 scans, 17 were positive and 14 were negative. SUV max range, 1.3 - 20.6 g/ml. Follow-up range, 8 - 51 months (median 15). Baseline scans with higher SUV max had a significantly lower PFS with hazard ratio (HR) of 1.55 (95% CI 1.001-1.33, p=0.048). KM curves demonstrated a trend of improved OS with lower SUVmax at baseline (p=0.11). Positive scans at completion trended toward lower OS with HR of 2.74, (p=0.48). The progression-free survival (PFS) was worse for positive groups at completion, HR of 12.12 (95% CI 1.22-120.49, p=0.03), with significant separation in KM curves (Log-rank, p=0.008).

CONCLUSION
18F-FDG PET/CT SUV max at baseline and qualitative therapy assessment at completion time points during intralesional IL-2 can predict PFS and show potential to predict OS, with larger sample size, in patients with cutaneous metastatic melanoma.

CLINICAL RELEVANCE/APPLICATION
A baseline PET/CT prior to intralesional IL-2 adds prognostic value. Additionally, using a qualitative therapy assessment method such as the 5PS increases the prognostic value of 18F-FDG PET/CT for therapy response in intralesional IL-2 treatment for cutaneous metastatic melanoma.

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PURPOSE
To assess the prevalence of undetected low bone mineral density (BMD) in a cohort of patients undergoing PET/CT with opportunistic quantitative computed tomography (QCT).

METHOD AND MATERIALS
A retrospective survey was conducted to identify PET/CT studies obtained between Oct/2015 and Jan/2016 in a Biograph 64 scanner (Siemens). CT images were processed with the QCT Pro software (Mindways). A calibration CT scan was obtained in the same PET/CT scanner using the asynchronous Model 4 QCT Phantom. Two radiologists and a trained research technician performed the analyses of trabecular BMD at vertebral bodies L1 and L2. The American College of Radiology (ACR) criteria was used for diagnosing low BMD. Total BMD of femoral necks were measured on DXA-equivalent images (CTXA) of the hips and used to generate FRAX-scores for calculating absolute fracture risks. We obtained clinical data from institutional medical records. Requirement for signed informed consent was waived by the IRB.

RESULTS
Sixty-nine studies were identified, two studies excluded due to severe scoliosis and one excluded due to Schmörn node affecting the analysis. The final cohort comprised 66 subjects (20F/46M, mean age: 53.8, SD: 12.1). Mean coefficient of variation (CV) for trabecular BMD in L1-2 between the 3 readers was 1.2%. Distribution of subjects according to ACR category is shown in Table 1. Thirty-two percent (21/66) of subjects showed low lumbar spine BMD on QCT. Twenty-four percent (5/21) of subjects with low BMD on QCT had a prior DXA scan, all of which showing low BMD. None of the subjects with normal BMD on QCT had a prior DXA scan. Femoral neck BMD was assessed with CTXA in 20 of 66 subjects by one radiologist and the research technician. Mean CV between the readers was 6.1%. Fifteen percent (3/20) of the subjects had a prior diagnosis of low BMD. Only 15% (1/3) of these subjects had a prior diagnosis of low BMD.

CONCLUSION
Low BMD was an under recognized condition in our sample. Future analysis will correlate metabolic activity (FDGuptake) with bone mass.

CLINICAL RELEVANCE/APPLICATION
PET/CT provides a unique opportunity to screen patients for occult low BMD by leveraging the quantitative capabilities of CT. Identification of subjects at risk for future osteoporotic fractures may not only improve outcomes, but also decrease downstream costs.
Endovascular thrombectomy (EVT) is supported by Level IA evidence for middle cerebral artery (MCA) M1 occlusion stroke, yet more distal occlusions lead to challenges in decision making. In stroke patients with large vessel MCA occlusion, distance to thrombus (DT) can be measured from the carotid T. We determined the value of DT in the context of established clinical and imaging parameters.

**METHOD AND MATERIALS**

We selected patients with isolated MCA occlusions (M1-M3) and follow-up-confirmed stroke. Two independent, blinded readers evaluated imaging. DT was measured as the distance from the carotid T to the proximal end of the thrombus on coronal CT angiography images. Established clinical and imaging parameters were assessed. Linear and ordinal regression analyses were performed to identify independent associations.

**RESULTS**

The study population of 162 patients had a median DT of 14.0 mm (interquartile range: 8.0-24.0 mm). Dichotomizing the study population by median DT, patients with DT ≤ 14.0 mm showed significantly higher median admission National Institutes of Health Stroke Scale scores (14 vs 9, p < 0.001; NIHSS), no significant difference in median final infarction volumes (31 mL vs. 23 mL, p = 0.224), but worse median non-contrast Alberta Stroke Program Early CT Scores (8 vs 9, p = 0.004) and 90 days (5 vs 2, p = 0.037).

Patients with shorter DT had worse median non-contrast Alberta Stroke Program Early CT Scores (8 vs 9, p < 0.001; NCCT-ASPECTS) and more frequently underwent EVT. When adjusted for age, sex, admission NIHSS, NCCT-ASPECTS, thrombolysis, EVT and DT, linear regression analyses revealed only significant associations of admission NIHSS (b = 0.229, p < 0.001) and NCCT-ASPECTS (b = 0.357, p < 0.001) with final infarction volumes. In similarly adjusted ordinal regression analyses on clinical outcomes, only admission NIHSS was an independent predictor of discharge mRS (b = 0.144, p < 0.001) and 90-day mRS (b = 0.137, p = 0.004).

**CONCLUSION**

In this comprehensive analysis on the value of DT in acute stroke, DT was outperformed by existing imaging parameters for morphologic outcome prediction and had no independent predictive value for clinical outcomes.

**CLINICAL RELEVANCE/APPLICATION**

In stroke imaging, DT is a quantifiable occlusion parameter yet carries no independent predictive value. However, DT could be used to standardize selection for randomized EVT trials on M2 occlusions.
Corticospinal tracts (CSTs) were performed. Laminar Gaussian-classes (noted L1-L5) were calculated, and tractography with lacunar infarcts as the seed areas to reconstruct the corona radiata, with residual motor deficit, and healthy controls (n=15). T1-component probability maps, dividing the cortex into 5 layers, were used to study motor cortex connectivity. We aimed to extend this knowledge by exploring in-vivo T1-relaxation 3T-MRI, surface-based cortical thickness analysis and tractography if (i) in patients with chronic lacunar infarct, involving the corticospinal tract, the cortical layers of the connected primary motor cortex are differently affected, and if (ii) these differences correlate with clinical symptomatology.

**PURPOSE**

To compare clinical workflow and functional outcome in acute ischemic stroke patients screened by Magnetic Resonance Imaging (MRI) or Computed Tomography (CT).

**METHOD AND MATERIALS**

Data were analyzed from THRACE, a multicenter, randomized, controlled trial that evaluated the efficacy of mechanical thrombectomy in addition to intravenous tissue-plasminogen activator (IV-tPA) in patients with acute ischemic stroke and proximal occlusion. Recruiting centers were free to use their routine MRI or CT stroke protocol before randomization. Brain imaging was performed within 4h of stroke onset. Workflow times were obtained from the trial database and extracted from Digital Imaging and Communications in Medicine (DICOM) metadata. All patients or their legal representative provided written informed consent.

**RESULTS**

403 patients were included: 300 based on MRI and 103 on CT. Median baseline National Institutes of Health Stroke Scale score was 18 in both groups. Time interval (median, interquartile range) from stroke onset to imaging was similar (MRI: 114 min (89-139); CT: 108 min (88-140); P = .23). MRI scan duration was overall longer (MRI: 13 min (10-16); CT/CT angiography: 9 min (7-12); P < .001), irrespective of the imaging protocol (without perfusion-weighted imaging [MRI: 12 min (10-15); CT: 7 min (2-11); P < .001] or with perfusion-weighted imaging [MRI: 16 min (15-19); CT: 10 min (8-13); P < .001]). Time from stroke onset to IV-tPA (MRI: 150 min (121-179); CT: 150 min (123-180); P = .31) and onset to entry in angiography suite (MRI: 200 min (170-250); CT: 213 min (180-246); P = .57) did not differ between groups. In the endovascular treatment arm, imaging modality of inclusion was not associated with unfavorable outcome (modified Rankin Score scale > 2) in multivariate analysis (MRI: odds ratio 0.72; 95% confidence interval: 0.33 - 1.54; P = .40).

**CONCLUSION**

In the THRACE trial, use of MRI at the acute phase of ischemic stroke did not delay treatment nor was associated with poorer functional outcome than CT after endovascular treatment.

**CLINICAL RELEVANCE/APPLICATION**

Efficient workflow allows to use MRI as a screening tool for stroke patients, without delay to treatment nor negative impact on clinical outcome.

**SSK15-03  Focal Thinning in Remote Cortical Layers via Degeneration of Connecting Fibers Correlates with Clinical Outcome in Lacunar Infarct Patients**

**Wednesday, Nov. 28 10:50AM - 11:00AM Room: E350**

**Awards**

**Student Travel Stipend Award**

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**PURPOSE**

Ischemic infarcts have been observed to exert structural effects distant from the acute lesion itself, in remote, connected cortex. We aimed to extend this knowledge by exploring in-vivo T1-relaxation 3T-MRI, surface-based cortical thickness analysis and tractography if (i) in patients with chronic lacunar infarct, involving the corticospinal tract, the cortical layers of the connected primary motor cortex are differently affected, and if (ii) these differences correlate with clinical symptomatology.

**METHOD AND MATERIALS**

Our cohort included patients (n=20) with history of chronic lacunar infarct, involving the posterior limb of the internal capsule or the corona radiata, with residual motor deficit, and healthy controls (n=15). T1-component probability maps, dividing the cortex into 5 laminar Gaussian-classes (noted L1-L5) were calculated, and tractography with lacunar infarcts as the seed areas to reconstruct the corticospinal tracts (CSTs) were performed.
RESULTS

Results demonstrated focal cortical thinning in the connected primary motor cortex (M1) and specifically only in its deepest L5-class compared to the non-affected mirrored cortex (P<0.001 and P=0.0001, respectively). There was loss of microstructural integrity of the affected CST connecting the lacunar infarct to the M1 with significantly increased mean diffusivity (MD) and decreased fractional anisotropy (FA) compared to the non-affected hemisphere (P=0.002 and P=0.0002, respectively). Increased MD and decreased FA were associated with focal thinning in M1 and in its deepest L5-class in the affected compared to the non-affected hemisphere (MD: P<0.07 and P=0.05, respectively; FA: P=0.02 and P=0.005, respectively). No significant difference was found between the laminar thickness pattern of the bilateral M1 or the microstructural integrity of the bilateral CSTs for the healthy subjects. Clinical scores were significantly correlated with microstructural damage of the CST and with thinning of both M1 and its deepest L5-class (P<0.05).

CONCLUSION

Our results support the concept of secondary neurodegeneration of Betz cells in layer V of connected M1, following a lacunar infarct affecting the CST, with a novel finding that the majority of the cortical thinning occurs in the deepest cortex.

CLINICAL RELEVANCE/APPLICATION

The severity of clinical symptoms is significantly correlated with the microstructural damage of the CST and with the connected M1 atrophy pattern.

SSK15-04 Clinical Decision Support Based on Automated Non-Contrast CT Density Measurements in Patients with Acute Ischemic Stroke

Wednesday, Nov. 28 11:00AM - 11:10AM Room: E350

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PURPOSE

To examine the clinical value of automated non-contrast CT (NCCT) density measurements in Alberta Stroke Program Early CT Score (ASPECTS) regions to support decision making in acute ischemic stroke.

METHOD AND MATERIALS

From a cohort of 1644 consecutive patients admitted for suspected stroke, we included patients with follow-up-confirmed middle cerebral artery infarction and available NCCT and CT perfusion (CTP) data. ASPECTS region density was assessed using automated software (Figure 1A). Relative Hounsfield units (rHU) were defined as the ratio of ipsilesional by contralesional region density. Extent of ischemic core was measured on CTP maps. Regression coefficients from a linear regression analysis on the association of regional rHU and infarction core volume were used as weighting factors to calculate a composite rHU score of all regions. Receiver operating characteristics (ROC) analyses were performed to test this score’s discriminative value regarding time from symptom onset (TFSO) <4.5h, current CTP trial selection criteria, and subacute stroke complications on follow-up imaging.

RESULTS

In total 121 patients were included. The composite rHU score resulted in significant classification of patients with TFSO<4.5h (area under the curve [AUC]=0.721, p=0.018). Moreover, the score was able to classify patients who meet CTP selection criteria of ischemic core size <70mL and target mismatch >1.8 (AUC=0.759, p<0.001). The score discriminated between patients with and without subsequent space-occupying edema development (AUC=0.771, p<0.001). ROC curves are shown in Figure 1B. The score could not classify patients by occurrence of hemorrhagic infarction or parenchymal hematoma (both p>0.05).

CONCLUSION

The composite rHU score on NCCT allowed significant classification of patients with thrombolysis-eligible symptom onset times and current CTP imaging criteria for extended time window thrombectomy selection. The score also identified patients with subsequent space-occupying edema development.

CLINICAL RELEVANCE/APPLICATION

Automated NCCT density measurements have the potential to act as observer-independent imaging biomarkers that could support decision making in patients with unknown TFSO or in centers in which CTP is not available.

SSK15-05 Does IV-tPA Induce Thrombus Migration? A Retrospective Study Comparing Bridging Therapy and Thrombectomy Alone

Wednesday, Nov. 28 11:10AM - 11:20AM Room: E350

Participants
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Public Health and Cost Consequences of Treatment Delays in Endovascular Thrombectomy for Stroke Based on HERMES Collaboration Data

Wednesday, Nov. 28 11:20AM - 11:30AM Room: E350

Awards
Trainee Research Prize - Resident

Participants
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PURPOSE

Thrombus migration (ThrMi) before mechanical thrombectomy (MT) is an epiphenomenon in acute ischemic stroke (AIS) treatment with few available data. The aim of this study is to evaluate ThrMi prior to MT in a bridging protocol (tPA-MT group) and stand-alone MT (MT group).

METHOD AND MATERIALS

205 consecutive AIS patients treated by MT (tPA and no tPA) were retrospectively analyzed. Distance between vessel origin and beginning of the thrombus in 3D time of flight and/or contrast enhanced magnetic resonance angiography sequences) and digital-subtracted-angiography (DSA) were measured in millimeters using a curve tool and the same anatomical parameters. DSA pixels were converted in millimeters by measuring 3 large vessels diameters in MRI and determining the ratio from pixels to millimeters.

RESULTS

129 patients were included in tPA-MT group, with ThrMi in 36.4%, and 76 patients in MT group, with ThrMi in 6.6% (p<0.0001). In tPA-MT group, 27 (20.9%) patients had a moderate migration between 5-10 millimeters, 11 (8.5%) patients had a distal migration of more than 10 millimeters or to another segment and 9 (7%) presented recanalization defined by spontaneous TICI score>=2B. In MT group, 69 (90.8%) patients had no ThrMi, moderate ThrMi in 6.6%, thrombus’ extension in 2.6%; no patient presented distal migration or recanalization. The two groups had the same clinical prognosis (bleeding event at 48hours, NIHSS at discharge, mRS and death at 3 months). Number of device passes to reach thrombectomy was 1.40 (±1.39) in tPA-MT group, 1.63 (±1.09) in MT group, p=0.061.

CONCLUSION

IV thrombolysis seems to promote thrombus migration, present in 36.4% of patients in tPA-MT group compared to 6.6% of patients in MT group. This study adds more data concerning IV thrombolysis effects on AIS treatment when MT is also involved.

CLINICAL RELEVANCE/APPLICATION

(dealing with acute ischemic stroke) ‘Before performing mechanical thrombectomy, the possibility of a thrombus migration favored by prior thrombolysis is an important data for neurointerventionalists.’

METHOD AND MATERIALS

A Markov model estimated lifetime quality-adjusted life years (QALY) of EVT-treated patients and associated costs based on stroke onset to arterial puncture time (model structure in Figure 1). The analysis was performed from a United States perspective with two cost frameworks: 1) healthcare costs and 2) societal costs, which include productivity losses and costs of informal care given by family members. Input parameters were based on best available evidence (Table 1), including patient data from the 7-trial HERMES collaboration (ESCAPE, EXTEND-IA, MR CLEAN, REVASCAT, SWIFT PRIME, PISTE, THRACE; Figure 2). In addition to diminished functional outcomes with later EVT, the model also projects that a proportion of patients becomes EVT-ineligible over time.
RESULTS

Lifetime QALYs decreased for every hour of time delay until arterial puncture (Figure 3A). Within the first 6 hours of onset, every hour of delay resulted in an average loss of 0.69 QALYs. The healthcare and societal costs of each QALY yielded by EVT increased for every hour of time delay (Figure 3B). Within the first 6 hours of onset, every hour of delay increased the cost of QALYs yielded by EVT by $5,310/QALY in healthcare costs and by $7,914/QALY in societal costs. Within the first 3 hours of onset, a treatment delay of 2 hours - the amount typically associated with drip-and-ship compared to mothership care delivery - would result in an average loss of 1.7 QALYs per patient. In addition, this delay would result in an extra of about $10,000/QALY gained incurred by the healthcare system and $15,000/QALY gained incurred by the society.

CONCLUSION

Every hour of treatment delay in EVT for stroke reduces a patient's QALYs by almost three-quarters of a year and substantially increases healthcare and societal costs per QALY.

CLINICAL RELEVANCE/APPLICATION

Investments in healthcare policies and procedures to improve the efficiency of pre-hospital triage and in-hospital workflow for earlier treatment of stroke patients are likely highly cost-saving.

SSK15-07 Association Between Wall Characteristics of Atherosclerotic Middle Cerebral Artery with High-Resolution Magnetic Resonance Imaging and Infarction Pattern

Wednesday, Nov. 28 11:30AM - 11:40AM Room: E350

Participants
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PURPOSE

To study the characteristics of atherosclerotic middle cerebral vascular wall by using 3.0 T high-resolution magnetic resonance imaging (HRMRI), explore the association between the characteristics of vascular wall and cerebral infarction, and predict the mechanism of infarction.

METHOD AND MATERIALS

Thirty-two patients with atherosclerotic patients were retrospectively enrolled and intracranial artery HRMRI was performed. HRMRI protocol included a 3D T1 weighted technique known as inversion-recovery (IR) prepared SPACE. The plaque morphology, distribution, enhancement, stenosis degree and reconstruction index (positive reconstruction) of the middle cerebral artery were analyzed. Characteristics of acute infarct on diffusion weighted imaging (DWI) were categorized according to the number (single or multiple infarcts) and the pattern of cerebral infarcts (cortical, border zone, or perforating artery territory infarcts). The relationship between wall characteristics and infarction patterns was evaluated.

RESULTS

In the Thirty-two patients with acute infarction, twenty-one patients had multiple acute cerebral infarcts and eleven showed single acute cerebral infarcts. Border zone infarcts were the most common (16, 76.2%) among multiple acute infarcts. Eleven single infarcts were subcortical deep penetrating artery infarcts (11, 100%). Thirty(93.8%) plaque were eccentric. Seven plaques (63.6%) in penetrating artery infarcts were located at the upper wall among single acute infarcts. Twelve plaques(75.0%) in border zone infarcts were located at the ventral wall among multiple acute infarcts. There was no significant difference in clinical data and laboratory examination of patients with single and multiple infarcts (P>0.05). The percentage of plaques located on the ventral wall, plaques with strong enhancement, pattern of PR reconstruction and degree of stenosis of the lumen in the multiple infarction were all significantly higher than those in the single infarction (P<0.05).

CONCLUSION

The strong enhancement plaque is associated with its vulnerability in the patients with intracranial MCA atherosclerosis. PR or obvious lumen stenosis were associated with artery to artery embolism. HR MRI provides insights into intracranial atherosclerosis, and predicting infarction patterns.

CLINICAL RELEVANCE/APPLICATION

HRMRI can provide insights into intracranial atherosclerosis, and predict infarction patterns.

SSK15-08 Deep Learning Based Quantitative Diagnosis of Ischemic Stroke on CT

Wednesday, Nov. 28 11:40AM - 11:50AM Room: E350

Awards

Student Travel Stipend Award

Participants
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PURPOSE
To evaluate a deep learning based tool for quantitative and objective CT diagnosis of acute ischemia, benchmarked on a large population with CT/MR correlation.

METHOD AND MATERIALS
After IRB approval, all patients with suspected ischemia in a five-year interval (January 2013 to 2018) receiving a non-contrast head CT followed by MR within 48 hours were identified. For each patient, DWI was co-registered to CT after brain extraction. For all MR exams, regions of reduced diffusion were segmented by a custom deep learning algorithm and confirmed through visual inspection. A hybrid 3D/2D object localization network based on the faster R-CNN architecture was implemented using a feature pyramid backbone (Figure 1A-D). A region proposal network identified potential regions of infarct, and a separate head network quantified the primary CT findings of acute ischemia: gray-matter hypoattenuation and mass effect (Figure 1E-F). Network outputs are represented on a normalized scale from 0 to 1 based on finding severity. After training, population statistics for hypoattenuation and mass effect were used to create a nomogram of stroke risk.

RESULTS
A total of 4,382 patients with short-interval CT/MR were identified, 831 of which had DWI-confirmed ischemia, yielding 326,394 images across 8,764 exams for analysis. As quantified by the neural network, degree of hypoattenuation (0.68 vs. 0.21; p < 0.001) and mass effect (0.59 vs. 0.11; p < 0.001) was more severe in patients with ischemia vs. controls. A nomogram based on deep learning quantification of these findings predicted ischemia with AUC, accuracy, sensitivity, specificity, PPV and NPV of 0.823, 0.815, 0.729, 0.835, 0.508 and 0.929 respectively. By varying the thresholds for diagnosis, algorithm sensitivity/PPV for ischemia detection ranged between 0.91/0.14 to 0.33/0.89.

CONCLUSION
A deep learning tool is presented for completely objective assessment of hypoattenuation and mass effect in the setting of acute ischemia. A deep learning based nomogram of stroke risk as a function of these two variables yields a powerful and flexible tool for ischemia detection. Arguably, prediction errors from this entirely objective approach may primarily be attributed to limitations in CT technology.

CLINICAL RELEVANCE/APPLICATION
A deep learning enabled nomogram of stroke risk based on quantitative image findings yields a powerful and flexible tool for completely objective diagnosis of acute ischemia on CT.

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PURPOSE
The purpose of this study was to investigate the difference of plaque characteristics in middle cerebral artery assessed by High-resolution Vessel Wall Imaging (HRVWI) between patients with positive and negative penumbra area, and to identify the risk factors affected penumbra volumes.

METHOD AND MATERIALS
Sixty-seven patients (44 males; age, 59.33 ± 10.57 years) with severe stenosis in the unilateral middle cerebral artery were enrolled. Patients were assigned to two groups: Positive Penumbra (PP group) and Negative Penumbra (NP group). MRI data were collected on a 3T Siemens MAGNETOM Trio Tim, including High-Resolution T1-SPACE, and DSC-PWI. The plaque characteristics in MCA was measured in the T1-SPACE, and all the cross-sectional image slices of a stenotic MCA on T1-SPACE were analyzed, and plaque characteristics was calculated as follows: outer vessel wall area (OWA), lumen area (LA) and wall area (WA). Other extended parameters include normalized wall index (NWI), arterial remodeling, plaque length, configuration and enhanced behavior. The Mismatch volume was acquired using the RApid processing of PerfusIon and Diffusion (RAPID) software. Independent sample t test, Kruskal-Wallis H test and Chi-square test was performed in the difference of plaque characteristics in PP group and NP group. The relationship between the plaque characteristics and penumbra volume was calculated with Spearman's correlation or Kruskal-Wallis H test.

RESULTS
The results showed that eccentric plaques were observed 10 (37.04%) in PP group and 32 (80.00%) in NP group, which means significant difference was found between two groups (χ²=12.72, p<0.001). There were no significant difference between two groups in WA (p=0.761), NWI (p=0.572), expansive remodeling (p=0.427), diffused plaque distribution (p=0.370) and enhancement (p=0.262). Patients with diffused plaque length had larger penumbra volume comparing with the focal one in PP group (Z=-2.754, p=0.005).
CONCLUSION

Plaque with eccentric distribution in MCA is a remarkable sign to predict the presence of penumbra. Based on the patients with positive penumbra, plaque with diffused plaque length hint the larger penumbra volume, which could be rescued by timely treatment.

CLINICAL RELEVANCE/APPLICATION

Plaque with eccentric distribution in MCA can predict the presence of penumbra area, and plaque with diffused length hint the larger penumbra volume, which could be rescued by timely treatment.
**SSK18**

**Physics (CT: Image Quality)**

Wednesday, Nov. 28 10:30AM - 12:00PM Room: E353C

| AI | CT | PH | SQ |

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

FDA Discussions may include off-label uses.

**Participants**

Michael F. McNitt-Gray, PhD, Los Angeles, CA (Moderator) Institutional research agreement, Siemens AG; 
John M. Boone, PhD, Sacramento, CA (Moderator) Patent agreement, Isotropic Imaging Corporation Consultant, RadSite

**Sub-Events**

**SSK18-01 Quantitative Impact of Denoising Strategies in Low-Dose CT**

**Participants**

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**PURPOSE**

CT number accuracy at low dose levels has been found to be strongly biased. It was demonstrated that the stochastic noise associated with photon detection is the root cause of inaccurate CT number. The purpose of this work is to investigate the impact of three different denoising strategies to alleviate CT number inaccuracy in FBP-based CT: image domain denoising, sinogram domain denoising and raw counts domain denoising.

**METHOD AND MATERIALS**

Data acquisition was performed in a benchtop CT system, which included a CdTe-based photon counting detector. A Catphan phantom, containing inserts of known composition, was scanned at 60 kV and two different CTDIw levels: 1.5 and 15 mGy. The acquired data was reconstructed using FBP with ramp filter. Locally adapted denoising diffusion filter was applied to the lowest dose data set, in image, sinogram and raw counts domain. The contrast of Teflon and LDPE inserts was measured in averaged images across repetitions. FBP reconstruction of the average raw counts at the highest dose was considered as reference.

**RESULTS**

Experimental results from this study corroborate that CT number estimates are inaccurate at low dose levels. As a consequence, the contrast of inserts relative to the background is overestimated. Particularly, the contrast of the analyzed inserts is doubled in the lowest dose scans. After adapted denoising, only the strategy to perform denoise in the raw counts domain was successful in restoring the reference contrast values.

**CONCLUSION**

Results in this study suggest that locally adaptive denoising is an adequate methodology to preserve the quantitative accuracy of low dose CT when performed in the pre-log projection domain.

**CLINICAL RELEVANCE/APPLICATION**

Healthy tissue and disease characterization often rely on both absolute CT number and relative contrast, for example: liver and pancreatic steatosis, acute cerebral venous sinus thrombosis, etc. Dose reduction efforts in CT must be guided by both imaging performance and quantitative capabilities.

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**SSK18-02 Task-Based Image Quality Assessment of X-ray CT Using Convolutional Neural Networks**

**Participants**

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Wednesday, Nov. 28 10:40AM - 10:50AM Room: E353C
Our proposed data-driven metal artifact reduction method may provide sufficient image quality in radiation therapy planning, which

CLINICAL RELEVANCE/APPLICATION

CONCLUSION

22.1685 for DestreakNet with perceptual loss.

image, 0.7014 and 18.8975 for the NMAR-corrected image, 0.8636 and 23.8582 for DestreakNet with MSE loss, and 0.8264 and

to the artifact-free truth. The SSIM and PSNR were 0.2382 and 9.1830, respectively, for the initial uncorrected reconstruction

metrics including structural similarity index (SSIM) and peak signal-to-noise ratio (PSNR) were calculated for all images in reference

To validate the network performance, hip and spine images withheld from training were used. In a hip case, the image quality

RESULTS

Machine learning based model observers as well as the CHOI and the human observer were highly correlated at each lesion size and dose level. With strategy A, Pearson's product-moment correlation coefficients r were 0.961 (95% confidence interval (CI): 0.863-0.989) for SR-MO and 0.974 (95% CI: 0.907-0.993) for CNN-MO. Mean absolute percentage differences (MAPD) between the model observer and the human observer were 1.1% for SR-MO and 1.0% for CNN-MO. With strategy B, r was 0.956 (95% CI: 0.845-0.988) for SR and 0.958 (95% CI: 0.854-0.989) for CNN. For CHOI, r was 0.971 (95% CI: 0.897-0.992). MAPD were 2.0% for SR-MO and 1.5% for CNN-MO. For the CHOI the MAPD was 1.9%.

CONCLUSION

Machine learning based model observers can accurately predict the performance of a human observer for all lesion sizes and dose levels in the evaluated signal detection task.

CLINICAL RELEVANCE/APPLICATION

Model observers are widely used in research regarding the development and optimization of medical imaging devices. Our results show that machine learning based model observers can accurately predict the performance of a human observer in a signal detection task for CT.

SSK18-03 DestreakNet: A Deep Convolutional Neural Network to Reduce Metal Streak Artifacts in CT Images

Participants
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PURPOSE

To design and train a deep convolutional neural network to reduce metal artifacts in CT images.

METHOD AND MATERIALS

Our network structure (DestreakNet) consists of two parallel streams, each with 20 residual units. In each residual unit, there are two convolution layers with batch normalization (BN) and rectified linear unit (ReLU) activation. The network is trained on the residual error between the input and output of the unit. The outputs of both streams are merged in the network's feature space, and then passed through nine more convolution layers to yield a final output. A mean squared error (MSE) and a perceptual loss function were both investigated for network optimization. All training, testing, and validation datasets were generated using CatSim, an industrial-grade CT simulator. Real data from the Visible Human Project were used to create voxelized phantoms of pelvic and spinal regions with and without metal implants. For initial correction, CT images were reconstructed using the state-of-the-art NMAR algorithm. The reconstructed images without metal were the ground truth and target of the network. From full-size images, approximately 150,000 patches of size 56x56 were extracted for training. Patches from the NMAR images were input to one network stream and patches from uncorrected CT images were input to the other to harness complimentary features simultaneously.

RESULTS

To validate the network performance, hip and spine images withheld from training were used. In a hip case, the image quality metrics including structural similarity index (SSIM) and peak signal-to-noise ratio (PSNR) were calculated for all images in reference to the artifact-free truth. The SSIM and PSNR were 0.2382 and 9.1830, respectively, for the initial uncorrected reconstruction image, 0.7014 and 18.8975 for the NMAR-corrected image, 0.8636 and 23.8582 for DestreakNet with MSE loss, and 0.8264 and 22.1685 for DestreakNet with perceptual loss.

CONCLUSION

Our network substantially reduced metal streak artifacts that remained in the CT image after initial correction by the NMAR algorithm.

CLINICAL RELEVANCE/APPLICATION

Our proposed data-driven metal artifact reduction method may provide sufficient image quality in radiation therapy planning, which
SSK18-04  Patient-Specific Local Noise Power Spectrum Measurement via a Deep-Learning Generative Adversarial Network

Participants
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Guang-Hong Chen, PhD, Madison, WI (Abstract Co-Author) Research funded, General Electric Company Research funded, Siemens AG

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PURPOSE
With the increased use of low-dose CT techniques which are characterized for its highly shift-variant noise properties, the measurement of the noise power spectrum (NPS) has become challenging and time consuming since current solutions require multiple scans of a given clinical scenario. In this work, a deep-learning generative adversarial network (GAN) was developed to address this challenge and provide a fast and accurate way to measure patient-specific local NPS.

METHOD AND MATERIALS
GANs were utilized to learn a mapping from white noise input to output CT noise realizations with correct CT noise correlations from a single local uniform ROI. To achieve this, a two-stage training strategy was implemented. In the pre-training stage, repeated scans of a quality assurance phantom were performed to extract 1600 (64x64) local MBIR noise-only images used as labels to train the network. This network characterized the noise magnitude and correlation in labels and was able to generate 64x64 noise-only images with similar characteristics as the input. For the next stage, a single scan of an anthropomorphic phantom was used for fine-tuning, while repeated scans were used for validation. First, a 101x101 ROI was extracted from a single MBIR image, detrended, and augmented to obtain 128 (64x64) training labels and fine-tune the pre-trained GANs. To validate the GAN-generated noise images, their NPS was compared to the NPS from the physical ensemble of repeated scans in terms of overall RMSE, noise magnitude, and mean frequency across 30 trials. This patient-specific approach was applied to clinical data reconstructed with MBIR (same patient at two doses) to assess the estimated NPS in terms of noise magnitude and coarseness.

RESULTS
The overall RMSE between the GAN-generated NPS and the physical NPS was 0.83 HU\textsuperscript{2}mm\textsuperscript{2}. The mean percent discrepancy for their noise magnitude and mean frequency were 4.51\% and 3.62\%, respectively. The runtime for the fine-tuning stage was <100s and 1s to generate 250 noise images.

CONCLUSION
It was demonstrated that GANs can characterize CT noise in terms of magnitude and coarseness and generate multiple noise realizations with comparable characteristics from a single noise realization.

CLINICAL RELEVANCE/APPLICATION
A fast and accurate way to estimate patient-specific local NPS was provided and can be easily adapted to any given CT system. This is an essential step towards patient-specific image quality assessment.

SSK18-05  Multi-Kernel Synthesis for CT Images Using a Deep Convolutional Neural Network

Participants
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PURPOSE
To produce a single synthetic image that combines the best qualities of images reconstructed with different kernels using a deep convolutional neural network (CNN).

METHOD AND MATERIALS
A CNN was trained from scratch to synthesize multiple input images, each produced with a different reconstruction kernel, into a single output image that exhibits improved image qualities (in terms of high sharpness and low noise levels) compared to each input individually. The CNN architecture was based on the ResNet design, and consisted of repeated blocks of residual units with a total of 32 convolutional layers. The CNN inputs consisted of three images produced by soft (B10), medium-sharp (B45), and sharp (B70) kernels that were stacked in the channel dimension. The CNN output was treated as a perturbation that was added to the sharp-kernel input, which reduced the required training time. The network was trained using supervised learning with both full-dose and simulated quarter-dose abdominal CT images. The simulated quarter-dose images obtained from different kernels were used as the
network input, and the corresponding full-dose images reconstructed with a sharp kernel were used as the ground truth to evaluate a mean-squared-error loss function. The network was trained on 500,000 example images of various sizes that were cropped from ten abdominal CT exams. After training, the performance was evaluated by comparing input and output images using a reserved set of full-dose abdominal, chest, and phantom CT scans that were not used in the network training.

RESULTS

The synthetic images improved the signal-to-noise ratio by 338% compared to the sharp kernel images, without observable blurring of sharp edges. No perceptible artificial texture was introduced that detracted from the natural appearance of the synthetic image. The algorithm was robust enough to be applied to multiple tissue types, including the bones, lungs, and liver.

CONCLUSION

An artificial neural network can be used to combine images from multiple reconstruction kernels into a single synthetic image that exhibits both low noise and a high degree of sharpness.

CLINICAL RELEVANCE/APPLICATION

CT Images from different reconstruction kernels can be merged using a neural network into a single image with superior qualities that can be used for reading multiple tissue types simultaneously.

SSK18-06 Correlation Between 2D Channelized Hotelling Observer in a Uniform Water Background and Human Observers in a Patient Liver Background for Low-Contrast Lesion Detection and Localization in CT

Wednesday, Nov. 28 11:20AM - 11:30AM Room: E353C

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Joel G. Fletcher, MD, Rochester, MN (Abstract Co-Author) Grant, Siemens AG; Consultant, Medtronic plc; ;
Cynthia H. McCollough, PhD, Rochester, MN (Abstract Co-Author) Research Grant, Siemens AG

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PURPOSE

To investigate the correlation between 2D channelized Hotelling observer (CHO) performance in a uniform water background (with single-slice viewing mode) and human observer (HO) performance in a patient liver background (with multi-slice scrolling viewing mode) for a low-contrast liver lesion detection and localization task when lesion location is uncertain.

METHOD AND MATERIALS

Seven routine dose abdominal patient scans (mean CTDIvol 12.6 mGy) were retrospectively collected. Patient scans at half and quarter of routine dose were simulated using a projection-based noise insertion tool. An abdomen-sized water phantom was repeatedly scanned (n = 10) on the same scanner. Lesion models generated from real metastatic liver lesions (size 7, 9 and 11 mm, and contrast 15, 20, and 25 HU) were inserted into both phantom and patient images using a projection-based method. CT images were created using filtered-back-projection (FBP) and iterative reconstruction (IR). Region-of-interests (ROIs) around lesions were extracted to generate trials for CHO and HO studies. Centers of the ROIs were shifted to randomly distribute lesion locations in the ROIs. A 2D CHO with 12 Gabor channels was applied to phantom images. Two subspecialized radiologists (10 and 25 years of experience) performed HO studies on patient images. For each trial, they localized lesions by scrolling through multiple slices. The performance of CHO and HO was compared across 12 experimental conditions with varying dose, lesion characteristics, and reconstruction types. Area under the receiver operating characteristic (ROC) curve and localization ROC curve were used as figure of merits for CHO and HO performance.

RESULTS

2D CHO performance in phantom images correlated well with HO performance in patient liver images (Pearson correlation coefficients 0.960 (p = 0.0023) and 0.984 (p = 0.0004) for detection and localization, respectively) for all conditions. No statistically significant difference was observed in Bland-Altman agreement analysis.

CONCLUSION

It is possible to use a simple single-slice viewing CHO and uniform water phantom to assess performance for realistic CT detection and localization tasks in patient liver backgrounds.

CLINICAL RELEVANCE/APPLICATION

Single-slice 2D CHO with Gabor channels provides a convenient tool to evaluate diagnostic performance and optimize abdominal CT scanning protocols.

Honored Educators

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SSK18-07 Can Deep Learning Unseat Iterative Reconstruction for Low-Dose CT?

Wednesday, Nov. 28 11:30AM - 11:40AM Room: E353C

Participants
Hongming Shan, Troy, NY (Presenter) Research Grant, General Electric Company
PURPOSE

Although widely applied in clinical practice, studies have reported that iterative reconstruction (IR) alters image appearance, and can adversely affect low contrast lesions. The purpose of this project is to systematically compare commercial/clinical iterative reconstructions by major vendors with FBP-reconstruction-based deep learning (FBP-DL) reconstruction for low-dose chest and abdomen CT exams.

METHOD AND MATERIALS

Our study included 80 low-dose chest and abdomen CT exams from three major CT vendors (de-identified). We created a neural network including 4 convolutional and 4 deconvolutional layers, each of the layers contains 32 filters except for the last layer with only 1 filter. For preserving image features, former feature-maps were reused at latter layers by three conveying-paths. The rectified linear unit was used for each layer. The network was optimized in the Wasserstein generative adversarial network framework with an additional perceptual loss. 128K normal- and low-dose FBP image patches from the MGH dataset were used in training our network. Image quality metrics including peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM) were calculated for all the images in reference to the normal-dose FBP images. Also, a blinded reader study was designed to evaluate the image quality. Then, the Wilcoxon signed-rank test was used to compare FBP-DL with commercially available state-of-the-art IR techniques.

RESULTS

FBP-DL achieves a significantly better image quality and performance than commercially available IR images evaluated by PSNR and SSIM for all the selected vendors. Also, the reader study demonstrated that FBP-DL images had superior visibility of small and subtle structures with lower noise and less severe artifacts as compared to the IR counterparts. In addition to that, deep learning is computationally more efficient than IR.

CONCLUSION

The deep learning method has a great potential to outperform the commercial/clinical iterative reconstruction for low-dose CT. An integrated deep learning workflow from raw data to final images/radiomics is under active development.

CLINICAL RELEVANCE/APPLICATION

Emerging deep learning-based CT methods may provide a superior diagnostic performance in routine clinical applications.
CT iterative reconstruction was introduced a decade ago and is continuing to be improved. The proposed image quality evaluation methods are useful for algorithm designers to achieve the best possible tuning of CT algorithms before clinical deployment.

**SSK18-09  Task Based Image Quality in Virtual Monoenergetic Images Across 3 Generations of Scanner Models**

**Participants**
Jayasai R. Rajagopal, BA, Durham, NC *(Presenter)* Nothing to Disclose
Yakun Zhang, MS, Durham, NC *(Abstract Co-Author)* Nothing to Disclose
Juan Carlos Ramirez-Giraldo, PhD, St Louis, MO *(Abstract Co-Author)* Employee, Siemens AG
Ehsan Samei, PhD, Durham, NC *(Abstract Co-Author)* Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc

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**PURPOSE**
To use task-based metrics to assess the impact of patient size, beam spectra separation, and radiation exposure on image quality for virtual monoenergetic images (VMIs) across three scanner platforms.

**METHOD AND MATERIALS**
This study used a commercially available phantom with iodine, soft tissue and calcium inserts (Gammex Multi Energy CT phantom). The phantom was configured with additional fat rings simulating five different sizes (20, 30, 35, 40, and 50 cm diameter). All scans used radiation exposures of 4, 8, 16, and 24 mGy, and were repeated on three DECT platforms from one manufacturer (Siemens Force, Flash and Edge). VMIs were reconstructed at 50, 70 keV and 150 keV. Noise and image texture in terms of average frequency of the noise power spectra (Favg) and the contrast-dependent spatial resolution in terms of the 50% amplitude of the iodine-task transfer function (F50) were calculated. A task-specific detectability index (d’) was calculated for iodine inserts using a 5 mm Gaussian circular disk as the task.

**RESULTS**
The Favg and F50 decreased with increasing phantom size. For 100/150Sn kV on Force scanner, Favg was 0.31, 0.30, 0.27, and 0.25 mm⁻¹ for the 20, 30, 35, 40 cm sizes; F50 was 0.43, 0.43, 0.37, 0.32 mm⁻¹, respectively. For the same phantom size, the Favg appeared to be insensitive to changes in acquisition spectra separations, but F50 increased with increasing spectra separation. Different keVs did not affect either Favg or F50, but affected the noise magnitude and contrast, and thus the detectability index. d’ for the 15 mg/ml iodine insert had an average of 23% increase for all sizes and kV combinations when keV decreased from 70 to 50. At 70 keV, the larger spectra separation (80/150Sn kV) led to an increase in d’ compared to less spectra separation (100/150Sn kV) at round 10% for the 20 and 30 cm phantoms, but only 3% higher d’ for the 35 and 40 cm phantoms. For a fixed keV, image contrast, Favg, and F50 were relatively insensitive to changes in radiation exposure for sizes below 40cm.

**CONCLUSION**
The system behaved non-linearly for different phantom sizes and spectra separation. Task based metrics was able to capture the characteristics of the VMIs. Highest detectability was achieved with larger spectra separation and for smaller sizes.

**CLINICAL RELEVANCE/APPLICATION**
Highest iodine detectability for the VMIs was achieved with larger spectra separation and for smaller sizes.
Solitary pulmonary nodules are among the most common diagnostic problems facing radiologists who interpret chest CT examinations. This component of the course will review technical considerations of CT of lung nodules, the characteristics of benign nodules and those CT features of SPNs that are concerning for malignancy. The evidence-based approach to small nodules detected incidentally on chest CT examinations will be reviewed, with a focus on the 2017 Fleischner Society guidelines for management of these lesions. Metastatic disease to the thorax is commonly encountered in clinical practice and can have a wide range of imaging manifestations. CT is typically used to detect the abnormality, guide diagnostic procedures and therapy, as well as assess treatment response. This presentation will review cases that illustrate main pathological mechanisms of metastatic spread to the chest, and imaging patterns on CT, characteristic for specific categories of primary malignancies, with focus on pulmonary metastases. Prognostic implications and available therapeutic options will be reviewed. Intrathoracic calcification is most often the result of prior granulomatous infection. Other intrathoracic calcifications will be presented by location: solitary pulmonary nodule, metastases. Prognostic implications and available therapeutic options will be reviewed. Intrathoracic calcification is most often the result of prior granulomatous infection. Other intrathoracic calcifications will be presented by location: solitary pulmonary nodule, multiple pulmonary nodules, diffuse parenchymal involvement, lymph node and pleura. The differential diagnosis includes malignant, metabolic, occupational, and idiopathic causes often with subtle differences in morphology that can be used to correctly diagnose these conditions. Malignant pleural disease can manifest as an isolated pleural effusion, a pleural effusion with uneven pleural thickening or more rarely by presence of isolated small pleural nodules, which is named dry pleural dissemination.

ABSTRACT

1) Identify CT features of benign solitary pulmonary nodules. 2) List morphologic features of solitary nodules that suggest malignancy. 3) Review current recommendations for management of incidentally-detected small lung nodules. 4) Recognize common mechanisms of intrathoracic metastatic spread with focus on pulmonary metastases. 5) Familiarize with pertinent imaging features and patterns of metastatic disease on CT. 6) Illustrate how to narrow the differential diagnosis regarding the primary site of malignancy. 7) Assess utility of imaging findings for diagnosis, prognosis and directing therapy of metastatic disease. 8) Describe intrathoracic calcification by location and identify those with characteristic morphology. 9) Identify signs of malignant pleural disease on CT examinations.

LEARNING OBJECTIVES

1) Identify CT features of benign solitary pulmonary nodules. 2) List morphologic features of solitary nodules that suggest malignancy. 3) Review current recommendations for management of incidentally-detected small lung nodules. 4) Recognize common mechanisms of intrathoracic metastatic spread with focus on pulmonary metastases. 5) Familiarize with pertinent imaging features and patterns of metastatic disease on CT. 6) Illustrate how to narrow the differential diagnosis regarding the primary site of malignancy. 7) Assess utility of imaging findings for diagnosis, prognosis and directing therapy of metastatic disease. 8) Describe intrathoracic calcification by location and identify those with characteristic morphology. 9) Identify signs of malignant pleural disease on CT examinations.

ABSTRACT

Solitary pulmonary nodules are among the most common diagnostic problems facing radiologists who interpret chest CT examinations. This component of the course will review technical considerations of CT of lung nodules, the characteristics of benign nodules and those CT features of SPNs that are concerning for malignancy. The evidence-based approach to small nodules detected incidentally on chest CT examinations will be reviewed, with a focus on the 2017 Fleischner Society guidelines for management of these lesions. Metastatic disease to the thorax is commonly encountered in clinical practice and can have a wide range of imaging manifestations. CT is typically used to detect the abnormality, guide diagnostic procedures and therapy, as well as assess treatment response. This presentation will review cases that illustrate main pathological mechanisms of metastatic spread to the chest, and imaging patterns on CT, characteristic for specific categories of primary malignancies, with focus on pulmonary metastases. Prognostic implications and available therapeutic options will be reviewed. Intrathoracic calcification is most often the result of prior granulomatous infection. Other intrathoracic calcifications will be presented by location: solitary pulmonary nodule, multiple pulmonary nodules, diffuse parenchymal involvement, lymph node and pleura. The differential diagnosis includes malignant, metabolic, occupational, and idiopathic causes often with subtle differences in morphology that can be used to correctly diagnose these conditions. Malignant pleural disease can manifest as an isolated pleural effusion, a pleural effusion with uneven pleural thickening or more rarely by presence of isolated small pleural nodules, which is named dry pleural dissemination.
thickening or more rarely by presence of isolated small pleural nodules, which is named dry pleural dissemination

**MSCT41B  Many Faces of Metastatic Diseases to the Chest**

Participants
Maya Galperin-Aizenberg, MD, Philadelphia, PA (Presenter) Nothing to Disclose

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Maya.Galperin-Aizenberg@uphs.upenn.edu

**LEARNING OBJECTIVES**

1) Identify CT features of benign solitary pulmonary nodules. 2) List morphologic features of solitary nodules that suggest malignancy. 3) Review current recommendations for management of incidentally-detected small lung nodules. 4) Recognize common mechanisms of intrathoracic metastatic spread with focus on pulmonary metastases. 5) Familiarize with pertinent imaging features and patterns of metastatic disease on CT. 6) Illustrate how to narrow the differential diagnosis regarding the primary site of malignancy. 7) Assess utility of imaging findings for diagnosis, prognosis and directing therapy of metastatic disease. 8) Describe intrathoracic calcification by location and identify those with characteristic morphology. 9) Identify signs of malignant pleural disease on CT examinations.

**ABSTRACT**

Solitary pulmonary nodules are among the most common diagnostic problems facing radiologists who interpret chest CT examinations. This component of the course will review technical considerations of CT of lung nodules, the characteristics of benign nodules and those CT features of SPNs that are concerning for malignancy. The evidence-based approach to small nodules detected incidentally on chest CT examinations will be reviewed, with a focus on the 2017 Fleischner Society guidelines for management of these lesions. Metastatic disease to the thorax is commonly encountered in clinical practice and can have a wide range of imaging manifestations. CT is typically used to detect the abnormality, guide diagnostic procedures and therapy, as well as assess treatment response. This presentation will review cases that illustrate main pathological mechanisms of metastatic spread to the chest, and imaging patterns on CT, characteristic for specific categories of primary malignancies, with focus on pulmonary metastases. Prognostic implications and available therapeutic options will be reviewed. Intrathoracic calcification is most often the result of prior granulomatous infection. Other intrathoracic calcifications will be presented by location: solitary pulmonary nodule, multiple pulmonary nodules, diffuse parenchymal involvement, lymph node and pleura. The differential diagnosis includes malignant, metabolic, occupational, and idiopathic causes often with subtle differences in morphology that can be used to correctly diagnose these conditions. Malignant pleural disease can manifest as an isolated pleural effusion, a pleural effusion with uneven pleural thickening or more rarely by presence of isolated small pleural nodules, which is named dry pleural dissemination.

**MSCT41C  Many Faces of Thoracic Calcifications**

Participants
Cristopher A. Meyer, MD, Madison, WI (Presenter) Investor, Elucent Medical; Consultant, NIOSH Certified B-reader

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cmeyer2@uwhealth.org

**LEARNING OBJECTIVES**

1) Identify the cause of diffuse lung parenchymal calcification based on morphology and distribution. 2) Describe the differential diagnosis for calcified mediastinal lymph nodes. 3) Be familiar with the entities of pleural plaque and pseudo-plaque in occupational exposure.

**MSCT41D  Many Faces of Pleural Disease**

Participants
Marie-Pierre Revel, Paris, France (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Identify CT features of benign solitary pulmonary nodules. 2) List morphologic features of solitary nodules that suggest malignancy. 3) Review current recommendations for management of incidentally-detected small lung nodules. 4) Recognize common mechanisms of intrathoracic metastatic spread with focus on pulmonary metastases. 5) Familiarize with pertinent imaging features and patterns of metastatic disease on CT. 6) Illustrate how to narrow the differential diagnosis regarding the primary site of malignancy. 7) Assess utility of imaging findings for diagnosis, prognosis and directing therapy of metastatic disease. 8) Describe intrathoracic calcification by location and identify those with characteristic morphology. 9) Identify signs of malignant pleural disease on CT examinations.
LEARNING OBJECTIVES

1) Recognize the vital role of CT Colonography (CTC) in colorectal cancer screening for the US population. 2) Explain aspects and procedural details of a single-center CTC program managed by a radiologist assistant. 3) Examine departmental resources required to establish and develop a CTC program. 4) Justify the use of a radiologist assistant to enhance involvement of radiologists in being at the forefront of colorectal screening in a safe, efficient and cost-effective manner.

ABSTRACT

Although technically not new in terms of how long CT Colonography (CTC) has been performed, it is potentially new to the procedural realm of the Radiologist Assistant (RA). Through routine practice analysis of Radiologist Assistant work in the United States, a variety of common fluoroscopic examinations have been identified as less commonly performed in recent years such as the barium enema, which has traditionally been considered the "gold standard" for colon screening in Radiology. In 2016, the US Preventive Services Task Force approved CTC as a colorectal screening option available to patients in what was viewed as a truly under-utilized preventive health strategy. To that end, the American Gastroenterological Association, the American College of Radiology and the American Cancer Society have also approved CTC use with equivalent sensitivity to optical colonoscopy for detecting significant colorectal polyps or cancers. CTC is a minimally invasive, patient-centric, low-dose CT examination of the colon that can be performed without the use of sedation and minimal risk of perforation or side effect and has been proven to increase adherence rates and attracts more patients that may have otherwise not chosen to get screened. As a physician extender that can safely and successfully perform and manage the CTC from start to finish, the Radiologist Assistant is uniquely poised to enhance the patient experience and, in the meantime, allow the radiologist to tend to critical interpretations and other physician-specific duties. The Radiologist Assistant can be a vital part of colorectal screening programs around the country. Involve one today!
BOOST: Advanced Techniques in Image-guided Therapy (Interactive Session)
Wednesday, Nov. 28 3:00PM - 4:15PM Room: S103CD

Participants
Theodore S. Hong, MD, Boston, MA (Presenter) Nothing to Disclose
Susanna I. Lee, MD,PhD, Boston, MA (Presenter) Editor, Wolters Kluwer nv
Homer A. Macapinlac, MD, Houston, TX (Presenter) Nothing to Disclose
Peter Balter, PhD, Houston, TX (Presenter) Research Grant, Varian Medical Systems, Inc; Research Grant, RaySearch Laboratories

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LEARNING OBJECTIVES
1) Explain and apply modern CT and MR imaging technologies and PET tracers for treatment planning of solid malignancies in the chest, abdomen and pelvis. 2) Explain and apply the modern techniques in radiotherapy safely and effectively in the chest, abdomen and pelvis.

ABSTRACT
The last decade has seen emergence of important advances in locoregional cancer therapy. Use of functional imaging and advanced radiotherapy often integrated with targeted chemotherapy have improved patient outcomes. This course will present the underlying principles in diffusion MRI, novel MR contrast agents, PET-MR and dual energy CT. PET tracers to be discussed are F-18 FDG, widely used for most solid tumors; C-11 choline/F-18 Fluciclovine for prostate cancer and Ga-68-DOTATATE for neuroendocrine tumors. Advanced radiotherapy techniques such as Image Guided Radiotherapy (IGRT), Intensity Modulated Radiation Therapy (IMRT), and Stereotactic Body Radiation Therapy (SBRT) using image guidance with X-ray, CT, MRI and PET will be described.

Honored Educators
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SSM04

**Cardiac (Arrhythmia and Electrophysiology)**

**Wednesday, Nov. 28 3:00PM - 4:00PM Room: S103AB**

**Purpose**
Atrial fibrillation (AF) is the most common sustained arrhythmia, affecting 1-2% of the population. Although endovascular pulmonary vein isolation (PVI) may temporarily reduce symptoms in patients failing medical management, recurrence rates are high and identifying patients likely to have successful outcomes remains elusive. Pulmonary vein morphology and left atrial size have been previously identified as radiographic markers for AF, but have not been assessed for PVI outcome. We explore pulmonary vein and left atrial morphometry as a means of predicting response to PVI.

**Method and Materials**
A retrospective review of PVI procedures from 2014-2016 excluding prior PVI or valve surgery revealed 314 cases. 154 had pre-PVI CT imaging and clinician-assessed PVI outcome recorded in the EMR at follow-up, with 50 cases diagnosed with recurrent AF within 3 months to 1 year. 50 non-recurrent cases were randomly selected to produce a balanced dataset for analysis (n=100). Radiographic features were obtained characterizing left atrium size, pulmonary vein morphology, and angle of vein entry into the left atrium using Syngo.Via (©Siemens Healthcare). The 5 most distinguishing features were selected by Wilcoxon rank-sum and used to train a support vector machine classifier in a 3-fold cross-validation setting. Ability to predict recurrence was assessed by area under the receiver operating characteristic curve (AUC) among all patients and the predictive ability including clinical features was investigated similarly.

**Results**
Distinguishing radiographic features include angle between right pulmonary veins (p = 0.063) and angle of left inferior pulmonary vein entry into the left atrium (p = 0.060). Radiographic features effectively predicted recurrence of AF within 1 year of PVI (AUC = 0.77 ± 0.02). Distinguishing clinical features include age (p < 0.001), BMI (p = 0.005), left ventricular ejection fraction (p = 0.014), history of hypertension (p = 0.016), NYHA class of I or greater (p = 0.016), and use of apixaban (p = 0.016).

**Conclusion**
Pulmonary vein morphology in CT successfully predicts recurrence of AF after endovascular treatment.

**Clinical Relevance/Application**
The ability to identify patients likely to have recurrent AF based on CT morphometric features may provide a pre-treatment indicator of response and anatomic features that may be targeted.

**SSM04-02 Relationship Between Chronicity of Atrial Fibrillation and Left Atrial Remodeling Determined with Cardiac Magnetic Resonance Imaging in Patients with Atrial Fibrillation: Significance of Regional Left Atrial Late Gadolinium Enhancement**

**Wednesday, Nov. 28 3:10PM - 3:20PM Room: S103AB**

**Participants**
Dong Kyu Lee, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Hwan Seok Yong, MD, PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
SSM04-03 Determination of Conducting Channels from LGE CMR in Patients with Myocardial Infarction-Direct Comparison with Electroanatomic Mapping for Ventricular Tachycardia Ablation

PURPOSE

Left atrial (LA) remodeling is associated with progression of atrial fibrillation (AF). Cardiac magnetic resonance (CMR) imaging can assess the LA remodeling with LA volume (LAV) and LA late gadolinium enhancement (LA-LGE). The distribution of LA-LGE by LAV is largely unknown. This study aimed to determine the relationship of LA-LGE distribution with LAV and progression of AF.

METHOD AND MATERIALS

195 patients (mean age: 55.7 ± 10.7 years, 82.6% men) underwent LGE-CMR examinations before ablation of paroxysmal AF (PAF, n = 121) or persistent AF (PeAF, n = 74). The LAV and LA-LGE were assessed by three-dimension reconstruction of LGE-CMR images. In each of all 9 preselected LA regions, the presence of LA-LGE was evaluated. Additionally, the incidences (in %) of LA-LGE were calculated in every LA region.

RESULTS

Of all the preselected LA regions, the anterior wall and left inferior pulmonary vein (LIPV) region showed a significantly different incidence of LA-LGE (p <0.05, respectively) depending on the LAV. In all 195 patients, the incidences of LA-LGE in the anterior wall and LIPV region were 15.4% and 15.9%. The patients with PeAF showed significantly higher LA-LGE incidence in the anterior wall (31.1% vs. 5.8%, p <0.001) and LIPV region (29.7% vs. 7.4%, p <0.001) than did those with PAF. After adjusting for LAV, the odd ratios for PeAF of the LA-LGE in anterior wall and LIPV region were 3.8 (95% CI = 1.40-10.41, p = 0.009) and 3.7 (95% CI = 1.46-9.75, p = 0.006), respectively.

CONCLUSION

In evaluation of LA remodeling using CMR imaging, the regional LA-LGE in anterior wall and LIPV region of LA may be associated with the presence of PeAF.

CLINICAL RELEVANCE/APPLICATION

Cardiac MRI can describe the LA remodeling related to the chronicity of AF. Furthermore, the LA remodelng determined with cardiac MRI may help understanding the AF mechanism.

SSM04-04 Comparison of Cardiac Venous Anomalies in Complete and Congenitally Corrected Transposition of

Participants
Avanti Gulhane, Philadelphia, PA (Abstract Co-Author) Nothing to Disclose
Sam Nazarian, MD, Baltimore, MD (Abstract Co-Author) Scientific Advisor, Johnson & Johnson Research funded, Johnson & Johnson
Harold I. Litt, MD, PhD, Philadelphia, PA (Presenter) Research Grant, Siemens AG ; ; ;

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PURPOSE

LGE CMR is an excellent tool to evaluate scar in patients after myocardial infarction (MI). Electroanatomic mapping (EAM) is traditionally used to locate areas in scar tissue giving rise to ventricular tachycardia (VT) and guide ablation. However, new software using pixel signal intensity (PSI) algorithms has made it possible to locate conducting channels (CC) in scar tissue which form VT substrate using LGE CMR. We compared LGE derived CC with EAM findings in patients with VT post MI.

METHOD AND MATERIALS

We evaluated retrospectively 28 patients with previous MI and VT who underwent CMR prior to EAM and VT ablation. Short axis LGE CMR were evaluated using ADAS-VT (Galgo Medical SL, Barcelona) to identify CC within myocardial layers. A PSI-based algorithm was applied to characterize the LGE area as scar core or border zone, using 60% and 40% of the maximum LGE intensity as thresholds. CC were identified topologically by finding border zone coursing through scar core, representing corridors of viable tissue. CC on LGE-CMR were co-registered with EAM on Carto system. This data was evaluated according to AHA 17 segment model for targeted sites of VT ablation on a per patient and per channel basis.

RESULTS

In 28 patients, 232 potential VT sites were identified on EAM-CMR merge, of which 129(55%) were targeted for ablation.138 sites of CC were identified. On a per patient basis, 4 CMR analyses were in total agreement with EAM, 24 had partial agreement. 87(67.4 %) CC sites matched sites of ablation, 50(21%) CC sites were detected only on CMR. 53(23%) scar sites had neither CC on CMR nor ablation on EAM. 42(32.5%) sites of ablation on EAM did not show CC on LGE CMR. CC were also correlated with sites having late(64%), fractionated(65%) potentials, critical isthmus, entry points (60%), pacing sites(60%) and induced VT(48%). LGE CMR PSI-based analysis showed sensitivity of 67.4%(95%CI 58.6%-75.4%), specificity of 52%, positive predictive value of 64%(95%CI 58 % - 69.6%) and negative predicting value of 56% and overall diagnostic accuracy of 60% in identifying sites of EAM sites of ablation.

CONCLUSION

LGE CMR PSI-based analysis has good sensitivity and positive predictive value in identifying sites of VT on EAM.

CLINICAL RELEVANCE/APPLICATION

Target sites for VT ablations can predicted by LGE-CMR to aid preprocedural planning, potentially reducing the need for extensive EAM and additional CC on CMR can also identify cause of recurrent VT
**the Great Arteries: Implications for Cardiac Resynchronization Therapy**

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S103AB

Participants
Hugo Vidal, MD, Toronto, ON (Presenter) Nothing to Disclose
Kate Hanneman, MD, FRCPC, Toronto, ON (Abstract Co-Author) Nothing to Disclose
Krishnakumar Nair, Toronto, ON (Abstract Co-Author) Nothing to Disclose
Elsie Nguyen, MD, Toronto, ON (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**
Cardiac resynchronization therapy (CRT) can help improve cardiac function of progressively failing subaortic morphologic right ventricles in both complete (c-TGA) and congenitally corrected (cc-TGA) transposition of the great arteries, but requires transvenous access to the subaortic morphologic right ventricle. We aim to compare the prevalence of cardiac venous anomalies and accessibility for CRT in c-TGA and cc-TGA using cardiac gated computed tomography angiography (CTA).

**METHOD AND MATERIALS**
With institutional review board approval, all CTA studies performed between 2007-2018 in patients with c-TGA and cc-TGA were retrospectively reviewed. CTAs were evaluated for cardiac venous anomalies and whether both subaortic and subpulmonic ventricles could be accessed via the subpulmonic atrium and coronary sinus. Statistical analysis included independent samples t-test for continuous variables and Fisher's exact test for categorical variables.

**RESULTS**
121 patients were included [mean age 36 years (range 18-69 yrs), 75 males (62%)] including 70 patients with c-TGA (44 atrial switch, 13 arterial switch, 13 Rastelli) and 51 with cc-TGA (48 no surgery, 3 double switch). Cardiac venous anomalies were more frequent in cc-TGA (30% vs. 6%; p<0.001). Accessibility was significantly higher in cc-TGA compared to c-TGA (86% vs 60%; p<0.002). Accessibility was also significantly lower among cc-TGA patients who had undergone double switch compared to those who had not (33% vs. 89%, p=0.048).

**CONCLUSION**
Cardiac CTA identifies cardiac venous anomalies that impact eligibility for CRT. CRT eligibility is significantly lower among both c-TGA patients who have undergone atrial switch procedure and cc-TGA patients who have undergone double switch procedure compared to patients who have not.

**CLINICAL RELEVANCE/APPLICATION**
Cardiac-gated CTA is essential prior to CRT due to high prevalence of cardiac venous anomalies that may render the patient ineligible due to lack of access.

**Honored Educators**
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Kate Hanneman, MD, FRCPC - 2017 Honored Educator
Kate Hanneman, MD, FRCPC - 2018 Honored Educator

**SSM04-05 Anatomical Shape Differences of Left Atrium on CT Predicts Post-Ablation Recurrence of Atrial Fibrillation**

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S103AB

Participants
Thomas Atta-Fosu, Cleveland, OH (Abstract Co-Author) Nothing to Disclose
Michael LaBarbera, Cleveland, OH (Presenter) Nothing to Disclose
Mina K. Chung, MD, Cleveland, OH (Abstract Co-Author) Nothing to Disclose
Anant Madabhushi, PhD, Cleveland, OH (Abstract Co-Author) Research funded, Koninklijke Philips NV

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**PURPOSE**
Approximately 30% of Atrial Fibrillation (AF) patients who undergo endovascular ablation experience recurring symptoms within the first year after ablation. Patients with long-standing AF demonstrate changes in left atrial morphology and the atrial appendage and pulmonary veins are known regions of interest in ablation, although the impact of morphology on ablation outcome remains unclear. In this study we employed image analysis and machine learning approaches to investigate whether the morphology of the left atrium (LA) was predictive of recurrence in patients undergoing ablation for AF.

**METHOD AND MATERIALS**
Pre-operative chest CT scans of 68 patients who underwent surgical ablation were acquired between July 2015 and November 2016, of which 31 had AF episodes between 3 and 12 months after ablation. LA masks were created for each patient using an in-house segmentation toolbox and verified by a cardiologist. All patient LA were registered to a common atlas defined by the LA with median volume. Sites of interest (SOI) was then defined for each patient as the regions on the atrial surface with significant difference between recurrent (AF+) and non-recurrent (AF-) patients using a t-test based comparison of the registered atrial. First order statistics of the Gaussian curvature of the surface within the SOI and deformation from atlas to patient LA were extracted,
and a 5-fold cross-validation scheme across 100 runs was conducted to evaluate performance of the features in distinguishing between AF+ and AF- patients using area under the receiver operating characteristic curve (AUC).

**RESULTS**

The identified regions of maximum shape variation consisted of sites around the atrial appendage and pulmonary veins. Employing feature maps from these regions to classify recurrence performed better (AUC=0.69±0.049) than features from the remaining atrial sites (AUC=0.58±0.58). Combining the feature maps with clinical features (Age, Height, BMI and Weight) produced an AUC of 0.77±0.09, while using Clinical variables alone produced AUC of 0.66±0.11.

**CONCLUSION**

We identified shape differences between AF+ and AF- patients as well as a set of features relating to local curvature within regions differing between the two populations that was correlated with likelihood of recurrence.

**CLINICAL RELEVANCE/APPLICATION**

A systematic process for identifying patients at increased risk for post-ablation recurrence may lead to improved management.

**SSM04-06  Detects Myocardial Dyssynchrony of Isolated Left Ventricular Noncompaction Patients with Preserved Ejection Fraction Using Cardiac Magnetic Resonance Feature Tracking**

**Participants**
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**PURPOSE**

Left ventricular non-compaction (LVNC) is a rare congenital cardiomyopathy, with or without LV dysfunction, and it may be asymptomatic or it may lead to severe HF, sudden death. The aim of our study is to early evaluate the myocardial dyssynchrony in isolated LVNC children with preserved EF by using cardiac magnetic resonance (CMR), and to explore the correlate factors of progress of LVNC.

**METHOD AND MATERIALS**

we investigated 17 isolated LVNC patients with preserved LVEF (EF>=50%), and 23 age- and gender-matched controls. The feature tracking parameters including peak strain (PS), peak displacement (PD) and strain rate in radial, circumferential, and longitudinal directions were measurement in all subjects.

**RESULTS**

In all patients, 14 patients were left ventricular apical (73.7%), two patients were left ventricular septum (10.5%), one patient were global left ventricular noncompaction (5.3%). The PS and PD in radial, circumferential, and longitudinal directions decreased significantly in the LVNC patients with preserved EF compared with the normal controls (all p<0.001). Furthermore, the PS in three directions were associated with the EF (r=-0.43; r=-0.41; r=-0.54); and PS in three directions were also significant correlates with age (r=-0.47; r=0.46; and r=0.47).

**CONCLUSION**

CMR feature tracking can be used for the detection of early myocardial deformation in the isolated LVNC children who are subclinical left ventricular dysfunctions, and early clinical intervention might be important for the decrease of LVEF function and myocardial deformation.

**CLINICAL RELEVANCE/APPLICATION**

(Dealing with MRI feature tracking) CMR feature tracking can detect early myocardial deformation in the isolated LVNC children with subclinical dysfunctions.
SSM05

Chest (Vascular/Interventional)

Wednesday, Nov. 28 3:00PM - 4:00PM Room: S404CD

Participants

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Sub-Events

SSM05-01 Image-guided Intratumoral Radiofrequency Hyperthermia-Enhanced HSV-TK Gene Therapy of Lung Cancer: The Underlying Molecular Mechanisms

Wednesday, Nov. 28 3:00PM - 3:10PM Room: S404CD

Participants

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PURPOSE
To develop a new interventional oncologic technique, namely 'image-guided intratumoral radiofrequency hyperthermia (RFH)-enhanced local HSV-TK/GCV-mediated suicide gene therapy of lung cancers' and investigate its associated bio-molecular mechanisms.

METHOD AND MATERIALS

Human lung cancer cells (A549) transduced with Luciferase/mCherry/lentivirus for in-vitro confirmation, and 24 nude rats with the same orthotopic lung cancers for in-vivo validation were divided into four study groups with different treatments of (i) combination therapy with intratumoral HSV-TK/GCV gene therapy followed by RFH at 41-42 °C for 30 minutes; (ii) HSV-TK/GCV gene therapy alone; (iii) RFH alone; (iv) PBS as a control. In in-vitro experiments, bioluminescence assay, confocal microscopy and flow cytometry were used to determine the viability and apoptosis of cells, while in the in-vivo experiments molecular optical/x-ray imaging was used to evaluate the changes of bioluminescent signals among different groups over 2 weeks. To investigate the potential mechanisms of apoptosis, IHC staining and WB were used for detecting the expression of Bcl-2/Bax, and Caspase-3. To determine mechanisms of immune-response, IHC and WB were used to exam the expression of HSP-70, IL-2 and CD94.

RESULTS

Of in-vitro experiments, compared with gene therapy alone, RFH alone or PBS, combination therapy induced the lowest cell viability (P<0.01), the highest cell apoptosis (P<0.001), and a significant decrease of relative bioluminescence signal (P<0.01). Of in-vivo experiments, optical imaging detected a significantly decreased bioluminescence signal of the tumor with combination therapy. Both WB analysis and IHC staining displayed the significantly decreased expression of Bcl-2, as well as increased expression of Bax, Caspase-3, HSP-70, IL-2 and CD94 in cancer tissues of combination therapy, compared to other control treatments.

CONCLUSION

This study validated the feasibility of image-guided interventional RFH-enhanced direct suicide gene therapy of orthotopic lung cancers, which is activated through the mechanisms of augmenting Bax/Bcl-2/caspase-3-depended apoptosis and the HSP-70/IL-2 depended immune regulation pathway.

CLINICAL RELEVANCE/APPLICATION

This alternative technique may open new avenues for effective treatment of lung cancers via integrating image-guided interventional oncology, RF technology, and direct gene therapy.
Impact of Availability of PET-CT Imaging on Diagnostic Accuracy and Biopsy Safety of CT-Guided Percutaneous Needle Biopsy (PNB) of Suspected Lung Cancer

Wednesday, Nov. 28 3:10PM - 3:20PM Room: S404CD

Participants
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PURPOSE
To determine whether the availability of PET-CT improves diagnostic yield and safety in lung cancer PNB.

METHOD AND MATERIALS
PNB diagnostic rates over 3yrs for 3 thoracic radiologists (6-17yr practice) were retrospectively reviewed. Radiologists review PET-CT, if available, prior to PNB, to target the maximum activity tissue (PET-CT-MA). The availability of PET-CT pre or post PNB was recorded, and whether PNB was ultimately taken from the PET-CT-MA (whether PET-CT pre- or post PNB). The number of needle passes, complications and biopsy results were recorded. The influence of lesion morphology on results was assessed.

RESULTS
353 PNBs were performed in 350 patients (median lesion size 30mm, 7-120mm). 178 PNB (50.4%) had PET-CT pre-PNB, in 102 (28.9%) cases PET-CT was post-PNB. In 73 (20.7%) PET-CT was never performed. Overall PNB success was 83.9% (95.8% malignant). 88.8% of 178 PNB with PET-CT pre-PNB were diagnostic, versus 78.9% of 175 PNB without PET-CT upfront (p<0.01 Fisher exact test). Correct targeting to PET-CT-MA was present in 87.1% of 278 cases with PET-CT. 88.8% of 242 PNB targeting the PET-CT-MA were successful, but only 52.8% of 36 PNB not targeting PET-CT-MA (p<0.0001). PET-CT pre-PNB had higher rates of PET-CT-MA targeting compared to PET-CT post PNB (91.0% v 80.0%, p=0.01). More patients with PET-CT pre-PNB (n=162) and correct localization had diagnostic PNB than patients with PET-CT pre-PNB (n=16) but incorrect localization (90.1% v 75%). Similarly, more patients with no PET-CT pre-PNB (n=80) but ultimately correct localization had successful PNB compared to patients with no PET-CT pre-PNB (n=20) and ultimately incorrect localization (86.3% v 35%, p<=0.0001). Patients with a PET-CT pre-PNB underwent fewer PNB passes (mean 2.6 v 3.1, p=0.0001 Mann Whitney U). Serious complications were less common in PET-CT pre-PNB group (4.5% v 10.9%, p<0.05). Pre-PNB PET-CT performance improvement applied to all 3 radiologists and was greatest for masses and infiltrative abnormalities.

CONCLUSION
PNB localisation to the PET-CT-MA is associated with higher diagnostic biopsy rates and appears to account for improved performance, less needle passes and complications when available pre-biopsy.

CLINICAL RELEVANCE/APPLICATION
Prospective studies are required to confirm the results that suggest PET-CT should be available prior to biopsy particularly for larger masses or infiltrative lesions.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Ioannis Vlahos, MRCP, FRCR - 2015 Honored Educator

Diagnostic Success and Complication Rate of Ultrasound-Guided Percutaneous Needle Biopsy of Thoracic Lesions: Study of 147 Cases

Wednesday, Nov. 28 3:20PM - 3:30PM Room: S404CD

Participants
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PURPOSE
The goal of this study was to assess the diagnostic yield and safety profile of US-guided biopsy in the diagnosis of thoracic lesions, including lesions located in the chest wall, mediastinal and lung parenchyma.

METHOD AND MATERIALS
A total of 147 US-guided percutaneous needle biopsies of thoracic lesions performed in 146 consecutive patients (66±7y, 83M, 63F)
were analyzed, including lesions originating from the lung (67/147), chest wall (54/147), mediastinum (14/147) and pleura (12/147), obtained with FNA and/or CNB (FNA/CNB). Lesions varied in size from 1.5cm to 16cm. The overall diagnostic yield and complication rate of US-guided biopsy as well as the influence of lesion location and size, biopsy technique (FNA or CNB) and number of specimens on diagnostic yield and complication were calculated. Fisher's exact test, Chi-square test and logistic regression were used for statistical analysis. Results with p<0.05 were considered to be statistically significant and yield was summarized as proportion with 95% CI.

RESULTS

The overall diagnostic yield of US-guided needle biopsy was 88%. Biopsy of lesions located in the chest wall were diagnostic in 91% of cases, compared to 88% for lung lesions and 75% for pleural lesions and 93% for mediastinal lesions, although this was not statistically significant (p = 0.45). The diagnostic yield of FNA was similar to that of CNB (89% and 86% respectively) and the number of specimens obtained for either FNA or CNB did not affect yield (p = 0.10). Complications occurred in 4/147(3%) cases, including pneumothorax in two and mild hemoptysis in one patient. In all cases patients were treated conservatively with no cases requiring intervention. Complications were not statistically associated with any of the covariates analyzed.

CONCLUSION

US-guided biopsy has high yield for the diagnosis of thoracic lesions, including lesions located in the mediastinum and lung parenchyma. Tissue diagnosis sufficient to direct specific management is often obtained. The safety profile of US-guided thoracic biopsy is excellent with very low complication rates.

CLINICAL RELEVANCE/APPLICATION

Imaging-guided percutaneous biopsy is a safe minimally invasive technique used for the diagnosis of thoracic lesions and usually considered the initial modality to obtain tissue diagnosis.

SSM05-04 Artificial Intelligence Based Aortic Diameter Quantification on Routine Unenhanced Chest CT

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S404CD

Awards

Student Travel Stipend Award

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PURPOSE

To validate a supervised machine learning algorithm to quantify thoracic aortic diameters on non-ECG synchronized, non-contrast material enhanced chest CT.

METHOD AND MATERIALS

A novel deep learning based radiology assistant was applied to a training dataset of manually annotated chest CTs. Aortic measurements were made by a single observer off of volumetric datasets utilizing double-oblique short axis measurements at 7 levels, as defined by the American Heart Association (sinuses of Valsalva, sino-tubular junction, mid ascending aorta, proximal aortic arch, mid aortic arch, proximal descending thoracic aorta, mid descending aorta). A deep convolutional image-to-image learning model was used to learn the mapping between the input CT volume and the ground truth aorta mask. The algorithm was then applied to a test set of 72 cases, and aortic diameters between manual measurements and the machine learning algorithm were compared.

RESULTS

The overall correlation between manual and machine learning measurements was r=0.86. The best correlation between manual and machine learning measurements was in the mid descending aorta (r=0.875). The model predictions resulted in an area under the curve of 0.877 when applying a threshold of 38 mm to detect an abnormally enlarged mid ascending aorta, with peak performance of the model set at cutoff 39 mm (indicating a small bias in the model) and resulting in sensitivity and specificity of 77% and 89%, respectively.

CONCLUSION

A machine learning algorithm may be able to automatically provide reliable quantitative measures of thoracic aortic diameters and flag abnormal values.

CLINICAL RELEVANCE/APPLICATION

Automated aortic measurements could enrich radiology reports for epidemiologic studies, save time for the interpreting clinician, and ensure that abnormally dilated aortas are not missed.
SSM05-05  Volume-Helical-Shuttle Mode with Low Contrast Dose and Low Tube Voltage in CT Pulmonary Angiography for Critically Ill Patients

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S404CD

Participants
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PURPOSE
To explore the value of using volume-helical-shuttle (VHS) mode with low contrast dose and low kVp in CT pulmonary artery (CTPA) imaging for critically ill patients.

METHOD AND MATERIALS
38 critically ill patients for CTPA were in the study group (Group A), and other 38 cases of conventional CTPA served as the control group (Group B). Group A used the VHS mode: tube voltage 80kVp, smart mA, noise index (NI) 25HU, pitch 1.375:1, rotation speed 0.5s for 4 passes with scan started 6s after the contrast injection. Contrast dose of 25mL (350mgI/ml) at 4mL/s flow rate was used. Images were reconstructed using 60%ASiR and the best images were selected from the 4 passes for analysis. Group B used tube voltage 120kVp, smart mA for NI of 12HU, pitch 1.375:1, rotating speed 0.8s and contrast dose of 60mL, and images were reconstructed with 40%ASiR. The CT values and SD values of vessels and the vertical spinal muscles were measured to calculate SNR and CNR for vessels. Artifacts near superior vena cava was graded with 5 being the worst. The attenuation difference between the right inferior pulmonary artery and right inferior pulmonary vein was calculated. Two experienced physicians also evaluated image quality double blindly using a 5-point scoring system. Measurements in both groups were statistically compared.

RESULTS
The total radiation dose in VHS mode (Group A) was the same as the conventional CTPA (P>0.05), but the contrast dose in Group A was reduced by 58% compared with Group B. The target vessel CT and SD values in Group A were both higher than group B (P<0.05), resulting in similar SNR and CNR values in both groups (P>0.05), except that the CNR values of MPA and RPA in group B were higher (P<0.05); There was no difference in the subjective score of image quality between the two groups (P>0.05). However, Group A was better in both the attenuation difference and superior vena cava artifacts (P<0.05).

CONCLUSION
CTPA using VHS mode at low kVp works for critically ill patients who were unable to cooperate. Compared with the conventional CTPA, the proposed method provides more satisfactory image results with the same total radiation dose and 58% contrast dose reduction.

CLINICAL RELEVANCE/APPLICATION
For critically ill patients, this method can reduce contrast dose, make multi-phase diagnosis, overcome difficulties that patients cannot cooperate well and ensure the success rate of examination.

SSM05-06  Real-Time Patient Specific Scan Initiation for Pulmonary Embolism CTA: Impact on Image Quality

Wednesday, Nov. 28 3:50PM - 4:00PM Room: S404CD

Participants
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PURPOSE
Real-time modulation of scan initiation based on patient specific hemodynamics may allow for optimal timing of contrast enhancement in the pulmonary arteries in evaluation of pulmonary embolism (PE), reducing the number of non-diagnostic scans. The purpose of this study is to assess image quality for PE chest CTA using a modulated scan initiation delay based on patient specific hemodynamics.

METHOD AND MATERIALS
This was a HIPAA compliant, IRB approved quality improvement project. Fluoroscopic administration of contrast was used for all PE chest CTA exams. A new modulated scan initiation delay software was evaluated in 30 patients (cohort 1) scanned on a dual-source 192 detector CT (Siemens FORCE, Forchheim, Germany) from 01/2018-04/2018. 30 patients (cohort 2, matched to cohort 1 for BMI and age) with exams performed using a fixed scan initiation delay of 5 seconds (sec) were identified from 10/2016-12/2017. Subjective image quality was graded on a 4-point Likert-scale (1=excellent, 2=good, 3=fair and 4=inadequate). Objective image quality was determined by measuring the Hounsfield (HU) values in the main pulmonary artery, the bilateral lower lobe segmental and subsegmental arteries (150 arterial segments/cohort). HU values and standard deviations were compared for both cohorts.
RESULTS

Average patient age was 54.5 vs 54.3 years for cohorts 1 and 2 respectively. Average BMI was 32.9 kg/m² for both cohorts. There was a statistically significant difference in scan initiation delay of 11±3.6 sec (range 7.8 to 27.8 sec) for cohort 1 vs the set delay of 5 sec for cohort 2 (P<0.01). Subjective image quality for cohort 1 was graded as excellent or good in 22 patients, fair in 5 and inadequate in 3 patients; for cohort 2 it was graded as excellent or good in 20 patients, fair in 4 and inadequate in 6 patients. Average HU values were higher for cohort 1 vs cohort 2 in segmental (382 vs 349 HU right/387 vs 359 HU left) and subsegmental arteries (371 vs 327 HU right/382 vs 330 HU left). A total of 20/150 segments in cohort 1 and 31/150 segments in cohort 2 were non-diagnostic (HU<250; 7.4% reduction).

CONCLUSION

Real time, patient specific modulated scan initiation delay achieved higher image quality than a set delay for PE chest CTA.

CLINICAL RELEVANCE/APPLICATION

A real-time patient specific scan initiation can improve subjective image quality for PE chest CTA exams and reduce the total number of non-diagnostic pulmonary artery segments.
 Purpose

 IgG4-related disease (RD) is an immune-mediated fibro-inflammatory disease that can affect the respiratory system. The goal of this study is to investigate the association between thoracic imaging manifestations of IgG4-RD, IgG4 antibody levels and pulmonary symptoms.

 Method and Materials

 In this IRB-approved retrospective study, 62 patients with a pathology-proven diagnosis of IgG4-RD and thoracic CT imaging were identified. Images were reviewed by two thoracic radiologists. IgG4 antibody levels, pulmonary symptoms and patient demographics were collected. Wilcoxon rank-sum test was used to assess for differences of the mean IgG4 levels between patients with and without thoracic imaging manifestations of disease. Fischer's exact test was performed to assess for independent association between IgG4 levels and the presence of imaging findings. Spearman correlation analysis was used to assess the correlation between the number of imaging findings and IgG4 levels. Univariate logistic regression analysis was performed to assess for independent contribution of IgG4 levels and pulmonary symptoms in predicting the presence of imaging manifestation on CT.

 Results

 Of the 62 patients enrolled, 36 patients (58%) had imaging findings attributable to IgG4-RD. Patients with imaging findings had significantly higher IgG4 antibody levels (897±218 mg/dL vs. 87±17 mg/dL in those without imaging findings) (p<0.01). Airway involvement was a common imaging finding, present in 19/36 (52.8%) patients. Patients with bronchial wall thickening (p<0.01), mosaic lung attenuation (p=0.01), and saber sheath trachea (p=0.03) had significantly higher serum IgG4 levels compared to those without airway involvement. IgG4 levels and pulmonary symptoms were independent predictors of presence of thoracic imaging manifestations on regression analysis (p=0.02 and 0.01 respectively). Overall, there was a positive correlation between the number of thoracic manifestations on CT and serum IgG4 levels (r=0.60, P<0.01).

 Conclusion

 Airway involvement is a common manifestation of IgG4-RD. High IgG4 levels and pulmonary symptoms are independently associated with presence of findings on chest CT in patients with IgG4-RD.

 Clinical Relevance/Application

 Elevated IgG4 antibody levels and the presence of pulmonary symptoms should prompt thoracic imaging to identify lung involvement and direct management decisions in patients with IgG4-RD.
SSM06-02  Chest CT Analysis for Prediction of Treatment Response in Organizing Pneumonia: A 20-year Retrospective Cohort Study

Wednesday, Nov. 28 3:10PM - 3:20PM Room: S402AB

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PURPOSE
To investigate the CT imaging features associated with poor clinical outcome after steroid treatment (Tx) in patients diagnosed with organizing pneumonia (OP).

METHOD AND MATERIALS
The study retrospectively enrolled 166 patients (M:F=55:111; mean age, 57.2; mean FVC, 65.9; mean DLco, 58.5) with the pathologically proven OP, which included 131 cases of cryptogenic OP (COP) and 35 cases of connective tissue disease-related OP (CTD). Baseline chest CTs prior to Tx were semi-quantitatively analyzed by two thoracic radiologists in consensus. Lesion extent (consolidation, GGO, reticulation, and total), dominant lesion pattern, dominant distribution, and presence of bronchiectasis (BE), lymph nodes, pleural or pericardial effusions, and reverse halo were evaluated. Uni- and multivariate logistic regression analyses were performed to identify variables associated with poor clinical outcomes including failure to achieve complete response (non-CR) and relapse after Tx.

RESULTS
CR was achieved in 40 (24%) patients and relapse was detected in 53 (31%) patients. While BE was detected in 30% of patients with CR, 65% of patients with non-CR were found to have BE on baseline chest CT. Average extent of consolidation for CR and non-CR group was 14.1% and 15.2%, respectively. Presence of BE (hazard ratio (HR), 4.38) and extent of consolidation greater than 10% of the lung (con>10%) (HR, 2.46) were significantly associated with higher non-CR rate (all, p < 0.01). CTD-OP was also found to have higher non-CR rate (HR, 4.19) than COP. On multivariate logistic regression analysis adjusted for age and sex, BE, con>10%, and CTD-OP all remained as significant predictors. For the prediction of relapse, significant associations were found with con>10% (HR, 2.66), total extent >25% (HR, 2.77), and CTD-OP (HR, 6.79). After adjusted for age and sex, con>10 % and CTD-OP were found be significant predictors of relapse.

CONCLUSION
In patients diagnosed with OP, patients with BE and greater extent of consolidation on baseline chest CT were less likely to achieve CR, and the latter was also associated with higher rate of relapse after treatment. Additionally, CTD-OP was found to have worse treatment outcome than COP.

CLINICAL RELEVANCE/APPLICATION
Patients with underlying CTD, bronchiectasis, and greater extent of consolidation at the time of diagnosis were found to have worse treatment outcome in OP, and therefore should be monitored with extra vigilance.

SSM06-03  Identification of CT Patterns for Disease Progression in CTs of Patients with Idiopathic Pulmonary Fibrosis - An Unsupervised Machine-Learning Approach

Wednesday, Nov. 28 3:20PM - 3:30PM Room: S402AB

Participants
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PURPOSE
To identify CT patterns which can be used as markers of disease progression in patients with idiopathic pulmonary fibrosis (IPF) using an unsupervised machine-learning approach.

METHOD AND MATERIALS
695 CT scans from 106 IPF patients (1-4 per patient) were investigated in the study. All CT studies were automatically segmented into super-voxels and gray-level co-occurrence features at the centroid positions were extracted. Twenty clusters of these super-voxels proved to be stable across the population in the feature space. The volume of each cluster relative to the entire lung was used as the signature of a lung. To identify prognostic markers in these signatures, we trained a random-forest classifier to predict for any pair of scans for one patient (scans A and B) if A was acquired prior to B or vice versa (overall 230 pairs). The classifier determined which features were most informative regarding the classification. To determine whether the signature was predictive and stable, a four-fold cross-validation was performed on the data set. The classifier was trained on 3/4 of the patients, and predicted an A/B sequence on the remaining 1/4 of these patients. To study the distribution of predictive information in the lung, we split the volume into upper-, middle-, and lower third, and performed the evaluation for each of them individually.
RESULTS
The random forest identified four distinct clusters as predictive for the temporal course. In the four-fold cross-validation experiment, using all lung data, the classifier correctly determined the sequence of scans for 80.35% of the cases. Using only cluster information in one of three parts of the lung reduces the accuracy, but reveals that the middle segment results in highest accuracy (76.52%) compared to upper (73.04%) and lower (72.61%) segments. Three clusters where among the top four most predictive clusters in all folds, and one cluster was in the top four for three of four folds.

CONCLUSION
The described approach identified four patterns that were markers of disease progression in lung CT data of IPF patients. The information contributed by individual clusters differs depending on their location in the lung.

CLINICAL RELEVANCE/APPLICATION
Data-driven identification of imaging markers enables the exploitation of complex patterns for the detection and quantification of progression.

SSM06-04 Interstitial Lung Abnormalities in Stage IV Non-Small Cell Lung Cancer Patients: A Validation Study for the Association with Poor Clinical Outcome

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S402AB

RESULTS
ILA was present (score 2) on baseline CT in 19 of the 484 patients (3.9%, 95%CI: 2.4 - 6.1 %). Patients with baseline ILA were older (median age: 69 vs. 62 years, Wilcoxon p=0.0008) and were more commonly male (68.4% (13/19) vs. 41.3% (192/465); Fisher p=0.03) compared to those without ILA. Other variables including race, smoking history, and histology were not significantly associated with baseline ILA. Patients with baseline ILA had significantly shorter overall survival compared to those without (median OS: 9.95 months [95%CI: 5.88-15.5] vs. 16.95 months [95%CI: 14.65-18.7]; Log-rank p=0.0002). In multivariable analyses, baseline ILA remained significant as a marker for shorter overall survival (HR=2.09; Cox p=0.004), after adjusting for age (>70 years using the 75th percentile; HR=1.48; Cox p=0.001), male gender (HR= 1.22; Cox p=0.055) and smoking (never vs. current/former smoker; HR=0.79; Cox p=0.051).

CONCLUSION
The presence of ILA at diagnosis of stage IV NSCLC was significantly associated with shorter survival, validating ILA as an independent marker for poor outcome.

CLINICAL RELEVANCE/APPLICATION
Recognition of ILA on chest CT at diagnosis of stage IV NSCLC is important, because ILA can serve as a marker for shorter survival and may contribute to patient monitoring and management.

SSM06-05 Juxta-Pleural and Acutely-Folded Bronchi: Differential CT Findings of IPF without Evidence Honeycombing From NSIP

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S402AB

RESULTS
The random forest identified four distinct clusters as predictive for the temporal course. In the four-fold cross-validation experiment, using all lung data, the classifier correctly determined the sequence of scans for 80.35% of the cases. Using only cluster information in one of three parts of the lung reduces the accuracy, but reveals that the middle segment results in highest accuracy (76.52%) compared to upper (73.04%) and lower (72.61%) segments. Three clusters where among the top four most predictive clusters in all folds, and one cluster was in the top four for three of four folds.

CONCLUSION
The described approach identified four patterns that were markers of disease progression in lung CT data of IPF patients. The information contributed by individual clusters differs depending on their location in the lung.

CLINICAL RELEVANCE/APPLICATION
Data-driven identification of imaging markers enables the exploitation of complex patterns for the detection and quantification of progression.

Awards
Student Travel Stipend Award

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Tetsuro Araki, MD, PhD, Boston, MA (Presenter) Nothing to Disclose
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PURPOSE
The presence of interstitial lung abnormalities (ILA) at diagnosis of stage IV non-small cell lung cancer (NSCLC) patients have previously shown to be associated with shorter survival. The present study aimed to validate the association in a larger cohort of treatment-naive stage IV NSCLC patients.

METHOD AND MATERIALS
This study included 484 patients (205 males and 279 females, median age: 62) with stage IV NSCLC. ILA was scored on the baseline chest CT scans at diagnosis prior to therapy using 3-point scale (0=no ILA, 1=equivocal for ILA, 2=ILA) using a sequential reading method by 3 readers as published previously. Clinical characteristics and overall survival (OS) were compared in patients with ILA (score 2) vs. those without ILA (score 0 or 1).

RESULTS
ILA was present (score 2) on baseline CT in 19 of the 484 patients (3.9%, 95%CI: 2.4 - 6.1 %). Patients with baseline ILA were older (median age: 69 vs. 62 years, Wilcoxon p=0.0008) and were more commonly male (68.4% (13/19) vs. 41.3% (192/465); Fisher p=0.03) compared to those without ILA. Other variables including race, smoking history, and histology were not significantly associated with baseline ILA. Patients with baseline ILA had significantly shorter overall survival compared to those without (median OS: 9.95 months [95%CI: 5.88-15.5] vs. 16.95 months [95%CI: 14.65-18.7]; Log-rank p=0.0002). In multivariable analyses, baseline ILA remained significant as a marker for shorter overall survival (HR=2.09; Cox p=0.004), after adjusting for age (>70 years using the 75th percentile; HR=1.48; Cox p=0.001), male gender (HR= 1.22; Cox p=0.055) and smoking (never vs. current/former smoker; HR=0.79; Cox p=0.051).

CONCLUSION
The presence of ILA at diagnosis of stage IV NSCLC was significantly associated with shorter survival, validating ILA as an independent marker for poor outcome.

CLINICAL RELEVANCE/APPLICATION
Recognition of ILA on chest CT at diagnosis of stage IV NSCLC is important, because ILA can serve as a marker for shorter survival and may contribute to patient monitoring and management.

Awards
Student Travel Stipend Award

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PURPOSE
To evaluate juxta-pleural and acutely-folded bronchi for the differentiation of IPF patients without honeycombing from idiopathic NSIP.

METHOD AND MATERIALS
The derivation cohort consisted of 80 consecutive patients (41 IPF and 39 NSIP; 17 probable, 10 indeterminate, 53 non-IPF CT patterns) who met following criteria in a single hospital: (a) multidisciplinary diagnosis of IPF or idiopathic NSIP with surgical biopsy from 2005 to 2017, (b) diagnostic thin-section chest CT, and (c) lack of honeycombing in case of IPF. For validation, 22 patients (14 IPF and 8 NSIP; 4 probable, 11 indeterminate, 7 non-IPF CT patterns) with the same condition were included from another institution. Two radiologists for derivation cohort independently assessed the presence of juxta-pleural and acutely-folded bronchi on axial, coronal, sagittal minimum intensity projection (MinIP) images (20mm overlap, 5mm increment; MEDIP software, MEDICALIP Co., Ltd. Seoul, South Korea). Juxta-pleural bronchus was defined as bronchiectasis attached perpendicular to the pleura 1.5cm or longer in length. Acutely-folded bronchus was defined if a single bronchus folded abruptly over 90 degrees and if bronchus branched at an angle of 135 degrees or larger. Logistic regression analysis was used to identify the association of the MinIP findings with IPF. For validation, we assessed the diagnostic accuracy and interobserver agreement of 4 radiologists blinded to any clinical information using a proportion of correct diagnosis of IPF and NSIP and ROC curve before and after reviewing MinIP images.

RESULTS
Non-juxta-pleural and juxta-pleural acutely-folded bronchi (OR, 3.5 95%CI, 1.37-8.66; p=0.008 and OR, 6.22, 95%CI, 1.62-23.84; p=0.008, respectively), and co-existence of non-juxta-pleural acutely-folded bronchi and juxta-pleural bronchi in same patient (OR, 5.67, 95%CI, 2.03-15.85; p=0.001) were significant imaging features for IPF. After reviewing MinIP images, the readers’ area under the curve mildly improved from 0.496-0.808 to 0.554-0.808 with increased proportion of correct diagnosis from 40.9-54.5% to 50.0-77.3%. Mean interobserver kappa values for juxta-pleural and acutely-folded bronchi were 0.373 and 0.475.

CONCLUSION
Juxta-pleural and acutely-folded bronchi were differential CT findings for IPF without honeycombing.

CLINICAL RELEVANCE/APPLICATION
Analysis of bronchial trajectory using MinIP images could increase an imaging confidence of IPF without honeycombing.

SSM06-06  Fibrotic Lung Disease on CT Predicts Adverse Outcomes in Patients Undergoing Transcatheter Aortic Valve Replacement

Participants
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Amira F. Hussien, MBChB, Rochester, NY (Abstract Co-Author) Nothing to Disclose
Rani K. Hasan, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Elliot K. Fishman, MD, Baltimore, MD (Abstract Co-Author) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc
Jon Resar, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
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PURPOSE
To evaluate the relationship between CT findings of diffuse lung disease (fibrosis and emphysema) and outcomes in patients who underwent transcatheter aortic valve replacement (TAVR).

METHOD AND MATERIALS
Retrospective review of pre-operative CT scans obtained from 507 patients who underwent TAVR during 2012-2017. Lung images were divided into ten contiguous axial sections spaced equally apart. The extent of fibrotic lung disease - characterized by reticular abnormality and/or honeycombing - was graded by a thoracic radiologist using a five-point scale based on the percent of lung parenchyma involved. A similar approach was used to grade the extent of emphysema. Scores from all the axial slices for each patient were summed to determine fibrosis and emphysema scores. Demographic and clinical data, including pulmonary function tests, were extracted from institutional data submitted to the national Transcatheter Valve Therapy (TVT) Registry. Outcome analyses were performed according to the Kaplan-Meier method using a combined endpoint of death and readmission as the primary outcome.

RESULTS
Complete clinical parameters and outcome data were available in 335 patients. Fibrosis was present in 91 out of 507 (18%) patients with fibrosis scores ranging from 1-34. Emphysema was seen in 33 out of 507 (6.5%) patients. Fibrosis scores between patients with and without chronic lung disease - defined according to TVT registry as FEV1 below 60% - were not statistically different (p=0.59). The presence of fibrotic lung disease on CT was significantly associated with the primary outcome (HR 1.62, 95% CI...
1.09-2.40; p=0.016) after adjustment for pre-specified covariates (including FEV1, smoking status, age, and LVEF). Emphysema scores were not associated with the primary outcome. FEV1 was also an independent predictor of worse outcome (HR 0.99; 95% CI 0.984-0.998; p<0.01).

CONCLUSION
The presence of fibrotic lung disease on pre-TAVR CT scans was a significant predictor of adverse events, independent of known risk factors for mortality. Radiologists should be aware that these pulmonary findings could help identify patients who are at higher risk among those referred for TAVR.

CLINICAL RELEVANCE/APPLICATION
Visual assessment of reticular abnormality and honeycombing on pre-operative CT scans can predict adverse events in patients undergoing transcatheter aortic valve replacement.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Stefan L. Zimmerman, MD - 2012 Honored EducatorStefan L. Zimmerman, MD - 2015 Honored EducatorElliot K. Fishman, MD - 2012 Honored EducatorElliot K. Fishman, MD - 2014 Honored EducatorElliot K. Fishman, MD - 2016 Honored EducatorElliot K. Fishman, MD - 2018 Honored Educator
Can Contrast Enhanced Ultrasound Be an Alternative to CECT for Grading and Triaging Management of Blunt Traumatic Solid Abdominal Organ Injuries?

METHOD AND MATERIALS

In this ethically approved study consecutive hemodynamically stable patients with BAT with CECT showing solid abdominal organ injuries were recruited. These patients underwent CEUS by a radiologist who was blinded to the findings of CECT. The injuries were graded on both modalities using the American Association for the Surgery of Trauma (AAST) scales. The agreement between the grading of injuries on CECT and CEUS was analysed through kappa statistics. The injuries were further classified as high grade (AAST grades IV & above) and low grade (AAST grades I to III) and agreement between the grading on CECT and CEUS was compared.

RESULTS

Among the 105 patients included as a part of a larger study, there were 66 hepatic and 43 splenic injuries detected on CECT. CEUS identified 63 out of the 66 liver injuries and these 63 injuries were graded and compared with CECT. There was significant agreement between their grading on CECT and CEUS with a kappa value of 0.95 (>0.75 is significant). On combining the grades as low grade and high grade injuries, there was significant agreement on both modalities with a kappa value of 1.00. Similarly, 40 splenic injuries were detected on CEUS out of the 43 detected on CECT and these were graded on both the modalities and compared. There was significant agreement between the grading with a kappa value of 0.87. On combining the grades as low grade and high grade injuries there was significant agreement between the grading of splenic injuries on both modalities with a kappa value of 0.91.

CONCLUSION

CEUS is accurate in grading of hepatic and splenic injuries in case of blunt traumatic solid abdominal organ injuries.

CLINICAL RELEVANCE/APPLICATION

CEUS can provide a radiation free alternative for accurately grading hepatic and splenic injuries and can suggest further management.
PURPOSE
The role of imaging has become more important for preoperative assessment of traumatic penetrating injuries (PIs). This study aims to evaluate the overall diagnostic accuracy of preoperative MDCT in abdominal and pelvic PIs.

METHOD AND MATERIALS
We used our hospital's trauma registry to retrospectively identify patients with penetrating abdominal and pelvic injuries from 1/1/2006 to 12/31/2016. Only patients who had a 64-MDCT scan at presentation and subsequently underwent laparotomy or laparoscopy were included in our study cohort. Each finding noted on MDCT was rated using a 5-point scale to indicate certainty of injury, with a score of 0 being definitive. Using surgical findings as the gold standard, the accuracy of radiology reports was analyzed in 2 ways. A kappa statistic was calculated to evaluate each pair of values for absolute agreement, and ratings for all organ systems were analyzed using a repeated measures ANOVA to determine if radiology and OR findings were similar enough to be clinically meaningful.

RESULTS
Of the 194 trauma patients identified from the trauma registry, 42 met our inclusion criteria - 14 of which sustained GSW, 25 sustained stab wounds, and 3 were miscellaneous penetrating injuries. Our cohort consisted of 38 males and 4 females with a median age of 29 years and a median injury severity score (ISS) of 15.6. For this study, 15 different organ groups were categorized and analyzed. Of those organ groups, absolute agreement between MDCT and surgical findings was found only for liver, spleen, peritoneal space and retroperitoneum (kappa values ranging from 0.2 to 0.5). Additionally, the ANOVA revealed an interaction between finding type and organ system (F (1, 33) = 7.4, p<0.001). The most clinically significant discrepancies between MDCT and OR findings were for gallbladder (GB), bowel and mesenteric, and diaphragmatic injuries (DI). In particular, MDCT imaging showed a slight tendency towards false negatives for GB, mesenteric and DI.

CONCLUSION
The detection of clinically significant injuries to solid organs in trauma patients with penetrating abdominal and pelvic injuries on 64-MDCT is adequate. However, detection of injury to the remaining organ groups on MDCT - especially the GI tract, mesentery, and diaphragm - remains a challenge.

CLINICAL RELEVANCE/APPLICATION
The accurate preoperative detection of bowel, mesenteric and diaphragmatic injuries on preoperative MDCT remains a challenge.

Honored Educators
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SSM07-03 Evaluation of CT and Clinical Features of Bowel and Mesenteric Injuries in Blunt Abdominal Trauma: A Case-Control Study

Wednesday, Nov. 28 3:20PM - 3:30PM Room: S404AB

Participants
Alexandre Lansier, Paris, France (Presenter) Nothing to Disclose
Camille Bournillon, Paris, France (Abstract Co-Author) Nothing to Disclose
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Charles-Andre Cuenod, Paris, France (Abstract Co-Author) Research collaboration, Guerbet SA Speaker, Guerbet SA

PURPOSE
To evaluate accuracy of individual or associations of CT and clinical signs To determine signs that are implied in missed diagnosis on first CT

METHOD AND MATERIALS
This retrospective case-control study included 30 cases with surgically confirmed bowel and/or mesentery requiring surgical repair and 52 consecutive controls with blunt abdominal or chest trauma and no surgically important bowel and/or mesenteric injury. CT findings were screened by two radiologists: a 10-year-experienced in abdominal imaging radiologist and a second-year resident blinded to the patients' outcome. Clinical outcomes were analysed by consulting the medical file. Sensitivity and specificity were calculated for each sign and a kappa coefficient were used to establish the interobserver variability.

RESULTS
The CT signs with best positive likelihood ratio were extra luminal air, bowel wall defect and thickening, decreased bowel wall enhancement and mesenteric vessels abnormalities. The specificity of clinical seat belt sign associated with anterior abdominal wall injury on CT was 98%. The sensitivity of free intraperitoneal fluid was 100% and its density was higher in cases. More than 50% of patients with missed diagnosis on first CT had a visceral injury associated. Diagnosis of mesenteric and/or bowel injury depends on
the experience of the radiologist (kappa = 0.6).

CONCLUSION
CT scan is accurate for the diagnosis of bowel and/or mesenteric injuries in blunt abdominal trauma depending on the experience of the radiologist. The association of clinical seat belt sign and anterior abdominal wall injury on CT is highly specific.

CLINICAL RELEVANCE/APPLICATION
The radiologist should know the relevant signs and have a stratified strategy for the diagnosis. Therefore we propose an algorithm for the diagnosis.

SSM07-04 Radiation Dose versus Injury Yield: A Study of CT Imaging Findings in Stabbing Related Injuries at an Urban Level 1 Trauma Center

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S404AB

Participants
Oliver Duxbury, MBCh,FRCR, London, United Kingdom (Presenter) Nothing to Disclose
Gurinder Nandra, FRCPMBChB, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Ioannis Vlahos, MRCPRCR, London, United Kingdom (Abstract Co-Author) Research Consultant, Siemens AG Research Consultant, General Electric Company

PURPOSE
Clinical uncertainty over stab injury severity results in extensive CT use based solely on anatomic location often without consideration of injury depth or other clinical parameters. The study aim was to determine whether the diagnostic yield of emergency department (ED) requests justifies the CT radiation dose exposure.

METHOD AND MATERIALS
All ED CT examinations performed for stabbing in 2017 at an Urban Level 1 Trauma Center were retrospectively assessed. CT coverage/protocol phases were determined by ED referral based on injury anatomic location. CT evaluation (Definition, Siemens Medical Solutions, Forchheim, DE) was performed with autoKv selection (80-140kVp, filtered back projection). Parameters recorded included: age, body parts imaged, phases per scan, identifiable site injuries and depth, organ injuries, presence of active bleeding and patient management. Effective radiation dose was calculated.

RESULTS
A total of 175 patients were scanned for 179 stabbing related injuries (median age 25, 87% male). A mean 1.6 phases of CT were performed per patient (range 1-3), imaging a mean 3.9 body part-phases/patient. Mean dose was 11.8mSv (1.5-43.9). A total of 79 organ injuries were identified in 61/179 patient episodes, imaged at a cost of 26.7mSv/organ injury. The injury site was identifiable in 95% of cases, but was limited to the subcutaneous layer in 38% and the muscular layer in 66% of patients. No injuries were fatal. 106/179 (59%) of studies had more than one phase, but only 17% of all patients demonstrated active bleeding and only one third of these required surgery or interventional radiology. Excluding 15 patients with clinically overt injuries (knife in situ, evisceration, needing chest drain prior to CT), only 22% of 164 patients had CT detected injuries necessitating treatment. The dose in patients without injuries was only slightly lower than patients with treatable injuries (11.3mSv v. 13.1mSv, p<0.05, Mann-Whitney U).

CONCLUSION
Most stab injuries are superficial, or not necessitating treatment. A high radiation dose burden in young patients without significant injury dictates better CT use criteria are required to limit imaging to the minority with significant injuries.

CLINICAL RELEVANCE/APPLICATION
The high radiation dose in young patients dictates better clinical criteria are needed to limit CT in stabbing injuries to the patient minority likelier to have injuries requiring further management.

Honored Educators
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SSM07-05 Diagnostic Value of IV Contrast Extravasation (CE) at CT for Major Arterial Injury After Blunt Pelvic Ring Disruption: A Meta-Analysis of 3855 Patients

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S404AB

Participants
David Dreizin, MD, Baltimore, MD (Presenter) Research Grant, Siemens AG ; Yuanyuan Liang, PhD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
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PURPOSE
The diagnostic performance of intravenous contrast extravasation on computed tomography for prediction of angiopositivity after pelvic ring disruption has not been previously assessed using meta-analysis, despite ongoing controversy and widely variable results
in the literature. We performed a meta-analysis to determine pooled accuracy of CE, and to assess the influence of CT scanner generation and multiphasic protocols.

METHOD AND MATERIALS

We conducted a systematic literature search to answer the following: 'What is the diagnostic accuracy of intravenous contrast extravasation (CE) at admission trauma CT for predicting angiopositivity and need for angioembolization in patients who have sustained blunt pelvic ring disruptions?'. MEDLINE, Embase, and Cochrane databases were queried using a combination of text words and MeSH terms. Of 206 potentially eligible studies, 23 studies that met criteria were assessed for methodologic quality using the QUADAS-2 tool. Sensitivity and specificity were synthesized using bivariate mixed-effects logistic regression. Heterogeneity was assessed using the I² statistic. Publication bias was examined using Deeks' test. Subgroup analyses were conducted to explore the heterogeneity based on the use of 64-section CT, multiphasic versus single phase protocols, study sample size, and prevalence of arterial bleeding on angiography.

RESULTS

23 included studies provided 3855 patients for meta-analysis. There was no evidence of publication bias (p=0.62) Pooled sensitivity and specificity were 80% (95% CI: 66-90%, I² = 92.65%) and 93% (CI: 90-96, I² = 89.34%), respectively, with substantial heterogeneity. Subgroup analysis showed pooled sens and spec of 94% and 89% for 64-section CT compared to 69% and 95% with older generation scanners. With multiphasic protocols, CE had pooled sensitivity and specificity of 95% and 92%, compared to 74% and 94% with single phase protocols. Studies with lower disease prevalence and larger sample size also had better diagnostic performance.

CONCLUSION

Multiphasic protocols and improved scanner quality result in substantial gains in sensitivity of CE, potentially at the expense of specificity.

CLINICAL RELEVANCE/APPLICATION

Little further improvement in sensitivity can be expected beyond 64MDCT. Increased conspicuity of small foci of self-limiting CE could potentially reduce specificity for angioembolization need.

SSM07-06 Whole Body CT Using Biphasic Injection Protocol with Adaptive Statistical Iterative Reconstruction-V (Asir-V) in Multi-Trauma Patients: Impact on Dose Reduction and Image Quality

Wednesday, Nov. 28 3:50PM - 4:00PM Room: S404AB

Awards

Student Travel Stipend Award

Participants

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PURPOSE

To evaluate potential dose savings and image quality after implementing adaptive statistical iterative reconstruction-V (Asir-V) algorism on a revised protocol for whole-body computed tomography (WBCT) for multi-trauma patients and compare it to conventional protocols.

METHOD AND MATERIALS

One hundred multi-trauma patients were scanned using a 256-multidetector CT system (GE Healthcare Revolution system). They were randomized into two groups using two different scanning protocols. Group (A) (n=50, age 32.48±8.09) underwent conventional protocol including unenhanced WBCT scan, then contrast-enhanced arterial-phase of the thorax and abdomen followed by a portal and delayed scan of the abdomen and pelvis. Group (B) (n=50, age 35.94±13.57) underwent biphasic injection protocol including unenhanced WBCT scan, followed by a one-step acquisition of the thorax, abdomen, and pelvis following a biphasic injection, the examination was ended by delayed phase for the abdomen and pelvis. All examination were done under 50 % ASiR-V. Image count, radiation dose, total acquisition time, mediastinal artifacts were compared. Two radiologists independently graded image quality from 1 to 5. In addition, contrast enhancement was measured in the pulmonary artery, aorta, inferior vena cava, portal vein, liver, spleen, and kidneys.

RESULTS

The mean ±SD) dose length product value for group (A) was 2202.3 ± 271.8 mGy*cm and higher when compared to group (B) (p < 0.001) which was 1485.8 ± 489.2 mGy*cm. Protocol B gave a dose reduction of 32.5% and 7.7 % acquisition time reduction. The Hounsfield unit values of the aorta, liver and spleen were significantly higher in group (A) while both kidneys values were higher in group (B). There was no statistically significant difference between the image quality scores for both groups however, group (A) scored higher grades (4.62±0.56 & 4.56±0.67).

CONCLUSION

Implementing Asir-V algorism on biphasic injection WBCT protocol reduced radiation dose significantly with maintenance of diagnostic accuracy and image quality.

CLINICAL RELEVANCE/APPLICATION

Whole body computed tomography (WBCT) is an important diagnostic tool for initial clinical trauma management. Dose reduction with maintenance of image quality is still a concerning subject for emergency radiologists.
SSM09

Gastrointestinal (Gallbladder and Bile Ducts)

Wednesday, Nov. 28 3:00PM - 4:00PM Room: S503AB

Participants
Alice W. Fung, MD, Portland, OR (Moderator) Nothing to Disclose
Benjamin Wildman-Tobriner, MD, Durham, NC (Moderator) Nothing to Disclose

Sub-Events

**SSM09-01** Apparent Diffusion Coefficient as a Potential Marker for Tumor Differentiation, Staging, and Long-Term Clinical Outcomes in Gallbladder Cancer

Wednesday, Nov. 28 3:00PM - 3:10PM Room: S503AB

Participants
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Seo-Youn Choi, MD, Bucheon, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jeong Eun Lee, Daejeon, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Kyung-Sook Shin, MD, Taegon, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To evaluate the correlation between tumor differentiation or stage of gallbladder cancer (GBC) and the apparent diffusion coefficient (ADC), as well as to assess whether ADC value can predict long-term disease-free survival (DFS) after surgery.

**METHOD AND MATERIALS**

This retrospective study was approved by the Institutional Review Board and the requirement for informed consent was waived. Between March 2008 and June 2016, 79 patients who underwent magnetic resonance (MR) imaging with diffusion-weighted image and subsequent surgery for GBC were included in this study. Correlations between quantitative ADC values, and tumor differentiation or stage based on the American Joint Committee on Cancer (AJCC) were assessed using Spearman's correlation analysis. Prognostic factors for DFS were identified with multivariate Cox regression analysis using imaging and clinical characteristics.

**RESULTS**

All patients were classified as having well- (n = 18), moderately- (n = 35), or poorly-differentiated GBCs (n = 26). The ADC value of GBCs was significantly correlated with tumor differentiation and AJCC stage (p < 0.001 and p < 0.001, respectively). Sixty nine patients were followed up for 2.0-92.4 months (median, 23.5 months). On multivariate analysis, the significant prognostic factor for DFS was not tumor differentiation or AJCC stage, but a binary tumor ADC value (hazard ratio, 4.29, p = 0.009).

**CONCLUSION**

The ADC value of GBCs was significantly correlated with tumor differentiation as well as AJCC stage. In addition, it predicted long-term outcomes after surgery in patients with GBC.

**CLINICAL RELEVANCE/APPLICATION**

Tumor recurrence after curative surgical resection in patients with GBC could be predicted by using ADC values on diffusion-weighted images preoperatively.

**SSM09-02** Is the MR Contrast Agent Gadoxetate Disodium Suitable for CT Cholangiography?

Wednesday, Nov. 28 3:10PM - 3:20PM Room: S503AB

Participants
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Thomas J. Vrieze, RT, Rochester, MN (Abstract Co-Author) Nothing to Disclose
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RESULTS
From the retrospective clinical cohort, mean contrast (± standard deviation) of 239±107HU and CNR of 12.8±4.2 were found in the bile duct relative to the liver. Comparing these metrics to the gadoxetate disodium samples, the highest concentration (9.6mgGd/ml) surpassed these thresholds at all energy levels. The 4.8mgGd/ml had sufficient CNR in the Force, but not in the Flash. The 3.4mgGd/ml had clinically relevant CNR at low kV of SE (<100kVp) and 50 keV of DE in the Force but was insufficient in the Flash. Images acquired by the Force had a lower noise level and greater CNR compared to the Flash. Similar trends were seen at both dose levels.

CONCLUSION
Gadoxetate disodium shows promise as a viable contrast agent for CT cholangiography, with CNR similar to those seen clinically with an iodine-based contrast agent. DE CT or low kV SE CT is helpful to enhance the signal.

CLINICAL RELEVANCE/APPLICATION
Gadoxetate disodium, a Gadolinium-based hepatobiliary contrast agent, shows promise as a CT cholangiography contrast agent with contrast-to-noise ratios similar to iodine contrast-enhanced CT.

METHOD AND MATERIALS
Vials containing four concentrations of gadoxetate disodium (9.6, 4.8, 3.4, and 1.9mgGd/ml) were placed in a 35x26cm2 water phantom and imaged on two CT scanners: Siemens Somatom Flash and Force (Siemens Healthcare, Erlangen, Germany). These concentrations correspond to the dose limit for a 200, 100, 70, 40kg patient, respectively. Single-energy (SE) scans were acquired at 70, 80, 90, 100, 120, and 140kVp. Dual-energy (DE) scans were acquired at 90/150Sn (Force) and 100/150 (Flash) for two dose levels (13 and 23 mGy). Virtual monoenergetic images at 50keV were created (Mono+, Siemens). The mean intensity and standard deviation for each concentration of gadoxetate disodium and the water background were extracted from each image set. To determine whether the signal provided by gadoxetate disodium was sufficient for clinical imaging, the contrast, noise, and contrast-to-noise ratio (CNR) were compared to measurements acquired from 12 clinical CT cholangiography exams performed with iodine-containing iodipamide meglumine.

CONCLUSION
Both Gadoxetate disodium and contrast-to-noise ratios similar to iodine contrast-enhanced CT.

TTT AND MATERIALS
A retrospective graph review conducted over a 5-year period identified adult ED encounters for right upper quadrant pain where patients were evaluated with CT and/or US. Those with prior cholecystectomy, current pregnancy, and acute trauma were excluded. Imaging studies were assessed for the reported presence of gallstones, gallbladder distension, wall thickening, and pericholecystic fluid/inflammation. A positive suspicion for cholecystitis required at least two findings, or a positive sonographic Murphy's sign with at least one additional finding. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each modality based on linked clinical, surgical, and pathology data. When both US and CT were performed, the second modality was determined to add value if it correctly identified cholecystitis when the first study was incorrect or provided a non-gallbladder alternative diagnosis for acute abdominal pain. The second study was determined to detract value if it was incorrectly positive or negative for cholecystitis when the first study was correct.

RESULTS
3495 ED encounters were reviewed, with 2859 meeting inclusion criteria. 91% of patients had one or more imaging studies performed, with US performed in 81%, CT performed in 30%, and both US and CT performed in 20%. 559 patients went on to cholecystectomy with pathology results available for 540. For US and CT, respectively: sensitivity 48% and 53%, specificity 93% and 93%, PPV 65% and 58%, and NPV 88% and 92%. Only NPV represented a statistically significant difference. When performed after CT, US added value in 8% and detracted value in 6% of cases. When performed after US, CT added value in 35% and detracted value in 2% of cases.

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PURPOSE
Gadoxetate disodium (Eovist®), a Gadolinium-based contrast agent, is primarily used in MR, with an FDA approved dose limit of 0.1 mL/kg. The purpose of this work is to determine whether low doses of gadoxetate disodium can be visualized for CT cholangiography using a phantom setup.

METHOD AND MATERIALS
Vials containing four concentrations of gadoxetate disodium (9.6, 4.8, 3.4, and 1.9mgGd/ml) were placed in a 35x26cm2 water phantom and imaged on two CT scanners: Siemens Somatom Flash and Force (Siemens Healthcare, Erlangen, Germany). These concentrations correspond to the dose limit for a 200, 100, 70, 40kg patient, respectively. Single-energy (SE) scans were acquired at 70, 80, 90, 100, 120, and 140kVp. Dual-energy (DE) scans were acquired at 90/150Sn (Force) and 100/150 (Flash) for two dose levels (13 and 23 mGy). Virtual monoenergetic images at 50keV were created (Mono+, Siemens). The mean intensity and standard deviation for each concentration of gadoxetate disodium and the water background were extracted from each image set. To determine whether the signal provided by gadoxetate disodium was sufficient for clinical imaging, the contrast, noise, and contrast-to-noise ratio (CNR) were compared to measurements acquired from 12 clinical CT cholangiography exams performed with iodine-containing iodipamide meglumine.

RESULTS
From the retrospective clinical cohort, mean contrast (± standard deviation) of 239±107HU and CNR of 12.8±4.2 were found in the bile duct relative to the liver. Comparing these metrics to the gadoxetate disodium samples, the highest concentration (9.6mgGd/ml) surpassed these thresholds at all energy levels. The 4.8mgGd/ml had sufficient CNR in the Force, but not in the Flash. The 3.4mgGd/ml had clinically relevant CNR at low kV of SE (<100kVp) and 50 keV of DE in the Force but was insufficient in the Flash. Images acquired by the Force had a lower noise level and greater CNR compared to the Flash. Similar trends were seen at both dose levels.

CONCLUSION
Gadoxetate disodium shows promise as a viable contrast agent for CT cholangiography, with CNR similar to those seen clinically with an iodine-based contrast agent. DE CT or low kV SE CT is helpful to enhance the signal.

CLINICAL RELEVANCE/APPLICATION
Gadoxetate disodium, a Gadolinium-based hepatobiliary contrast agent, shows promise as a CT cholangiography contrast agent with contrast-to-noise ratios similar to iodine contrast-enhanced CT.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Sudhakar K. Venkatesh, MD, FRCR - 2017 Honored Educator

SSM09-03 CT and Ultrasound for the Diagnosis of Cholecystitis in the Adult Emergency Department: A Comparison of Accuracy and Incremental Value Offered By Each Modality Over the Other

Wednesday, Nov. 28 3:20PM - 3:30PM Room: S503AB

Awards
Student Travel Stipend Award

Participants
Kevin D. Hiatt, MD, Winston-Salem, NC (Presenter) Nothing to Disclose
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PURPOSE
To compare the diagnostic accuracy and relative value of CT and ultrasound (US) in the workup of cholecystitis in adult emergency department (ED) patients.

METHOD AND MATERIALS
A retrospective chart review conducted over a 5 year period identified adult ED encounters for right upper quadrant pain where patients were evaluated with CT and/or US. Those with prior cholecystectomy, current pregnancy, and acute trauma were excluded. Imaging studies were assessed for the reported presence of gallstones, gallbladder distension, wall thickening, and pericholecystic fluid/inflammation. A positive suspicion for cholecystitis required at least two findings, or a positive sonographic Murphy's sign with at least one additional finding. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each modality based on linked clinical, surgical, and pathology data. When both US and CT were performed, the second modality was determined to add value if it correctly identified cholecystitis when the first study was incorrect or provided a non-gallbladder alternative diagnosis for acute abdominal pain. The second study was determined to detract value if it was incorrectly positive or negative for cholecystitis when the first study was correct.

RESULTS
3495 ED encounters were reviewed, with 2859 meeting inclusion criteria. 91% of patients had one or more imaging studies performed, with US performed in 81%, CT performed in 30%, and both US and CT performed in 20%. 559 patients went on to cholecystectomy with pathology results available for 540. For US and CT, respectively: sensitivity 48% and 53%, specificity 93% and 93%, PPV 65% and 58%, and NPV 88% and 92%. Only NPV represented a statistically significant difference. When performed after CT, US added value in 8% and detracted value in 6% of cases. When performed after US, CT added value in 35% and detracted value in 2% of cases.
CONCLUSION

In this patient cohort, imaging diagnosis of cholecystitis by CT was non-inferior to the more commonly utilized gold standard of US. There was also little added value for use of US after already obtaining a CT.

CLINICAL RELEVANCE/APPLICATION

CT performance in the diagnosis of cholecystitis is essentially equivalent to ultrasound and has an advantage in supplying additional information for adult ED patients presenting with right upper quadrant pain.

SSM09-04 Development and Validation of Deep Learning Based Clinical Decision Supporting System for the Diagnosis of Neoplastic Gallbladder Polyps Using High Resolution Ultrasonography: Preliminary Results

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S503AB

Awards

Student Travel Stipend Award

Participants

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PURPOSE

To investigate the added value of the deep learning based clinical decision supporting system for the differential diagnosis of neoplastic gallbladder (GB) polyps using high resolution ultrasonography (HRUS)

METHOD AND MATERIALS

We retrospectively collected 337 patients with GB polyps (>4 mm) proved by cholecystectomy. They were divided into training set (239 patients) and test set (98 patients) according to the time period. Based on pathology, all images of polyps (neoplastic: 1822 images in 137 patients, non-neoplastic: 2058 images in 200 patients) were manually cropped into a square box containing the polyp and labeled as either neoplastic or non-neoplastic. The binary classification convolutional neural network model was constructed by transfer learning based on Inception-v3 architecture. Using test set, two radiologists with different experience level, retrospectively graded the possibility of neoplastic polyp using a 5-point confident scale. After providing model's probability value on the test set for each patient, reviewers requested to re-evaluate the grade. Diagnostic performances were measured by ROC analysis and sensitivity, specificity, and accuracy were calculated.

RESULTS

For the diagnosis of neoplastic polyp, model itself provided AUC 0.920, sensitivity 82.1%, specificity 88.1%, accuracy 85.4% with optimal cut off >0.503 in training set and AUC 0.903, sensitivity 80.5%, specificity 85.3%, accuracy 82.8% with optimal cut off >0.726 in test set. On the first review, highly and less experienced reviewers showed AUC 0.944 and 0.775; sensitivity 88.6% and 71.4%; specificity 85.7% and 68.2%; accuracy 86.7% and 69.4%, respectively. On the second review with the supporting system, less experienced reviewer's AUC was improved from 0.775 to 0.859 (p=0.0513), whereas, highly experienced reviewer's AUC showed no significant change (0.944 to 0.940).

CONCLUSION

Our preliminary results suggest that deep learning based clinical decision supporting system for differential diagnosis of neoplastic GB polyp is helpful for improving diagnostic performance, especially in less experienced readers.

CLINICAL RELEVANCE/APPLICATION

Differential diagnosis of neoplastic GB polyp is important as it has a malignant potential. Our decision supporting system can improve the diagnostic performance of radiologists using HRUS.

SSM09-05 Differentiation Between Gallbladder Premalignant or Malignant Polyps and Cholesterol Polyps Using Contrast-Enhanced Ultrasound: Preliminary Study

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S503AB

Participants

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PURPOSE

To differentiate between gallbladder (GB) premalignant or malignant polyps and cholesterol polyps using contrast-enhanced
ultrasound (CEUS).

METHOD AND MATERIALS

From September 2017 to March 2018, 20 patients with large GB polyps (\( \geq 1 \) cm) who were scheduled to undergo cholecystectomy were prospectively enrolled. All patients underwent conventional US including color Doppler and CEUS prior to surgery. CEUS was performed using a LOGIQ E9 US scanner (GE Healthcare) after an injection of 2.5 ml of SonoVue\textsuperscript{®} for 1 minute. After CEUS, perfusion US parameters including peak enhancement, mean transit time, fall time (FT), wash-in rate (WIR), and wash-out rate (WoR) were obtained using VueBox\textsuperscript{®} software. Patients were separately classified into the cholesterol polyp group (\( n = 6 \)) and premalignant or malignant polyp group (\( n = 14 \)) according to the final histopathology. All US features and quantitative CEUS parameters between the two groups were compared using the Mann-Whitney U test. Diagnostic performances of the parameters were assessed using receiver operating characteristic (ROC) analysis.

RESULTS

Among US imaging features, there were significant differences in lesion size (2.20 cm for adenomatous polyps and 1.18 cm for cholesterol polyps) and internal homogeneity between the two groups (\( P < 0.05 \)); internal homogeneity was more commonly found in cholesterol polyps (5/6, 83%) than in malignant polyps (4/14, 28%). On quantitative analysis of CEUS parameters, FT and WoR demonstrated significant differences between the two groups (\( P < 0.05 \), i.e., premalignant or malignant polyps showed significantly longer FT (12.74 sec) and smaller WoR (183.3 arbitrary units [a.u]) than cholesterol polyps (5.37 sec and 1068.3 a.u). On ROC analysis, an area under the curve (AUC) of 1.00, 100% (14/14) sensitivity, and 100% (4/4) specificity were demonstrated when the cut-off value was set at 9.62 sec for FT; and WoR yielded an AUC of 0.89, sensitivity of 100% (14/14), and a specificity of 75% (3/4) using a cut-off value of 78.4 a.u.

CONCLUSION

CEUS can be useful for the differentiation of premalignant or malignant GB polyps from cholesterol polyps \( \geq 1 \) cm.

CLINICAL RELEVANCE/APPLICATION

CEUS can help distinguish premalignant or malignant GB polyps from cholesterol polyps \( \geq 1 \) cm, thereby aiding in the selection of an optimal management option for large GB polyps.

SSM09-06 Fully Automated Detection of Primary Sclerosing Cholangitis (PSC) in 3D-MRCP Images Using Deep Learning

Wednesday, Nov. 28 3:50PM - 4:00PM Room: S503AB

Participants

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PURPOSE

To automatically detect PSC-typical cholangiographic changes in 3D-MRCP images.

METHOD AND MATERIALS

428 patients (\( m = 274 / w = 154 \), age 42.5 \( \pm \) 18.5 years) who underwent liver MRI including 3D MRCP were included in this retrospective study. The study population consisted of 206 patients with confirmed PSC (based on clinical, typical cholangiographic and confirmatory histologic findings) and 222 patients in whom this diagnosis was excluded. The patients were randomized into a training (\( n = 386 \)) and validation group (\( n = 42 \)). For each individual case, 20 uniformly distributed axial MRCP rotations, covering a total of 180\(^\circ\), were calculated, followed by a maximum intensity projection (MIP). This resulted in a training record of 7720 and a validation record of 840 2D images. An Inception ResNet (Inception-v4 arXiv: 1602.07261) was trained, which was initialized with weights previously learned from ImageNet. Finally, we fine-tuned the entire network with a small learning rate of 10-5.

RESULTS

The mean absolute error (MAE) on the validation record was 30% and therefore insufficient. This value could be improved to 7.1% (3/42) by applying an ensemble strategy. For this purpose, the 20 related MRCP projections of each patient were binned and a majority vote was conducted. With this approach, sensitivity, specificity, positive predictive and negative predictive value for the detection of PSC-typical cholangiographic changes were 95.0%, 90.9%, 90.5%, and 95.2% respectively.

CONCLUSION

The results of this study demonstrate the feasibility of transfer learning to detect PSC-typical cholangiographic changes in 3D MRCP images with an MAE of \( \sim 7\% \). Further validation with more and multicentric data should be made, as experience shows that neural networks tend to overfit the characteristics of the dataset.

CLINICAL RELEVANCE/APPLICATION

Automatic detection of PSC typical changes at MRCP may improve early detection and aid in follow-up imaging, especially of subtle changes.
**SSM16**

**Nuclear Medicine (Thyroid/Parathyroid Imaging and Therapy)**

**Wednesday, Nov. 28 3:00PM - 4:00PM Room: S504CD**

**AMA PRA Category 1 Credit ™**: 1.00
**ARRT Category A+ Credit**: 1.00

**FDAs**

Discussions may include off-label uses.

**Participants**

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Brian M. Rodgers, MD, New Orleans, LA (Moderator) Nothing to Disclose

**Sub-Events**

**SSM16-01 Complementary Gadoxetic Acid-Enhanced MRI in Addition to 18F-DOPA-PET/CT Improves Liver Staging in Patients with Medullary Thyroid Carcinoma**

**Wednesday, Nov. 28 3:00PM - 3:10PM Room: S504CD**

**Participants**

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**PURPOSE**

To investigate the additional diagnostic value of gadoxetic acid-enhanced MRI to 18F-DOPA-PET/CT for liver staging in patients with medullary thyroid carcinoma (MTC).

**METHOD AND MATERIALS**

41 consecutive patients with histologically confirmed MTC who underwent gadoxetic acid-enhanced MRI and 18F-DOPA-PET/CT within one month between 2010 and 2015 were selected for this retrospective study. The 18F-DOPA-PET/CT and multiparametric gadoxetic acid-enhanced MRI data sets were analyzed by two blinded radiologists. A 5-point Likert scale (based on the LI-RADS criteria: 1-definitely benign, 2-probably benign, 3-intermediate risk for metastasis, 4-probably metastasis, 5-definitely metastasis) was used for lesion categorization in both modalities. The additional value of MRI was defined as detection of 18F-DOPA-PET/CT-occult category 5 lesions or a definitive categorization (category 1 or 5) of lesions remaining inconclusive on the 18F-DOPA-PET/CT scan.

**RESULTS**

We categorized a total of 212 liver lesions (166 lesions on 18F-DOPA-PET/CT, 212 lesions on MRI; 165 metastases, 37 cysts, 18 hemangiomas). Out of 165 category 5 lesions on MRI, only 94 were classified as category 5 lesions on 18F-DOPA-PET/CT. In 65% (30/46) of inconclusively categorized lesions on 18F-DOPA-PET/CT (category 2-4), a definitive lesion classification was possible with MRI (change in categorization to categories 1 or 5, respectively). A change in lesion classification by MRI was made in 12 patients (lesions with a change in category from 2 to 1: n=10; from 3 to 1: n=3; from 4 to 5: n=12; from 3 to 5: n=5).

**CONCLUSION**

Complementary liver-specific MRI allows for the detection of 18F-DOPA-PET/CT-occult metastases and optimizes liver lesion classification in MTC patients.

**CLINICAL RELEVANCE/APPLICATION**

The definitive categorization of detected liver lesions and timely identification of liver metastases in MTC patients is essential in guiding treatment decisions on early surgical or interventional management.

**SSM16-02 Radiotheranostics for Regionally Advanced and Metastatic Differentiated Thyroid Cancer: Outcomes Following Initial Treatment Strategy Informed By Diagnostic 131-I Scintigraphy with SPECT/CT**
Participants
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PURPOSE
Diagnostic staging 131-I scans with SPECT/CT (Dx scan) guide patient-individualized 131-I therapy for differentiated thyroid cancer (DTC). The objective of this study was to determine dynamic risk stratification outcomes after surgery and activity-adjusted 131-I therapy informed by diagnostic 131-I scintigraphy with SPECT/CT.

METHOD AND MATERIALS
Single-institution retrospective cohort study analysis of clinical outcomes in 350 patients with DTC associated with histopathologic risk factors, nodal metastases, and/or distant metastases treated at University of Michigan. Post-operatively all patients underwent Dx 131-I SPECT/CT scans for completion of staging and risk stratification. 131-I therapy was based on integration of information from histopathology, stimulated thyroglobulin (Tg) and scintigraphy. The patients were followed for 1-5 years (mean 39.6 ±23.4 months)

RESULTS
23 patients (6.6%) underwent re-operative neck dissection for removal of unsuspected residual nodal metastases identified on Dx scans. Dynamic risk stratification outcomes were: 84.3% complete response; 1.4% biochemical incomplete response; 2.3% indeterminate response and 12% structural incomplete response. Of the entire cohort only 8 patients (2.3%) had persistent iodine-avid metastatic disease which required repeated 131-I therapy. Of 31 patients with iodine-avid distant metastases identified on Dx scans, 13 patients (42%) achieved complete response with a single 131-I treatment.

CONCLUSION
Detection of regional and distant metastases on postoperative Dx scans permits adjustment of prescribed 131-I activity for targeted treatment, as compared to fixed-activity ablation. This approach resulted in complete response after a single 131-I treatment in 88% patients with histopathologic risk factors and regional metastases, and 42% patients with distant metastases. Most patients (81%) with structural incomplete response had negative follow-up 131-I scans and positive PET/CT and/or CT scans consistent with altered tumor biology (non-iodine avid disease).

CLINICAL RELEVANCE/APPLICATION
Postoperative Diagnostic 131-I scans with SPECT/CT are useful for identification of regional and distant metastases in thyroid cancer, informing 131-I therapy decisions. Elimination of iodine-avid regional and distant metastases with complete therapeutic response is achieved in the majority of patients after a single 131-I treatment based on radiotheranostics principles.

SSM16-03 I-131 Thyroid Dosimetry in Patients with Lung Metastases

Participants
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PURPOSE
To protect bone marrow from excessive radiation, maximum permissible activity (MPA) of I-131 to treat thyroid cancer is the value that limits absorbed dose to blood (as a surrogate of marrow) to < 200 cGy. Pts with thyroid carcinoma pulmonary metastases potentially are a unique subgroup because I-131 uptake in the lungs could result in apparently accelerated blood clearance, which in turn could lead to an overestimation of MPA. The objective of this investigation was to test the hypothesis that in pts with diffuse lung metastases from thyroid carcinoma, MPA based on blood measurements alone is not affected by the presence of diffuse lung metastases.

METHOD AND MATERIALS
Data were analyzed retrospectively for 87 thyroid cancer pts (60±15 yrs; 45 female; 42 male) referred for determination of MPA prior to I-131 treatment. Method1 for determining MPA computed total absorbed dose to blood (DTotal) as the sum of mean whole-body γ ray dose component (Dγ) from un-collimated gamma-camera measurements, along with dose due to β emissions (Dβ) from blood samples. Method2 estimated DTotal from Dβ alone, using linear regression to associate in-vitro blood sample measurements.
RESULTS

Six pts had iodine avid diffuse lung metastases. MPA values were similar for Method1 & Method2 for all pts (14.3±8.9 versus 14.1±8.7 GBq, p = 0.34), pts with lung metastases (12.4±6.9 versus 11.7±6.4 GBq, p = 0.06) & for pts without lung metastases (14.4±9.0 versus 14.3±8.8 GBq, p = 0.52). MPA values were similar for pts with lung metastases & pts without lung metastases (12.4±6.9 versus 14.4±9.0 GBq, p = 0.59). Correlations between Method1 & Method2 MPA values were similar for all pts (r = 0.990, p < 0.0001), those with lung metastases (r = 0.999, p < 0.0001), & those without lung metastases (0.989, p < 0.0001).

CONCLUSION

Our data suggest that in pts with iodine avid diffuse lung metastases from thyroid carcinoma, MPA can be accurately estimated by measuring I-131 blood clearance alone without the need to perform un-collimated gamma camera whole body counting.

CLINICAL RELEVANCE/APPLICATION

MPA can be estimated by I-131 blood clearance alone in pts with lung metastases from thyroid carcinoma.

SSM16-04 Influence of Age on Multivariate Analysis of Disease Specific Survival in Differentiated Thyroid Cancer

Wednesday, Nov. 28 3:30PM - 3:40PM Room: S504CD

Participants

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PURPOSE

The aim of the study was to analyze the influence of age (<45 years versus >=45 years) on disease-specific survival (DSS) and its prognostic factors in patients with differentiated thyroid cancer (DTC).

METHOD AND MATERIALS

569 DTC patients were treated with I-131 (RAI) in our institution from 2001 to 2010. We analyzed DSS and its predicting factors in all 569 patients as well as in different age groups (Group I<45 years, 237 patients and Group II: >=45 years, 332 patients) by Kaplan-Meier's method. Statistical significance of differences was tested by Log rank test.

RESULTS

There were 185 (32.51%) high risk and 378 (66.43%) low-risk patients, while T was not defined in 5 (0.88%) patients; 132 (23.2%) males, 437 (76.8%) females; 57 (10%) follicular and 465 (81.7%) papillary carcinomas, while histology was not defined in 3 (0.53%) patients. Initial regional metastases were present in 202 (35.5%) patients. DSS was 96.5%; 93.5%; 87%, and 69.6% after 5,10,15 and 17 years, respectively. Prognostic factors that significantly influenced DSS were: gender (p=0.003), age (p=0.0001), T stage (p=0.02), initial metastases (p=0.0001), histology (p=0.039), type of initial treatment (p=0.01), while number of RAI course did not influence the survival (p=0.087). In Group I, DSS after 5, 10 and 15 years was 99.1%. Prognostic factors that significantly influenced DSS in this group were: initial metastases (p=0.015) and histology (p=0.007), while gender, type of initial therapy, T stage, and number of RAI courses had no significant influence (p=0.89; p=0.143; p=0.969; p=0.504, respectively). In Group II, DSS after 5 years was 94%, after 10 years = 89.3% and after 15 years = 78%. Strong predicting factors were: gender (p=0.0001), initial metastases (p=0.0001), type of initial therapy (p=0.028), and number of RAI courses (p=0.031), while histology and T stage had no influence to DSS (p=0.275; p=0.101, respectively).

CONCLUSION

DSS prognostic factors differ among age groups. Young patients show longer DSS significantly influenced by the presence of initial metastases and histology. In contrast, elderly patients have shorter DSS with significant influence of gender, type of initial therapy, presence of initial metastases and number of RAI courses.

CLINICAL RELEVANCE/APPLICATION

In comparison to elderly, young DTC patients have longer DSS that is influenced by different prognostic factors.

SSM16-05 Feasibility of Parathyroid Adenoma Localization with Fluciclovine (18F) PET-CT

Wednesday, Nov. 28 3:40PM - 3:50PM Room: S504CD

Awards

Student Travel Stipend Award

Participants

Akinwumi A. Akintayo, MD, Atlanta, GA (Presenter) Nothing to Disclose
Olayinka A. Abiodun-Ojo, MD, MPH, Atlanta, GA (Abstract Co-Author) Nothing to Disclose
Collin Weber, MD, Atlanta, GA (Abstract Co-Author) Nothing to Disclose
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Mark M. Goodman, PhD, Atlanta, GA (Abstract Co-Author) Royalties, Nihon Medi-Physics Co, Ltd
David M. Schuster, MD, Decatur, GA (Abstract Co-Author) Institutional Research Grant, Nihon Medi-Physics Co, Ltd; Institutional Research Grant, Blue Earth Diagnostics Ltd; Institutional Research Grant, Advanced Accelerator Applications SA; Consultant,
Evaluation of the Role of Tc99m Sestamibi Scan in Parathyroid Surgery: A 10-Year Institutional Experience

**Wednesday, Nov. 28 3:50PM - 4:00PM Room: 5504CD**

**Participants**
Parul Mohan, MBBS, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose
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**Purpose**
In this study we aim to evaluate the (99mTc) sestamibi parathyroid scan as a single localizing modality, and we also assess its relation to the weight of the gland and to the preoperative parathyroid hormone (PTH) levels.

**Method and Materials**
We reviewed 744 patients from our hospital from 2007 to 2017, with a mean age of 56.6 years and a female to male ratio of 3.3:1. With primary hyperparathyroidism, all of them had (99mTc) sestamibi parathyroid scan for the localization of the parathyroid adenoma. Preoperative and postoperative PTH levels were recorded. The histopathology reports confirmed the diagnosis and weight of the diseased gland, which were recorded every time. The results were analyzed and correlated with the sestamibi results, to evaluate its accuracy.

**Results**
506 patients (68%) of the 744 had an exact match (EM) sestamibi results, 227 (30.5%) had a partial match, and only 11 patients were reported as mismatch. Analyzing the mean weight of the gland in each group between matching (EM, PM) versus mismatch resulted in a mean difference of 0.823 g (1.05 and 0.247 g, respectively) P = 0.045. Hyperplasia to adenoma ratio was more in the partial matching group (18.5%) versus the exact matching group (7.6%). Finally the mean PTH level was higher in the EM group (36.8 pmol/L) compared to the mismatch group (10.1 pmol/L) P = 0.02. Overall sensitivity and specificity for the (99 mTc) sestamibi in our data was 98.1 and 97%, respectively.

**Conclusion**
(99mTc) sestamibi is a highly accurate test that can be employed as a single localizing modality for identifying a hypersecreting parathyroid, a parathyroid adenoma, or a parathyroidectomy. The weight of the gland plays an important role in the accuracy of the test, as also the preoperative PTH levels.

**Clinical Relevance/Application**
(99mTc) sestamibi is a highly accurate test that can be employed as a single localizing modality for identifying a parathyroid adenoma.
**SSM17**

**Neuroradiology/Head and Neck (Dual-Energy CT in Head and Neck Imaging)**

Wednesday, Nov. 28 3:00PM - 4:00PM Room: N228

- **CT**
- **HN**
- **NR**

**AMA PRA Category 1 Credit ™**: 1.00
**ARRT Category A+ Credit**: 1.00

**Participants**
- Reza Forghani, MD,PhD, Cote-saint-Luc, QC (Moderator) Stockholder, Real-Time Medical, Inc; Founder, 4 Intel Inc; Stockholder, 4 Intel Inc; Consultant, General Electric Company; Speaker, General Electric Company
- Salman Qureshi, MBChB, BSc, Sale, United Kingdom (Moderator) Nothing to Disclose

**Sub-Events**

**SSM17-01 Differentiation of Benign and Malignant Neck Lymph Nodes on Dual-Energy CT**

Wednesday, Nov. 28 3:00PM - 3:10PM Room: N228

**Awards**

- **Student Travel Stipend Award**

**Participants**
- Jeanne Kochkodan, BS, Ann Arbor, MI (Presenter) Nothing to Disclose
- Remy R. Lobo, MD, Ann Arbor, MI (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

Differentiation of benign versus malignant metastatic lymph nodes in the head and neck currently relies on size, morphology and functional status, such as abnormal FDG metabolism. Dual energy CT (DECT) has shown potential in differentiating benign and malignant head and neck lesions in prior studies. Our aim was to evaluate the utility of DECT derived parameters in differentiating benign and metastatic lymph nodes in head and neck squamous cell carcinoma (HNSCC).

**METHOD AND MATERIALS**

This retrospective IRB approved study included 14 patients with HNSCC who underwent head/neck DECT and PET/CT within 60 days of each other. One reader placed regions of interest within multiple lymph nodes deemed metastatic (on PET/CT, histopathology or both), normal nodes and skeletal muscle in the same patients (32 metastatic, 49 normal nodes). Independent sample t-tests were used to compare differences in DECT parameters between the two groups, including node HU at 40keV, 50keV, 70keV, 140keV, HU40keV-HU140 keV, effective Z and iodine concentration after normalizing the values by creating node to muscle ratios. When gross necrosis was present in the nodes, ROIs including entire node and those that excluded the necrotic portion were separately studied.

**RESULTS**

Significant differences in node HU40keV and RATIO-HU40keV were seen between normal and metastatic nodes (207 vs 177 HU, p=0.048; 2.29 vs 1.91, p=0.027) when necrosis was excluded. Similarly, significant differences were seen in node HU140keV and RATIO-HU140keV between normal and metastatic nodes (30.4 vs 38.2 HU, p=0.003; 0.75 vs 0.62, p=0.012), as well as RATIO-HU40-140keV (p=0.047). The other DECT parameters studied did not reveal any differences between the two groups.

**CONCLUSION**

DECT derived lymph node HU at monochromatic 40keV and 140 keV and ratio of node to muscle HU at monochromatic 40keV and 140 keV are significantly different between normal and metastatic nodes in patients with HNSCC, implying that DECT could have utility, in addition to size and morphology of nodes, in distinguishing these groups. We plan to further study the thresholds that can be used for employing this in clinical practice.

**CLINICAL RELEVANCE/APPLICATION**

Since most patients with HNSCC undergo CT examination for disease workup, utilizing DECT based metrics for improving the differentiation of normal from metastatic nodes in patients with HNSCC without any additional radiation can help better stage disease.

**SSM17-02 Diagnostic Value of Dual-energy Spectral Computed Tomography in Differentiating Parotid Gland Tumors**

Wednesday, Nov. 28 3:10PM - 3:20PM Room: N228

**Participants**
- Lin Li, MD, Beijing, China (Presenter) Nothing to Disclose
**SSM17-03**  
Comparison of Dual and Single Source Dual Energy CT in Head and Neck Imaging  
Wednesday, Nov. 28 3:20PM - 3:30PM Room: N228

**PURPOSE**
To quantitatively evaluate the value of single-source dual-energy spectral computed tomography in differentiating parotid gland tumors.

**METHOD AND MATERIALS**
43 patients underwent enhanced neck dual-energy spectral CT scan before operation. The spectral CT scan protocol included tube current of 260mA, helical pitch of 0.984 and rotation speed of 0.7s/r. The material decomposition images and monochromatic images were reconstructed and transferred to a GE AW4.6 workstation for spectral analysis using the Gemstone Spectral Imaging (GSI) Viewer software. Tumors were divided into pleomorphic adenomas (PAs), Warthin tumors (WTs) and malignant tumors (MTs) types. The CT number as function of photon energy, iodine concentration (IC) and water concentration (WC) of tumors were measured. The slope value (HU) of the spectral HU curve and normalized iodine concentration (to common carotid artery, NICA) were calculated and compared among the three types of tumors. The statistical analysis was performed with SPSS 13.0 software. ROC analysis was performed to evaluate the efficiency of these multiple parameters for the differential diagnosis.

**RESULTS**
52 tumors were confirmed by pathology and were included in our study, including 12 pleomorphic adenomas, 24 Warthin tumors (15 patients), and 16 malignant tumors. The IC, NICA and HU values of WTs (2.45±0.82mg/ml, 0.33±0.08 and 2.76±0.08, respectively) were significantly higher than those of MTs (1.48±0.90mg/ml) which were in turn higher than those of PAs (0.59±0.28mg/ml) (all P<0.05). The optimal IC, NICA and HU threshold was 0.91mg/ml, 0.15 and 1.09, respectively for differentiating PAs from MTs, achieving sensitivity of 91.7%, 91.7% and 91.7%, specificity of 95.0%, 85.0% and 95.0%, and accuracy of 94.2%, 86.5%and 94.2%, respectively for distinguishing PAs from MTs. The optimal IC, NICA and HU threshold was1.46mg/ml, 0.20 and 1.72, achieving 91.7%, 95.8% and 91.7% sensitivity, 89.3%, 85.7% and 89.3% specificity, respectively. The accuracy was 90.4%, 90.4%and90.4%, respectively for distinguishing WTs from MTs.

**CONCLUSION**
The single-source dual-energy spectral CT-related measurements such as iodine concentration in parotid tumors in the enhanced CT scans are useful in the differential diagnosis of parotid tumors.

**CLINICAL RELEVANCE/APPLICATION**
The single-source dual-energy spectral CT imaging is helpful to differentiate various pathological types of parotid gland tumors.

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**SSM17-05**  
Iodine Quantification in Patients with Initially Diagnosed Head and Neck Cancer Using Dual-Layer Spectral Imaging  
Wednesday, Nov. 28 3:20PM - 3:30PM Room: N228

**PURPOSE**
Aim of this study was to compare image quality of Single-Source Dual-Energy CT (SS-DECT) with third-generation Dual-Source dual energy CT (DS-DECT) in head and neck cancer.

**METHOD AND MATERIALS**
102 patients with histologically proven head and neck cancer were prospectively randomized to undergo radiation dose matched SS-DECT (n=51, 120 kV, split filter technique, 384 ref. mAs) or DS-DECT (n=51, 80/Sn150 kV, tube A 100/ tube B 67 ref. mAs). Inline default images (DI) and virtual monoenergetic images (VMI) for two different low energies (40 and 60 keV) were reconstructed. Objective image quality was evaluated as dose normalized contrast to noise ratio (CNRD) and subjective image quality was rated on a 5-point Likert-scale.

**RESULTS**
In both groups highest CNRD values for vessel and tumor attenuation were obtained at 40 keV. DS-DECT was significantly better than SS-DECT regarding vessel and tumor attenuation. Overall subjective image quality in the SS-DECT group was highest on the DI followed by 40 keV and 60 keV. In the DS-DECT group subjective image quality was highest at 40 keV followed by 60 keV and the DI. 40 keV and 60 keV were significantly better in the DS-DECT compared to the SS-DECT group (both p<0.01).

**CONCLUSION**
In split filter SS-DECT as well as DS-DECT highest overall image quality in head and neck imaging can be obtained with a combination of DI and low keV reconstructions. DS-DECT is superior to split filter SS-DECT in terms of subjective image quality, vessel and tumor attenuation.

**CLINICAL RELEVANCE/APPLICATION**
This is the first study comparing image quality of two different dual energy techniques of the same vendor in a radiation dose-matched setting for head and neck imaging.

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**Detector Spectral CT: Which Factor Could Significantly Affect the Tumoral Iodine Concentration?**

**PURPOSE**

We aimed to investigate the impacts of patient- and tumor-related factors on the dual-layer detector spectral CT-derived iodine concentration (IC) in patients initially diagnosed with head and neck squamous cell carcinoma (HNSCC).

**METHOD AND MATERIALS**

From July 2016 to March 2018, a total of 46 patients (M:F=41:5, mean age: 62.8 years) initially diagnosed with HNSCC which were identified by contrast-enhanced neck CT examination using a double-layer detector spectral CT (IQon CT, Philips healthcare) were retrospectively enrolled. To obtain the IC of the primary tumors, an experienced neuroradiologist drew the region of interest (ROI) on the representative axial images after reviewing the corresponding MRI images, and then copied the same ROI on the additional iodine density map. In addition, other ROIs were drawn on the aortic arch and ipsilateral neck muscle for normalization. We statistically determined the variables which significantly influenced the IC and normalized IC (nIC) of primary HNSCC using a multivariate linear regression: age, gender, iodine concentration, body surface area, T stage, histologic grading and location of tumor.

**RESULTS**

According to our quantitative analysis obtained from contrast-enhanced neck CT examination with fixed scan delay (50 sec), only histologic grading significantly influenced the mean IC of primary HNSCC (p<0.05). The mean IC (mg/ml) was significantly highest in well differentiated (n=11; 2.2±0.84), followed by moderately differentiated (n=12; 2.0±0.65), poorly differentiated (n=4; 1.8±0.49) and non-keratizing type were lowest (n=4; 1.40±0.18).

**CONCLUSION**

Dual-layer detector spectral CT-derived mean IC could be used as a useful predictor of histologic grading in patients initially diagnosed HNSCC.

**CLINICAL RELEVANCE/APPLICATION**

Iodine quantification using dual-layer detector spectral CT might potentially improve the role of contrast-enhanced CT examination in the HNSCC.

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**Spectral CT in the Diagnostic Value of Papillary Thyroid Microcarcinoma**

**PURPOSE**

The aim of the current study was to retrospectively analyze spectral CT images of papillary thyroid microcarcinoma (PTMC) and evaluate the detection and diagnostic value for PTMC.

**METHOD AND MATERIALS**

33 cases (35 lesions) of PTMC which were confirmed by surgical pathology from January 2015 to January 2016 were included in this retrospective study. All the patients underwent spectral CT scan using Discovery CT750 HD scanner. All the spectral CT images were divided into 3 groups: polychromatic image (group A), optimal monochromatic image (group B), and the fused image which blended optimal monochromatic image with iodine-based material decomposition image together (group C). The image qualities of group A and B were evaluated objectively, and the detection abilities of the 3 groups were evaluated subjectively.

**RESULTS**

The optimal CNR level is (65.96±4.01) keV (range from 62 to 75 keV). The CNR of optimal monochromatic image of spectral CT was higher than that of polychromatic image (t=5.626, p<0.001), and the noise of optimal monochromatic image was lower than that of polychromatic image (t=12.00, p<0.001), and the differences were significant (P<0.05). The detection rate of the 3 groups of images for microcarcinoma lesions were 91.4% (32/35), 97.1% (34/35), and 100% (35/35) respectively, while the subjective scores of the 3 groups of images were 2.54±1.15, 3.31±0.93, and 3.46±0.74 respectively. The detection ability of fused image was better than that of polychromatic image and similar to that of optimal monochromatic image. The characteristics of microcarcinomas were irregular shape (19 cases, 54.3%), indistinct margin (24 cases, 68.6%), heterogeneous density (24 cases, 68.6%), detection of microcalcification (16 cases, 45.7%), and lymph node metastasis (20 cases, 57.1%). The lesions' average iodine concentration, normalized iodine concentration, and the average spectral HU curve slope values were (25.0±10.3)×100 µg/ml (range from (9~43)×100 µg/ml), 0.33±0.14 (0.14~0.61), and 2.99±1.59 (-0.83~5.38), respectively.

**CONCLUSION**

Spectral CT could provide more detailed information for PTMC diagnosis, and the fused image which blended optimal monochromatic image with iodine-based material decomposition image may be useful for PTMC detection and diagnosis in the clinics.

**CLINICAL RELEVANCE/APPLICATION**

No significant clinical relevance or application is provided in the abstract.
Spectral CT imaging is helpful to detect and diagnose papillary thyroid microcarcinomas.
**Participants**

Guang-Hong Chen, PhD, Madison, WI (Moderator) Research funded, General Electric Company Research funded, Siemens AG
Katsuyuki Taguchi, PhD, Baltimore, MD (Moderator) Research Grant, Siemens AG; Consultant, JOB Corporation

**Sub-Events**

**SSM21-01 Improving Iodine Contrast to Noise Ratio on a Whole-Body Photon-Counting-Detector CT System using Virtual Mono-Energetic Imaging and Spectral Prior Image Constrained Compressed Sensing**

**For information about this presentation, contact:**

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**PURPOSE**

Virtual mono-energetic images (VMIs) at lower keV can improve iodine contrast but have increased noise. For photon-counting-detector (PCD)-CT, spatio-spectral data redundancy exists between VMIs and the low-energy threshold (TL) images, which are reconstructed using all available photons and have the lowest noise. Here, we develop a denoising technique named spectral image constrained compressed sensing (SPICCS) that exploits this data redundancy to denoise VMIs and improve iodine contrast-to-noise ratio (CNR).

**METHOD AND MATERIALS**

A multi-energy CT phantom (Sun Nuclear) and iodine inserts of different concentrations (2, 5, 10, 15 mg/mL) were scanned on a whole-body PCD-CT using a routine abdomen protocol (140 kV, 100 mAs, energy thresholds = 25/75keV). VMIs at 40-70keV were generated using vendor-supplied software (Mono+, Siemens). The images were then denoised using the SPICCS algorithm which is applied in the image domain by minimizing an objective function consisting of a data fidelity term and a regularization term. The regularization term penalizes total variation (TV) of the VMIs and TV of the difference between VMIs and TL images. A uniform water phantom and a thin wire phantom were scanned to assess noise texture and spatial resolution, respectively. With IRB approval, patient images were acquired on the same PCD-CT (140 kV, 100 mAs, energy thresholds = 25/75keV). The iodine CNR was calculated from VMIs before/after SPICCS.

**RESULTS**

VMIs processed with SPICCS preserved iodine contrast and reduced noise compared to the original VMIs (129±51 vs. 128±27 HU before/after SPICCS, measured from 5mg/mL iodine insert at 50keV), which improved iodine CNR especially at lower keV (5.65 vs 10.3 at 50keV). Compared with TL images, SPICCS-processed VMIs had improved CNR at lower keV (e.g., 50keV). MTF and NPS data showed that SPICCS preserved resolution and noise texture compared to TL images and original VMIs. The 50 keV VMI from patient data demonstrated similar improvement in iodine CNR (1.8 fold increase in iodine CNR at 50 keV).

**CONCLUSION**

We developed a denoising framework to improve iodine CNR in VMIs acquired on PCD-CT using SPICCS, while preserving spatial resolution and noise texture.

**CLINICAL RELEVANCE/APPLICATION**

The proposed denoising scheme improved iodine CNR for VMIs acquired on a whole-body PCD-CT system while preserving spatial resolution and noise texture, which may improve clinical diagnosis.
Imaging large patients with conventional dual-source dual-energy (DSDE) CT using energy-integrating-detectors (EIDs) is challenging due to artifacts in lower kV (80-100) images caused by photon starvation and electronic noise. Although the use of higher kV (e.g., 120) can reduce this effect, the energy separation is insufficient for multi-energy CT (MECT) imaging, even with the addition of a tin filter in the high kV beam. Photon-counting-detector (PCD) CT is more resistant to electronic noise and can provide spectral information with a single tube potential, which may be more suitable for MECT imaging on large patients. This work aims to evaluate the feasibility of MECT imaging on large patients assuming a dual-PCD acquisition system.

METHOD AND MATERIALS

An anthropomorphic CT phantom was padded with an additional 5 cm tissue-mimicking layer to simulate a large patient, and scanned on a conventional DSDE EID-CT system with 100 kV and Sn140 kV (i.e., 140 kV with additional tin filter) tube potentials. In addition, iodine inserts of known concentrations (2, 5, 10, 15 mg/mL) were attached to the phantom. The same phantom was then scanned on a whole-body PCD-CT system. This system was built based on a conventional DSDE CT platform, with the second EID replaced with a PCD. A dual-source, dual-PCD acquisition was emulated by scanning the object separately with tube potentials of 100 kV and Sn140 kV. Tube current for PCD scans was matched to that of EID scans. Material decomposition was then performed to generate iodine and water maps.

RESULTS

The low-energy image (100 kV) acquired on the conventional DSDE EID-CT system showed noticeable shading, which limited its use for clinical diagnosis. These artifacts were largely eliminated in images acquired on the PCD system. The iodine quantification root-mean-square-errors (RMSE) measured from iodine inserts was 2.3 mg/mL for EID and 2.1 mg/mL for PCD.

CONCLUSION

This work demonstrated the feasibility of MECT imaging for large patient assuming a dual-source PCD acquisition. The DS-PCD system out-performs conventional DS-EID CT system by reducing image artifacts and yet providing reasonable energy separation.

CLINICAL RELEVANCE/APPLICATION

Imaging large patients using DECT is known to be challenging. This work demonstrated the feasibility of MECT imaging for large patients using PCD, which allows all patients to benefit from MECT.

SSM21-03  Photon-Counting CT: Dependence of Noise Power Spectra, Task-Transfer Function, and Detectability Index (d’) on Patient Size, Imaging Mode, and Reconstruction Kernel

Wednesday, Nov. 28 3:20PM - 3:30PM Room: S104B

Participants

Jayasai R. Rajagopal, BA, Durham, NC (Presenter) Nothing to Disclose
Pooyan Sahbaee, Malvern, PA (Abstract Co-Author) Employee, Siemens AG
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Elizabeth C. Jones, MD, Bethesda, MD (Abstract Co-Author) Nothing to Disclose
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PURPOSE

To evaluate image quality in photon-counting CT due to change in patient size, imaging mode, and reconstruction kernel as measured by a tiered phantom

METHOD AND MATERIALS

The study utilized a five-tiered size variant phantom (Mercury Phantom, Gammex/Duke University). Images were acquired on a prototype photon-counting CT system (Siemens, Germany) using two imaging modes: Macro and Ultra High-Resolution (UHR) with effective voxel sizes of 0.5 and 0.25 mm, respectively, at a clinically-relevant dose (CTDlvol = 16 mGy). UHR scans were also done at maximum allowable mAs. Images were reconstructed with three kernels of increasing sharpness with 5 mm slice thickness. A task-based assessment was performed including calculation of noise power spectrums, task-transfer function, and detectability index (d’) of an iodine insert using the standard methodology of AAPM TG 233.

RESULTS

UHR had a higher d’ of 8-88% across all reconstruction kernels and phantom sizes when compared to Macro mode. For softer kernels, TTFs were comparable between the two modes. The magnitude and shape of the noise power spectrum was different influencing d’. Sharp kernel showed edge enhancement with increased noise magnitude for UHR mode and different TTFs for different imaging modes. For ultra-sharp kernels, UHR mode showed a significant reduction of noise magnitude while preserving the shape of the spectra and the TTF. As expected, increasing dose led to a reduction in noise magnitude without affecting the task
**CONCLUSION**

UHR mode showed reduced noise and superior detectability for an iodinated task when controlling for patient size and reconstruction kernel. Task performance was dependent on selected reconstruction kernel and imaging mode.

**CLINICAL RELEVANCE/APPLICATION**

Ultra high-resolution mode in photon-counting CT offers improved spatial resolution and superior detectability compared to macro mode, and superior to conventional energy-integrating CT.

**SSM21-04 Deep Inpainting for Photon-Counting Cone-Beam CT**

**Wednesday, Nov. 28 3:30PM - 3:40PM Room: S104B**

Participants
Elias Eulig, BSC, Heidelberg, Germany (Presenter) Nothing to Disclose  
Joscha Maier, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose  
Andreas Hahn, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose  
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**PURPOSE**

To provide an efficient method to close the gaps of large area photon counting detectors in x-ray imaging and cone-beam CT (CBCT).

**METHOD AND MATERIALS**

Photon counting detector technology promises improved CT image quality at reduced patient dose. Moreover, the new detectors have the potential to provide diagnostic image quality in cone-beam CT systems that, today, still suffer from inferior image quality. However, the limited size of the ASICs (typically about 3x3 cm) requires tiling of many detector modules in order to assemble detectors large enough for almost any medical application. Inevitably, one or more pixel wide gaps between the modules may occur. Prior to reading the x-ray images or to reconstructing the CBCT data, the gaps or dead pixels need to be closed by inpainting. Therefore, we developed a deep adversarial architecture based on a generator and discriminator network that trains itself to fill the dead pixels. Training was performed using uncorrupted CBCT thoracic and abdominal patient data with artificially induced pixel gaps. Since the adversarial approach is unsupervised the same architecture can be applied to photon-counting flat detector data in the same way. The performance was compared to a linear inpainting, to a diffusion-based inpainting and to an exemplar-based inpainting algorithm. Our novel approach was implemented using the PyTorch Deep Learning framework and trained on 6400 samples for 20 epochs on a GeForce GTX 1080 Ti GPU.

**RESULTS**

The visual impression of the correction was best with the deep inpainting approach and the exemplar-based algorithm, second best with the linear interpolation and worst with the diffusion-based algorithm where the location of the gaps was clearly visible after inpainting. The computation time per 1024x768 projection was 83 ms, 52 s, 29 ms and 2 s, respectively. The network was running on the GPU while all the other algorithms were running on the CPU.

**CONCLUSION**

Deep inpainting has the potential to remove pixel defects or gaps between detector modules at least as good as exemplar-based inpainting while reducing computation times drastically.

**CLINICAL RELEVANCE/APPLICATION**

Photon counting detector technology has the potential to improve CT and CBCT imaging in the near future. An efficient inpainting approach, such as the deep inpainting algorithm presented here, brings the new detector technology one step closer to clinical routine.

**SSM21-05 Can a Universal Protocol for Photon-Counting-Detector CT Provide Equivalent Iodine Detectability as Optimal kV Energy-Integrating-Detector CT: A Feasibility Study**

**Wednesday, Nov. 28 3:40PM - 3:50PM Room: S104B**

Participants
Wei Zhou, PhD, Rochester, MN (Presenter) Nothing to Disclose  
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**PURPOSE**

To determine iodine detectability using a single-kV universal protocol on a photon-counting-detector (PCD) CT for different phantom sizes, and to compare with optimized-kV single-energy (SE) and dual-source, dual-energy (DSDE) CT using an energy-integrating-detector (EID).
A 4-mm diameter hole in a water-equivalent cylinder was filled with iodine solutions at one of 4 concentrations (0.2, 0.5, 1.0 and 2.0 mg/cc) and the cylinder was inserted into one of 3 abdomen phantoms (QRM, lateral widths of 30, 35 and 40 cm). The whole phantom was scanned on a 2nd generation DSDE CT with SE and DE protocols using a kV or kV pair adjusted for phantom size. The phantom was also scanned on a whole body PCD CT using a single-kV universal protocol for all phantom sizes: 140 kV, 25 and 75 keV energy thresholds. EID-SE tube current was automatically adjusted (CareDose4D, 120 kV, 200 QRM), resulting in CTDIvol of 6.9 to 17.7 mGy for different size phantoms. EID-DE and PCD tube current was adjusted to match the CTDIvol of the EID-SE scans. Scans were repeated 200 times for each of 24 conditions: 4 concentrations, 3 phantom sizes and 3 protocols. All images were reconstructed with a quantitative kernel (D30) and 5 mm thickness. Virtual monoenergetic images (VMI) at 50 keV were generated from PCD and EID-DE images. CNR and AUC of the ROC from a calibrated channelized hotelling observer (CHO) model were calculated as figures of merit for quantifying iodine detection for PCD VMI@50 keV, EID-SE, and EID-DE PCD VMI@50 keV.

RESULTS
VMI@50 keV from PCD and EID-DE showed higher iodine CNR than the EID-SE images for all phantom sizes. For 0.5 mg/cc iodine, VMI@50 keV from PCD (0.93) and EID-DE (0.94) showed comparable AUC for iodine detection on a 30cm phantom and superior AUC for 35 cm (PCD: 0.93; EID-DE: 0.90) and 40 cm (PCD: 0.81; EID-DE: 0.88) phantoms compared to that of EID-SE (30 cm: 0.95; 35cm: 0.83; 40 cm: 0.77). A similar trend showing preference for VMI from PCD and EID-DE was observed for other iodine concentrations.

CONCLUSION
VMI images from a single kV PCD acquisition demonstrated comparable or improved iodine detectability and CNR compared to SE images where kV was selected based on patient size.

CLINICAL RELEVANCE/APPLICATION
A universal PCD CT protocol can maintain iodine sensitivity, simplify protocol selection and avoid sub-optimal images from inappropriate kV (or kV pair) selection with EID CT.

A Method of Calculating Lesion Detectability in Photon-Counting Spectral CT

Participants
Mats Persson, Stanford, CA (Presenter) Stockholder, Prismatic Sensors AB; Consultant, Prismatic Sensors AB
Paurakh L. Rajbhandary, BS, Palo Alto, CA (Abstract Co-Author) Nothing to Disclose
Norbert J. Pelc, DSc, Stanford, CA (Abstract Co-Author) Research support, General Electric Company; Consultant, General Electric Company; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Scientific Advisory Board, Theranos, Inc; Stockholder, Theranos, Inc; Medical Advisory Board, OurCrowd, LP; Scientific Advisory Board, Izotropic, Inc; Stockholder, Izotropic, Inc

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METHOD AND MATERIALS
Using a Monte Carlo simulation of an X-ray beam incident on a 3 mm thick cadmium telluride detector with 0.5x0.5 mm2 pixels and five energy bins, the energy-dependent point-spread function and autocorrelation function were calculated. Correlation between pixels due to fluorescence and charge diffusion was included in the simulation model. A recently developed linear-systems methodology was used to calculate the optimal-linear-observer detectability, i.e. the maximal detectability that can be obtained through optimal weighting of the data from the five energy bins. This detectability was computed for nonenhancing (soft tissue) and enhancing (10 mg/ml iodine) spherical lesions of different sizes in a 250 mm soft tissue cylinder, for a system with detector-limited resolution and a 120 kVp spectrum with 2.5 mm Al filtration. The results were compared to an ideal detector with perfect spatial and energy resolution and to an energy-integrating detector with 1x1 mm2 pixels but otherwise ideal.

RESULTS
The ideal-linear-observer detectability, relative to the ideal detector, was 67%, 83% and 91% for nonenhancing lesions with 1 mm, 2 mm and 10 mm diameter. For enhancing lesions the corresponding values were 48%, 58% and 62%, respectively. This is an improvement of 6-98 % (nonenhancing) and 58-203% (enhancing) compared to the energy-integrating detector.

CONCLUSION
Whereas large-area image quality metrics such as CNR have been used to characterize photon-counting CT scanners in previous work, so far there has not been a method of calculating the attainable detectability for smaller objects with energy-resolving photon-counting detectors. This simulation study demonstrates for the first time how the detectability of lesions in a photon-counting CT scanner can be simulated, taking energy resolution, pixel size and cross-talk between pixels into account. The results show that the detector performance is closer to ideal for nonenhancing lesions than for enhancing lesions.

CLINICAL RELEVANCE/APPLICATION
With photon-counting CT scanners expected to become clinically available in a few years, the proposed method will enable comprehensive comparison of systems and optimization of imaging protocols.
SSM24

**Vascular Interventional (Portal Interventions)**

Wednesday, Nov. 28 3:00PM - 4:00PM Room: E264

CT GI IR VA

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

**Participants**
Naganathan B. Mani, MD, Chesterfield, MO (Moderator) Nothing to Disclose
Nael E. Saad, MBBC, ROCHESTER, NY (Moderator) Nothing to Disclose

**Sub-Events**

**SSM24-01 Effect of Portal Decompression on Pulmonary Gas Exchange in Patients with Budd-Chiari Syndrome and Hepatopulmonary Syndrome**

Wednesday, Nov. 28 3:00PM - 3:10PM Room: E264

**Participants**
Jiaywei Tsauo, Beijing, China (Presenter) Nothing to Disclose
Xiaowu Zhang, Beijing, China (Abstract Co-Author) Nothing to Disclose
He Zhao, Beijing, China (Abstract Co-Author) Nothing to Disclose
Tao Gong, Beijing, China (Abstract Co-Author) Nothing to Disclose
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Xiao Li, PhD, Chengdu, China (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To evaluate the effect of portal decompression on pulmonary gas exchange in patients with Budd-Chiari syndrome (BCS) and hepatopulmonary syndrome (HPS).

**METHOD AND MATERIALS**

From June 2014 to June 2015, all patients with BCS undergoing balloon angioplasty and transjugular intrahepatic portosystemic shunt creation at our institution were eligible for inclusion in this study. The primary endpoint was the changes in alveolar-arterial oxygen gradient (A-aO2) before and over 3 months after portal decompression.

**RESULTS**

Eleven patients with HPS (mean age, 51.7 years; six males) and 14 patients without HPS (mean age, 47.2 years; nine males) were included. Of the 11 patients with HPS, dyspnea was found in three (27.3%), all of which (100%) reported improvement in dyspnea after portal decompression. However, this improvement was not maintained at 3-month follow-up in two (33.7%) patients. For patients with HPS, the mean change in A-aO2 was statistically significant before and at 1 month (-11.7 ± 6.4 mmHg; P < .001) but not at 2-3 days (-3.2 ± 11.9 mmHg; P = .412) and 3 months (-1.3 ± 12.5 mmHg; P = .757) after portal decompression. For patients without HPS, the mean change in A-aO2 was not statistically significant before and at 2-3 days (+1.4 ± 8.3; P = .543) and 1 (+3.5 ± 8.1 mmHg; P = .137) and 3 months (+1.3 ± 8.2 mmHg; P = .565) after portal decompression. The overall mean changes in A-aO2 before and over 3 months after portal decompression was statistically significant for patients with HPS (-5.4 ± 6.9 mmHg; P = .035) but not for patients without HPS (+2.0 ± 7.6 mmHg; P = .333).

**CONCLUSION**

Portal decompression can improve pulmonary gas exchange in patients with BCS and HPS, but this effect is not sustainable at 3 months.

**CLINICAL RELEVANCE/APPLICATION**

1. Hepatopulmonary syndrome are common in patients with Budd-Chiari syndrome. 2. Portal decompression via balloon angioplasty and transjugular intrahepatic portosystemic shunt creation is effective and safe for the treatment of hepatopulmonary syndrome in patients with Budd-Chiari syndrome. 3. The treatment effect of balloon angioplasty and transjugular intrahepatic portosystemic shunt creation on hepatopulmonary syndrome is not sustainable at 3 months in patients with Budd-Chiari syndrome.
PURPOSE

Many cirrhotic patients who cannot undergo liver transplantation are symptomatically treated for recurrent ascites with paracenteses and/or transjugular intrahepatic portosystemic shunts (TIPS). Placing TIPS earlier in the cirrhosis disease process can potentially decrease the cost and inconvenience of repeated paracenteses. This study aimed to determine if there were differences in paracenteses and hospital admissions from bacterial peritonitis, variceal bleeds, and hepatic encephalopathy between cirrhotic patients who did and did not receive TIPS.

METHOD AND MATERIALS

A retrospective analysis was performed on all cirrhotic patients, age 18 and older, with refractory ascites between January 1, 2008 and December 31, 2016 at our institution. Demographics, cirrhosis etiology, lab values, paracentesis, TIPS, and hospitalization information were documented. A shared frailty model with TIPS placement as a time-varying covariate was used to calculate the association of time between paracentesis with TIPS placement, while chi-square tests examined the association between hospitalization rates for each outcome with TIPS placement.

RESULTS

A total of 344 patients with refractory ascites and a median age of 57 (IQR=50–62) were included. Of these, 92 (26.8%) received TIPS. Median MELD score at refractory date was higher among patients without TIPS compared to patients with TIPS (18 and 13, respectively; p<0.01). TIPS and the risk of paracentesis for ascites were highly associated (p<0.01). A 60% reduction in the risk of a paracentesis post-TIPS was observed regardless of MELD score, age, or gender (HR=0.40, 95%CI=0.33, 0.49). There was no significant difference in hospitalizations for bacterial peritonitis (p=0.13), variceal bleeding (p=0.23), or hepatic encephalopathy (p=0.46) between patients with and without TIPS.

CONCLUSION

This study found that cirrhotic patients with refractory ascites have a 60% reduction in the risk of receiving a paracentesis for symptomatic ascites after TIPS is placed with no change in hospitalizations for TIPS-associated outcomes. This suggests that TIPS placement should be considered earlier in the cirrhosis disease process to improve symptomatic control and decrease the need and associated costs of frequent paracenteses.

CLINICAL RELEVANCE/APPLICATION

Early placement of TIPS in cirrhotic patients reduces risk of repeat paracenteses without effecting hospitalization rates for common complications of ESLD.
In monochromatic imaging of portal vein for the assessment of transjugular intrahepatic portosystemic shunt (TIPS) stent lumen using 16-cm wide-detector spectral CT, images at 55 keV manifested best objective image quality (CT attenuation, SNR and CNR), while 65 keV images demonstrated best subjective image quality and diagnostic confidence.

**CLINICAL RELEVANCE/APPLICATION**

It is recommended to conduct CT portal venography using 16-cm wide-detector spectral CT for the visualization of TIPS stent lumen in liver cirrhosis patients at 65 keV.

**SSM24-04 Metal Artifact Reductions with Monochromatic Imaging in Spectral CT Portal Venography after Gastric Coronary Vein Embolization (GCVE) in Portal Hypertension: A Comparative Study**  
Wednesday, Nov. 28 3:30PM - 3:40PM Room: E264

Participants  
Jian Dong, PhD, Beijing, China (Presenter) Nothing to Disclose  
Fuliang He, Beijing, China (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To investigate the clinical value of metal artifact reductions (MARs) combined with monochromatic imaging in spectral CT portal venography (CTPV) after gastric coronary vein embolization (GCVE) by comparison with 120 kVp-like imaging.

**METHOD AND MATERIALS**

Thirty-one patients with GCVE artifacts were performed CTPV with spectral CT in our study. All raw data were reconstructed as 120 kVp-like imaging without MARs (group A), and monochromatic imaging with MARs at 65 keV (group B) and 74 keV (group C), respectively. Three slices of CTPV images were evaluated, including main portal vein, heaviest artifacts and no artifacts level from all groups. Objective indexes for portal vein included signal intensity (SI), standard deviation (SD), signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR) and artifact index (AI). Subjective indexes were assessed by two radiologists separately with 5-point scale. Statistical analyses were analyzed.

**RESULTS**

With the use of MARs, AI in group B (29.1 ± 3.6) and C (35.6 ± 4.4) are much lower than group A (87.2 ± 11.3) (P<0.01). As for the quantitative indices of main portal vein, group B demonstrates the highest SI (243 ± 20.6), SNR (22.1 ± 3.7) and CNR (11.5 ± 2.6) than the other two groups (all P<0.01), while there is no statistical differences in SI (184 ± 19.7 Versus 179 ± 21.6), SNR (20.4 ± 3.1 Versus 21.6 ± 3.7) and CNR (9.2 ± 2.4 Versus 9.6 ± 2.9) between group A and C (all P>0.05). For subjective assessment, group B (3.8 ± 1.6) is superior to group A (2.1 ± 1.4) and (3.1 ± 1.1) (P<0.01).

**CONCLUSION**

Combination of MARs with monochromatic imaging decreased metal artifacts, and improved image quality in spectral CT portal venography with GCVE, with 65 keV as the optimal energy level.

**CLINICAL RELEVANCE/APPLICATION**

It is recommended that 65 keV with MARs as the optimal CTPV protocol for liver cirrhosis patients with GCVE.

**SSM24-05 Role of Preoperative MSCT and MRI for Endovascular Procedures in Budd-Chiari Syndrome with Inferior Vena Cava (IVC) Obstruction: A Retrospective Study of 112 Cases**  
Wednesday, Nov. 28 3:40PM - 3:50PM Room: E264

Participants  
Xiangwen Xia, Wuhan, China (Presenter) Nothing to Disclose  
Dehan Liu, Wuhan, China (Abstract Co-Author) Nothing to Disclose  
Tianhe Ye, Wuhan, China (Abstract Co-Author) Nothing to Disclose  
Chuansheng Zheng, Wuhan, China (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

This article focuses specifically on the obstructive characteristics, collateral vessels and floating thrombus demonstrated on preoperative imaging, to determine the role of preoperative MSCT and/or MRI for endovascular procedures.

**METHOD AND MATERIALS**

This retrospective analysis included 112 patients who underwent endovascular procedures for BCS between October 2009 and June 2017 in our institution. All patients had preoperative MSCT and/or MRI imaging. Two radiologists independently assessed (on a 5-point scale) the imaging data to evaluate diagnostic accuracy, inter-reader agreement, and association between imaging presentation and interventional procedures.

**RESULTS**

Eighty-two patients had preoperative MSCT data and corresponding sensitivities were 83.33%, 86.96%, 88%, and 81.25% for reader 1, and 83.33%, 91.30%, 92.00%, and 81.25% for reader 2. Thirty-two patients had preoperative MRI data and corresponding sensitivities were 88.89%, 100%, 100%, and 83.33% for reader 1, and 100%, 100%, 100% and 100% for reader 2. Areas under the receiver operating characteristic curves (AUCs) for judging IVC secondary thrombus were 0.88 for reader 1, 0.87 for reader 2 in group MSCT, and 0.975 for reader 1, 0.933 for reader 2 in group MRI. Inter-reader agreement was substantial or excellent for diagnostic accuracy (κ=0.745-0.927).
CONCLUSION

In patients with BCS, it is important to focus preoperatively on the degree and extent of the obstruction, collateral vessels and floating thrombus, to optimize interventional procedures and minimize complications.

CLINICAL RELEVANCE/APPLICATION

Interventional therapy is the preferred microinvasive therapeutic for patients with BCS, however, varying degree of procedure-related complications still exist. If we properly estimate obstructive characteristics preoperatively and detect risk factors, such as dangerous collateral vessels and IVC secondary thrombosis, we can design a reasonable interventional program and minimize complications.

PURPOSE

The purpose of this study was to investigate the feasibility and utility of the overlay technique under cone-beam computed tomography (CBCT) which was used as a navigation method for portal vein puncture during transjugular intrahepatic portosystemic shunt (TIPS).

METHOD AND MATERIALS

From February 2016 to April 2017, 15 consecutive cirrhotic patients (12 males and 3 females; mean age 58 years, range from 44 to 68 years) received TIPS treatment and prospectively enrolled in this study. An initial CBCT image acquisition was performed before TIPS and we applied the overlay technique by register the preoperative contrast enhanced CT or MRI portal venous phase images with the newly acquired CBCT images. According to the overlaid images, a planned needle path was made and displayed simultaneously on the axial, sagittal and coronal plane. The angle from hepatic vein to portal vein was calculated manually on three planes and intended for the interventional radiologists’ reference. The contrast material consumption, number of needle puncture attempts, radiation dose and fluoroscopic time were recorded from hepatic vein catheterization to portal vein entry.

RESULTS

The overlay technique was technically feasible in 14 of 15 patients (93%). The only failure was due to the overlay misregistration caused by progress of ascites. No complications were observed postoperative monitoring. The mean (± SD) contrast material consumption was 38 ± 9.2mL, number of needle attempts was 1.9 ± 1.1 punctures (range 1 to 4), dose area product (DAP) was 138 ± 55.8 Gy·cm², fluoroscopic time was 19 ± 5.5min.

CONCLUSION

The overlay technique under CBCT guidance is a feasible and safe method for TIPS portal vein puncture. It contributes to the creation of TIPS and facilitate the portal vein pressure reduction.

CLINICAL RELEVANCE/APPLICATION

The overlay technique under cone-beam computed tomography for portal vein puncture during TIPS is feasible, safe and helps portal puncture vein pressure reduction.
LEARNING OBJECTIVES

1) Describe consensus CTV delineation for spine metastases in intact vertebra based on the extent of gross disease. 2) Describe consensus CTV delineation for post-operative spine SBRT including the imaging series most valuable in the contouring process. 3) Describe optimal spinal cord delineation. 4) Explain when CT myelogram may be important in treatment planning for SBRT for spinal metastases.

ABSTRACT

To perform stereotactic body radiotherapy for spinal metastases safely and effectively, proper target delineation based on patterns of failure and practice guidelines and proper spinal cord contouring are paramount. This session will provide guidance for contouring.
Controversy Session: CT or MRI after Equivocal Appendix Visualization on Pediatric Ultrasound?

Wednesday, Nov. 28 4:30PM - 6:00PM Room: N226

CT GI MR PD US

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.75

Participants
Geetika Khanna, MD, MS, Iowa City, IA (Moderator) Nothing to Disclose

Sub-Events
SPSC43A CT for Appendicitis

Participants
Andrew T. Trout, MD, Cincinnati, OH (Presenter) Author, Reed Elsevier; Research Grant, Siemens AG; Research Grant, Canon America Medical Systems Corporation; Board Member, Joint Review Committee on Educational Programs in Nuclear Medicine Technology; Travel support, Koninklijke Philips NV; Consultant, Guerbet SA

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LEARNING OBJECTIVES
1) Examine the evidence for CT for acute appendicitis in children. 2) Debate the role of CT versus other modalities for imaging of appendicitis in children. 3) Define the optimal imaging strategy for appendicitis in their practice.

SPSC43B MRI for Appendicitis

Participants
Michael S. Gee, MD, PhD, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To learn indications for MRI in pediatric appendicitis evaluation. 2) To apply knowledge of current literature on MRI performance for pediatric appendicitis diagnosis. 3) To analyze technical and patient-related considerations for performance of MRI in children for appendicitis evaluation.
Controversy Session: CTA or MRA?
Wednesday, Nov. 28 4:30PM - 6:00PM Room: E353A

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 0
FDA
Discussions may include off-label uses.

Participants
Vincent B. Ho, MD, MBA, Bethesda, MD (Moderator) Institution, In-kind support, General Electric Company
Martin R. Prince, MD, PhD, New York, NY (Moderator) Patent agreement, General Electric Company; Patent agreement, Hitachi, Ltd; Patent agreement, Siemens AG; Patent agreement, Canon Medical Systems Corporation; Patent agreement, Koninklijke Philips NV; Patent agreement, Nemoto Kyorindo Co, Ltd; Patent agreement, Bayer AG; Patent agreement, Lantheus Medical Imaging, Inc; Patent agreement, Bracco Group; Patent agreement, Mallinckrodt plc; Patent agreement, Guerbet SA;

LEARNING OBJECTIVES
1) Discuss CTA and MRA methods and techniques for optimized vascular imaging in clinical practice. 2) Debate the advantages and disadvantages of CTA and MRA in clinical practice. 3) Recommend the application of CTA or MRA for common challenging clinical scenarios.

Sub-Events

SPSC45A   MRA
Participants
Scott B. Reeder, MD, PhD, Madison, WI (Presenter) Institutional research support, General Electric Company; Institutional research support, Bracco Group; Founder, Calimetrix, LLC; Shareholder, Elucent Medical; Consultant, ArTara
Robert R. Edelman, MD, Evanston, IL (Presenter) Nothing to Disclose
J. Paul Finn, MD, Los Angeles, CA (Presenter) Speakers Bureau, Bayer AG; Scientific Advisory Board, AMAG Pharmaceuticals, Inc

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SPSC45B   CTA
Participants
Elliott K. Fishman, MD, Baltimore, MD (Presenter) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc
W. Dennis Foley, MD, Milwaukee, WI (Presenter) Research Consultant, General Electric Company
Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Consultant, HeartFlow, Inc; Consultant, General Electric Company;

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Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Elliot K. Fishman, MD - 2012 Honored Educator Elliot K. Fishman, MD - 2014 Honored Educator Elliot K. Fishman, MD - 2016 Honored Educator Elliot K. Fishman, MD - 2018 Honored Educator
SPDL50

Neuro Nightmares: Headscratchers from Overnight (Case-based Competition)

Thursday, Nov. 29 7:15AM - 8:15AM Room: E451B

CT MR NR

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
Vadim Spektor, MD, New York, NY (Presenter) Nothing to Disclose
Nazmus Sakib, MD, Newark, NJ (Presenter) Nothing to Disclose
William B. Zucconi, DO, Madison, CT (Presenter) Nothing to Disclose
Yair Levy, Newark, NJ (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Analyze traumatic and non-traumatic emergent neuroradiology imaging. 2) Interpret neuroradiologic diagnoses using multimodality and case based approach. 3) Integrate critical pathophysiological and clinical issues of each clinical scenario. 4) Optimize technical parameters needed for image interpretation.

ABSTRACT
Imaging plays a critical role in assessing patients with acute neurologic symptoms. Every patient with neurologic symptoms will have some form of cross-sectional neurologic exam, CT or MRI. Large proportion if not majority of acute neurologic patients present after normal daytime hours. Radiology residents are often asked to provide the first line diagnosis in complicated and often confusing neurologic cases and initial treatment is often based on resident interpretation of these exams. We are presenting a collection of challenging Neuro cases that presented overnight in our emergency rooms.
Participants
Daria Manos, MD, FRCP, Halifax, NS (Moderator) Nothing to Disclose
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LEARNING OBJECTIVES
1) Identify and distinguish common and important CT patterns of diffuse and interstitial lung disease. 2) Understand the clinical importance of HRCT pattern recognition, the overlap between patterns and the key imaging features to help avoid diagnostic error. 3) Use clinical context to tailor HRCT differential diagnosis. 4) Describe an approach to diffuse airspace disease detected on CT chest. 5) List 3 common causes of acute diffuse airspace disease. 6) List 3 common causes of chronic diffuse airspace disease. 7) Accurately identify the common and important features of cystic lung disease on HRCT. 8) Recognize distinguishing features from other mimics of cystic lung disease on HRCT. 9) Use clinical context and other ancillary findings to tailor HRCT differential diagnosis.

Sub-Events
RC601A  Approach to Nodular Patterns
Participants
Daria Manos, MD, FRCP, Halifax, NS (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Identify and distinguish common and important CT patterns of diffuse and interstitial lung disease. 2) Understand the clinical importance of HRCT pattern recognition, the overlap between patterns and the key imaging features to help avoid diagnostic error. 3) Use clinical context to tailor HRCT differential diagnosis.

RC601B  Diffuse Airspace Disease: Practical Tips
Participants
Elsie Nguyen, MD, Toronto, ON (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Describe an approach to diffuse airspace disease detected on CT chest. 2) List 3 common causes of acute diffuse airspace disease. 3) List 3 common causes of chronic diffuse airspace disease.

RC601C  Cystic Lung Disease: What Are You Missing?
Participants
Judith L. Babar, MBChB, Thriplow, United Kingdom (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Accurately identify the common and important features of cystic lung disease on HRCT. 2) Recognize distinguishing features from other mimics of cystic lung disease on HRCT. 3) Use clinical context and other ancillary findings to tailor HRCT differential diagnosis.

RC601D  Fibrotic Lung Disease: Not Always UIP
Participants
Susan J. Copley, MD, FRCP, London, United Kingdom (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES

1) Accurately identify the common and important features of fibrotic lung disease on HRCT. 2) Describe the common and important HRCT features of UIP. 3) Recognize distinguishing features of other patterns of fibrotic lung disease on HRCT.
LEARNING OBJECTIVES

1) Discuss the role of CT for procedural planning and device selection. 3) Review how CT can be used to help improve clinical outcomes.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/

Stefan L. Zimmerman, MD - 2012 Honored Educator
Stefan L. Zimmerman, MD - 2015 Honored Educator

For information about this presentation, contact:

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LEARNING OBJECTIVES

1) Understand the technical advancements associated with new scintillation cameras and SPECT-CT and PET-CT cameras. 2) Appreciate the benefits of CT attenuation correction. 3) Appreciate the adjunctive benefits of anatomic definition provided with CT and physiologic/function information provided by SPECT and PET. 4) Improve interpretive skills related to SPECT and PET-CT.

ABSTRACT

Camera and software technology recently has rapidly advanced, providing improved SPECT image resolution and increased counting statistics. These advancements in turn have provided the possibility of reduced-time and reduced radiopharmaceutical dose image acquisitions. Moreover, increased flexibility in imaging protocols has been realized. Future development of these methods hold promise in increasing diagnostic accuracy and expanding diagnostic applications. The addition of CT to SPECT and PET has afforded the ability to perform attenuation correction, thereby minimizing attenuation artifacts and increasing diagnostic specificity. With CT acquisitions of sufficient resolution, complementary anatomic diagnostic information is provided. In addition, more precise anatomic localization of SPECT and PET abnormalities significantly increases clinical applicability.

Participants

E. Gordon Depuey, MD, New York, NY (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) Implement protocols that facilitate patient-centered imaging and that reduce patient radiation exposure. 2) Understand software methods to cope with lower SPECT counting statistics in order to reduce scan acquisition time and/or radiopharmaceutical injected activity and their clinical impact. 3) Understand instrumentation advances that allow new cameras to perform SPECT with markedly reduced acquisition times and/or less radiopharmaceutical activity and their clinical impact. 4) Review myocardial perfusion SPECT scans systematically to avoid artifacts and maximize diagnostic accuracy.

ABSTRACT

There has been an intersocietal effort to promote patient-centered imaging with a focus on appropriateness guidelines, cost-containment, radiation dose reduction, and the selection of the most appropriate imaging test and protocol to suit particular patient needs. The following technical advancements described facilitate implementation of patient-centered imaging. New software methods and new innovative hardware now allow for significantly shortened SPECT acquisition times without a decrease in image quality. Advances include iterative reconstruction, resolution recovery, and noise reduction software, and focused collimation and solid state detectors incorporated into new camera designs. Attenuation correction increases diagnostic specificity and facilitates stress-only protocols. Software advancements such such as high resolution imaging, scatter correction, and respiratory gating increase diagnostic sensitivity. Even with such technical advancements, however, attention to technical detail is essential to assure optimal image quality. Camera and radiopharmaceutical quality control deserve the highest priority. A systematic review of myocardial perfusion SPECT images is essential to recognize artifacts and optimize diagnostic accuracy. Case examples will be presented to reinforce this approach.

Participants

Sharmila Dorbala, MD,MPH, Boston, MA (Presenter) Research Grant, Astellas Group

LEARNING OBJECTIVES

1) Review the advantages and disadvantages of myocardial perfusion PET compared to SPECT for evaluation of coronary artery disease. 2) Learn the added value of absolute quantitative parameters derived from PET for assessment of coronary artery disease. 3) Discuss novel clinical applications of cardiovascular PET imaging in systemic diseases. 4) Review Case Examples of Cardiac PETs.

ABSTRACT

Advances in PET detectors, radiotracer availability, clinical software, as well as hybrid PET/CT and PET/MR scanners have revolutionized the clinical and investigative applications of cardiac PET. Cardiac PET myocardial perfusion imaging, in the 1970's, was a predominantly investigative tool, with home-grown software, available at select major academic centers with access to a cyclotron. Over the last decade, with easy access to PET scanners, and to positron emitting perfusion tracers, the use of cardiac PET has exploded -well beyond major academic centers to several hospitals and to large office-based practices. Robust clinical evidence coupled with commercially available software has made quantitative myocardial blood flow assessment, a main-stream clinical application. Hybrid PET/CT scanner applications- calcium score and CT based coronary angiography-have further advanced...
the applications of cardiac PET. A growing body of recent literature supports the role of targeted molecular PET to image inflammatory, infectious and infiltrative heart diseases. PET/MR is an emerging technology with promising cardiovascular applications. Each of these exciting developments has transformed cardiac PET from a predominantly investigative tool of the 1970's to the current advanced clinical tool. The primary goal of this session is to discuss the present-day clinical and emerging applications of cardiac PET/CT and PET/MR using a practical case-based approach.

RC611C Cases, Clinical Examples-Panel: How to Build Practice (Both PET and SPECT)

Participants
E. Gordon Depuey, MD, New York, NY (Presenter) Nothing to Disclose
Sharmila Dorbala, MD,MPH, Boston, MA (Presenter) Research Grant, Astellas Group

LEARNING OBJECTIVES

1) Interpret cardiac SPECT and PET scans with optimal sensitivity and specificity. 2) Recognize technical and patient-related artifacts. 3) Characterize myocardial perfusion defects whereby patients can be risk stratified with regard to risk of future cardiac events. 4) Formulate reports in a clinically relevant manner.
**Advances in CT: Technologies, Applications, Operations - CT Systems**

Thursday, Nov. 29 8:30AM - 10:00AM Room: S403A

**ABSTRACT**

CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

**LEARNING OBJECTIVES**

1) Introduce recent development of multi-detector CT (MDCT) system. 2) Describe some of the latest CT acquisition techniques, including high pitch, gating, dynamic, and automatic kV selection. 3) Explain clinical applications of these novel acquisition techniques.

**Sub-Events**

**RC621A**  **MDCT Systems and Acquisitions**

Participants
Ehsan Samei, PhD, Durham, NC (Coordinator) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc
Lifeng Yu, PhD, Chicago, IL (Coordinator) Nothing to Disclose

For information about this presentation, contact:
yu.lifeng@mayo.edu

**LEARNING OBJECTIVES**

1) Understand the principles of cone-beam CT imaging. 2) Understand the challenges to cone-beam CT image quality and emerging techniques for image quality improvement. 3) Understand the scope of clinical applications in diagnostic and image-guided procedures utilizing cone-beam CT.

**ABSTRACT**

1) Understand the principles of cone-beam CT imaging. 2) Understand the challenges to cone-beam CT image quality and emerging techniques for image quality improvement. 3) Understand the scope of clinical applications in diagnostic and image-guided procedures utilizing cone-beam CT.
**RC622**

**Advances in Cone Beam CT Acquisition and Reconstruction in Radiotherapy**

Thursday, Nov. 29 8:30AM - 10:00AM Room: S504AB

**Participants**
Douglas Moseley, PhD, Toronto, ON (Moderator) License agreement, Modus Medical Devices Inc; Consultant, Elekta AB

**Sub-Events**

**RC622A**  **State of the Art in Advanced CBCT Acquisition and Reconstruction**

Participants
Wojciech Zbijewski, PhD, Baltimore, MD (Presenter) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG

For information about this presentation, contact:
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**LEARNING OBJECTIVES**

1) Identify key challenges to image quality in CBCT. 2) Discuss latest developments in CBCT instrumentation. 3) Describe recent advances in reconstruction algorithms and artifact correction methods for CBCT. 4) Compare CBCT image quality achievable on their systems to state-of-the-art.

**RC622B**  **Clinical Need for Advanced CBCT Imaging in Radiotherapy**

Participants
Tianyu Zhao, PhD, St. Louis, MO (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Gain greater understanding on the clinical need of CBCT in radiotherapy in the following applications: Image-Guided Radiotherapy (IGRT) with more precise tumor localization and better patient setup, 4D CBCT in managing respiratory motion, and adaptive radiotherapy (ART).

Active Handout:Tianyu Zhao

**RC622C**  **Technical Challenges in the Integration of CBCT Imaging into Radiotherapy**

Participants
Douglas Moseley, PhD, Toronto, ON (Presenter) License agreement, Modus Medical Devices Inc; Consultant, Elekta AB

For information about this presentation, contact:
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**LEARNING OBJECTIVES**

1) Identify the technical challenges when using CBCT imaging for image-guided radiation therapy. 2) Discuss strategies for commissioning and QA of the IGRT workflow in the clinic. 3) Describe the future direction of in-room image guidance.

**ABSTRACT**

The Scan-Plan-Treat paradigm is becoming too simplistic to describe the workflow in the modern radiation therapy clinic. Multiple CBCT scans are performed during the treatment delivery that may trigger, re-Scans and re-Plans. This presents several challenges.
LEARNING OBJECTIVES

1) Describe common CT findings of blunt abdominal trauma. 2) Review key components for classification of traumatic injuries of abdominal organs. 3) Discuss the role of imaging findings in patient triage and management.

ABSTRACT

Blunt abdominal trauma is a significant cause of morbidity and mortality worldwide. Contrast-enhanced computed tomography (CT) is the most efficient and commonly used imaging modality to evaluate patients presenting after sustaining blunt abdominal trauma. Familiarity with common imaging findings and mechanism of injury are critical to the proper diagnosis and triage of patients. In this session, the key imaging findings and classifications of blunt abdominal trauma will be reviewed.

LEARNING OBJECTIVES

1) To discuss the role of MDCT in patients with Penetrating abdominal Trauma. 2) Describe MDCT protocols for PAT. 3) Review the MDCT findings of selected penetrating abdominal injuries.

ABSTRACT

Patients with PAT who are in a hemodynamically stable condition may forgo laparotomy if they do not have surgically pertinent MDCT findings. This lecture focuses on key MDCT findings in patients with penetrating abdominal trauma.

LEARNING OBJECTIVES

1) An approach to CTA of the thorax in trauma. 2) Highlight the differences between blunt and penetrating trauma. 3) Emphasize the importance of direct and indirect signs.

ABSTRACT

CTA is frequently used in the assessment of thoracic trauma. Potential pitfalls can result in unnecessary work up if they are not appreciated and subtle injuries can easily be overlooked. This lecture will use cases to highlight an approach to CTA of the thorax in trauma and teh importance of direct vs. indirect signs.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Sanjeev Bhalla, MD - 2014 Honored EducatorSanjeev Bhalla, MD - 2016 Honored EducatorSanjeev Bhalla, MD - 2017 Honored EducatorSanjeev Bhalla, MD - 2018 Honored Educator
Motorcycle Injuries: Head to Toe

Participants
Stacy E. Smith, MD, Boston, MA (Presenter) Nothing to Disclose
**SSQ02**

**Cardiac (Great Vessels and Cardiopulmonary Disease)**

Thursday, Nov. 29 10:30AM - 12:00PM Room: S404AB

**Participants**
Matthew D. Cham, MD, New York, NY (Moderator) Nothing to Disclose
Seth J. Kligerman, MD, Denver, CO (Moderator) Nothing to Disclose
Jeremy D. Collins, MD, Chicago, IL (Moderator) Consultant, Guerbet SA Grant, Siemens AG Grant, C. R. Bard, Inc

**Sub-Events**

**SSQ02-01 3rd Generation Dual Source CT Pulmonary Angiographic Study at Very Low Contrast Doses: A New Frontier**

Thursday, Nov. 29 10:30AM - 10:40AM Room: S404AB

**Participants**
Nicolo Schicchi, MD, Ancona, Italy (Presenter) Nothing to Disclose
Matteo Oliva, MD, Ancona, Italy (Abstract Co-Author) Nothing to Disclose
Corrado Tagliati, Ancona, Italy (Abstract Co-Author) Nothing to Disclose
Giacomo Agliata, MD, Saint-Denis, France (Abstract Co-Author) Nothing to Disclose
Paolo Esposto Pirani, Ancona, Italy (Abstract Co-Author) Nothing to Disclose
Andrea Giovagnoni, MD, Ancona, Italy (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

Pulmonary Angio-CT is the first diagnostic choice for the evaluation of pulmonary embolism and usually performed with iodinated contrast media (CM) injection. The purpose of this study is to evaluate the lower amount of iodinated CM required in order to obtain a diagnostic quality pulmonary Angio-CT with the new Dual Source CT technology.

**METHOD AND MATERIALS**

36 patients (16 males, 20 females; mean age 40 years) were enrolled with medium-high pre-test probability of pulmonary embolism and underwent a 3rd generation Dual Source CT (Somatom Force Siemens Healthineers) scan. Three groups of 12 patients each one were randomized using 400 mgI/mL iodinated CM with different doses: group A (<5 ml), group B (<10 ml) and group C (<15 ml). The Hounsfield Unit (HU) values were sampled at predefined points of the pulmonary arteries. Each exam was also assessed qualitatively with a 5-point scale.

**RESULTS**

HU evaluation did not show statistically significant difference between groups A and B, while they showed statistically significant difference between group C and groups A-B (Kruskal-Wallis, p=0.025). Qualitative analysis did not find statistically significant difference between groups A, B and C (Kruskal-Wallis, p=0.12).

**CONCLUSION**

The new 3rd Dual Source CT technology allows for an optimization of pulmonary angio-CT study in order to obtain a diagnostic quality images with low doses of iodinated CM.

**CLINICAL RELEVANCE/APPLICATION**

The purpose of this study is to evaluate a reduced contrast media administration in patients with suspected pulmonary embolism in an emergency setting, especially in patients with higher risk of contrast-induced nephropathy (CIN) (i.e. nephropatic or type 2 diabetic patients).

**SSQ02-02 2D-PC MRI Measurement of Pulmonary Artery Blood Flow and Left Atrial Function in Smokers: A Correlational Research**

Thursday, Nov. 29 10:40AM - 10:50AM Room: S404AB

**Participants**
Shuangchun Ma, Dalian, China (Presenter) Nothing to Disclose
Zhiyong Li, Dalian, China (Abstract Co-Author) Nothing to Disclose
Ruyi Bao, MD, Dalian, China (Abstract Co-Author) Nothing to Disclose
Chen Hui, Dalian, China (Abstract Co-Author) Nothing to Disclose
Xin Li, Dalian, China (Abstract Co-Author) Nothing to Disclose
Ailian Liu, MD, Dalian, China (Abstract Co-Author) Nothing to Disclose
PURPOSE
To investigate the correlation between main pulmonary artery blood flow and left atrium functional parameters in smokers using two-dimensional phase contrast magnetic resonance imaging (2D-PCMRI).

METHOD AND MATERIALS
Twenty-eight smokers (all men, mean age: 39.8±7.0 years) were enrolled in this study. All of them underwent main pulmonary artery 2D-PC and cardiac scan at 3.0T MR from December 2017 to March 2018. Blood flow parameters include Peak Positive Velocity (PPV) (cm/s), Peak Negative Velocity (PNV) (cm/s), Average flow (AF) (ml/beat), Average Positive Flow (APF) (ml/beat), and Average Negative Flow (ANF) (ml/beat). The correlation between main pulmonary artery blood flow and left atrial functional parameters was analyzed.

RESULTS
There is a statistically correlation between pulmonary artery PPV and left atrial active ejection fraction (LAEFa) (p=0.022, r=0.431), and left atrium total ejection fraction (LAEFt) (p=0.032, r=0.406) respectively. Similarly, there is a statistically correlation between pulmonary artery AF and left atrium maximum volume (LAVi max) (p=0.048, r=0.378), LAEFa (p=0.040, r=0.391) and LAEft (p=0.008, r=0.488) respectively. There is a statistically correlation between APF and LAVi max (p=0.039, r=0.392), LAEft (p=0.028, r=0.415), respectively.

CONCLUSION
There is a positive correlation between the main pulmonary artery blood flow and left atrium function in smokers.

CLINICAL RELEVANCE/APPLICATION
This correlational research of pulmonary artery blood flow and left atrium function is helpful in further to understand and reveal the effect of smoking on the cardiovascular system.
Addition, for the LV, early but not late diastolic filling rate was negatively associated with lung volume (β = -2.14, p = 0.02; β = -1.45, p = 0.004) showed negative associations with lung volume, while ejection fraction, peak ejection rate multivariate adjustment, stroke volume as well as end-diastolic volume of both LV (β = -2.75, p = 0.001; β = -1.71, p = 0.001) and RV parameters. In univariate analysis, a negative correlation of LV and RV stroke volume to lung volume was observed. After multivariate adjustment, stroke volume was related to end-diastolic volume of both LV (β = -2.75, p = 0.001; β = -1.71, p = 0.001) and RV (β = -2.14, p = 0.02; β = -1.45, p = 0.004) showed negative associations with lung volume, while ejection fraction, peak ejection rate and myocardial mass were not associated with lung volumes (Figure 1). These values were stronger for the LV than for the RV. In addition, for the LV, early but not late diastolic filling rate was negatively associated with lung volume.

RESULTS

There were six patients with enlarged left and right ventricles (37.5%), three patients with enlarged whole-heart (18.75%), two patients with double superior vena cava and enlarged left atrium and ventricle (12.5%). The scan time of 3D TEE sequence was one minute and forty seconds to two minutes and thirty seconds (1min 40s to 2 min 30s), the scan time of 3D BTEE sequence was five minutes and twenty seconds to six minutes and thirty seconds (5 min 20s to 6 min 30s). For the grade of imaging quality, five patients were classes as 0-2 grade (31.25%), 11 patients were 3-5 grade (68.75) by the 3D TEE sequence, and six patients were 0-2 grade (37.5%), 11 patients were 3-5 grade (62.5%) by the 3D BTEE sequence.

CONCLUSION

3D whole-heart coronary arteries magnetic resonance imaging could obtain similar imaging quality with less scan time, it may be an excellent method to image, evaluate, diagnose, and follow-up coronary arteries lesions in pediatric patients with Kawasaki diseases.

CLINICAL RELEVANCE/APPLICATION

(dealing with 3D coronary arteries magnetic resonance imaging) 3D whole-heart coronary arteries magnetic resonance imaging could obtain similar imaging quality with less scan time.

SSQ02-07 Automatic Segmentation of Lung Volumes in Population-based Whole-Body MR Imaging: Association with Subclinical Cardiac Impairment

Thursday, Nov. 29 11:30AM - 11:40AM Room: S404AB

Participants

Ricarda V. von Kruchten, MD, Heidelberg, Germany (Presenter) Nothing to Disclose
Roberto Lorbeer, Greifswald, Germany (Abstract Co-Author) Nothing to Disclose
Tanja Zeezelsberger, MD, Tuebingen, Germany (Abstract Co-Author) Nothing to Disclose
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Stefan Karrasch, Neuherberg, Germany (Abstract Co-Author) Nothing to Disclose
Annette Peters, Neuherberg, Germany (Abstract Co-Author) Nothing to Disclose
Hans-Ulrich Kauczor, MD, Heidelberg, Germany (Abstract Co-Author) Research Grant, Siemens AG Research Grant, Bayer AG Speakers Bureau, Boehringer Ingelheim GmbH Speakers Bureau, Siemens AG Speakers Bureau, Koninklijke Philips NV Speakers Bureau, Bracco Group Speakers Bureau, AstraZeneca PLC
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METHOD AND MATERIALS

Both cardiac and pulmonary morphology and function can be simultaneously assessed during a single MR scan. Previous studies have shown an association between obstructive lung disease with cardiac dysfunction. Our aim is to evaluate the relationship between lung volumes and cardiac impairment in a population-based cohort study using whole-body MR scans.

RESULTS

A total of 356 subjects presented an average MRI-based lung volume of 4.0±1.1L and mostly standard values for cardiac parameters. In univariate analysis, a negative correlation of LV and RV stroke volume to lung volume was observed. After multivariate adjustment, stroke volume as well as end-diastolic volume of both LV (β = -2.75, p = 0.001; β = -1.71, p = 0.001) and RV (β = -2.14, p = 0.02; β = -1.45, p = 0.004) showed negative associations with lung volume, while ejection fraction, peak ejection rate and myocardial mass were not associated with lung volumes (Figure 1). These values were stronger for the LV than for the RV. In addition, for the LV, early but not late diastolic filling rate was negatively associated with lung volume.
Cardiac function and volume parameters derived from non-dedicated whole-body MRI, such as stroke volumes and biventricular end-diastolic volumes were significantly associated with lung volumes in a patient cohort without cardiovascular disease.

**CLINICAL RELEVANCE/APPLICATION**

These results suggest, that MRI could be an accurate, radiation-free, and possibly one-stop-shop screening tool, with the potential for early detection of subclinical heart disease in patients with emphysema and subclinical cardiovascular dysfunction.

**SSQ02-08 Double Region of Interest Timing Bolus Technique to Perform Aortic CT Angiography with 40 mL of Contrast Medium**

**Participants**

Nobuo Tomizawa, MD, Matsudo, Japan (Presenter) Nothing to Disclose
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Tatsuya Nakao, Matsudo, Japan (Abstract Co-Author) Nothing to Disclose
Hiroaki Arakawa, Matsudo, Japan (Abstract Co-Author) Nothing to Disclose
Kodai Yamamoto, Bunkyo, Japan (Abstract Co-Author) Nothing to Disclose
Shinichi Inoh, MD, Tokyo, Japan (Abstract Co-Author) Nothing to Disclose
Takeshi Nojo, MD, PhD, Matsudo-shi, Japan (Abstract Co-Author) Nothing to Disclose
Sunao Nakamura, Matsudo, Chiba, Japan (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

We developed a novel method to track the peak of the injected contrast medium by placing two regions of interest (ROI) at the timing bolus image. The purpose of this study was to compare the enhancement of the aorta when CT angiography was performed with 40 mL of contrast medium using the novel double ROI timing bolus (DRTB) technique with the enhancement using the conventional method.

**METHOD AND MATERIALS**

We prospectively included 21 patients from February to March 2018 who underwent repeated CT angiography of the aorta. In the prior scan, a total of body weight × 1.7 mL of contrast medium was injected for 25 s, and the scan timing was determined by the bolus tracking technique. The tube potential was 120 kVp and the table speed was set as fast as possible to acquire the entire aorta. In the DRTB method, timing bolus technique was performed using 9 mL of contrast medium at the level of the aortic root. An ROI was placed at the ascending and descending aorta, respectively. Time density curves of the two ROIs were drawn and the difference of the peak time (Tdiff) was recorded. The blood flow of the aorta was calculated by dividing the length of the thoracic aorta by Tdiff. The main scan was performed with a tube potential of 100 kVp. We injected 40 mL of contrast medium for 9 s and adjusted the table speed to follow the peak of the injected contrast bolus. We evaluated the attenuation of the aorta at the level of aortic root, arch, descending, celiac trunk, and iliac bifurcation.

**RESULTS**

The injected contrast medium during the main scan significantly reduced from 87 ± 11 to 40 mL (p <0.001). The attenuation of the aorta at the level of the aortic root, arch, descending, celiac trunk, and iliac bifurcation using the DRTB method were 408 ± 125, 425 ± 99, 421 ± 96, 414 ± 96, 417 ± 101 HU, respectively, which were all significantly higher than using the conventional method (341 ± 72, 370 ± 61, 362 ± 59, 349 ± 96, 362 ± 70 HU, respectively, all p <0.05).

**CONCLUSION**

DRTB method could dramatically reduce the contrast medium during aortic CT angiography while improving the enhancement than the conventional method.

**CLINICAL RELEVANCE/APPLICATION**

Aortic CT angiography using the DRTB method would reduce the risk of contrast induced nephropathy and also widen the indication of aortic CT to patients with chronic kidney disease.

**SSQ02-09 Subclinical Changes in Cardiac Functional Parameters as Determined by Cardiovascular Magnetic Resonance (CMR) Imaging in Patients with Sleep Apnea and Snoring: Findings from UK Biobank**

**Participants**

Adrian Curta, MD, Munich, Germany (Presenter) Nothing to Disclose
Holger Hetterich, MD, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Regina Schinner, Munich, Germany (Abstract Co-Author) Nothing to Disclose
Aaron M. Lee, London, United Arab Emirates (Abstract Co-Author) Nothing to Disclose
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Jackie Cooper, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Jose M. Paiva, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Valentina Carapella, Oxford, United Kingdom (Abstract Co-Author) Nothing to Disclose
Stefan Neubauer, Oxford, United Kingdom (Abstract Co-Author) Shareholder, Perspectum Diagnostics Ltd; Non-Executive Director, Perspectum Diagnostics Ltd

**Thursday, Nov. 29 11:50AM - 12:00PM Room: S404AB**
Obstructive sleep apnea (OSA) is a common disorder that shows an increased risk for left ventricular (LV) and, more rarely, right ventricular (RV) dysfunction. Most studies to date have examined populations with manifest cardiovascular disease and have used echocardiography to analyze ventricular dysfunction, with little or no reference to ventricular volumes or myocardial mass. We hypothesized that there would be stepwise increase in LV mass and RV volumes from the unaffected, to the snoring and the OSA group.

**METHOD AND MATERIALS**
We analyzed cardiac MRI data from 4493 UK Biobank participants free from cardiovascular disease. Participants were allocated into three cohorts: (i) with OSA; (ii) with self-reported snoring; and (ii) without OSA or snoring (n=38; 1919; and 2536 respectively). We determined ventricular volumes, ejection fraction and LV mass from balanced cine-SSFP sequences.

**RESULTS**
Trend analysis showed a stepwise increase for LV mass in both genders (p<0.001) and for LV and RV ejection fraction (EF) and stroke volume (SV) as well as LV end diastolic volume in males (p<0.02). There was no significant difference when comparing the OSA group to the unaffected group but we found a significant difference when comparing snoring to unaffected in LV mass of females (β=1.45±0.55g; p=0.009) and in LVEF and RVEF as well as LVSV and RV end systolic volume of males (β=0.80±0.28%; p=0.005, β=1.17±0.28%; p<0.001, β=1.68±0.76ml; p=0.027 and β=-2.41±0.90ml; p=0.008) respectively.

**CONCLUSION**
Our study suggests that the transition from snoring to OSA is an evolving process which is associated with LV hypertrophy. The different results based on the gender in the pilot data point to a gender specific progression. Separate prospective studies are needed to further explore the direction of causality.

**CLINICAL RELEVANCE/APPLICATION**
Sleep apnea and snoring lead to gender specific alterations in cardiac function which may require diversified prevention and treatment strategies.
**SSQ03-01** Cardiac Keynote Speaker: Technical Advances in Coronary Artery Imaging  
**Participants**  
Borek Foldyna, MD, Boston, MA (Moderator) Nothing to Disclose  
Cristina Fuss, MD, Portland, OR (Moderator) Spouse, Officer, ViewRay, Inc

**SSQ03-03** Free-Breathing Coronary CT Angiography Using 16-Cm Wide-Detector for Challenging Patients: Comparison with Invasive Coronary Angiography  
**Participants**  
Tao Shuai, Chengdu, China (Presenter) Nothing to Disclose

**Purpose**  
To detect the superiority of free-breathing coronary computed tomography angiography (CCTA) with 16-cm wide-detector CT for challenging patients who cannot hold breath.

**Method and Materials**  
A total of 76 patients (62% with either heart rate >75 bpm or arrhythmia) unable to hold breath underwent both free-breathing CCTA and ICA were included. Two reviewers evaluated coronary arteries on the per-segment (using 18-segment model), per-vessel and per-patient basis for image quality using a four-point scale and stenosis degree. CCTA results were compared with ICA to calculate the diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

**Results**  
Out of 1368 total segments, 228 (16.7%) were less than 1.5 mm in diameter and were excluded in CT, 32 (2.3%) with calcification and 26 (1.9%) with motion artifacts and were considered positive in CT. 1082 segments (79.1%) were evaluated both on CCTA and ICA and 128 (11.8%) segments had stenosis >=50% on ICA. The diagnostic accuracy, sensitivity, specificity, PPV, and NPV of CCTA were 90.8%, 88.3%, 91.1%, 91.1% and 98.3% on a per-segment basis; 93.4%, 90.6%, 94.2%, 80.5% and 97.4% on a per-vessel basis; and 92.1%, 100%, 85%, 85.7% and 100% on a per-patient basis. For patients with high heart rates or arrhythmia, 81% (vs. 79.1%) segments were evaluable, and the accuracy, sensitivity, specificity, PPV, and NPV were statistically the same as the entire study population.

**Conclusion**  
Free-breathing CCTA using 16-cm wide-detector CT has high accuracy for detecting coronary artery stenosis for challenging patients in comparison with ICA.

**Clinical Relevance/Application**  
Wide-detector CT has high clinical value for detecting coronary artery stenosis in CCTA for patients unable to hold breath.

**SSQ03-05** Influence of Contrast Media Parameters on Image Quality in Cardiac Computed Tomography: Insights from a Multicenter Registry  
**Participants**  
Ludovico La Grutta, MD, Palermo, Italy (Presenter) Nothing to Disclose  
Alberto Clemente, Massa, Italy (Abstract Co-Author) Nothing to Disclose  
Erica Maffei, MD, Parma, Italy (Abstract Co-Author) Nothing to Disclose  
Giambattista Privitera, Catania, Italy (Abstract Co-Author) Nothing to Disclose  
Patrizia Toia, MD, Palermo, Italy (Abstract Co-Author) Nothing to Disclose  
Filippo Cademartiri, MD, PhD, Rotterdam, Netherlands (Abstract Co-Author) Research Consultant, Somahlution  
Marco Francone, MD, PhD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
Deep Learning Analysis in Coronary Computed Tomographic Angiography Imaging for the Evaluation of Patients with Coronary Artery Atherosclerosis Stenosis

Thursday, Nov. 29 11:30AM - 11:40AM Room: S404CD

RESULTS

With only 100 CCTA cases as the training dataset, based on transfer learning, CHD-AI provided a relatively accurate simulated CCTA imaging with a Kappa value of 0.327 for detecting calcified plaque and non-calcified plaque compared to CCTA (P<0.001). For detecting coronary artery atherosclerosis with moderate and above stenosis, CHD-AI provided good sensitivity of 72% (11% more than CCTA) and negative predictive values of 80% (only 4% less than CCTA). Specificity (51%), coincidence (58%) and positive predictive values (40%) were relatively low.

CONCLUSION

The proposed CHD-AI allows the generation of simulated CCTA images from a series of 2D CT images. This approach provides good sensitivity and negative predictive value for detecting stenosis and is relatively accurate for detecting calcified plaque and non-calcified plaque compared to CCTA. But it is still relatively high in false-positive rate.

CLINICAL RELEVANCE/APPLICATION

This CHD-AI can omit some CCTA reconstruction steps to some extent, reduce diagnostic time and the error of human eyes in assessing the degree of coronary stenosis compared with current CCTA imaging.
Deep Learning Enables Inline Image Reconstruction of Accelerated, Single-shot Coronary QISS MRA in Patients with Congenital Heart Disease

Purpose

Our previous study demonstrated the feasibility of 1-shot, real-time coronary Quiescent-Interval Slice-Selective (QISS) MRA in children with congenital heart disease using compressed sensing (CS). While CS produced clinically acceptable image quality, it is a poor fit for inline image reconstruction because of its slow reconstruction time (~60 s per image). Deep learning (DL) is an alternative framework for reconstructing MR images with considerably higher speed. The purpose of this study is to demonstrate the feasibility of inline image reconstruction of accelerated coronary QISS MRA using DL.

Method and Materials

This study entailed 2-fold accelerated, 2-shot coronary QISS MRA data sets obtained from 26 pediatric patients (mean age = 16.4 ± 7.9 years; 16 boys and 10 girls) scanned on a 1.5T scanner (Aera, Siemens). The QISS data were undersampled by an additional factor of 2 (i.e., 1-shot, real-time) and reconstructed using CS with total variation (TV) and a deep convolutional neural network adapted from a U-Net (layer depth = 5, 64 features on the first layer, GPU based tensorflow framework in Python). We fed 1-shot and 2-shot QISS images from first 20 patients (283 images) as input and output pairs to train the U-Net. Subsequently, images from the remaining 6 patients (69 images) were used to validate the trained U-Net. Using the 2-shot QISS with CS as control, we measured the DICE coefficients as a metric of reproducibility for 1-shot QISS with zero padding, 1-shot QISS with CS and 1-shot QISS with U-Net.

Results

Both 1-shot QISS with CS and DL produced image quality that is comparable to 2-shot QISS (Fig. 1). The mean DICE coefficients for 1-shot QISS with zero padding, 1-shot QISS with CS and 1-shot QISS with U-Net images were 77.3 ± 7.4%, 90.0 ± 4.4% and 87.3 ± 4.1%, respectively. While the differences in DICE were significantly different for all pairs (p < 0.05), the difference between CS and U-Net was only 3%. The reconstruction time for U-Net (0.42 ± 0.04 s) was significantly lower (p < 0.05) than CS (52.3 ± 2.1 s).

Conclusion

This study demonstrates the feasibility of performing inline reconstruction of single-shot coronary QISS MRA using DL.

Clinical Relevance/Application

Pediatric patients with congenital heart disease who require non-invasive evaluation of coronary origins for planning a surgical intervention may benefit from non-contrast, 1-shot coronary QISS MRA with inline image reconstruction using deep learning.
**SSQ04**

**Chest (Radiomics)**

Thursday, Nov. 29 10:30AM - 12:00PM Room: E353A

- **BQ**
- **CH**
- **CT**
- **OI**

**AMA PRA Category 1 Credits™**: 1.50  
**ARRT Category A+ Credit**: 1.75

**FDA** Discussions may include off-label uses.

**Participants**  
Brett W. Carter, MD, Houston, TX (Moderator) Editor, Reed Elsevier;  
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**Sub-Events**

**SSQ04-01  Nodule Malignancy Prediction: A Systematic Comparison of Deep Learning and Radiomics**  
Thursday, Nov. 29 10:30AM - 10:40AM Room: E353A

**Participants**  
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**PURPOSE**

Radiomics is a field of study that extracts features from medical images using data characterization algorithms. It has been applied to classify pulmonary nodule malignancy. Recent development in computer vision shows that deep learning is a powerful tool to extract image features. This paper systematically compares a deep learning (DL) method and previously established radiomics methods to extract features from chest CT scans to predict nodule malignancy.

**METHOD AND MATERIALS**

We collected CT scans of 463 patients from LIDC (a public dataset) and of 915 patients from a collaborating hospital. Each CT scan contained one nodule whose malignancy was pathology proven. The whole dataset was randomly separated into a training dataset (1154: 391 from LIDC) and a testing dataset (224: 72 from LIDC). Three methods were used to extract nodule features. (1) radiomics condition, all nodules were segmented first, and 1008 features were extracted from each nodule using PyRadiomics (van Griethuysen et al, 2017). PCA was applied to select 95.3%, 96.2%, 97.8%, 98.4% and 99.2% information from the original features. (2) DL condition, we used a 3D-CNN model and average pooling to extract 128 features based on the same segmented nodules. The same PCA method was applied to DL features. (3) radiomics&DL condition, we concatenated the features from both (1) and (2) after the PCA processing. In all 3 conditions, we trained a random forest classifier based on outputs from PCA to predict nodule malignancy. We replicated the experiment 10 times to average out randomness caused by random forest.

**RESULTS**

As shown in Table 1, (1) radiomics condition achieved classification AUCs between 0.840 and 0.845; (2) DL method’s AUCs ranged from 0.841 to 0.858. (3) radiomics&DL condition (AUCs: 0.855 to 0.872) outperformed the above two conditions. Figure 1 shows ROC plot of the 98.4% situation in Replication 1.

**CONCLUSION**

Radiomics combined with DL consistently achieved significantly higher AUCs than the DL or radiomics method alone, and DL performed marginally better than radiomics at nodule malignancy prediction. This study suggests that features extracted by DL can to some extent complement information extracted by radiomics.

**CLINICAL RELEVANCE/APPLICATION**

This paper shows that deep learning methods could extract extra features from CT images to complement traditional radiomics methods to improve clinical evaluation of pulmonary nodule malignancy.

**SSQ04-02  A Novel Prediction Model for Pulmonary Nodule Diagnosis Combining Plasma Biomarkers, Radiomics, Conventional Imaging Features, and Clinical Data**
Thursday, Nov. 29 10:40AM - 10:50AM Room: E353A

Awards

Trainee Research Prize - Medical Student

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PURPOSE

For both screening and incidental findings it is important but also challenging to classify pulmonary nodules as benign or malignant at first presentation. The objective of this study is to develop a novel prediction model for lung cancer diagnosis combining plasma biomarkers, radiomics, conventional imaging features and clinical data.

METHOD AND MATERIALS

We performed a retrospective study with 121 NSCLC patients and 117 controls. Specific tumor-derived autoantibodies were analyzed in plasma of all patients. The nodules were contoured by a thoracic radiologist from chest CT images and texture features were extracted using the PORTS radionics library. Another thoracic radiologist (blinded to the outcomes) evaluated semantic features including size, shape, density, emphysema, etc. All plasma biomarker variables, texture features, clinical and semantic features were input into a LASSO penalized logistic regression model. The most significant input variables for this regression are then determined and used to generate a new logistic regression model. We performed 5-fold cross-validation for the model to generate ROC curves. The AUC for these ROC curves was computed and the 95% confidence interval determined.

RESULTS

There were 11 plasma tumor biomarkers, 8 clinical and semantic features and 4 texture features selected by the LASSO penalized logistic model. The cross-validated AUCs for the model with all 23 plasma tumor biomarkers, clinical and imaging variables was 90% (CI:0.807-0.972), higher than the model with only clinical and imaging features with the AUC of 86%(CI:0.746-0.961).

CONCLUSION

Using a novel combination of plasma tumor biomarkers, radiomic texture features, conventional clinical and semantic features, our model classifies nodules with a AUC of 90% after cross-validation, which is higher than the performance reported by other models. The combination of these 4 sets of features outperforms each separate set of features in pulmonary nodule diagnosis.

CLINICAL RELEVANCE/APPLICATION

Combining plasma biomarkers, radiomics, conventional imaging features and clinical data has the potential to improve and facilitate management of pulmonary nodules.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Sudhakar N. Pipavath, MD - 2013 Honored EducatorSudhakar N. Pipavath, MD - 2015 Honored Educator

SSQ04-03 Combination of Intra- and Peri-Tumoral Radiomic Features on Baseline CT are Prognostic of Recurrence and Overall Survival in Early Stage Non-Small Cell Lung Cancer (ES-NSCLC) Patients

Thursday, Nov. 29 10:50AM - 11:00AM Room: E353A

Participants
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PURPOSE

ES-NSCLC has up to a 55% risk of recurrence following curative resection with a OS ranging between 35-50%. The ability to predict aggressiveness and prognosticating survival of ES-NSCLC from pre-treatment CT scans can aid oncologists in identifying which patients will benefit from adjuvant chemotherapy following curative resection.

METHOD AND MATERIALS

The single site study comprised 316 ES-NSCLC patients who had curative surgery and/or chemotherapy. Following retrospective chart review, pre-treatment CT scans with clinical follow-up and outcome data was obtained for each patient. All patients underwent surgery with the primary tumor having relapsed in 75 total cases. This cohort was randomly divided into a training
RESULTS
The top six most predictive features included a combination of two intratumoral (Gabor, Haralick) and four peritumoral (Laws-Laplace, Collage, Gabor) from an annular ring 0-12 mm outside the nodule. These features were also found to be relatively stable with an ICC of 0.8 calculated on the RIDER CT test-retest dataset. These features separated patients who recurred from those who did not (AUC=0.65; p<0.001) and also were prognostic of 5-year recurrence-free survival (RFS) (p<0.005) on the independent validation set (n=256).

CONCLUSION
We identified radiomic texture features from within and outside the lung nodule that are able to predict recurrence in early stage non-small cell lung cancer. These features were also found to be prognostic of 5-year RFS.

CLINICAL RELEVANCE/APPLICATION
ES-NSCLC patients who were predicted to recur based off diagnostic CT scans would be ideal candidates for treatment escalation including adjuvant chemotherapy following curative surgical resection.

SSQ04-05  CT-Based Quantitative Radiomic Features Predict Brain Metastasis in T1 Stage Lung Adenocarcinoma

Thursday, Nov. 29 11:00AM - 11:10AM Room: E353A

Participants
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PURPOSE
To retrospectively evaluate the use of computed-tomography (CT) based quantitative radiomic features (QRF) to predict brain metastasis (BM) in patients with T1 stage lung adenocarcinoma (LAD).

METHOD AND MATERIALS
Eighty patients with pathologically confirmed lung adenocarcinoma were collected. T1 stage was established by the 8th edition of the TNM staging system. All patients had brain MRI scans (BM+: 26; BM- :54). In total, 1160 QRFs were calculated from the primary lung cancer tumor in each patient. Three machine-learning algorithms were applied sequentially to build the radiomic prediction model. Firstly, unsupervised hierarchical clustering was used to exclude highly correlated QRFs; secondly, the minimum Redundancy Maximum Relevance (mRMR) feature selection algorithm was employed to rank QRFs according to their relevance to BM and redundancy with other features; finally, the K-Nearest-Neighbor (k=5) classification algorithm was adopted to construct model by using the informative and non-redundant QRFs. The area under the receiver operating characteristic (ROC) curve (AUC) and the ten-fold cross-validation were employed to evaluate the prediction model. Yuden's Index for the ROC curve was calculated to determine the optimal sensitivity and specificity.

RESULTS
The radiomic prediction model achieved AUC (95% CI) of 0.879 (0.694, 0.959), and sensitivity and specificity of 0.808 and 0.815, respectively. The most significant QRFs to build the prediction model were LoGU (‘Uniformity of Laplacian of Gaussian Filter’) and MGE (‘Maximal Gabor Energy’), which were designed to characterize tumor homogeneity and boundary sharpness, respectively. We found that tumors with BM+ were of higher LoGU and MGE values than those with BM- (both p-values <0.001).

CONCLUSION
CT-based radiomic features could be used to predict brain metastasis in T1-stage LAD. For T1-stage LAD, solid tumor with sharp boundary were more prone to BM than those with ground glass opacity and unclear boundary.

CLINICAL RELEVANCE/APPLICATION
Radiomic features extracted from noninvasive and routinely acquired CT can be applied to help radiologists to predict brain metastasis in patients with T1 stage lung adenocarcinoma.

SSQ04-05  The Radiomics Prognostic Score (RadScore): The New Prognostic Imaging Biomarker After Stereotactic Body Radiation Therapy In Patients with Lung Cancer

Thursday, Nov. 29 11:10AM - 11:20AM Room: E353A

Participants
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PURPOSE
To develop the radiomics prognostic score (RadScore) for the patients with lung cancer treated with stereotactic body radiation therapy (SBRT) and to evaluate prognostic impact on progression free survival

METHOD AND MATERIALS
In this retrospective study approved by our institutional review board, we reviewed 241 patients who underwent SBRT for lung cancer between July 2006 and November 2016. After excluding patients who had no pathological diagnosis, no pretreatment computed tomography (CT) and clinical diagnosis of Stage III/IV, 43 patients were analyzed. The RadScore was developed using the linear predictor of multivariate Cox proportional hazard regression with LASSO (Least Absolute Shrinkage and Selection Operator) method for shrinkage of variables. The variables for the regression were the results of histogram (kurtosis and skewness) and texture analysis (gray level co-occurrence matrix) for solid part within the region of interest for the lung cancer which was placed on pre- and post-contrast-enhanced axial CT images. To reveal the impact of RadScore in the prediction of progression free survival (local / distant recurrence or death), an another multivariate Cox proportional hazard regression analysis was performed.

RESULTS
Among the 132 variables by histogram and texture analysis, 2 variables by histogram analysis and 2 variables by texture analysis were selected. In the multivariate Cox regression, the RadScore was the only significant predictive factor for progression free survival (95% confidence interval of hazard ratio: 1.89-24.14, p<0.005), whereas the following variables were not significant: male (0.53-4.34, p=0.44), age (0.94-1.12, p=0.53), pathological diagnosis of adenocarcinoma (0.81-7.06, p=0.11), and clinical stages (IB: 0.59-3.96, p=0.36; IIA: 0.17-15.33, p=0.67; IIB: 0.42-56.65, p=0.21).

CONCLUSION
The RadScore was an independent prognostic factor for progression free survival in patients of post-SBRT for lung cancer.

CLINICAL RELEVANCE/APPLICATION
The RadScore was a prognostic factor for progression free survival in patients of post-SBRT for lung cancer. The RadScore have potential to become one of indications of SBRT for lung cancer.

SSQ04-06  CT-Based Quantification of Lung Disease in Cystic Fibrosis Using Radiomics

Thursday, Nov. 29 11:20AM - 11:30AM Room: E353A

Participants
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Marie-Pierre Revel, Paris, France (Abstract Co-Author) Nothing to Disclose

PURPOSE
To build imaging biomarkers from chest computed tomography (CT) using radiomics to evaluate the severity of lung disease in adults with cystic fibrosis (CF).

METHOD AND MATERIALS
This single-center, retrospective, observational study was approved by an institutional ethics committee and the need for patient consent was waived. One hundred and sixty-two CF outpatients referred for unenhanced chest CT during follow-up between January 2013 and December 2015 were included and randomly divided into 2 equal cohorts. After lung segmentation, 38 imaging features were extracted. Chest CT from the development cohort were used to build 5 CT scores, each with a different machine learning technique (lasso, ENET, ridge regression, decision tree and SVM). The aim was to correlate these scores with a clinical prognostic score (Nkam score). Correlations between radiomics-based CT scores and 3 prognostic scores (Nkam, Liou and CF-Able), forced expiratory volume in 1 second (FEV1) and respiratory tract exacerbations were evaluated in the validation cohort.

RESULTS
Four of the 5 radiomics-based CT scores correlated well with the Nkam score in the validation cohort (R = 0.54 to 0.69; p<0.001) while they all correlated well with the Liou (R=0.64 to -0.74; p<0.001), and moderately with the CF-able (R=0.46 to 0.62; p<0.001) scores. All CT scores correlated well with FEV1 (R=0.65 to -0.77; p<0.001) and moderately with the number of pulmonary exacerbations in the 12 months after the CT exam (R=0.47 to 0.56; p<0.001).

CONCLUSION
Radiomics can be used to build imaging biomarkers that correlate well with clinical prognostic scores in adult CF patients

CLINICAL RELEVANCE/APPLICATION
Radiomic models were trained to predict the Nkam score, and were also well correlated with FEV1 and the Liou score, another prognostic score for CF, as well as with individual variables known to be markers of CF lung disease severity.

SSQ04-07  Radiomics Approach for Survival Prediction in Chronic Obstructive Lung Disease

Thursday, Nov. 29 11:30AM - 11:40AM Room: E353A

Hiroshi Onishi, MD, Yamanashi, Japan (Abstract Co-Author) Nothing to Disclose

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PURPOSE
To develop the radiomics prognostic score (RadScore) for the patients with lung cancer treated with stereotactic body radiation therapy (SBRT) and to evaluate prognostic impact on progression free survival

METHOD AND MATERIALS
In this retrospective study approved by our institutional review board, we reviewed 241 patients who underwent SBRT for lung cancer between July 2006 and November 2016. After excluding patients who had no pathological diagnosis, no pretreatment computed tomography (CT) and clinical diagnosis of Stage III/IV, 43 patients were analyzed. The RadScore was developed using the linear predictor of multivariate Cox proportional hazard regression with LASSO (Least Absolute Shrinkage and Selection Operator) method for shrinkage of variables. The variables for the regression were the results of histogram (kurtosis and skewness) and texture analysis (gray level co-occurrence matrix) for solid part within the region of interest for the lung cancer which was placed on pre- and post-contrast-enhanced axial CT images. To reveal the impact of RadScore in the prediction of progression free survival (local / distant recurrence or death), an another multivariate Cox proportional hazard regression analysis was performed.

RESULTS
Among the 132 variables by histogram and texture analysis, 2 variables by histogram analysis and 2 variables by texture analysis were selected. In the multivariate Cox regression, the RadScore was the only significant predictive factor for progression free survival (95% confidence interval of hazard ratio: 1.89-24.14, p<0.005), whereas the following variables were not significant: male (0.53-4.34, p=0.44), age (0.94-1.12, p=0.53), pathological diagnosis of adenocarcinoma (0.81-7.06, p=0.11), and clinical stages (IB: 0.59-3.96, p=0.36; IIA: 0.17-15.33, p=0.67; IIB: 0.42-56.65, p=0.21).

CONCLUSION
The RadScore was an independent prognostic factor for progression free survival in patients of post-SBRT for lung cancer.

CLINICAL RELEVANCE/APPLICATION
The RadScore was a prognostic factor for progression free survival in patients of post-SBRT for lung cancer. The RadScore have potential to become one of indications of SBRT for lung cancer.
METHOD AND MATERIALS

The study included 371 adult COPD patients (mean age, 64.2). Patients were followed up for an average of 68 months and 45 cases of mortality were observed. From 3-D volumetric chest CT data of each patient, 525 radiomics features were semi-automatically extracted. Radiomics features were extracted from four phenotypical compartments of COPD; emphysema, airway measurement, pulmonary vessels, and air-trapping. In order to remove features that were highly related to one and another, pairs with correlation coefficients greater than 0.9 were identified and the feature with lower c-index (Harrell’s concordance index) was eliminated. Then, least absolute shrinkage and selection operator (LASSO) Cox regression model and used to select the features most useful for OS prediction. Afterward, a RS was generated through the summation of selected features multiplied by their respective coefficients and cut-off value was determined by X-tile plot analysis. The difference of survival between low and high RS groups was evaluated with Kaplan-Meier survival analysis.

RESULTS

Five features which remained after LASSO analysis were as follows: (1) Low attenuation area (LAA-950), (2) PI-10 at 6th generation bronchi, (3) Average vessel cross-section area at 18mm from pleural surface, (4) Lobar heterogeneity of PI-10, (5) Z-axis heterogeneity of WA%. On multivariate Cox regression analysis, prediction performance (c-index) of the 5 features was 0.774. The c-index for pulmonary function test (PFT) results alone (DLCO, FEV1, FEV1/FVC) was 0.758. When radiomics features were combined with PFT, c-index was increased to 0.805. Patients who were classified into the high-risk group based on the generated RS demonstrated significantly worse OS than the low-risk group (log-rank test, p < 0.001; hazard ratio, 7.18:1).

CONCLUSION

The radiomics signature demonstrated good survival prediction performance in COPD patients and adequately classified patients into high and low-risk groups.

CLINICAL RELEVANCE/APPLICATION

The radiomics approach yielded a reliable survival prediction performance in this study and could potentially be adopted as an effective imaging biomarker for estimation of OS in COPD patients after further validation.

SSQ04-08 Radiomic Prediction of Survival in Patients with Rheumatoid Arthritis-Associated Interstitial Lung Disease Based on Deep-Learning, Hyper-Curvature, and Texture Features of Lung CT Images

Participants

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PURPOSE

To evaluate the comparative performance of deep-learning, hyper-curvature, and texture features of lung CT images in the prediction of the overall survival of patients with rheumatoid arthritis-associated interstitial lung disease (RA-ILD).

METHOD AND MATERIALS

We retrospectively collected 70 RA-ILD patients with thin-section lung CT and serial pulmonary function tests. After automated extraction of the lung regions on the CT images, an experienced observer delineated regions of interest (ROIs) and labeled them into one of four ILD patterns (ground-class opacity, reticulation, consolidation, and honeycombing). We computed deep-learning features by training a 5-layer convolutional neural network on these ROIs for classifying the 4 patterns and by extracting the output of the last convolutional layer. We also computed hyper-curvature features including principal curvatures, curvedness, bright/dark sheets, cylinders, blobs, and curvature scales for the lungs as well as gray-level co-occurrence matrix texture features on the ROIs. An elastic-net penalty method was used to select and combine these features with a Cox proportional hazards model for predicting patient survival. Concordance index (C-index) was used as a measure of the prediction performance of the feature combinations with bootstrapping by 1,000 replications, in comparison to an established clinical prognostic biomarker known as the gender, age, and physiology (GAP) index by a two-sided t-test.
Results

Bootstrap evaluation yielded C-index values of (a) GAP: 78.3%, [95% confidence interval (CI): 70.1, 86.5]; (b) hyper-curvature features: 80.8% [CI: 71.9, 89.7], P<0.01 in comparison with (a); (c) deep-learning features: 81.8% [CI: 71.9, 89.7], P<0.01; and (d) combined radiomic features: 86.9% [CI: 81.3, 93.1], P<0.0001. Kaplan-Meier survival curves of patients stratified to low- and high-risk groups based on combined radiomic features showed statistically significant (P < 0.0001) difference.

Conclusion

The combined radiomic features yield higher performance than GAP in the prediction of overall survival. Thus, they can be an effective imaging biomarker for predicting overall survival of patients with RA-ILD.

Clinical Relevance/Application

Combined radiomic features that are automatically calculated from lung CT images can provide an effective prognostic imaging biomarker for precise management of patients with RA-ILD.

SSQ04-09 Radiogenomics of Non-Small Cell Lung Cancer: Predictive Modeling of miRNA Signature and CT Imaging Features

Participants

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Purpose

Radiomics and genomics characteristics have been widely explored to predict tumor responses to radiotherapy and in recent years, the combined application of them, radiogenomics, have increased. In this study, we developed a radiogenomics signature to estimate tumor responses to radiotherapy in patients with non-small cell lung cancer (NSCLC) and optimize management of this disease.

Method and Materials

This study consisted of 87 patients with non-small cell lung cancer and was approved by the institutional ethical board. The CT-based radiomics features were extracted by LIFEx. MiRNAs associated radiosensitivity was obtained from our previous study and literature retrieval. Then a radiogenomics signature was generated by LASSO and was associated with tumor responses to radiotherapy in non-small cell lung cancer patients. The Recist 1.1 was used for short-term effect and the overall survival (OS) was used for long-term effect evaluation. Multivariate Cox regression validated the radiogenomics signature as an independent biomarker. Then a radiogenomics nomogram with this signature was constructed, which was assessed to validation, calibration and discrimination.

Results

The radiogenomics signature was significantly associated with radiosensitivity and OS, independent of other clinic pathologic factors. The radiogenomics nomogram has displayed a good performance for estimation of OS (C-index: 0.78, 95% confidence interval [CI]: 0.75, 0.80). Calibration curve for it was almost satisfactory, which indicated its clinical usefulness.

Conclusion

The radiogenomics signature is an independent biomarker and the nomogram combining it with other clinic pathologic factors could be used as a model to predict tumor responses to radiotherapy in non-small cell lung cancer, which might make a step forward individualized medicine.

Clinical Relevance/Application

A biomarker to predict the radiosensitivity in non-small cell lung cancer
To assess the changes of regional ventilation (V) and perfusion (Q) status in COPD patients after pharmacologic treatment using combined xenon-enhanced V and iodine-enhanced Q dual-energy CT (DECT).

**METHOD AND MATERIALS**

Combined V and Q DECT were performed at baseline and after 3-month pharmacologic treatment in fifty-three COPD patients. Virtual noncontrast images, V and Q maps were anatomically co-registered with in-house software. Normalization of V and Q values of each pixel were performed. For visual analysis, V/Q pattern was determined to be matched, mismatched, or reversed-mismatched and compared with the regional disease patterns—emphysema, bronchial wall thickening, or normal lung—in each segment in baseline and follow-up. Mean V, Q, and V/Q values, standard deviation of V/Q (V/QSD), and proportions of lung area with reversed-mismatch (Rev), mismatch (Mis) and match (Mat) of each patient were quantified and compared with pulmonary function test (PFT) parameters in baseline and follow-up. Changes of quantified CT parameters and PFT results between baseline and follow-up were compared.

**RESULTS**

Most of segments showed a matched V/Q, whereas about thirty percent of segments with bronchial wall thickening showed a reversed-mismatched V/Q. On follow-up, V/Q pattern did not change in most of segments with matched and mismatched V/Q. In about forty percent of segments with reversed-mismatched V/Q, V/Q pattern changed into matched. Quantified mean V, Q, V/Q and Rev values of baseline and follow-up CTS were positively correlated with PFT parameters, respectively ($r = 0.286-0.630$, $p < 0.05$), while V/QSD values were negatively correlated with PFT parameters ($r = -0.528$ and $-0.375$; $p < 0.05$). Changes of mean V, V/Q and Mat were positively correlated with change of FEV1 ($r = 0.315-344$; $p < 0.05$) and changes of Rev were negatively correlated with change of FEV1 ($r = -0.353$; $p = 0.010$).

**CONCLUSION**

Quantitative and visual analysis of combined V and Q DECT showed that the improvement of ventilation and V/Q mismatch may be associated with the response to pharmacological treatment in COPD patients.

**CLINICAL RELEVANCE/APPLICATION**

Combined V and Q DECT imaging can be applied to assessment of changes of regional V and Q status after pharmacologic treatment in COPD patients.
In COPD patients, distribution of emphysema shows various patterns (diffuse, unilateral, or focal), however, there is no report about distribution of emphysema in lung cancer patients. The purpose of the research is to compare heterogeneity of emphysema between lung cancer patients and lung cancer screening patients.

METHOD AND MATERIALS

Total 109 subjects with smoking history and thin section chest CT (51 patients with lung cancer M : F = 29 : 22, age = 68.10 ± 9.26, 58 lung cancer screening patients; M : F = 31 : 27, age = 64.03 ± 6.65) were retrospectively enrolled. Using commercial software (AVIEW, Coreline soft, South Korea), volume and low attenuation area under -950 HU were semi-automatically quantified in whole lung and each lobe by two radiologists. Emphysema index (EI) and emphysema heterogeneity were calculated. Intra-class correlation coefficient (ICC) and independent t-test were performed. ANOVA was performed for subgroup analysis according to cancer pathology.

RESULTS

ICC of each lobe volume among two radiologists were 0.993, 0.987, 0.999, 0.999, and 0.999. EI in RUL, RML, RLL, LUL, and LLL of two groups were 6.43 ± 9.94, 6.80 ± 9.28, 3.66 ± 5.54, 5.86 ± 6.60, and 3.83 ± 5.86 in the cancer group, and 6.56 ± 7.82, 8.24 ± 8.44, 5.68 ± 7.08, 7.16 ± 7.05, and 5.28 ± 6.66 in the screening group. EI and emphysema heterogeneity in whole lung of two groups were 5.10 ± 6.56, and 12.20 ± 5.14 respectively in the cancer group, and 6.43 ± 6.95, 8.44 ± 4.92 in the screening group. EI showed no significant difference between two groups. However, emphysema heterogeneity of the cancer group was significantly larger than that of the screening group (p < 0.001). In subgroup analysis, emphysema heterogeneity of the cancer subtypes of adenocarcinoma and squamous cell carcinoma were significantly larger than that of screening group (p = 0.006 and 0.042).

CONCLUSION

Semi-automated quantification of emphysema in each lobe was feasible. Smokers with lung cancer showed more heterogeneous distribution of emphysema than smokers without lung cancer.

CLINICAL RELEVANCE/APPLICATION

Quantification of regional and whole lung heterogeneity of emphysema may potentially help in risk stratification of COPD patients in developing lung cancer.

SSQ05-03  Hyperpolarized Xenon-129 MRI for Detection of Gas Exchange in Healthy Subjects and Lung Cancer Patients

Thursday, Nov. 29 10:50AM - 11:00AM Room: E353B

Participants
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PURPOSE

To determine whether a novel functional magnetic resonance imaging (MRI) technique using hyperpolarized Xenon-129 (HPX) can quantify the xenon gas transfer dynamics (XGTD) from alveoli into the Pulmonary Tissue and Blood Plasma (PTBP), and Red Blood Cell (RBC) compartments of the lungs, and identify XGTD differences in patients with COPD and lung cancer pre and post radiation.

METHOD AND MATERIALS

A novel spectroscopic MRI technique was developed using Iterative Decomposition of water and fat with Echo Asymmetry and Least-square estimation (IDEAL) approach. This technique allowed acquisition of the time-series IDEAL gas, PTBP and RBC compartment images of lungs with various gas transfer times in a single breath-hold interval. The time-series IDEAL gas, PTBP and RBC compartment images were acquired from five healthy subjects at two different time points. XGTD curves were obtained from 10 scans (n=10) that represented the control group. The control group was compared to two lung-cancer patients before radiation therapy started and after radiation therapy ended.

RESULTS

In the control group, there was no statistical difference in XGTD between the left and right lungs (P-value >0.4). XGTD in the control was statistically different than the lung cancer patients (P-value <0.01) suggesting that the novel time-series IDEAL technique was sensitive to the gas exchange abnormalities. Additionally, the ratio of XGTD from the irradiated lung to un-irradiated lungs was compared pre and post radiation therapy. We found that xenon gas in the alveoli diffused into the PTBP compartment with a slower rate of 20-35% in the irradiated lungs from the lung cancer patients.
The feasibility of the novel IDEAL MRI technique has been successfully demonstrated in healthy subjects and lung cancer subjects. To our knowledge, this is the first-in-man study showing the time course of arrival of Xenon-129 gas from the alveoli to PTBP and RBC compartments of the lungs and to the pulmonary vasculature and the left ventricle of the heart in healthy subjects and patients with COPD and lung cancer.

**CLINICAL RELEVANCE/APPLICATION**

This technique may have potential clinical applications ranging from the detection of regional differences in gas transfer on imaging to the detection of early-stage radiation-induced lung injury.

**SSQ05-04 Effect of Aging and Smoking on Regional Air Volume Change Distributions in Normal Chest CT**

**PURPOSE**

Image registration has been increasingly used to assess pulmonary dynamics between paired inspiratory and expiratory CT images in patients with pulmonary disease. However, information of pulmonary dynamics of normal subjects is insufficient. The purpose of the study is to describe regional air volume change distributions of subjects with normal CT and to investigate the effects of aging and smoking.

**METHOD AND MATERIALS**

242 subjects (114 male, 128 female) over the age of 18 years with normal inspiration and expiration CTs were included in the study. VIDA Apollo software (Coralville, IA) and an image registration technique were used to compute regional distribution of air and tissue volumes, air volume fractions, and the relative regional changes between inspiration and expiration, including relative regional air volume changes (RRAVC). In each lobe, the upper lobes, the lower lobes, and the whole lung, the mean values and standard deviations were correlated with aging and compared to those of smoking groups. Regional volumetric changes were further analyzed using 3D visualization of acinar scale parenchymal units.

**RESULTS**

Inspiratory air volume of the lower/upper lobes decreased with age in both nonsmoking males and females (r=-0.388; p=0.006 and r=-0.258; p=0.004, respectively). RRAVC map demonstrates the increase of air volume change from apico-ventral to dorso-basal region in non-smokers, representing gravitational dependency in normal pulmonary dynamics. In comparison, the directionality of gravitational dependency of regional volume change tends against normality in smokers, and the coefficient of variation (CV) of RRAVC decreased in the whole lung in the smokers (0.64 and 0.35, p=0.020).

**CONCLUSION**

The air volume of the lower/upper lobes tends to decrease with aging, and the directionality of gravitational dependency of the air volume change appeared to be against normality in smokers. Visualization of RRAVC map helped recognize these findings more easily.

**CLINICAL RELEVANCE/APPLICATION**

Regional air volume change distribution helped understand the gravitational volume change of the lung in normal adults, and so it is expected that the localized functional abnormalities of the lung effected by aging and smoking are easily comprehended.

**SSQ05-05 Whole-Lung Dynamic Contrast-Enhanced Perfusion Area-Detector CT: Capability for Pulmonary Function Assessment and Morphological Change Evaluation in Stage IA Non-Small Cell Lung Cancer**

**PURPOSE**

To prospectively and directly compare the capability of whole-lung dynamic contrast-enhanced (CE-) perfusion area-detector CT...
(ADCT) for pulmonary functional loss assessment and morphological change evaluation in Stage I A non-small cell lung cancer (NSCLC) patients.

**METHOD AND MATERIALS**

63 consecutive NSCLC patients (39 males, 24 females; mean age 68 years) underwent dynamic CE-perfusion ADCT performed at two or three different positions as single examination, pulmonary function test, surgical treatment, and pathological examination. From all perfusion ADCT data in each subject, whole lung total perfusion (TP), pulmonary arterial perfusion (PAP) perfusion, systemic arterial perfusion (SAP) maps were computationally generated based on dual-input maximum slope method by previously reported software. In each subject, regional perfusion parameters were assessed by ROI measurements, and averaged to determine mean values. According to pathological examination results, all ROIs within operated lung were divided into following four structure groups: normal lung, emphysema, non-specific interstitial pneumonia (NSIP) and usual interstitial pneumonia (UIP). To determine the capability of each perfusion parameter for pulmonary function, Pearson's correlation was performed. To compare each perfusion parameter among all structure groups, Tukey's HSD test was performed. Finally, discrimination accuracy for morphological change evaluation was compared among all indexes and combined method.

**RESULTS**

All perfusion parameters except SAP had significant correlation with each pulmonary function parameter (TP: 0.47

Whole-lung dynamic first-pass CE-perfusion ADCT is useful for pulmonary functional loss assessment and morphological change evaluation in stage IA NSCLC patients.

**CLINICAL RELEVANCE/APPLICATION**

Whole-lung dynamic first-pass CE-perfusion ADCT is useful for pulmonary functional loss assessment and morphological change evaluation in stage IA NSCLC patients.

SSQ05-06  
**Denoised Ultra Low Dose for Screening Lung Cancer**

**PURPOSE**

To assess the effect of a denoising method (D) for ultra low dose CT (ULDCT) LungRADS categorization.

**METHOD AND MATERIALS**

36 consented patients, referred for an outpatient chest CT, underwent 2 scans: a normal dose CT (NDCT), 120 kVp and automatic current modulation, with or without contrast media, immediately followed by an ULDCT, 120 kVp and fixed current at 10 mA for bmi <29 and 20 mA for bmi>=29. Reconstruction for lung and soft tissue kernels were performed for each scan. Consecutively, each ULDCT was denoised using a locally-consistent non-local-mean (LCNLM) algorithm to obtain a high signal to noise ratio (SNR) version of the ULDCT. The LCNLM algorithm leverages large databases of image patches extracted from high-SNR chest CT scans to denoise ULDCTs while enforcing local spatial consistency to preserve fine details and structures in the image. Blinded to all clinical information, a chest radiologist separately assessed the NDCT, ULDCT, and denoised ULDCT (D), documented findings, assigned a LungRADS category and a subjective suspicion for highly suspicious lesions for lung cancer (H).

**RESULTS**

Radiation dose using NDCT reduced the radiation for patients with a BMI > 29 by an average of 93% and for those with a BMI of up to 29 by an average of 96%. For patients with a BMI > 29 the average effective radiation dose for ULDCT was 0.41 mSv, whereas for those with a BMI of up to 29 it was 0.24 mSv. For the three imaging methods, the same score was seen in 63.9% (n=23) and a different score in 36.1% (n=13). There was complete agreement on LungRADS 4A (or higher) between NDCT and D, but ULDCT categorized one of the 4A patients as LungRads 2. One lesion assigned as LungRads 4X by ULDCT was assigned LungRads2 by D and NDCT. Of the 8 patients highly suspicious for lung cancer by NDCT, D indicated so in all 8 whereas ULDCT indicated so only in 4.

**CONCLUSION**

Interpretation of ULDCT may cause errors in LungRADS categorization but implementation of the LCNLM algorithm for denoising improves ULDCT images so that LungRADS categorization is similar to normal dose scans.

**CLINICAL RELEVANCE/APPLICATION**

Denoising ULDCT with the LCNLM algorithm enables screening for lung cancer with dose reductions of greater than 90%.

**Honored Educators**

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Edith M. Marom, MD - 2015 Honored Educator Edith M. Marom, MD - 2018 Honored Educator

SSQ05-07  
**Comparison of SENCEFUL-MRI and Lung Scintigraphy for Detection of Lung Perfusion Defects in**
Participants
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PURPOSE
To compare self-gated non-contrast enhanced functional lung MRI (SENCEFUL) and V/Q (ventilation/perfusion) scintigraphy regarding detection of lung perfusion defects in patients with chronic thromboembolic pulmonary hypertension (CTEPH).

METHOD AND MATERIALS
Following review board approval and informed consent, 16 patients diagnosed with CTEPH and pathologic findings in V/Q scans were included into this prospective study. Patients were scanned at 3T using the SENCEFUL approach based on a 2D-FLASH sequence. Color-coded maps of the lung perfusion and the local blood arrival time i.e. the pulsation phase were manually segmented and rated for perfusion defects in lung quadrants by three independent radiologists using a 6-point Likert scale. Coronal V/Q scan images were rated by a nuclear medicine physician accordingly. Due to variation of slice thickness between both techniques, covered lung volumes were divided into four sectors in coronal orientation each containing four quadrants to improve comparability. Statistical tests included intraclass correlation coefficient (ICC) and Mann-Whitney-U-test.

RESULTS
Comparison of quadrant-wise rating between SENCEFUL-MRI and V/Q scans revealed good agreement between all raters when the lung perfusion and pulsation phase maps were rated simultaneously (ICC 0.75, 95% CI 0.69-0.80, p<0.05) and an improvement to perfusion rating alone (ICC 0.61, 95% CI 0.52-0.69, p<0.05). Inter-rater reliability of the radiologists for combined perfusion/pulsation phase rating was good (ICC 0.77, 95% CI 0.69-0.82, p<0.05). Analysis of a peak-to-offset ratio of pulsation phase histograms showed a significant difference between lung quadrants rated pathologic in scintigraphy and quadrants rated healthy (p<0.05).

CONCLUSION
SENCEFUL-MRI showed good agreement for detection of perfusion defects compared with V/Q scans being the current screening method for CTEPH. Analysis of MRI maps by a peak-to-offset ratio of pulsation phase showed a significant difference between quadrants rated pathologic and healthy by V/Q scans suggesting a quantifiable value for future determination of threshold values in SENCEFUL-MRI.

CLINICAL RELEVANCE/APPLICATION
SENCEFUL-MRI could be an alternative screening method for detection of lung perfusion defects in patients with suspected CTEPH without the need of contrast agent administration or radiation exposure.

SSQ05-08 Applicability of Monochromatic Energy with 40 keV for Pulmonary Embolism Detection in the Pulmonary Embolism CT Angiography: Experience Using a Dual-Layer Detector Spectral CT

Thursday, Nov. 29 11:40AM - 11:50AM Room: E353B

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PURPOSE
Previous studies have shown that the optimal energy level of virtual monoenergetic images (VMI) for pulmonary artery (PA) enhancement is 40 keV in spectral CT. The aim of this study is to evaluate the applicability of VMI at 40 keV for pulmonary embolism (PE) detection in the CT angiography (PECT).

METHOD AND MATERIALS
A total of 876 consecutive PECT using spectral CT were identified between August 2016 and March 2018. Of these, PE at least 4 mm in diameter was detected in 73 PECT. Among these, suboptimal enhancement of PA (<250 HU) was shown in 19 cases. Contrast-to-noise ratio (CNR), signal-to-noise ratio (SNR) of VMI at 50 keV, 60 keV, 70 keV, and conventional 120-kVp images (COV) were compared with VMI at 40 keV in all PECT and suboptimal PECT. Readers’ subjective scores for PE detection was also recorded. The mean diameters of PE were measured, and they were compared between VMI at 40-70 keV and COV. The frequency of significant PE diameter reduction (>40%) in VMI compared with COV was also recorded and compared between VMIs. The cut off
value of the minimum visible PE diameter at 40 keV was investigated in COV.

RESULTS
There was no significant difference in CNR between 40 keV and 50 keV, although the highest CNR and SNR were obtained at 40 keV. In the suboptimal subgroup, there were no significant differences in both CNR and SNR between 40 keV and 50 keV. The subjective scores were significantly lower at 40 keV, compared with other algorithms in both all PECT and the suboptimal group (P<0.05). The mean diameters of PE were significantly decreased in 40 keV and 50 keV, compared with those in COV (40 keV, 5.6±5.8 mm; 50 keV, 7.2±5.3 mm; COV, 8.9±4.9 mm; all P<0.05). The frequency of significant PE diameter reduction was significantly higher in 40 keV than in 50 keV (36.8% vs. 12.8%, P<0.001). The cut off value of the minimum visible PE diameter at 40 keV was 6.4 mm in COV.

CONCLUSION
VMI at 40 keV was not the best option for PE detection, although the best CNR and SNR were obtained at 40 keV. The diameter of PE was often decreased and small PE was not even detected at 40 keV.

CLINICAL RELEVANCE/APPLICATION
We propose that not only 40 keV but also other algorithms such as 50 keV should be used for PE detection to ensure that we do not miss small PEs.

SSQ05-09  Fluorine-19 MRI Ventilation Defect Analysis in Cystic Fibrosis

Awards
Student Travel Stipend Award

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PURPOSE
The purpose of this study is to investigate the ability of novel fluorine-19 (19F) based MRI to characterize ventilation in subjects with cystic fibrosis.

METHOD AND MATERIALS
Coronal images of nine healthy controls and twelve subjects with CF were acquired using a multinuclear capable 3.0 T MRI scanner (PRISMA, Siemens) along with spirometry. Subjects inhaled 19F labelled perfluoro-propane (PFP) gas mixed with 21% O2 or room air during the wash-in phase of the scan. Fifteen second 19F GRE vibe breath hold images were obtained following three breaths of PFP for five cycles. This was repeated five times after switching PFP gas to room air for the wash-out phase. A 19F maximum intensity projection image over time was created and segmented using a semi-automatic approach with an empirically determined ventilation threshold. Anatomic 1H series taken at full inspiration were then manually segmented for all subjects. After correcting for differences in respiratory effort by comparing apex-base measurements of the lung in 19F and 1H series, the ventilation defect volume (VDV) was computed by subtracting 19F segmentation volume from 1H volume and a ventilation defect percentage (VDP) was also computed relative to 1H volume.

RESULTS
In healthy controls, the mean ventilation defect percentage (VDP) was 10% (SD 11%); for mild CF 13% (SD 25%); and for severe CF 31% (SD 24%). A significant difference was found when comparing all CF patients to normal (p=0.0275 via t-test with Satterthwaite correction). VDP had a negative correlation with FEV1 (-0.56 via Spearman correlation, p=0.011). The rate constant for gas filling (τ1) was significantly increased in CF patients compared with controls, suggesting delay in filling. No safety concerns were detected throughout the study.

CONCLUSION
This study showed the ability of novel 19F ventilation MRI to rapidly and safely quantify regional ventilation defects and gas wash-in and wash-out dynamics. 19F MRI identified ventilation defects in cystic fibrosis subjects even in the setting of normal spirometry with some variability in healthy volunteers.

CLINICAL RELEVANCE/APPLICATION
This novel imaging technique has advantages over xenon ventilation MRI including cheaper contrast material and inert compound allowing functional imaging with multiple image sets. We anticipate applications for many other lung diseases including pediatric lung malformations, lung resection, COPD monitoring, and bronchiectasis.
SSQ06

Gastrointestinal (General Abdominal Imaging)

Thursday, Nov. 29 10:30AM - 12:00PM Room: E350

Participants
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Sub-Events
SSQ06-01 Abdomen Radiographs in the CT/MR Era: What the Surprising Numbers Tell Us

Participants
David J. DiSantis, MD, Jacksonville, FL (Presenter) Nothing to Disclose

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PURPOSE
To quantify 21st century abdomen radiograph volume trends as an indicator of that examination's current relevance, both clinically and in our training curriculum.

METHOD AND MATERIALS
Nationwide Medicare procedure data from 2000 through 2016 were analyzed to quantify volume trends for the three most common abdomen radiograph studies: • SINGLE VIEW ABDOMEN • TWO VIEW ABDOMEN (SUPINE plus UPRIGHT OR DECUBITUS) • COMPLETE ABDOMEN SERIES (TWO VIEW ABDOMEN plus FRONTAL CHEST)

RESULTS
In the latest year with data available (2016), 11.29 million abdomen radiographs were performed in the United States. Single view abdomen volume grew by a quite surprising 37% between 2000 and 2016, to 7.55 million. In contrast, two view abdomen 2016 volume fell 43% from its peak year of 2002, to 2.04 million. Similarly, 2016 acute abdomen series volume fell 55% from its peak year of 2004, to 1.7 million.

CONCLUSION
Despite the ascendancy of cross-sectional imaging, supine frontal abdomen radiograph volume has shown not merely resilience but remarkable growth in the 21st century.

CLINICAL RELEVANCE/APPLICATION
With over 11 million studies yearly, abdomen radiograph interpretation will remain a necessary skill in radiology practice, and our residency curricula must reflect that reality.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ David J. DiSantis, MD - 2014 Honored Educator

SSQ06-02 A Comparative Study Between Pseudomyxoma Peritonei and Ascites Due to Cirrhosis Using Spectral CT Imaging

Participants
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To explore the feasibility of differentiating pseudomyxoma peritonei from ascites due to cirrhosis on the basis of quantitative spectral features using spectral CT imaging.

METHOD AND MATERIALS

Six patients with pseudomyxoma peritonei and 5 patients with ascites due to cirrhosis were examined by spectral imaging of revolution CT. And pseudomyxoma peritonei was confirmed by subsequent operation and pathology. Using GSI viewer, various CT images were acquired at different energy levels and different material compositions. The GSI viewer displays the spectral curve and the spectral imaging parameters (CT values of different mono energy level, iodine-water concentration) were calculated and compared between the 2 groups. Thirty-seven regions of interest (ROI) were placed on pseudomyxoma peritonei and 52 ROIs were placed on cirrhotic ascites. The difference of these spectral parameters between the 2 groups was calculated statistically by independent sample t test.

RESULTS

From 40 to 140 keV images, the mono energy CT values of the 2 groups has statistical significant difference (P<0.05). On 60keV images, the difference of CT values of the 2 groups was the largest, the mean CT values of pseudomyxoma peritonei [(18.45±4.58)Hu] was significantly higher than that of cirrhotic ascites[(10.54±4.14)Hu] (t=-8.32, P<0.00). The iodine-water concentration of pseudomyxoma peritonei [3.28±0.99]g/L] was significantly higher than that of cirrhotic ascites[(2.72±1.10) g/L] (t=-2.22, P=0.01).

CONCLUSION

The CT spectral curve and spectral imaging parameters of pseudomyxoma peritonei is found to be different from ascites due to cirrhosis. Revolution spectral CT imaging may provides a new multiparameter method to differentiate pseudomyxoma peritonei and ascites due to cirrhosis.

CLINICAL RELEVANCE/APPLICATION

The CT spectral curve and spectral imaging parameters may be helpful in differentiating pseudomyxoma peritonei and ascites due to cirrhosis.

SSQ06-03 Automated Spleen Volumetry Based on MR Hepatic Proton Density Fat Fraction Imaging in Patients with Nonalcoholic Fatty Liver Disease

Thursday, Nov. 29 10:50AM - 11:00AM Room: E350

Awards

Student Travel Stipend Award

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Institutional research contract, Bristol-Myers Squibb Company;
Institutional research contract, Enanta;
Institutional research contract, Genentech;
Institutional research contract, General Electric Company;
Institutional research contract, Gilead Sciences, Inc;
Institutional research contract, Guerbet SA;
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Institutional research contract, Intercept Pharmaceuticals, Inc;
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Consultant, MEDIAN Technologies;
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Consultant, Novo Nordisk AS;
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Lab service agreement, Shire plc;
Lab service agreement, Alexion Pharmaceuticals, Inc;
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PURPOSE

In patients with nonalcoholic fatty liver disease (NAFLD), spleen volume is a marker of disease progression and can predict the likelihood of nonalcoholic steatohepatitis (NASH) and portal hypertension. Manual spleen segmentation for accurate spleen volumetry is laborious and impractical for routine use. Convolutional neural networks (CNNs) can automatically segment spleen volume using dedicated spleen imaging sequences, but are not well suited to estimate hepatic proton density fat fraction (PDFF) and are not routinely acquired in NAFLD research exams. It would be more practical to measure spleen volume on MR hepatic PDFF imaging sequences already obtained, even though the sequences are not optimized for spleen imaging. Here we assess the
feasibility of using an automated CNN method to measure spleen volume based on PDFF sequences.

METHOD AND MATERIALS

We retrospectively identified 172 patients (ages 28 to 71; 67% female) with confirmed NAFLD who underwent MR PDFF exams for clinical care at our institution. Each exam included a magnitude-based PDFF sequence comprising six gradient-echo images at sequential nominally out- and in-phase echo times. Manual-segmentation-determined spleen volumes were measured by an image analyst on 5th echo images for all 172 exams to serve as ground truth. We developed a spleen-segmentation CNN using a 2D U-Net to compute spleen volume separately on each of the six echoes to capture a range of T2* weighting. We trained the CNN in 100 of the 172 patients selected at random and then evaluated its accuracy (Dice score, linear regression, and Bland-Altman analyses) against the ground truth in the other 72 patients.

RESULTS

In the test cohort, spleen volumes were 318±148 mL for manual segmentation of the 5th echo, and 300±137 mL for automated segmentation of all six echoes. Mean Dice score was 0.88 ± 0.09. Regression slope and intercept were 0.90 and 13.0 mL with R²=0.94. The CNN underestimated spleen volume by 17 mL (p<0.0001) with Bland-Altman 95% limits of agreement of [-88 mL, 52 mL].

CONCLUSION

Automated spleen segmentation based on MRI-PDFF is feasible, but further CNN refinement is needed to ensure robust spleen volumetry amongst all patients and signal weightings.

CLINICAL RELEVANCE/APPLICATION

A CNN can measure spleen volume automatically based on MR PDFF images. With further refinement, this CNN may aid in monitoring disease progression in NAFLD and other diseases.

SSQ06-04 Characterization of Abdominal Lymph Node Enlargement: Value of Dual-Energy CT-Based Iodine and Fat Quantification

Participants
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PURPOSE

To investigate the potential of dual-energy computed tomography (DECT)-derived iodine and fat quantification for the differentiation of varying entities in patients with abdominal lymph node enlargement.

METHOD AND MATERIALS

In this retrospective study, 94 patients (51 men; mean age, 64.5 years) with histopathologically confirmed diagnosis of malignant lymphoma, lymph node metastasis, or inflammatory lymph node enlargement were included. For each lesion, contrast-enhanced attenuation, as well as DECT-derived iodine density and fat fraction measurements were recorded. Mean attenuation and material density values were compared between different entities. The receiver operating characteristic (ROC) curve analysis was adopted to estimate the optimal threshold for the diagnosis of lymph node metastasis. A control group (n = 95) was analyzed for comparison of attenuation and material density values of normal abdominal lymph nodes.

RESULTS

Assessment of DECT-derived iodine density and fat fraction values revealed significant differences between lymph node metastases (1.7±0.4 mg/ml and 15.5±7.3%), malignant lymphomas (2.5±0.5 mg/ml and 26.7±12.2%), and inflammatory lymph nodes (2.9±0.7 mg/ml and 20.1±10.3%) (P<=0.022). Attenuation values showed no significant differences between the different entities (P>=0.054). Normal lymph nodes revealed an iodine density of 2.4±0.8 mg/ml and fat fraction of 24.1±10.8% with no significant differences compared to malignant lymphomas (P<=0.1.65). An iodine concentration of 2.0 mg/ml represented the optimal threshold for the diagnosis of lymph node metastasis with a sensitivity of 91% and a specificity of 89%.

CONCLUSION

The differentiation of enlarged lymph nodes due to inflammation, primary and secondary malignancy is feasible using DECT iodine density and fat fraction analysis.

CLINICAL RELEVANCE/APPLICATION

DECT material density analysis optimizes the clinical workflow in patients with abdominal masses as iodine density and fat fraction values differ significantly between malignant abdominal lymphomas, lymph node metastases, and inflammatory lymph nodes. This may be beneficial in order to reduce the frequency of additional MRI and ultimately, lymph node biopsy.
**SSQ06-05** CT-Based Quantification of Abdominal Aortic Calcification is Superior to the Framingham Risk Score for Predicting Cardiovascular Events in Asymptomatic Adults

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**PURPOSE**
Determine if abdominal aortic calcification (AAC) predicts cardiovascular (CV) events independent of Framingham risk score (FRS).

**METHOD AND MATERIALS**
This retrospective HIPAA-compliant study was approved by the institutional review board. Electronic health records for 829 asymptomatic patients (mean age, 57.9 years; 451 women, 378 men) who underwent unenhanced screening CT colonography between April 2004-March 2005 were reviewed to identify patients with subsequent CV events (defined as MI, CVA, CHF, or death); mean follow-up interval was 11.2±2.8 years. CT-based AAC was quantified as a modified Agatston score using a semi-automated tool (V3D-Calcium Scoring, Viatronix). Kaplan-Meier curves and Cox proportional hazards models were used for time-to-event analysis; ROC curves and net reclassification improvement (NRI) were used to compare predictive abilities of AAC and FRS.

**RESULTS**
An index CV event occurred after CT in 156 (18.8%) of 829 subjects (6.7±3.5 years after CT). AAC was significantly higher in the CV event cohort (mean AAC, 3478 vs 664). AAC was a strong predictor of CV events at both univariate and multivariate Cox modeling, independent of FRS (p<0.0001). KM plots showed better separation with AAC over FRS. The ROC-AUC was higher for AAC than FRS at all evaluated time points (eg, AUC =0.819 versus 0.642 at 2-years; AUC for FRS-AAC combined =0.819). Using a cut-point of 200, AAC improved upon FRS risk categorization with NRI of 35.4%.

**CONCLUSION**
CT-based AAC is a strong predictor of future cardiovascular events, outperforming the FRS. This suggests a potential opportunistic role in abdominal CT scans performed for other clinical indications.

**CLINICAL RELEVANCE/APPLICATION**
Abdominal aortic calcification (AAC), which can be quantified at abdominal CT performed for other indications, can serve as a useful biomarker for estimating risk for future cardiovascular events.

**Honored Educators**
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Perry J. Pickhardt, MD - 2014 Honored Educator Perry J. Pickhardt, MD - 2018 Honored Educator

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**SSQ06-06** Reduction of Artifacts in the Hepatic Arterial Phase of Gadoxetic Acid-Enhanced MR Imaging: Effect of Warming Before Injection

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**PURPOSE**
To investigate if the warming of gadoxetic acid affects the frequency and degree of artifacts in the arterial phase of magnetic resonance (MR) imaging.

**METHOD AND MATERIALS**
Two hundred and seventy-one patients who underwent gadoxetic acid-enhanced abdominal MR imaging were included in the study. All dynamic MR imaging was performed with a 1.5 T MR scanner (Achieva, Philips). Either warmed (37°C, n = 137) or non-warmed (24°C, n = 134) gadoxetic acid (Primovist; Bayer HealthCare) was intravenously injected at a dose of 0.025 mmol/kg for 5 seconds, followed by 20 mL of saline. Breath-hold time of each phase was fixed at approximately 20 s. Two abdominal radiologists evaluated the severity of artifact of precontrast, arterial and portal phase images in a consensus fashion as follows: 1 = none; 2 = mild; 3 = moderate; and 4 = severe. Comparison of artifact scores in precontrast, arterial and portal phases as well as patient background was performed between the 37 °C group and the 24 °C group.
RESULTS

There was no significant difference between the 37 °C and the 24 °C groups in terms of age, sex, body weight, body mass index or frequency of underlying medical conditions (liver cirrhosis, ascites, pleural effusion and pulmonary disease). The mean artifact score of the arterial phase in the 37 °C group was significantly lower than that in the 24 °C group (1.38 ± 0.78 vs 1.62 ± 0.92, p < 0.05), whereas those of the precontrast and portal phases did not show a significant difference between the two groups. The rate of substantial artifact (score = 3 or 4) in the arterial phase was significantly lower in the 37 °C group than in the 24 °C group (11.2% vs 21.1%, p < 0.05). The rate of patients that showed high artifact score in the arterial phase compared to the precontrast image was also lower in the 37 °C group than in the 24 °C group (21.6% vs 36.0%, p < 0.01).

CONCLUSION

Warmed gadoxetic acid could reduce the artifact in the arterial phase of dynamic MR imaging. Since the viscosity of gadoxetic acid decreases as temperature increases, we speculate the warmed gadoxetic acid may get more homogenous in the vessel early after injection than non-warmed one. This homogeneity could influence the degree or frequency of the artifact.

CLINICAL RELEVANCE/APPLICATION

(dealing with MR artifacts) The artifact in the arterial phase of dynamic MR imaging can be easily reduced by warming of gadoxetic acid without spending time and effort.

SSQ06-07 Leakage After Laparoscopic Sleeve Gastrectomy (LSG): What Is the Role of Routine Postoperative CT Scan?

Thursday, Nov. 29 11:30AM - 11:40AM Room: E350

Participants

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PURPOSE

LSG has become one of the most common bariatric procedures; even so, gastric leak remains the most feared complication of this procedure with a difficult treatment. Our aim was to investigate the role of routine postoperative CT scan in the early identification of factors representing potential substrates of leakage after LSG.

METHOD AND MATERIALS

We enrolled 170 patients(112F,58M;43±12years;43±6.4kg/m2) who underwent primary LSG between September 2015 and February 2018. CT scan was performed within 72 hours from surgery; CT protocol included the use of intravenous and oral contrast. Imaging post processing consisted in measurement of the distance proximal from the pylorus to the first staple firing(stapler to pylorus distance - StP). We also evaluated the presence of perigastric hematoma and of any twisting of the stomach remnant (defined as rotation of all or part of the stomach around its longitudinal axis).

RESULTS

8 patients suffered from gastric leak(4.7%). The mean StP was 38.7±16.7mm; this distance was significantly lower in patients who suffered from gastric leak(24.2±11.9mm vs. 40.3±16.4mm; p=.005). By means of ROC analysis we identified as best threshold for StP 29.9mm below which patients demonstrate a higher risk of gastric leak(AUC:.83;Se:81.8%;Sp:75.4%). Hematoma was found in 9 patients(5.3%); patients with hematoma were found to be more likely to develop gastric leak after LSG(33.3%; p=.005). 15 patients developed twist of stomach remnant(8.8%); we identified two types of twist: type A(10 patients,5.9%), if the twist involves the first third of the gastric remnant; type B(5 patients,2.9%), if it involves its middle and distal part. 4 out of 5 type B patients suffered from gastric leak, while no gastric leak was found in type A group. Type B twisting of the stomach remnant significantly increases the probability of gastric leak after LSG(p=.004). A stepwise multivariate analysis identified this CT sign as the strongest risk factor for gastric leak after LSG(p=.005).

CONCLUSION

On routine postoperative CT scan the assessment of StP<3cm and the presence of perigastric hematoma and type B twisting of gastric remnant are to be considered risk factors for leakage after LSG.

CLINICAL RELEVANCE/APPLICATION

Routine postoperative CT scan has a promising role in the risk stratification of patients who underwent LSG.

SSQ06-08 Real-Time MRI of the Gastroesophageal Junction: Dynamic Imaging in Patients with GERD-Like Symptoms After Surgical Fundoplication

Thursday, Nov. 29 11:40AM - 11:50AM Room: E350

Participants

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Alexander Beham, Goettingen, Germany (Abstract Co-Author) Nothing to Disclose
Purposes: To assess the diagnostic potential of dynamic real-time MRI in patients with persistent or recurrent GERD-like (gastroesophageal reflux disease) complaints after surgical fundoplication.

Method and Materials
22 consecutive patients (male n=11; female n=11; median age 59y) presenting with recurrent or persistent GERD-like symptoms after surgical fundoplication were enrolled between 2015-2017. Median duration of GERD-like symptoms was 21 months. MRI was performed at a median of 5 years after initial surgery. Real-time MRI at 3.0 Tesla was performed with temporal resolution of 40 ms. Based on undersampled radial fast low angle shot (FLASH) acquisitions with iterative image reconstruction by regularized nonlinear inversion (NLINV). Dynamic MRI movies visualized bolus transit of pineapple juice through the gastroesophageal junction, position of the fundoplication wrap as well as recurring hemia or reflux during Valsalva maneuver. MRI results were compared to endoscopic findings.

Results
Real-time MRI was successfully completed in all patients without adverse events and average examination time of 15 minutes. A morphological correlate for GERD-like symptoms was evident in 20 patients (90.1%): Gastric reflux was present in 19 of these cases. Nine patients (40.1%) were diagnosed with wrap disruption and recurrent gastric hernia. Wrap migration or telescoping hernia were detected in 9 patients (40.1%). Only 1 patient presented with continued reflux despite intact wrap. Esophageal dysmotility with delayed bolus passage was observed in 1 case. On endoscopy, gastric hernia or wrap migration were diagnosed in 6 cases. Repeated fundoplication was performed in 12 patients (54.4%) with gastric hernia or wrap migration based on MRI findings.

Conclusion
Real-time MRI is a fast and safe modality for dynamic imaging after fundoplication, without radiation exposure or administration of gadolinium-based contrast media. In a relevant number of cases real-time MRI reveals correlates for GERD-like symptoms.

Clinical Relevance/Application
Dynamic real-time MRI is a novel imaging technique for postsurgical detection and characterization of fundoplication failure. Different patterns on MRI may assist planning of redo fundoplication.

SSQ06-09 Novel Murine Model of Liver Microbleeding Using Electric Field Ablation

Participants
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Purpose
Approximately 5% of gastrointestinal bleeding (GIB) cannot be identified on initial workup. Over two years, an average of 7.3 diagnostic tests, 5 hospitalizations, and 46 units of blood per patient are required during workup. Improved diagnostic approaches of obscure GIB are needed. To evaluate emerging diagnostic agents, we describe a novel murine GIB model using irreversible electroporation (IRE) which can be detected with contrast enhanced micro-computed tomography (micro-CT).

Method and Materials
C57BL/6 mice (n=10) were placed under anesthesia. Prior to the IRE procedure, 200U/kg heparin was injected followed by 300µl 1:1 v/v heparinized saline and 350mg/ml iohexol. The mice were divided into two experimental groups: 60 and 120V/mm IRE treatment. IRE was performed using 1cm2 tweezer electrodes applied to both sides of the right median liver lobe. Microperfusion was measured using Laser Speckle Contrast Analysis (LASCA) at baseline and at 1, 5, 10, 20, 30 min post-IRE. Prior to euthanasia, another 300µl of v/v heparinized saline and 350mg/ml iohexol was injected. Whole body contrast enhanced micro-CT scan was performed with settings of: 32µm pixel size, 55Kv, 181µA, rotation step 0.25°, frame average 3, with a 0.5mm aluminum filter. Liver tissues were harvested for additional micro-CT and histology.

Results
Visual inspection of the IRE site showed evidence of contusion within the tissue in both groups. LASCA imaging demonstrated decreased, but maintained perfusion. 30min post-IRE perfusion for 60V/mm and 120V/mm was 71% and 35% of baseline, respectively (p=0.006). Micro-CT showed increased attenuation at the liver IRE site, suggestive of bleeding. Extravasation of erythrocytes within the hepatic parenchyma was evident on microscopy with a greater effect seen in the 120V/mm group.

Conclusion
We demonstrate a novel, non-traumatic model of liver microbleeding which can be identified using non-invasive micro-CT imaging and confirmed by histology. Although trauma induced animal hemorrhage models exist, this is the first described model of microbleeding of the abdomen. This model can be useful to test emerging bioengineered hemostatic and imaging agents.

Clinical Relevance/Application
A GIB model can help test emerging diagnostic and therapeutic agents which can be targeted to sites of microbleed. New agents have potential to improve costs, morbidity and mortality of obscure GIB.
**SSQ07**

**Gastrointestinal (Gastric Cancer)**

**Thursday, Nov. 29 10:30AM - 12:00PM Room: E351**

AMA PRA Category 1 Credit™: 1.50  
ARRT Category A+ Credit: 1.75

*Participants*

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Olga R. Brook, MD, Boston, MA (*Moderator*) Nothing to Disclose  
Desiree E. Morgan, MD, Birmingham, AL (*Moderator*) Institutional Research Grant, General Electric Company

*Sub-Events*

**SSQ07-01** **CT Detected Extramural Vessel Invasion combined with N Staging as the Prognostic Predictor in Patients with T4a Gastric Cancer**

**Thursday, Nov. 29 10:30AM - 10:40AM Room: E351**

*Participants*

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**PURPOSE**

To investigate the 3-year progressive-free survival (PFS) of extramural vessel invasion (EMVI) and the nodal status detected with contrast MDCT in patients with clinical T4a gastric cancer.

**METHOD AND MATERIALS**

Between January 2009 and February 2015, 143 patients with preoperative ceMDCT diagnosed T4a gastric cancer based on the criteria of the AJCC 8th were included in this retrospective study. All patients underwent curative D2 gastrectomy, adjuvant chemotherapy and conventional follow-up. Potential prognostic factors including clinical and pathological N status, EMVI tumor location/growth pattern, histological type/tumor differentiation and tumor size were recorded. Disease progression was defined as the presence of radiological or pathology-confirmed metachronous metastases, local recurrence, or gastric cancer related death. Survival estimated for PFS were obtained in patients according to the following four categories: ctEMVI+/ctN+, ctEMVI+/ctN-, ctEMVI-/ctN+, ctEMVI-/ctN-, by using the Kaplan-Meier product limit. Hazard ratios for 3-year PFS were generated using a Cox proportional hazards regression analysis.

**RESULTS**

The prevalence of EMVI detected with ceMDCT was 55.9% (80/143) in the entire cohort of patients with clinical T4a patients. The 3-year PFS according to ctEMVI and CT detected nodal status were ctEMVI+/ctN+ 25.0%, ctEMVI+/ctN− 53.1%, ctEMVI-/ctN+ 75.6% and ctEMVI-/ctN− 64.7%, respectively. There was significant difference in 3-years PFS with ctEMVI+/ctN+ (as the reference) and the other three groups (ctEMVI+/ctN−, ctEMVI-/ctN+, and ctEMVI-/ctN−) (Logrank test, *P*<0.05). In a Cox proportional hazards regression analysis, ctEMVI+/ctN+ was demonstrated as the independent factors for reduced 3-year PFS with HR of 2.169 (95%CI:1.300-3.618, *P*=0.003).

**CONCLUSION**

EMVI combined with nodal status detected with ceMDCT, could be an more valuable preoperative factor to counsel patients regarding ongoing risks of metastatic disease, implications for surveillance, and systemic chemotherapy.

**CLINICAL RELEVANCE/APPLICATION**

Clinical N staging combined with the status of CT detected EMVI could be used as an independent poor prognostic predictors for the T4a gastric cancer patients. EMVI and ctN both positive might be a useful risk-stratified factors to balance benefit of survival with induced long-term toxicities from neoadjuvant chemotherapy for regional advanced gastric cancer.

**SSQ07-02** **Diffusion Kurtosis Imaging: Assessment of Poor Response to Neoadjuvant Chemotherapy in Advanced Gastric Cancer**

**Thursday, Nov. 29 10:40AM - 10:50AM Room: E351**

*Participants*
To assess the effectiveness of diffusion kurtosis (DK) imaging in treatment response to neoadjuvant chemotherapy in locally advanced gastric cancer.

METHOD AND MATERIALS

This study was approved by the local institute review board. A total of 28 patients (median age, 60.3 years; age range, 35-79 years) with gastric cancer who underwent MR imaging on a 1.5T MR scanner. All patients were underwent DKI examination (b=0, 200, 500, 800, 1000, 1500, 2000s/mm²) and conventional diffusion-weighted imaging (b = 0, 800s/mm²) before and after chemotherapy. ADC value, diffusivity (D), Kurtosis (K) were measured. Change value (ΔX) and ratio (%ΔX) of these parameters were calculated. The response to neoadjuvant chemotherapy was evaluated according to pathological tumor regression grade scores (NCCN) as the standard reference (good responders TRG 0-2, poor responders, TRG 3). Mann-Whitney U test, ROC curve were used for statistical analysis.

RESULTS

There were 16 cases of good response and 12 cases of poor response. The Kpre and Kpost values in poor response group were significantly higher than those in good response group ([0.671±0.026] and [0.641±0.019] vs. [0.584 ± 0.023] and [0.519±0.018] respectively, p<0.001). ADCpost and Dpost in the poor response group were significantly lower than those in good response group (p<0.05). In addition, significant difference were also observed for parameters %ΔK, ΔD and %ΔK between the two groups (p<0.05). The operating characteristic curve for the assessment of poor response was highest using Kpost (0.958, cutoff value=0.614) compared with other parameters. The Kpre and Kpost respectively had highest sensibility (91.70%) and specificity (93.8%) compared with other image indices.

CONCLUSION

Both DKI and conventional DWI exhibit potential in evaluation of treatment response in gastric cancer with neoadjuvant chemotherapy. The DKI parameters, especially K, showed better performance in differentiating poor response.

CLINICAL RELEVANCE/APPLICATION

DKI is a non-invasive imaging technique that may be useful in monitoring poor responder for advanced gastric cancer.

SSQ07-03 Predicting Gastric Cancer Response to Neoadjuvant Chemotherapy Using a Non-Gaussian Fractional Order Calculus Diffusion Model

Thursday, Nov. 29 10:50AM - 11:00AM Room: E351

Participants
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PURPOSE

To investigate whether pre-treatment MRI can predict tumor response grade (TRG) to neoadjuvant chemotherapy (NAC) of gastric cancer using a non-Gaussian fractional order calculus (FROC) diffusion model.

METHOD AND MATERIALS

With IRB approval, 30 patients (9 females and 21 males) with gastric cancer underwent MRI scans at 1.5T prior to NAC. The histologic TRG was evaluated based on the following grading system: TRG0: complete, TRG1: moderate, TRG2: minimal, and TRG3: poor response. According to this criterion, 3 patients were identified with TRG0, 2 with TRG1, 12 with TRG2, and 13 with TRG3. For analysis, TRG0-TRG2 groups were combined as low-TRG to be compared with high-TRG (TRG3) group. The MRI protocol included T1-weighted (VIBE), T2-weighted (turbo spin echo with respiratory trigger), and diffusion-weighted (DW) imaging with 11 b-values (0 to 2000 s/mm²). Diffusion coefficient D, fractional order parameter β (which correlates with tissue heterogeneity), and a microstructural quantity μ were calculated by fitting the DW images to a FROC model. Apparent diffusion coefficient (ADC) was also computed using b=50 and 800 s/mm² images. For group analysis, the test parameters were computed as the mean value from the tumor region of interest for β and μ. For D or ADC, the mean values were computed from the lower 25% of their histograms to improve robustness against contamination from the body fluid. The low- and high-TRG groups were compared using a Mann-Whitney U test. A receiver operating characteristic analysis was performed to assess the performance of FROC model for predicting TRG in comparison with ADC.

RESULTS

The FROC parameters, D and μ, were significantly lower in high-TRG than low-TRG group (p-values<0.05), whereas ADC or β did not show significant difference between the groups. The combination of D and μ produced higher accuracy (76% vs. 64%), specificity...
The combination of pre-treatment FROC parameters, $D$ and $\mu$, improved the performance over ADC in predicting TRG in gastric cancer patients receiving NAC.

**CONCLUSION**

The combination of pre-treatment FROC diffusion model parameters can be used to predict gastric cancer response to NAC.

**CLINICAL RELEVANCE/APPLICATION**

Preoperative TN stage and EMVI diagnosed by ceMDCT can be used to predict 1-year DFS rate of gastric cancer.

**METHOD AND MATERIALS**

Between January 2009 and December 2015, 237 patients with pathological-proved gastric cancer were included in this retrospective study. Two radiologists reviewed all abdominal ceMDCT images and reached a consensus on categories of tumor and lymph node (ctT/ctN), the presence of ctEMVI, tumor location/growth pattern, and tumor size. Kaplan-Meier method was used to compare the 1-year DFS rate between ctEMVI-positive and ctEMVI-negative group. Cox proportional hazards regression was used to find the independent risk factors of 1-year DFS rate. According to the number of independent risk factors, the patients were classified to the different risk stratifications, and the difference of 1-year DFS rate between different risk stratifications was compared.

**RESULTS**

The ctEMVI-positive group had significantly lower 1-year DFS rate (55.3%) than the ctEMVI-negative group (90.2%) (Log-rank test, $P < 0.0001$). In a Cox proportional hazards regression analysis, ctT, ctN and ctEMVI were identified as independent prognostic factors of 1-year DFS with hazard ratio (HR) of $3.35$ (95% CI: $1.25-8.99$, $P = 0.018$), $1.99$ (95% CI: $1.08-3.63$, $P = 0.0269$) and $3.40$ (95% CI: $1.79-6.47$, $P = 0.0002$), respectively. The risk stratification analysis showed that with the increase of the number of independent risk factors, 1-year DFS rate decreased gradually in patients with gastric cancer ($P < 0.0001$).

**CONCLUSION**

Preoperative TN stage and EMVI diagnosed by ceMDCT were independent risk factors for the prognosis of gastric cancer, and can be used for risk stratification to predict 1-year DFS rate of gastric cancer.

**CLINICAL RELEVANCE/APPLICATION**

Preoperative risk stratification based on TN stage and EMVI defined by ceMDCT can be used to predict 1-year DFS rate of gastric cancer.
then used to develop a radiomics model incorporating the radiomics signature and subjective CT findings. A nomogram was displayed. The receiver operating characteristic (ROC) curve was constructed for each cohort and the area under the curve (AUC) was calculated to measure the diagnostic ability. DeLong test was used to verify whether there were statistical differences between the ROC curves.

RESULTS
The radiomics signature comprised 273 hand-crafted features and 30 features extracted based on the CNN. The individualized radiomics model, which incorporated the arterial radiomics signature and three CT findings (nodular, perigastric fat infiltration, high enhanced serosa sign) showed moderate discrimination. The AUC (95% confidence interval) in primary and validation cohort was 0.815 (0.759-0.870) and 0.804 (0.739-0.868), respectively. The accuracy, sensitivity and specificity of the primary cohort was 0.770, 0.798, 0.719, respectively. The prediction accuracy, sensitivity, and specificity of the validation cohort was 0.744, 0.756 and 0.734, respectively.

CONCLUSION
Based on the contrast enhanced CT images of three phases, we developed a radiomics model, which may be used to identify serosa invasion and provide reference for individualized clinical treatment.

CLINICAL RELEVANCE/APPLICATION
The radiomics model we developed and the derived nomogram that incorporates the radiomics signature and CT findings provides patients and doctors with an effective tool for evaluating serosa invasion and for determining further treatment plans.

**SSQ07-06** Diagnostic Accuracy of Dual-Energy CT-Based Nomogram to Predict Lymph Node Metastasis in Gastric Cancer

Thursday, Nov. 29 11:20AM - 11:30AM Room: E351

Participants
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**PURPOSE**
To develop and validate a dual-energy CT based nomogram for the preoperative prediction of lymph node metastasis (LNM) in patients with gastric cancer (GC).

**METHOD AND MATERIALS**
A total of 210 surgical confirmed GC patients (159 males, 51 females; mean age: 59.8 ± 7.7 years, range: 28-79 years) who underwent spectral CT scans were retrospectively enrolled and split into a primary cohort (n=140) and validation cohort (n=70). Clinical information and follow up data including overall survival (OS) and progression free survival (PFS) were collected. The iodine concentration (IC) of the primary tumours at the arterial phase (AP) and venous phase (VP) were measured and then normalized to aorta (nICs). Univariate analysis, multivariable logistic regression analysis and Cox regression analysis were performed to screen predictive indicators for LNM and outcome. A nomogram for risk factors of LNM was developed and its performance was measured using ROC, accuracy and Harrell's concordance index (C-index).

**RESULTS**
Tumour thickness, Borrmann classification and ICVP were independent predictors for LNM. The nomogram was significantly associated with LN status (P <0.001). The AUCs for predicting LNM were 0.760 (95% confidence interval [95% CI], 0.680-0.840) in primary cohort and 0.793 (95% CI, 0.678-0.908) in validation cohort. The nomogram also exhibited a prognostic ability with C-indices of 0.675 (95% CI, 0.571-0.779; P <0.001) for PFS and 0.643 (95% CI, 0.518-0.768; P =0.025) for OS.

**CONCLUSION**
This study presented a dual-energy quantification based nomogram, which can be used to facilitate the preoperative individualized prediction of LNM in patients with GC.

**CLINICAL RELEVANCE/APPLICATION**
Dual-energy CT based nomogram enables superior preoperative individual prediction of LNM in GC.

**SSQ07-07** Evaluation of Iodine Concentration Measurement by Dual Energy CT Scan on Predicting Prognosis for Patients with Advanced Gastric Adenocarcinoma

Thursday, Nov. 29 11:30AM - 11:40AM Room: E351

Participants
Li Yang, MD, Shijiazhuang, China (Presenter) Nothing to Disclose
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Jiangyang Pan, Shijiazhuang, China (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**
To evaluate iodine concentration measurement by dual energy CT scan on tumor angiogenesis and predicting prognosis for patients with advanced gastric adenocarcinoma.

**METHOD AND MATERIALS**
This retrospective study included 97 patients with advanced gastric adenocarcinoma who had preoperative enhanced dual-energy CT scan. Standardized iodine concentration (SIC) of the primary tumor was measured. The correlations between SIC and clinical, pathological, angiogenic findings compared with patient survival were analyzed. The Kaplan-Meier test was employed to evaluate the patients' disease free survival (DFS) and overall survival (OS). COX regression model was adopted to improve the multiple factors analysis.

RESULTS
Different values of SIC values were found 0.81 at diffuse, 0.54 at both intestinal and mixed type (F=18.717,P<0.001); 0.52 at non-T4 and 0.66 at T4 group (t=2.728,P=0.008); 0.53 at N0 and 0.64 at N1-3 group (t=2.084,P=0.040); 0.50 at non-III staging and 0.68 at III staging group (t=4.135,P<0.001); 0.48 at VEGF negative and 0.69 at positive expression group (t=4.684,P<0.001); 0.55 at low and 0.67 at high MVD group (t=2.802,P<0.05); 0.72 at recurrence and 0.55 at non-recurrence group (t=3.791,P<0.001), respectively. DFS of low SIC (< mean value of 0.62) and high SIC (>= 0.62) groups were 28 and 22 months (X2=11.920,P=0.001). OS of the two groups were 29 and 26 months (X2=12.907,P<0.001). Invasion, metastasis, pTNM and SIC were identified as the independent risk factors affecting to DFS (0.195,0.379,6.623 and 2.802, respectively). Invasion, pTNM and SIC independent risk were affecting to OS (0.281, 7.225 and 2.835, respectively).

CONCLUSION
The SIC of advanced gastric adenocarcinoma has the relationship with Lauren classification, invasion depth, lymph node metastasis, pathological TNM staging and tumor angiogenesis. The SIC as a independent risk factor could affect DFS and OS, and has the potential to be used for predicating the patient prognosis.

CLINICAL RELEVANCE/APPLICATION
The SIC of advanced gastric adenocarcinoma has the relationship with Lauren classification, invasion depth, lymph node metastasis, pathological TNM staging and tumor angiogenesis. The SIC as a independent risk factor could affect DFS and OS, and has the potential to be used for predicating the patient prognosis.
PURPOSE

To investigate the optimal diagnostic threshold and accuracy of spectral parameters for metastatic lymph nodes of gastric cancer with dual energy CT and to compare with conventional CT parameters.

METHOD AND MATERIALS

This study received institutional review board approval, and all participants provided written informed consent. From December 2014 to December 2016, 86 patients with gastric cancer confirmed by gastroscope pathology underwent preoperative enhanced CT that included precontrast, arterial phase(AP) and venous phase(VP) in Discover GSI CT scanner. The spectral parameters(iodine value of lymph nodes in AP and VP) and the conventional parameters(short diameter, long diameter, the ratio of short to long diameter and CT number in AP and VP) were measured and recorded in iodine based images and monochromatic images at 70 keV respectively. The diagnostic efficiency of each factor to lymph nodes metastasis was assessed by using t test and receiver operating characteristic(ROC) curve analysis.

RESULTS

Among 552 lymph nodes found in CT images, 338 nodes were positive and 214 were negative with pathological results as the gold standard. The results of t test showed that the short diameter, the ratio of short to long diameter, the CT number and iodine value in AP and VP of positive lymph nodes were higher than these of negative lymph nodes(all P<0.05). The area under curve of the short diameter, the ratio of short to long diameter, the CT number in AP and VP, the iodine value in AP and VP of lymph nodes were 0.600, 0.880, 0.755, 0.864, 0.835, respectively. The diagnosis accuracy of iodine value in AP and VP were 86.9%, 82.2%, respectively with threshold of 9.65,15.65(100ug/cm3). These were higher than the CT number in AP and VP( 86.9% vs 69.9%, 66.9% vs 82.2%, both P<0.05). Taking the ratio of short to long diameter over 7.25 as optimal diagnosis threshold, the diagnosis accuracy was 75.6%. Combined the ratio of short to long diameter with the iodine value in AP, the diagnosis accuracy was 89.2%.

CONCLUSION

The diagnosis accuracy of dual-energy CT parameters was higher than conventional CT for lymph nodes metastasis in gastric cancer and could be improved by combining size and spectral CT parameters.

CLINICAL RELEVANCE/APPLICATION

Multifunctional parameters of spectral CT can improved the diagnosis accuracy of lymph node metastasis in gastric cancer.
Can Fully Iterative Reconstruction Technique Enable Routine Abdominal CT at Less Than 1 mSv?

**Purpose**

We assessed the effect of a new fully iterative reconstruction technique (FIRST) on lesion detection and image quality of routine abdominal CT at radiation dose <1 mSv.

**Method and Materials**

24 patients (age 64±1 years, BMI 27±3 kg/m) undergoing routine abdomen CT on 640-slice MDCT (Aquillion One, Canon Medical System), gave written informed consent for acquisition of an additional ULD CT series immediately after their clinically-indicated regular dose CT (SD). The ULD CT series were reconstructed with FIRST (at STD (Standard) and STR (Strong) levels), and SD CT series with filtered back projection (FBP). Two radiologists performed the subjective image evaluation on a five-point scale (1 = image quality better than SD CT; 5 = image quality unacceptable) to assess subjective image quality, and presence of artifacts on all image series (SD (n=24) and ULD (n=72). Lesions were first detected on ULD FBP images. ULD FIRST (STD and STR) and ULD FBP images were then compared side-by-side to SD-FBP images in an independent, randomized, and blinded fashion. Patient demographics, radiation dose descriptors (CTDivoL, DLP) and image noise were recorded. Descriptive statistics and inter-observer variability were calculated for data analysis.

**Results**

Mean CTDivoL for SD and ULD CT were 13±3 mGy and 2.2±0.4 mGy, respectively. There were 46 'true positive' lesions detected on SD CT. Radiologists detected 38/46 lesions on ULD FIRST STD series compared to 26/46 lesions on ULD FIRST STR series. Twenty lesions (0.5-1.5 cm) missed on ULD FIRST STR images (pancreatic lesions, liver and kidney cysts) were seen in patients with BMI >27.6. Eight lesions (liver and kidney cysts, pancreatic lesions, sub-cm peritoneal lymph node) missed on ULD FIRST STD were seen in patients with BMI >25.8. Diagnostic confidence for lesion assessment was optimal in ULD FIRST STD setting in most patients regardless of their size. The inter-observer agreement (kappa-value) for overall image quality were 0.98 and 0.84 for ULD FIRST STD and STR levels, respectively.

**Conclusion**

FIRST enabled optimal lesion detection, and diagnostic confidence in submSv abdominal CT in most non-obese adult patients compared to SD CT at 85% lower radiation dose levels.

**Clinical Relevance/Application**

The new fully iterative reconstruction (FIRST) technique can allow routine abdominal CT at less than 1 mSv with sufficient diagnostic confidence in smaller patients (<27.6 BMI).
SSQ08-02 Contrast Volume Reduction Using Measured Lean Body Weight and Related to Image Quality for Abdomen CT Examinations: Preliminary Results of a Prospective Multicentric Study

Thursday, Nov. 29 10:40AM - 10:50AM Room: E352

Participants
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PURPOSE
To assess i.v. contrast media (CM) volume differences correlated to image quality (IQ) when using lean body weight (LBW) or total body weight (TBW) for abdomen CT examinations.

METHOD AND MATERIALS
A CT scanner i.v. contrast media (CM) volume optimization protocol based on LBW was implemented in a multicenter medical imaging group (8 CT scanners) following a dose optimization program according to clinical indication. Patients assessed for a suspected liver, pancreas or renal lesion, were prospectively included. A single i.v. CM (iopamidol 370mg/ml) was used. In phase 1, a 600mg/kg of TBW injection protocol was applied. 948 prospective patients were included (Group 1): M:438/F:510, mean age: 59, mean BMI: 26.06 (range 13.8-44.6). In phase 2, a 750mg/kg of LBW injection protocol was applied. 124 prospective patients were included (Group 2): M:59/F:65, mean age: 60, mean BMI: 26.3 (range 16.45 - 37.55). LBW was measured using a bi-frequency tetrapolar bioelectrical impedance technique (BIA-ACC®, Biotekna, Italy). Contrast volume and injection rate were recorded in a single dose management software (Dosewatch™, GE). IQ (level of enhancement) was assessed by two independent readers in pre- and post-contrast portal phase images on 3mm axial reconstructions, with quantitative HU measurements for liver parenchyma enhancement (Δ target: 50HU), using ROIs of identical size and location. Image noise was also quantitatively reported using image Hounsfield unit standard deviation (SD) values indicated with the ROI density measurement. Mann-Whitney U Test and One way ANOVA test were used to assess differences as appropriate.

RESULTS
Injected i.v. CM volume is statistically significantly different (~26%) between group 1 (median: 118.3ml) and 2 (median: 87.6ml) (p<0.001). Enhancement of liver parenchyma (median group 1/group 2: 26/50, SD:15.7/17.3) presents a statistically significant difference (p<0.05), but remains in target range. There is no statistically significant difference between readers for image quality assessment (parenchymal enhancement): reader 1/2, group 1: 60/61 (SD16.3/15.1), group 2 : 49/50 (SD17.6/17).

CONCLUSION
For abdomen CT examinations, injected i.v. CM volume is significantly less when using LBW instead of TBW, without impairing image quality.

CLINICAL RELEVANCE/APPLICATION
Excessive amounts of i.v. CM is delivered when using TBW instead of LBW for abdominal CT examinations.

SSQ08-03 Personalized Contrast Media Injection Protocols for Abdominal CT Studies

Thursday, Nov. 29 10:50AM - 11:00AM Room: E352

Participants
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Anushri Parakh, MD, Boston, MA (Abstract Co-Author) Research support, General Electric Company Medical Advisory Board, Allena Pharmaceuticals, Inc

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PURPOSE
To compare Abdomen CT exams performed using power injector generated customized contrast media (CM) injection protocols based on total body weight (TBW) and kV to fixed CM injection protocols.

METHOD AND MATERIALS
A total of 384 patients underwent abdominal CECT studies (GE Revolution and Siemens Edge). 263 of 384 patients were scanned using 100kV and 121 with DECT (65 keV). CM (370 mgI/mL, Iopamidol) was administered using a software platform (P3T, Certegra, Medrad), connected to the power injector, which customized the CM injection (Cinj) based on TBW in kg’s. In 149-Cinj patients (80 with 100kV; 69 with DECT) a comparison with 120kV exams was available using fixed CM injections (Finj) using TBW based thresholds ([TBW]< = 59 kg, 80 ml= Group A; 60-89 kg, 90 ml= Group B; >=90 kg, 120 ml= Group C). Subjective image quality and mean HU and CNR were calculated from ROIs within the liver, pancreas, portal vein, and aorta.

RESULTS
In the 384-Cinj patients a mean CM volume of 85.7±14.8 was injected, 9.4% lower than using TBW. Group A received a mean CM volume of 70.3±1.2 vs 80ml (-12%), group B of 82.3±9.3 vs 90ml (-8.5%), and group C 108±6.9 vs 120ml (-10%). All exams were...
judged diagnostic. In comparison to 120 kV Finj, 100kV-Cinj images showed comparable HU mean and significantly higher CNR (+36-87%; p=<0.05) in all three groups. DECT-Cinj images showed significantly higher HU (+7-22%; p=<0.05) and CNR (+14%-86%) mean.

CONCLUSION
The software platform (P3T) with power injector enables personalized CM injection protocols using substantially lower iodine dose for low kV/keV exams while yielding diagnostic quality images with comparable/higher attenuation and CNR values compared to 120kV exams using fixed CM injection volumes.

CLINICAL RELEVANCE/APPLICATION
Automation of Customized CM injection protocols using a power injector platform entails reduction of the iodine load with optimized image quality. There are potential benefits for the patients safety, CT workflow and lowering exam cost.

Honor Educators
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SSQ08-04 Improvement of Diagnostic Image Quality of Abdominal CT by Using a Deep-Learning Based Reconstruction: Initial Clinical Trial Targeting Hypervascular Hepatocellular Carcinoma

Thursday, Nov. 29 11:00AM - 11:10AM Room: E352

Participants
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PURPOSE
Deep learning is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. We developed a new image processing reconstruction method, Deep Learning based Reconstruction (DLR), which could generate CT image with better quality using deconvolution neural network trained by CT images which are scanned with sufficient radiation dose and reconstructed with model-based iterative reconstruction. The purpose of this study was to confirm clinical feasibility of our method compared with conventional hepatic CT images targeting hypervascular hepatocellular carcinoma.

METHOD AND MATERIALS
We evaluated 43 hypervascular hepatocellular carcinomas in 40 patients who had undergone hepatic dynamic CT. The CT images at arterial phase were reconstructed with DLR and hybrid iterative reconstruction (Hybrid-IR). A radiologist measured standard deviation of the attenuation measured in the paraspinal muscle as image noise, and calculated contrast-to-noise ratio (CNR) = (ROIL - ROIT)/N, where ROIL is the mean attenuation of the liver parenchyma, ROIT is the mean attenuation of the tumor, and N is noise. Each liver lesion was reviewed by other two radiologists and graded on a 5-point confidence scale ranging from 1 = cannot identify to 5 = can detect lesion without diagnostic compromise. The difference between CT images processed with Hybrid-IR and DLR was determined using two-sided Wilcoxon signed-rank test.

RESULTS
Image noise was significantly lower on images with DLR compared to Hybrid-IR (median 12.8 and 20.0 HU for DLR and Hybrid-IR, respectively, p<0.01). In addition, CNR on images with DLR was significantly higher than that on images with Hybrid-IR (median 2.3 and 1.5 for DLR and Hybrid-IR, respectively, p<0.01). Confidence score for liver lesions was significantly higher on images with DLR compared to those with Hybrid-IR (p<0.01).

CONCLUSION
The DLR improved quantitatively and qualitatively image quality of abdominal CT for evaluation of hypervascular hepatocellular carcinoma.

CLINICAL RELEVANCE/APPLICATION
DLR yielded better image quality of abdominal CT compared to Hybrid-IR, indicating that DLR can improve identification and characterization of hypervascular hepatocellular carcinoma.

SSQ08-05 Prior Iterative Reconstruction (PIR) to Lower Radiation Dose and Preserve Radiologist Performance for Multiphase Liver CT: A Multi-Reader Pilot Study

Thursday, Nov. 29 11:10AM - 11:20AM Room: E352

Participants
Bernhard Schmidt, PhD, Forchheim, Germany (Abstract Co-Author) Employee, Siemens AG
Joel G. Fletcher, MD, Rochester, MN (Presenter) Grant, Siemens AG; Consultant, Medtronic plc;
To prospectively evaluate colorectal cancer (CRC) hepatic metastasis detection and characterization between reduced-dose (RD) and standard dose (SD) contrast-enhanced CT (CECT) of the abdomen and to qualitatively compare between reconstruction algorithms.

METHOD AND MATERIALS

Patients with archived projection MCT data with proven malignant or benign liver lesions by reference criteria were included. Reference criteria for malignancy included histopathology or progression/regression, with stability on CT/MR > 6 months required for benign lesions. A validated noise insertion tool created reduced dose MCT images (50% dose in 2 phases, 25% dose in 1 phase). For each patient, the phase of enhancement most relevant to the diagnostic task was selected for evaluation. Four abdominal radiologists reviewed routine dose and lower dose PIR images in randomized and blinded fashion in two reading sessions, interpreting a patient’s images once/session, and marking benign and malignant lesions, rating confidence for malignancy, and scoring image quality metrics. JAFROC Figures of Merit (FOM) were calculated for each dose/reconstruction using -0.10 as a limit of non-inferiority.

RESULTS

30 patients with 27 primary liver malignancies, 6 metastases, and 26 benign lesions were included. Pooled JAFROC FOM for malignancy for routine dose MCT was 0.615 (95% CI: 0.464, 0.767) compared to 0.662 for PIR (95% CI: 0.527, 0.797). The estimated difference between the routine dose and lower dose PIR images was + 0.047 (95% C.I.: -0.023, +0.116). GEE sensitivity and specificity for routine dose images was 70%/68% compared to 73%/66% for lower dose PIR. Lower dose PIR had lower diagnostic image quality (mean 3.8 vs. 4.2, p = 0.0009) and was less sharp (mean 2.3 vs. 2.0, p = 0.0071).

CONCLUSION

PIR is a promising method to substantially reduce radiation dose for multiphase contrast-enhanced abdominal CT, preserving observer performance despite small reductions in image quality. Further work to develop and validate this technique is warranted.

CLINICAL RELEVANCE/APPLICATION

While multiphase CT is of great diagnostic importance, radiation is of concern. PIR is a promising method to reduce radiation dose while maintaining observer performance for multiphase exams.

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**METHOD AND MATERIALS**

Fifty-one adults with biopsy-proven CRC and hepatic metastases by prior CT underwent portal venous phase SD-CECT followed by RD-CECT in the same breathhold. Three readers, blinded to reconstruction details and comparison examinations, performed detection and characterization of lesions 2-15 mm in size on the SD filtered back projection (SD FBP) and RD adaptive statistical iterative reconstruction-V 60% (ASIR-V 60%) series. Readers then qualitatively assessed overall image quality and lesions side-by-side between 8 different reconstructions (SD FBP, SD ASIR 80%, SD ASIR-V 30%, SD ASIR-V 60% and RD model-based iterative reconstruction (MBIR), RD ASIR 80%, RD ASIR-V 30%, RD ASIR-V 60%) on a 0 to -4 Likert scale with 0 being best. Two, non-blinded consensus reviewers established the reference standard.

**RESULTS**

RD-CECT mean CTDInvol was 11.77 ± 3.28 mGy resulting in a mean radiation dose reduction of 53.86% compared to SD-CECT. Of the 260 lesions detected by reference standard (233 metastatic; 27 benign), RD-CECT only detected 82% of lesions, while SD-CECT detected 97% of lesions (p<0.0001); pooled data demonstrated a sensitivity of 0.79 and 0.93 (p<0.0001) and accuracy of 0.75 and 0.84 (p<0.0005), respectively. Mean qualitative scores for each series, in order from best to worst, were SD ASIR-V 60%, SD ASIR-V 30%, SD ASIR 80%, SD FBP, RD ASIR-V 30%, RD ASIR-V 60%, RD ASIR 80%, and RD MBIR.

**CONCLUSION**

Reduced radiation dose CECT demonstrates inferior diagnostic performance for detecting low-contrast liver lesions. Qualitative image evaluation suggests that performance of the RD scan may have been worse had FBP, ASIR or a lower percentage ASIR-V been utilized; the findings also suggest that SD exams benefit from iterative reconstructions.

**CLINICAL RELEVANCE/APPLICATION**

Oncologic CT evaluation of low contrast liver lesions is compromised in the setting of modest radiation dose reduction and iterative reconstructions appear to only partially mitigate this reduced performance. If the clinical task requires the detection of possible small, low-contrast liver lesions, proper radiation dose levels should be maintained with reference to the ACR dose index registry.
SSQ08-08  Quantitative Comparison of Metal Artifact Reduction Techniques in Abdominopelvic CT

Thursday, Nov. 29 11:40AM - 11:50AM Room: E352

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Francesco Macri, MD, PhD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Avinash R. Kambadakone, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose

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PURPOSE
To compare the performance of various metal artifact reduction (MAR) approaches for different metals on low-tube voltage single energy CT, and dual-energy CT exams.

METHOD AND MATERIALS
In this phantom study, seven metal implants from titanium (Ti) or cobalt chromium (CoCr) (n=2 hip prosthesis, n=2 embolization coil, and n=3 spinal hardware) were suspended, sequentially, in an iodinated gelatin medium (0.4%; CT density 40-50HU). The phantom was scanned on three CT scanners (Somatom Definition Flash (scanner A) and Edge (scanner B); Siemens HC, and Discovery 750HD (scanner C); GE HC) using SECT (120/100/80kVp), and DECT (80/140 kVp) acquisitions. SECT images and high-energy (110-140keV) VMC images from DECT were reconstructed with and without vendor-specific MAR algorithms (iMAR; Siemens HC, and MARS; GE HC). Metal-related artifacts/noise (SD) was measured in the near (<3cm) and far (>3cm) fields. Differences among MAR approaches were tested using ANOVA.

RESULTS
Metal-related noise was comparable for Ti and CoCr on 120kVp images from all scanners (p=0.23), except on scanner C, where lower near-field noise was observed for Ti (48±12SD vs. 122±24SD; p<0.01). Higher near- and far-field noise on low-kVp images (37-54%) decreased substantially (63-72%) when using different modes of iMAR (p<0.001). High-keV VMC reduced both near- (16 to 32%) and far-field noise (32-41%) for both metals, with a slight variability between vendors. MARS (on scanner C) showed significant near-field noise reduction (59-91%) for both metals when added to VMC images (p<0.001). However, no effect on far-field noise was observed for Ti (14±8 vs. 13±1SD; p=0.51).

CONCLUSION
CT platforms from different vendors show variable metal-related noise, depending on the metal type. MAR algorithms applied to 80 or 100kVp have significant benefit for noise/artifact reduction and yield lower noise than 120kVp without MAR. While high-keV VMC alone reduce metal-related noise, further reduction is achieved by including MAR algorithms.

CLINICAL RELEVANCE/APPLICATION
Knowledge about existing MAR-approaches is desired for consistent IQ across vendors and to use MAR algorithms tailored to specific types of metallic implants.

Honored Educators
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SSQ08-09  Reducing Bowel Peristalsis Artifact with Dual-Energy CT: A Phantom Study Across Multiple Dual-Energy CT Platforms

Thursday, Nov. 29 11:50AM - 12:00PM Room: E352

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Benjamin M. Yeh, MD, San Francisco, CA (Abstract Co-Author) Research Grant, General Electric Company; Consultant, General Electric Company; Author with royalties, Oxford University Press; Shareholder, Nextrast, Inc; Research Grant, Koninklijke Philips NV; Research Grant, Guerbet SA; 

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PURPOSE
The purpose of this study was to evaluate the ability of different dual-energy CT (DECT) platforms to reduce peristalsis artifact in a bowel phantom.

METHOD AND MATERIALS
In a water filled cylinder we placed a z-direction 1.7 Hz oscillating air filled 3 cm diameter corrugated tube to simulate peristalsing bowel. We scanned the phantom at similar CTDIvol 5 times on each of four different DECT platforms: spectral-detector (SD), rapid-
kVp-switching (RS), split-filter (SF) and dual-source (DS) DECT. Material decomposition (iodine and virtual unenhanced (VUE)) and 120 kVp-like images were reconstructed. On 50 random slices for each scanner, both material decomposition images and 120 kVp-like images were rated for overall artifacts (4-Point Likert-scale: none (0), mild (1), moderate (2), severe (3)) on 50 random slices. The value of material decomposition images to assess pseudoenhancement was rated (reveals pseudoenhancement (0), no added value (1), falsely confirms true enhancement (2)). Comparisons between images and scanners were made using ANOVA with Bonferroni correction.

RESULTS

120 kVp-equivalent images showed moderate to severe artifacts on all 4 DECT platforms, but were less severe for the DS (1.5±0.84) and SF (1.72±0.78) systems than for SD (2.56±0.73, p<0.001) and RS (2.52±0.65, p<0.001). Peristalsis artifacts were markedly reduced in iodine images for SD- (1.00±0.08, p<0.001) and RS-DECT (1.34±0.07, p<0.001), and were unchanged or worse on the VUE images. For DS and SF-DECT artifacts were more severe on both the iodine (2.36±0.14 & 2.6±0.09, respectively) and VUE images (2.38±0.14 & 2.62±0.09, respectively) (p<0.001 for each). Iodine images helped reveal true from pseudoenhancement on SL-detector and RS-DECT on all evaluated slices, but at DS and SF-DECT did not exclude pseudoenhancement.

CONCLUSION

DECT scanners reduce bowel peristalsis artifact. For SD and RS-DECT, iodine images minimize peristalsis artifact and reveals artificial hyperdensities as pseudoenhancement. For DS and SF-DECT, mixed 120 kVp-like images are preferred. Inter-scanner differences likely relate to geometry and postprocessing.

CLINICAL RELEVANCE/APPLICATION

Peristalsis artifact reduction is a valuable benefit of DECT, knowledge of scanner-type allows for selection of appropriate image reconstructions to minimize artifact and associated pseudoenhancement.
**Nuclear Medicine (Technical Innovations and Emerging Opportunities)**

**SSQ14**

**Initial Results From the World’s First Total-Body Positron Emission Tomograph**

**Participants**
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- **Chadwick L. Wright, MD, PhD, Lewis Center, OH** (Moderator) Nothing to Disclose

**Sub-Events**

**SSQ14-01**

**Initial Results From the World’s First Total-Body Positron Emission Tomograph**

**Participants**
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**PURPOSE**

Positron Emission Tomography (PET) offers the most sensitive method for *in vivo* imaging assays of physiologically important compounds, but it is fundamentally limited by low signal and/or high radiation dose to the subject, which negatively impacts image quality, scan times and the kinds of diseases that may be investigated. PET also has the capacity to dynamically track the fate of biomolecules *in vivo*, allowing for pharmacokinetic analysis. However, standard clinical scanners have an axial field of view (AFOV) of 15-30 cm, which limits such analysis to single organs. This research program aims to address all these limitations by building extended AFOV scanners. Here we report initial results from a 194 cm long device - the first medical tomograph capable of simultaneously imaging the entire human body.

**METHOD AND MATERIALS**

The scanner consists of 8 rings of 24 PET detector modules, each containing 5 x 14 detector blocks. Blocks consist of 6 x 7 LYSO crystals of size 2.76 x 2.76 x 18.1 mm³ (total ~560 kg of LYSO), read out by silicon photomultipliers. The PET component is paired with an 80-channel CT scanner. PET detector performance has been characterized and system construction and integration has been completed. Static data from a 200 cm phantom has been acquired and reconstructed to investigate detector response uniformity. A 30-second dynamic scan of activity moving through a tube has also been acquired to verify dynamic frame generation.

**RESULTS**

Detector time-of-flight resolution is 409±39 ps and energy resolution is 11.7%±1.5% at 511 keV. Detector dead-time of 3.5% was found at count-rates similar to those expected in clinical operation. Images of the 200 cm phantom show reasonable uniformity even though not all corrections have been implemented yet. The dynamic dataset shows that frame creation is working as expected.
CONCLUSION
The world’s first total-body PET/CT scanner has been built. Detector performance is in line with expectations. The system is operational and producing images. Implementation and validation of corrections for accurate quantification is under way. Further performance characterization is planned.

CLINICAL RELEVANCE/APPLICATION
Total-body PET aims to improve all clinical PET through ultra-fast (<1min) scans; ultra-low-dose (<0.35mSv) scans; improved image quality; and total-body kinetic modeling for precision medicine.

**SSQ14-02 The Effect of a Novel Bayesian Penalised Likelihood (BPL) PET Reconstruction on the Herder Risk Prediction Model of Malignancy in Solitary Pulmonary Nodules Undergoing Assessment with 18F-FDG PET-CT**

Thursday, Nov. 29 10:40AM - 10:50AM Room: S505AB

Participants
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PURPOSE
The British Thoracic Society (BTS) guidelines recommend using 18F-FDG PET-CT with the Herder model to assess the risk of malignancy in solitary pulmonary nodules (SPNs). Qualitative assessment of FDG uptake in SPNs, using an ordinal scale, integral to the Herder model, is based on analysis of standard Ordered Subset Expected Maximisation (OSEM) reconstruction PET images. Novel PET reconstructions improve image quality by increasing signal-noise ratio and suppressing image noise. Our aim was to assess the impact of a novel Bayesian Penalised Likelihood (BPL) PET reconstruction on the Herder risk prediction model of malignancy in SPNs in comparison with standard OSEM images.

METHOD AND MATERIALS
Subjects with a SPN who underwent 18F-FDG PET-CT between 2014-2017, with assessable OSEM and BPL reconstructions, and either histological confirmation of malignancy or histological and/or imaging follow-up confirmation of benignity were included. Two readers independently and blindly classified FDG uptake in each SPN on both OSEM and BPL images (BTS score; 1=none; 2=MBP but <2x liver; 4=>2x liver). The BTS score in combination with other clinico-radiological features was used to calculate the Herder risk score (%) for both OSEM and BPL images.

RESULTS
97 subjects (age 69±10 years, 52% male, 84% current/former smokers, mean nodule size 16±6mm) with 75 (77%) malignant SPNs were included. There was very good inter-observer agreement for the BTS score for both OSEM (κ=0.85) and BPL images (κ=0.87). BPL images increased the BTS score in 25 (26%) SPNs (20 malignant & 5 benign); 9 SPNs (7 malignant) increased from a BTS score 2 to 3, and 16 (13 malignant) from a BTS score 3 to 4, with a mean increase of 18±22% in Herder risk score. The mean Herder score using BPL images was significantly higher than OSEM for all SPNs (73±29 vs 68±32% respectively, p=0.001), and for malignant SPNs (83±19 vs 78±25%, p=0.004), but not for benign SPNs (42±35 vs 37±34%, p=0.07).

CONCLUSION
The use of BPL PET reconstruction increases the Herder score in approximately 25% of SPNs compared to standard OSEM datasets with the potential to affect subsequent management decisions.

CLINICAL RELEVANCE/APPLICATION
Novel BPL PET reconstruction, compared to standard reconstruction, may increase the estimated risk of malignancy in a SPN, using the Herder model, thus potentially affecting management decisions.

**SSQ14-03 Impact of Point Spread Function Reconstruction on 68Ga DOTATATE PET/CT Quantitative Imaging Parameters**

Thursday, Nov. 29 10:50AM - 11:00AM Room: S505AB

Awards
**Trainee Research Prize - Medical Student**

Participants
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PURPOSE
A total of 38 patients with 42 68Ga DOTATATE PET/CT scans and 125 lesions were included. Scans were reconstructed with and without PSF modulation. For each lesion, one reader measured the maximum and peak standardized uptake value (SUVmax and SUVpeak), metabolic tumor volume (MTV), total lesion somatostatin avidity (TLS), and tumor somatostatin receptor expression heterogeneity (TH) using area under the curve method. Intraclass correlation coefficient (ICC) and Bland-Altman analyses were used to compare PSF and non-PSF values. Subgroup analysis was performed to determine the impact of lesion size.

CONCLUSION

PSF and non-PSF values for 68Ga DOTATATE PET/CT quantitative parameters were highly correlated. PSF reconstruction increased SUVmax and SUVpeak, decreased TH, and had a variable effect on MTV and TLS depending on lesion size.

CLINICAL RELEVANCE/APPLICATION

PSF reconstruction increases SUVmax and SUVpeak and should be considered in evaluating 68Ga DOTATATE PET/CT quantitative parameters for diagnosis and therapy response assessment of NETs.

RESULTS

Mean age of the patients was 55 ± 15 years. 21 patients were male and 17 were female. Of the 42 scans, 11 were baseline scans and 31 were follow-up scans. Of the 125 lesions, 51 were located in the liver, 31 in lymph nodes, 17 in bone, 8 in pancreas, 4 in lung, and 14 in other sites. Correlation coefficients between PSF and non-PSF values were excellent for SUVmax (ICC=0.97), SUVpeak (ICC=0.99), MTV (ICC=0.98), and TLS (ICC=0.99), and was good for TH (ICC=0.81). Comparison of PSF with non-PSF values showed a bias (mean percent change ± SD) of +27.5 ± 14.7% for SUVmax, +15.9 ± 9.5% for SUVpeak, -18.6 ± 37.6% for MTV, +0.8 ± 28.1% for TLS, and -7.1 ± 11.0% for TH. For lesions less than 2 cm in size (n=75), comparison of PSF with non-PSF values showed a bias of +32.7 ± 15.8% for SUVmax, +19.3 ± 9.3% for SUVpeak, -27.9 ± 45.4% for MTV, -1.7 ± 35.4% for TLS, and -5.0 ± 12.2% for TH. For lesions 2 cm or more in size (n=50), comparison of PSF with non-PSF values showed a bias of +19.7 ± 8.0% for SUVmax, +9.8 ± 6.2% for SUVpeak, +0.01 ± 23.1% for MTV, +4.6 ± 8.8% for TLS, and -10.4 ± 7.9% for TH.

CONCLUSION

The use of IMAR in PET/CT significantly improves delineation of both physiological and pathological structures in the vicinity of metal implants in CT. The PET quantification and image quality are not significantly affected by the use of IMAR based attenuation correction.

CLINICAL RELEVANCE/APPLICATION

PSF reconstruction increases SUVmax and SUVpeak, decreased TH, and had a variable effect on MTV and TLS depending on lesion size. SUVmax and SUVpeak, decreased TH, and had a variable effect on MTV and TLS depending on lesion size.
Metal related artifacts impair image quality and increase the risk of missing pathological findings in PET/CT. Lesion delineation is quantitatively and qualitatively improvable by iMAR.

SSQ14-05 PET/CT versus PET/MR: Quantitative Accuracy in Y-90 Dosimetry Analysis

Thursday, Nov. 29 11:10AM - 11:20AM Room: S505AB

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PURPOSE
The purpose of this study is to compare Y-90 dosimetry estimates based on PET/MR versus PET/CT, identify errors in PET/MR dosimetry related to MR-based attenuation correction (AC) and PET detector equipment, and offer methods to avoid these errors.

METHOD AND MATERIALS
An IRB-approved prospective study was performed on eight patients receiving Y-90 radioembolization for liver malignancies. Following the intervention, patients were scanned by PET/CT (Siemens Biograph mCT) and PET/MR (Siemens Biograph mMR). PET/CT scans were performed arms-up, while the PET/MR scans were performed either arms-up, arms-down, or both. AC for PET/CT was derived from a low-dose CT scan. AC for PET/MR was performed with three class segmentation using the Dixon technique. Dosimetry calculations were performed using MIMs 6.5 software (MIM-Software Inc.). PET/CT dosimetry was used as the standard to compare PET/MR dosimetry analysis. Accuracy of PET/MR dosimetry was analyzed in relation to injected activity, background liver and tumor dose, and PET/MR arm location.

RESULTS
PET/MR dosimetry provided accurate dosimetry estimates (within 20% of PET/CT) in the majority of cases. Inaccuracies in PET/MR dosimetry were most pronounced in studies having segmentation errors or truncation errors in the PET/MR AC map, causing inappropriate attenuation correction. Inaccurate PET/MR dosimetry also occurred in cases with high Y-90 injected activity (>3 GBq). Such errors were attributed to the slow characteristics of the Biograph mMR PET detectors given the high singles rate arising from bremsstrahlung x-rays, leading to inaccurate dead-time correction and increased noise and inaccurate corrections for random coincidences. These causes for error can be avoided by ensuring the AC map is accurate, checking for truncation errors, and using Y-90 doses less than 3 GBq.

CONCLUSION
PET/MR can provide accurate Y-90 dosimetry estimates as compared to PET/CT, provided that the injected activity is not excessive and the MR-based AC map has no major errors. Newer technologies, namely high-speed PET detectors using silicon photomultipliers and new atlas-based methods for PET/MR AC, are expected to improve accuracy of PET/MR Y-90 dosimetry.

CLINICAL RELEVANCE/APPLICATION
PET/MR can provide accurate Y-90 dosimetry estimates as compared to PET/CT, provided that the injected activity is not excessive and the MR-based AC map has no major errors.

SSQ14-06 Evolution of PET/MR Protocols Since 2011: A Single-Center Observational Study Including 1797 Examinations

Thursday, Nov. 29 11:20AM - 11:30AM Room: S505AB

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PURPOSE
PET/MR is a versatile hybrid imaging modality especially used for oncologic imaging. Since the introduction of combined PET/MR systems in 2011 this relatively new technology has undergone significant developmental stages and has evolved into a robust clinical modality. The purpose of this study was to record and evaluate the development of clinical PET/MR examinations in our institution with respect to acquisition times, protocol complexity and tracer dosage.

METHOD AND MATERIALS
Essential parameters of 1797 clinical PET/MR examinations were recorded in an institutional database between 01/2013 and 12/2017 including total examination time, PET acquisition time, number of PET bed positions, number of generated images, injected tracer dose and administration of MR contrast agent. All examinations were conducted on a clinical PET/MR system (Siemens Biograph...
mMR, 3 T). PET/MR protocols were iteratively adjusted according to available optimal settings over the observation period. We evaluated the recorded PET/MR parameters with respect to their development over time and with respect to their variation among different examination groups (adult patients, pediatric patients and brain studies).

RESULTS

The 1797 examinations included in the final database consisted of 1004 adult patient studies, 278 pediatric patient studies, and 515 brain studies. Average examination time decreased significantly between 01/2013 and 12/2017 from 75.7±26.7 to 66.6±23.4 min (P < 0.5). Compared to adult patients, the average pediatric examination time was longer but also significantly shortened between 01/2013 and 12/2017 (from 96.8±21.2 min to 84±23.0 min (P < 0.5)). In the same period however, overall examination complexity measured by the number of acquired images significantly increased from 2697 to 3696 acquired images per examination (P < 0.01).

CONCLUSION

PET/MR is a complex and time-consuming imaging modality producing a large number of complex image data. Despite increasing protocol complexity however, examination times were significantly reduced by the introduction of accelerated MR imaging techniques and protocol optimization.

CLINICAL RELEVANCE/APPLICATION

By optimizing examination protocols PET/MR scan times can be reduced, potentially increasing patient comfort and patient compliance, which is particularly important when examining children.

SSQ14-07 Feasibility of “Low Dose MR” Dixon Technique for Imaging FDG PET-MR Lymphoma

Thursday, Nov. 29 11:30AM - 11:40AM Room: S505AB

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PURPOSE

Clinical whole body PET-MR imaging has wrestled with the problem of acquiring high quality multiplanar MR sequences compared to lower resolution fast MR sequences. "Low dose MRI" is a term used in the nuclear medicine community to describe fast acquired PET-MR scan protocols that relied heavily on PET images for diagnosis. In this study, we sought to determine if the Dixon sequences obtained for attenuation correction could be used as a diagnostic sequence for interpreting PET-MRI lymphoma cases.

METHOD AND MATERIALS

We retrospectively identified 40 patients who underwent 88 FDG PET-MR body imaging studies for staging or restaging lymphoma. Brain images were not reviewed. A radiologist and nuclear medicine physician blindly reviewed PET images, attenuation correction coronal Dixon MRI, PET-MR fusion with Dixon, and multisequence (ms) MR, and ms PET-MR images. Lesions were characterized based on location, imaging characteristics, size, max SUV, and malignant potency.

RESULTS

All patients were adults with average study age 43.8 y. Studies consisted of 40 females and 48 males with 7 for staging and 81 for restaging. All patients had systemic lymphoma with 29 being diffuse large B-cell lymphoma. 37 studies had active lymph nodes (LN) on Dixon PET-MR that agreed with ms PET-MR in 33 positive cases (89.1%) having avg SUV 10.2 +/-7.74 SD. 4 Dixon PET-MR cases did not detect lesions, avg SUV 2.3 +/-0.5 SD, read as minimal residual activity, ms MR identified 11 patients with enlarged LN without FDG uptake, not seen on Dixon. All 5 studies with bones lesions were detected by Dixon PET-MR as well as 2 soft tissue cases did not detect lesions, avg SUV 2.3 +/-0.55 SD, read as minimal residual activity. ms MR identified 1 patient with nonactive healed bone lesions. 55 true negative. Compared to ms PET-MR, Dixon had 89.2% sensitivity, 100% specificity with no false positive studies.

CONCLUSION

In this retrospective study, Dixon PET-MR was shown to be sensitive and specific compared to ms PET-MR in the detection of lymphoma. Low number of cases not detected had minimally active LN that resolved on subsequent imaging and probably were not clinically important.

CLINICAL RELEVANCE/APPLICATION

Low dose MRI sequences using the Dixon technique for interpretation may play a role in PET-MR imaging when scan time becomes important. This may be necessary in patients with comorbidity, claustrophobia, or when multiplanar MR of particular areas be necessary.

SSQ14-08 An Unsupervised Dixon-Based Five-Tissue 18F-Sodium Fluoride Synthetic CT Generation for PET/MR Attenuation Correction

Thursday, Nov. 29 11:40AM - 11:50AM Room: S505AB

Participants
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For information about this presentation, contact:
Investigation on PET/MR Image Fusion Mismatch Due to Expanding Bladder: A Pilot Study

Thursday, Nov. 29 11:50AM - 12:00PM Room: S505AB

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PURPOSE
A considerable change of the urinary bladder shape between consecutive bed positions poses a unique challenge on a multi-bed simultaneous PET/MR scan. Our aim is to report our initial experience on the fusion error caused by expanding bladder.

METHOD AND MATERIALS
120 patients (63 males and 57 females, average age = 51.3 years, range 22-70 years) who had been diagnosed with cancer or had previous history of cancer were recruited. Each patients were scanned on a simultaneous whole-body PET/MR system with 5 bed positions (feet in first, 4 bed positions for body and 1 for head). All PET/MR images were visually examined by two independent experts to evaluate the pelvis fusion accuracy with a Likert scale scoring system (1-5, 5 as the best quality).

RESULTS
The mean and standard deviation of the score is 4.57 and 0.75 correspondingly. 14 patients(11.7%) were rated less or equal to 3 by both readers all because of mismatch in the bladder area. This is due to the fact that the bladder area is in the overlap region of PET images from two consecutive bed positions, so the image of the bladder area is a weighted sum of these two PET images based on the sensitivity curve. Because the bladder expanded significantly between these two bed positions, the average of the two very different bladder images cannot match the MRI image from either bed position. This effect is magnified with PET/MR scanning because the scan duration for each bed position is usually significantly longer than that of a PET/CT system due to the limitation of MRI.

CONCLUSION
Our initial clinical results shows that, in most scenarios PET/MRI can achieve very good image fusion accuracy in the pelvis area. However, it is important to know that expanding bladder might cause mismatch between PET and MRI images when the bladder area is in the PET overlap region of two bed positions. Special care might be needed if there is diagnostic interests of the area near bladder. This effect can be avoided by arranging bed position accordingly so that bladder is close to the center of one bed position.

CLINICAL RELEVANCE/APPLICATION
This study provides a guideline for simultaneous PET/MR scan protocol to avoid the fusion error in pelvis area due to expanding bladder.
SSQ17-01  Radiopaque 3D Printing of Patient Phantoms for Computed Tomography and Radiation Therapy

Participants
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Sub-Events
SSQ17

Participants
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PURPOSE
To develop methods for 3D printing realistic anthropomorphic phantoms of individual patients for simulation of patient exposure in computed tomography and radiation therapy.

METHOD AND MATERIALS
In a first step, patient CT images are printed with inkjet technology and radiopaque ink on paper. In a second step, the printed paper sheets are processed with paper based 3D printing methods to mechanically stable phantoms with the attenuation properties and the external contour of the patient. The resulting patient phantoms are examined in the CT scanner (Canon Aquilion One and Aquilion Prime). Acquisition parameters (tube voltage, tube current, acquisition mode, pitch, reconstruction technique) are systematically combined and dose and image quality are analyzed.

RESULTS
Radiopaque 3D printing achieves detailed patient phantoms with individual anatomy and pathology. Phantom Hounsfield units correlate linearly with patient Hounsfield units ($r = 0.9925$) and phantom attenuation values correspond to patient values for different radiation energy levels. Systematic analysis of 72 combinations of acquisition and reconstruction parameters on patient phantoms yields a dose optimum with automated tube potential selection in combination with automated tube current modulation, volume acquisition and iterative reconstruction. Dose reduction potential of iterative reconstruction is $>60\%$ in comparison with filtered back projection.

CONCLUSION
Radiopaque 3D printed patient phantoms provide a detailed simulation of patient exposure and allow systematic investigation of dose and image quality.

CLINICAL RELEVANCE/APPLICATION
Realistic patient phantoms allow systematic development and analysis of dose reduction, optimization and imaging techniques.
**PURPOSE**

Low contrast detectability (LCD) is a metric of fundamental importance in CT imaging, but cannot easily be measured with nonlinear reconstruction methods because concepts such as contrast-noise ratio (CNR), modulation transfer function (MTF) and noise power spectrum (NPS) do not directly apply. We introduce a new framework for rapidly measuring LCD using model observers with a single scan.

**METHOD AND MATERIALS**

We place a large number of low-contrast markers into the field of view and assess their detectability using a model observer. In this work, we used a non-prefiltering (NPW) observer that searches the image for candidate marker locations by subtracting an estimate of the local background signal, convolving with a template disk image, and then identifying local maxima above a response threshold. More sophisticated alternatives to NPW could also be used. By varying the threshold, we can produce free-response ROC curves. We used this framework to compare iterative reconstruction (IR) with filtered backprojection (FBP) in simulations. We also tested the framework on experimental data, fabricating a phantom consisting of small polycarbonate spheres interspersed in acrylic spheres and placed in 13.5% sugar solution. The sugar solution was iso-attenuating with acrylic, leading to a dispersion of low-contrast polycarbonate bead markers of about 20 HU.

**RESULTS**

In simulations with anisotropic noise, IR+NPW showed consistently better performance than FBP+NPW, with sensitivity at one false positive (FP) of 80% compared to 57%. With uniform noise, the difference disappeared and the sensitivities at 1 FP were 70% and 67% for IR+NPW and FBP+NPW, respectively. Experimental scans demonstrated the feasibility of low-contrast automated detection (of polycarbonate spheres) with an easily constructed phantom.

**CONCLUSION**

An objective metric for LCD can be produced by scanning a specialized, target-rich phantom and using model observer software. This framework holds equally well for iterative or analytic reconstruction algorithms, and could be used for comparison of scanners, assessment of new reconstruction algorithms, or routine quality assurance.

**CLINICAL RELEVANCE/APPLICATION**

Automatic detection of LCD could be used in routine quality assurance and could also be used to elucidate conditions (for example, non-uniform statistics) that affect detectability.

**SSQ17-03 Diagnostic Accuracy of Sub-Millisievert Coronary CT Angiography on 16cm Wide-Detector CT Using 70kVp for Patients with High Heart Rate: Comparison with Digital Subtracted Angiography**

**Thursday, Nov. 29 10:50AM - 11:00AM Room: N229**

**Awards**

**Student Travel Stipend Award**

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**PURPOSE**

To investigate the image quality and diagnostic accuracy of coronary CT angiography (CCTA) on a 16cm wide-detector CT using 70kVp for patients with high heart rate using Digital Subtracted Angiography (DSA) as reference standard.

**METHOD AND MATERIALS**

Forty-three patients with heart rates higher than 80 bpm underwent both CCTA on a 256-row, 16cm wide-detector CT (Revolution CT) and DSA. All CCTA scans were acquired in one heart beat with bolus-tracking technique using 70 kVp and automatic tube current modulation for noise index of 36HU at 0.625mm image thickness, and at weight-dependent contrast dose rate of 16mgI/kg/s for 8s injection. Images were reconstructed at the best cardiac phase with the least motion with 80%ASIR-V and with Snapshot Freeze Motion Correction in all patients. Two experienced cardiovascular radiologists and two cardiovascular specialists evaluated the subjective and objective image quality of CCTA study and the DSA results, separately and independently. CCTA performance for diagnosing >=50% stenosis was analyzed against the DSA results. The sensitivity and accuracy of CCTA were calculated. The volumetric CT dose index (CTDvol), dose length product (DLP) were recorded to calculate the effective dose.

**RESULTS**

The mean heart rate was 96.2±17.1 bpm (range: 81-156bpm). The mean effective radiation dose was 0.46±0.21 mSv. All CCTA images were deemed to have diagnostic quality, and 94.2% (650/690) of the coronary segments were analyzed for stenosis. Using DSA as the reference standard, sensitivity and accuracy for diagnosing >=50% stenosis with CCTA were 100% and 90.7% on a per-patient basis. These values were 92.3% and 89.0% on the per-vessel basis and 77.6% and 87.2% on the per-segment basis.

**CONCLUSION**

CCTA on a 16cm wide-detector CT using low tube voltage of 70kVp provides high quality images and high accuracy for diagnosing stenosis at sub-mSv radiation dose even for patients with high heart rates.

**CLINICAL RELEVANCE/APPLICATION**

CCTA with 70kVp on 16cm wide-detector CT that enables 1-beat imaging at sub-mSv radiation may be used to provide high image quality and diagnostic accuracy for cardiac patients with heart rates.

**SSQ17-04 Low Contrast Detectability Observer Study For Four Different Reconstruction Algorithms in CT**
Participants
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PURPOSE
This report performs a comparative human and model observer study for low contrast detectability, following the MITA recommendations. Standard filtered backprojection (FBP) is compared to model based iterative reconstruction (MBIR) and two different methods for noise reduction in image space: edge preserving denoising and deep learning algorithm.

METHOD AND MATERIALS
Data was scanned 50 times at 3 different dose levels each using MITA low contrast module phantom and subsequently reconstructed with the aforementioned four reconstruction methods. We used 120kV scans with 50, 40 and 30 mAs. Dose levels were chosen to be low enough to make the signals seemingly saturated with noise, making the detectability task difficult in standard FBP for a human observer. Eight human observers were asked to review obtained images using 4-alternative-forced-choice method with 3 signal-absent images and 1 signal-present image. The objective was to understand the capability of advanced image reconstruction methods to improve the low contrast detection over the standard FBP reconstruction. The same images were also fed into a publically available model observer tool to understand whether a model observer can be used in place of human observers in the future examinations.

RESULTS
Human observers consistently performed with approximately two times higher detectability indices in images reconstructed using MBIR when compared to the standard FBP. A similar result was also repeated in detectability indices for images denoised by the deep learning method. An edge preserving denoising used in this study had relatively same detectability index as the standard FBP (between 0.8 and 1.2). Model observer technique for low contrast detectability task performed with similar trends as the human observers, but absolute values for the detectability indices were higher by a factor of 1.5.

CONCLUSION
Advanced reconstruction and noise reduction methods can improve the low contrast detectability indices in CT imaging, but not all methods perform the same way. One has to perform tuning when attempting to replace human observers with the model observers.

CLINICAL RELEVANCE/APPLICATION
Low contrast detectability tests with MITA phantom and diagnostic tasks in liver and brain studies are closely related. Clinical users should expect an improved performance in imaging with MBIR and deep learning algorithms, when compared to the standard reconstruction methods.

SSQ17-05 The Weight of ASIR-V in Low Radiation Dose Cranio cerebral CT Scan

Participants
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PURPOSE
To explore the weight of ASIR-V under low radiation dose cranio cerebral CT scan that was comparable that obtained in conventional scanning

METHOD AND MATERIALS
60 Patients who underwent cranio cerebral CT scan were prospectively and randomly divided into two groups. Group A (n=30) use conventional 120kVp scanning protocol while group B (n=30) use 100kVp scanning protocol. The data in Group A were reconstructed with ASIR-V 50% images while the data in Group B were reconstructed with ASIR-V weights of 60%, 80% and 100% images. Three slices were selected in each group of patients. The CT values of bilateral frontal gray matter, parietal gray matter and centrum ovale white matter were measured at the centroid ovale slice. The CT values of bilateral frontal gray matter, temporal lobe gray matter, occipital lobe gray matter, lenticular and white matter were measured at the basilar nucleus slice. The CT values of bilateral cerebellum gray matter, temporal lobe gray matter, and white matter were measured at the cerebellum slice. The ROI were drawn in the front of the forehead to measure the air standard deviations (SD). SD of air is used as the background noise. Three slices of gray/white matter SNR were calculated and the CNR of gray-white matter were calculated. The subjective noise, contrast of gray-white matter and posterior fossa artifacts score was evaluated blindly by two radiologists independently using a 5-point scoring system.

RESULTS
The effective dose in group B (1.02mSv) decreased by 34.3% compared to group A (0.67mSv). Group B with ASIR-V 60% was only higher than group A (p<0.01), and the other was similar to group A (all p>0.05). Gray/white matter SNR with ASIR-V 100% was
higher than group A in the three slices (all p<0.05), and the other was similar to group A (all p>0.05). the gray-white matter-CNR with ASiR-V 80% and 100% was higher than group A in the basilar nucleus slice (all p<0.05), and the other was similar to group A (all p>0.05). There were no significant difference in noise, contrast of gray-white matter and posterior fossa between the Group B with ASiR-V 60% and Group A (all Adjust-p>0.05).

CONCLUSION
The image quality of ASiR-V 60% in group B was similar to group A in objective parameters and subjective evaluation in craniocerebral CT scan.

CLINICAL RELEVANCE/APPLICATION
In craniocerebral CT scan, low radiation dose scan combined with the increased ASiR-V weight could ensure adequate image quality.

SSQ17-06  Low-Contrast Detectability of Clinical CT Images in 3D Reformatted Planes

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PURPOSE
3D reformatted images are frequently generated in clinical CT for diagnostic purposes. Due to the difference between axial and 3D-reformatted images in terms of spatial resolution and noise correlation, it is unknown if the low-contrast detectability of 3D-reformatted images is comparable to that of axial images from the same data. The purpose of this work was to use a Channelized Hotelling Observer (CHO) to evaluate the index of detectability for low-contrast objects of various sizes in the coronal plane compared to in the axial plane.

METHOD AND MATERIALS
A 3D-printed phantom with embedded spheres of various sizes and contrast levels was scanned 50 times on a 192-slice scanner (Force, Siemens) to provide an ensemble dataset for CHO calculation. Images were reconstructed in the axial and coronal planes using filtered backprojection (FBP) with a Br40 kernel and an iterative reconstruction (IR) method (ADMIRE, Siemens) with the same Br40 kernel but two strength settings, Br40-3 and Br40-5. The reconstruction planes were across the center of the spheres. Pixel size was kept the same between reconstructions. A CHO with 12 Gabor channels (previously validated against human observer performance) was used to calculate the index of detectability for low-contrast objects of various sizes in the coronal plane compared to in the axial plane.

RESULTS
For FBP, d’ in the coronal plane was similar to that in the axial plane for both size spheres (9 mm: 5.78±0.58 in coronal vs. 5.87±0.61 in axial; 3 mm: 2.15±0.24 in coronal vs. 1.96±0.25 in axial). When IR was applied, d’ improved over FBP for the large sphere in both planes, but the improvement in the coronal plane was less than that in the axial plane. For the smaller sphere, applying IR appeared to have no effect on d’.

CONCLUSION
Given the same slice thickness and reconstruction kernel, the low-contrast detectability was similar in the axial and coronal planes using the FBP reconstruction. When IR was used, the low-contrast detectability in coronal planes appeared to improve less than that in axial planes, especially for large objects.

CLINICAL RELEVANCE/APPLICATION
Low-contrast detectability in 3D-reformatted planes appears to be similar to that in routine axial planes using FBP reconstruction method. The performance may differ when IR is used.

SSQ17-07  Assessment of Beam-Hardening Artifact Reduction Effect on CT

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PURPOSE
To evaluate the effect of beam-hardening artifacts reduction technologies on 256 Multi-Detector wide-coverage CT and high-definition gemstone spectral CT(HDCT) by comparing the two CT models.

METHOD AND MATERIALS
A cylindrical plastic phantom with 9 hard plastic tubes which were filled with different concentrations(20, 10, 0 mgI/ml) of iodine
solution was used in phantom (the diameter is 18mm), the highest concentration (20mg/ml) is the center of the plastic phantoms, and the other 8 tubes were located clockwise in outer circle. The phantom was scanned using three different modes respectively: 1) a 256 Multi-Detector CT (Revolution CT) scanner equipped with Multi-Material Artifact Reduction (MMAR) technology and Volume High Definition (VHD) image reconstruction technology, which scans by axial mode (Group A), 2) HDCT (Discovery CT) scans with conventional 120kvp mode (Group B) and GSI mode (Group C) were respectively performed. In each of the three groups, ROIs with the same area were placed on regions that were most significantly affected by beam-hardening artifact (between tubes with 20 and 10 mgI, 20 and 10 mgI, 20 and 0 mgI iodine solution). Image noise (SD) in these ROIs were measured and artifact index (AI) was calculated as AI2 = SD2 - SDb2 (SDb was the background noise).

RESULTS
The average image noise in the three groups (Group A, Group B and Group C) were 6.4±0.6, 8.7±2.1 and 2.7±0.2, and the AI were 8.3±0.5, 10.3±1.8 and 6.8±0.1 respectively. Compared with conventional 120kvp mode of HDCT, Revolution CT with VHD technology and MMAR technology, and GSI mode of HDCT can reduce image noise and AI, the effect of GSI mode is better than Revolution CT.

CONCLUSION
Revolution CT scan with VHD technology and MMAR technology, and HDCT-GSI mode can reduce hard-artifact index (AI), and improve image quality, but the effect of HDCT-GSI mode is best.

CLINICAL RELEVANCE/APPLICATION
256 Multi-Detector CT (Revolution CT) with 16 cm wide body detector, by one rotation can complete a single organ (such as the heart, brain, substantial / hollow organs) imaging. It return to the origin of CT scan- axial scan equipped with Multi-Material Artifact Reduction (MMAR) technology and Volume High Definition (VHD) image reconstruction technology for better image quality.

SSQ17-08 Evaluation of CT Image Quality and Liver Lesion Detectability with Different Dose Levels and Different Levels of the Iterative Reconstruction Algorithm ASiR-V

Thursday, Nov. 29 11:40AM - 11:50AM Room: N229

Participants
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PURPOSE
The aim of this study was to optimize image quality and dose levels with different levels of ASiR-V.

METHOD AND MATERIALS
A novel anthropomorphic liver phantom customized for quantitative and qualitative image analysis (Phantom Laboratory, NY US) was scanned at three different dose levels (CTDiVol 15, 10, and 5 mGy) and 120 kVp on a GE Revolution 16 CT scanner (GE Healthcare, Milwaukee, WI US). Images were reconstructed using a standard abdominal kernel and different levels of the iterative reconstruction (IR) algorithm ASiR-V (0-100%). Mean CT values, noise, signal to noise ratio (SNR), contrast to noise ratio (CNR), low contrast detectability and noise power spectrum (NPS) was analyzed. Noise texture deviation (NTD) was evaluated to look at IR specific artifacts. Lesion detectability was assessed on a 5-point scale by 5 readers. The areas under the receiver operating characteristic (ROC) curve were calculated.

RESULTS
Mean CT-values and low contrast detectability did not change with increasing level of ASiR-V. Compared to filtered back projection the noise was reduced while SNR and CNR increased for ASiR-V levels 10-100%. The NTD analysis showed that the mean NTD was not different from NTD calculated for FBP for ASiR-V 10-40 % for CTDI 15 mGy and ASiR-V 10-50 % for CTDI 10 and 5 mGy (p>0.05). Mean NTD increased to be different from FBP for ASiR-V 50-100% for CTDI 15 mGy and ASiR-V 60-100 % for CTDI 10 and 5 mGy (p<0.05). The area under the ROC curve increased with increasing level of ASiR-V. For the CTDiVol 15, 10 and 5 mGy reconstructions with 90%, 80 % and 100% ASiR-V gave the highest area under the ROC curve respectively. Lower dose levels reduced the lesion detectability, low contrast detectability, SNR and CNR. Preliminary analysis of the NPS showed that the peak frequency decreased slightly as the level of ASiR-V increased.

CONCLUSION
This study showed that increasing the level of ASiR-V improved liver lesion detectability when using a standard abdominal kernel. SNR and CNR increased at increasing level of ASiR-V while low contrast detectability remained constant. Noise texture deviation analysis showed that IR artifacts increased for higher levels of ASiR-V (above level 40%).

CLINICAL RELEVANCE/APPLICATION
Iterative reconstruction aims to reduce patient dose in CT. Lesion detectability and image quality need to be assessed to ensure satisfactory examination quality, which was the purpose in this study.

SSQ17-09 Technical Assessment of a Mobile CT Scanner for Image-Guided Brachytherapy: Image Quality, Dose, and Technique Protocols

Thursday, Nov. 29 11:50AM - 12:00PM Room: N229

Participants
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A technical assessment of imaging performance and radiation dose is reported for a recently introduced mobile CT scanner (Airo, Brainlab, Munich, Germany), with application to image-guided brachytherapy. Such quantitative assessment guides selection of technique protocols for pertinent imaging tasks and facilitates translation to new applications.

METHOD AND MATERIALS

Four studies were performed to assess 3D image quality and dose of the system: (1) Objective measures of uniformity and noise (20 cm diameter water phantom), HU accuracy and contrast (tissue-simulating materials (Gammex RMI)), and spatial resolution (modulation transfer function, MTF); (2) Visual image quality using anthropomorphic phantoms with realistic bone and soft-tissue anatomy of the head, chest, abdomen, and pelvis; (3) Image quality and artifacts measured using custom phantoms emulating transvaginal brachytherapy via cylindrical or tandem-and-ring applicators adjacent to soft-tissue; and (4) Radiation dose (CTDI) measured in 16 cm (head) and 32 cm (body) cylinders. Image quality and dose were assessed for manufacturer-specified techniques as well as custom protocols spanning a wide range of kV, mA, scan mode (axial or helical), smoothing kernel, and (optional) metal artifact reduction (MAR).

RESULTS

The technical assessment provided quantitative insight on system performance and limitations. Image uniformity and HU accuracy were within 5%, supporting dose calculation in brachytherapy. Helical scans (1.4 pitch) reduced dose and scan time compared to axial scans, but also reduced z-direction MTF and introduced windmill artifacts about high-contrast structures and instrumentation, diminishing soft-tissue visibility. Contrast and noise performance were sufficient for soft-tissue visualization in brachytherapy of the cervix and uterus. The MAR algorithm greatly improved soft-tissue visualization in the presence of needles and applicators.

CONCLUSION

The imaging system provided excellent accuracy and uniformity with sufficient contrast and spatial resolution for application in transvaginal brachytherapy. The technical assessment identified opportunities for dose reduction (lower kV protocols) and artifact reduction in helical scan mode.

CLINICAL RELEVANCE/APPLICATION

New mobile CT systems can improve precision and safety of image-guided interventions. Rigorous assessment of image quality and dose helps guide adoption and future application of such technology.
Estimating Embryo and Fetal Dose from Abdomen/Pelvis CT Scans That Use Tube Current Modulation

PURPOSE
Estimates of embryo and fetal dose have previously been limited to fixed tube current exams. However, tube current modulation (TCM) is used routinely in clinical practice. Therefore, the purpose of this work is to develop patient size-specific CTDIvol-to-fetal-dose conversion coefficients from TCM abdomen/pelvis (A/P) CT exams of pregnant patients of various gestational ages.

METHOD AND MATERIALS
Twenty-four publicly available voxelized pregnant patient models were used in Monte Carlo (MC) simulations of A/P CT scans using TCM. The models represent a range of gestational ages from less than 5 to 36 weeks and have maternal and fetal anatomy identified from image data. Attenuation characteristics were estimated from simulated topograms of each voxelized patient model. Predicted TCM schemes were then generated for each patient model using a validated method that accounts for both patient attenuation and scanner model characteristics. Embryo and fetal doses were obtained by incorporating each TCM scheme into an MC source model of a 64-slice MDCT scanner, simulating the A/P exam and tallying dose to the fetus. If the fetus was not visible (i.e. early gestational age) then dose to the gestational sac or uterus was used to estimate embryo dose. Water equivalent diameter (Dw) was used as the size metric and was calculated at the image containing the three-dimensional geometric centroid of either the fetus or the gestational sac. All embryo and fetal doses were normalized by scan-specific 32 cm CTDIvol values based upon the average tube current across the entire simulated scan. Normalized embryo and fetal doses were then parameterized as a function of Dw using an exponential function similar to SSDE.

RESULTS
Embryo and fetal doses from the 24 simulated CT A/P exams using TCM demonstrate an exponential relationship between normalized dose and Dw which has a coefficient of determination of 0.79. This relationship is slightly different from that of SSDE, which is not an explicit representation of organ or fetal dose.

CONCLUSION
A method to estimate embryo and fetal dose that account for patient size (through Dw) and TCM has been developed which uses an exponential function similar to SSDE.

CLINICAL RELEVANCE/APPLICATION
Using this methodology, embryo and fetal dose at various gestational ages can be reasonably estimated with the scanner-reported CTDIvol and a metric of patient size such as Dw.

Web-Platform for Fast and Accurate Assessment of Radiation Dose Received by Conceptus in Clinical CT

PURPOSE
Using this methodology, embryo and fetal dose at various gestational ages can be reasonably estimated with the scanner-reported CTDIvol and a metric of patient size such as Dw.
Computed tomography (CT) is sometimes required during pregnancy. In this case the radiation dose received by conceptus should be evaluated. Existing methods are either limited in their accuracy or require complicated measurements and calculations. The aim of this study is to develop a web-based tool for radiation dose assessment received by conceptus in CT; validate this tool and implement it in clinical routine.

**METHOD AND MATERIALS**

The tool is based on the doses derived from Monte Carlo (MC) simulations performed for generic CT system on virtual phantoms, representing a range of various patient sizes and gestational ages. For validation, the values calculated by the online tool were compared against dose values calculated by detailed MC simulations performed on real patients' data. The data for 30 pregnant patients, underwent clinically indicated examinations on CT scanner of two different vendors (Siemens, GE) were collected. Detailed MC simulations took individual patient geometry and scan parameters into account. After the validation the software framework was designed in order to provide the free of charge access to the tool for multiple clients, without installing the software locally. The feedbacks from the users have been collected.

**RESULTS**

The validation of the tool has shown that the average error of the dose values calculated by the online tool was 23%, with the overestimation of about 41% in case of obese patients. The biggest error of 56% was found in patient when additional hardware (i.e., fixation device) was applied and visible in the reconstructed image, resulting in the higher current values applied by the CT system, and thus higher fetal dose values estimated by the program. The users have found the program convenient and intuitive for use in clinical routine. The average time required for calculating single patient case is less than 2 minutes.

**CONCLUSION**

The online platform provides fast and reliable evaluation of the radiation dose, received by conceptus from CT examination.

**CLINICAL RELEVANCE/APPLICATION**

This tool can be used by physicians for fetal dose assessment and performing risk-benefit analysis. It can be also used for training purposes.

**SSQ18-03  The Impact of Scanning Heads Within a Dedicated Head Holder Versus the Table Top on Effective Mas, Image Quality, and CTDI**

**Thursday, Nov. 29 10:50AM - 11:00AM Room: N228**

Participants
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**PURPOSE**

Often, especially in the CT trauma setting, heads must be placed on the table top instead of in a head holder. A head holder attenuates the beam less than the table top requiring less effective mAs to obtain the same image quality. The purpose of this study is to quantify this difference.

**METHOD AND MATERIALS**

264 adult head (193 head holder, 71 table top) head data was collected under IRB approval. The effective mAs and CTDIvol were recorded for each case. Phantom scans were performed with a 16 cm CTDI phantom placed on the table top and in the head holder. Regional (center, top, bottom of the phantom) noise values and regional (center, top hole, bottom hole) CTDI100 values were measured. The use of AEC, which allowed the scanner to account for the extra attenuation of the table versus the head holder, and manual mA were used to scan the phantom. For the human scans, we also documented the presence or absence of patient transport "slider boards" and dental amalgam to evaluate their impact on scanner output.

**RESULTS**

The mean effective mAs for the clinical scans increased by a factor of 1.7 times for heads imaged on the table top relative to the head holder. Statistically significant differences in image noise were observed from the phantom scans for table top versus head holder positioning in manual mA mode. A statistically significant difference in image noise between the top and bottom of the CTDI phantom was observed for table top imaging, but not for head holder imaging indicating noise is more uniform for head holder scans. The presence of dental amalgam and "slider boards" did not cause a statistically significant difference in CTDIvol. Head holder and table top positioning produced statistically significant differences (6% versus 23% respectively) between top and bottom hole CTDI100 measurements.

**CONCLUSION**

This study demonstrates the superiority of using AEC versus a manual technique for head. Using a manual technique inhibits one's scanner from being able to compensate for the attenuation differences between the table and head holder.

**CLINICAL RELEVANCE/APPLICATION**

Using manual mA for head imaging does not account for attenuation differences between table top and head holder patient positioning leading to poorer image quality for the latter.
**SSQ18-04  Clinical Study of Measurement of Mammary Gland Dose Using Organ-Based AEC**

**Participants**
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**CONCLUSION**

For plain chest CT of Japanese women, Organ-Based AEC reduces the exposure dose to mammary glands by 14.6%. Earlier studies, conducted using phantoms, overestimated the reduction effect of Organ-Based AEC.

**Background**

Chest CT requires suppression of exposure to mammary glands. Many reports of earlier studies have described that Organ-Based AEC can reduce the exposure dose by 25-60%. In a report that analyzed CT images retrospectively, it is considered that most of the mammary glands are not included in the dose reduction area. However, these phantom data and simulation studies did not actually measure patients. Therefore, the effect of Organ-Based AEC exposure dose reduction in clinical research has not been clarified. This clinical study measured mammary gland doses using Organ-Based AEC in chest CT. Furthermore, the properties of Organ-Based AEC were examined by phantom study.

**Evaluation**

This observational study examined plain chest CT scans of female patients: 30 using Organ-Based AEC, and 30 not using Organ-Based AEC. Subjects were randomly extracted. Their mammary gland doses were measured. An OSL dosimeter was affixed to 12 patients' breasts. The equipment used was Aquilion ONE® (Toshiba Medical systems). Organ-Based AEC used OEM (Organ Effective Modulation). In the Organ-Based AEC, as the size of the subject became smaller, the reduction effect was also lower. The Organ-Based AEC had the greatest reduction effect in the anterior side of the subject, the reduction effect got lower as approaching the lateral side. In clinical study, results show that 9.18 ± 1.96 mGy doses were received when Organ-Based AEC was used, but 10.76 ± 2.58 mGy doses were received when Organ-Based AEC was not used. The radiation dose reduction ratio of mammary glands was therefore 14.6%.

**Discussion**

The results of phantom studies of earlier studies have a greater dose reduction effect than our clinical studies. The reason is that in the earlier study, part of the mammary gland is out of the dose reduction zone, and it is not considered that the physique affects the reduction ratio of Organ-Based AEC.

**SSQ18-05  How Much Does Low kV Imaging Increase Skin Radiation Dose in Contrast-Enhanced CT? - A Simulation Study on a Virtual Population of Patient Models**

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**PURPOSE**

To compare the effect of utilizing a lower kV setting over a standard high kV setting (70 vs 120 kV) on skin dose in contrast enhanced CT.

**METHOD AND MATERIALS**

The scanner-specific geometry was modeled for a state of the art CT scanner (Revolution CT, GE Healthcare) on a GPU-based Monte Carlo tool based on the MC-GPU framework. This tool was utilized in association with a virtual population of 58 anthropomorphic XCAT patient models (age, 18-78 y.o.; BMI, 18.21–38.81 kg/m2; sex #(M/F), (34/24)) to estimate organ doses for the abdominopelvic protocol (1.375 pitch, 80 mm collimation) at tube voltages of 70 and 120 kV. The organ dose values for both tube voltages were then normalized to a volumetric CTDI value of 12, to make them representative of a typical abdominopelvic scan. In addition to tabulating an average skin dose value for each tube voltage, the ratio of the skin dose to the effective dose (reff) and cumulative dose (rcum) was also computed as additional metrics of dose comparison. The standard deviation for each metric was calculated to represent the dose variability over the virtual patient population.

**RESULTS**

The absorbed dose values for skin were estimated to be 1.49±0.16 and 1.36±0.14 mGy for 70 and 120 kV tube voltages,
respectively. The corresponding values for reff were 0.80±0.12 and 0.59±0.06 respectively. For the same pair of tube voltages, the 
rcum value were 0.030±0.004 and 0.023±0.002. Lowering tube voltage from 120 to 70 kV didn't translate to a statistically 
significant increase in the absorbed skin dose as observed over a virtual population of 58 XCAT patients.

CONCLUSION

The lowering of kv setting from 120 to 70 kV did not lead to a significant increase in skin dose for the virtual patient population, thereby mitigating potential concerns related to the detrimental effects of low kV on skin dose.

CLINICAL RELEVANCE/APPLICATION

CT imaging at lower kV potentially leads to greater dose efficiency and increased image quality, especially for contrast enhanced CT. Concerns about drastic increases in skin radiation dose seem to be overstated with only marginal increases in skin dose.

SSQ18-06 Retrospective Assessment of Radiation Dose in Abdominopelvic CT: Inter- and Intra-Scanner Variability

Thursday, Nov. 29 11:20AM - 11:30AM Room: N228

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PURPOSE

To develop a practical data-crunching solution for retrospectively assessing inter- and intra-scanner variabilities and inconsistencies in abdominopelvic CT dose using clinical patient data.

METHOD AND MATERIALS

This IRB-exempt study evaluated CT abdominopelvic (AP)-related examinations performed in 2016 and 2017 from 12 scanners (4 GE 750 HD, 2 GE VCT, 4 Siemens Flash, and 2 Siemens Definition AS) in 3 site hospitals in an enterprise. An in-house developed informatics system automatically extracted protocol information, patient size (cross-sectional diameter), radiation dose, and in vivo noise magnitude within images. Protocol nomenclature categorization was performed using a decision-tree machine learning algorithm. Dose reference and fit lines were defined for each scanner by using machine learning logistic regression algorithms between dose and patient size. For a predefined reference patient size, Reference dose (RfD: intersect point of dose fit line and reference patient size) and dose deviation index (DDI: a ratio of received dose and ideal dose minus one) were then calculated.

RESULTS

17,000 (Data2016) and 17,000 (Data2017) AP studies for patients ages 0-70 and sizes 13-48 cm were identified. 12 dose reference lines with slopes 0.03-0.1 from Data2016 and 24 dose fitting lines (1th and 99th) from Data2017 were constructed. RfDs were calculated using a reference size of 31 cm and ranged from 466-568 mGy-cm for GE 750 HD, 630-674 mGy-cm for GE VCT, 401-428 mGy-cm for Siemens Flash, and 220-306 mGy-cm for Siemens Definition AS. DDIs ranged from 0.15-0.55. A multi-dimensional metrics compositing the above results was then established and visualized for system performance evaluation across systems.

CONCLUSION

This study offers the first even data-crunching solution for assessing inter- and intra-scanner variabilities in CT dose with clinical patient data. High dimensional metrics built upon patient data are essential for quantitatively assess protocol- and system-inconsistencies as well as optimize the quality, patient safety, and clinical operation.

CLINICAL RELEVANCE/APPLICATION

This study fulfilled an unmet need for quantitative assessment of system-inconsistencies, along with device performance assessment and optimization, to ensure rigorous patient safety and consistent image quality.

SSQ18-07 Explore the Feasibility of 'Four-Low' Scanning Protocol in Coronary Imaging Using Wide-Detector Revolution CT

Thursday, Nov. 29 11:30AM - 11:40AM Room: N228

Participants
Zhijun Hu SR, Xi’an, China (Abstract Co-Author) Nothing to Disclose
Jun Gu SR, Beijing, China (Presenter) Nothing to Disclose
Xin Li, Xian, China (Abstract Co-Author) Nothing to Disclose
Haitao Yu SR, MD, MD, Peking, China (Abstract Co-Author) Nothing to Disclose
Anhui Zhu, Beijing, China (Abstract Co-Author) Nothing to Disclose
Dou Li, Xi’an, China (Abstract Co-Author) Nothing to Disclose
Donghong Wei Sr, Xi’an, China (Abstract Co-Author) Nothing to Disclose
Qi Wang, Xi’an, China (Abstract Co-Author) Nothing to Disclose
Zhen Tang Liu, Xi’an, China (Abstract Co-Author) Nothing to Disclose
Xin Chun Bao II, Xi’an, China (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
41088898@qq.com
**PURPOSE**
To investigate the feasibility of low-kVp, low-contrast medium, low-flow rate, low-dose "four-low'scans for coronary artery imaging using wide-detector Revolution CT.

**METHOD AND MATERIALS**

60 patients underwent coronary artery CT imaging with coronary heart disease diagnosed in our hospital were divided into two groups. Group A use 100 kVp and group B use 80 kVp with 30 cases in each group. Contrast agent iopamidol (370 mgI/mL), both use standard (25 ml/kg/s) iodine flow rate, dose and flow rate calculation formula. Scanning parameters: cardiac axial scan, Smart mA (200-650 mA), NI=26, fixed collimator width 140mm, Auto gating ECG, Pre-Asir-V=70%, Post-Asir-V=80. The CT values and SD standard deviations of aortic root, coronary artery RCA, LAD, LCX proximal lumen and surrounding adipose tissue were measured, SNR, CNR were calculated, CTDI, DLP were recorded, and the effective radiation dose ED was calculated. Subjective evaluations were conducted using a 4-point grading system by two senior-level physicians by double-blind method according to the American Heart Association (AHA) coronary 13 segments. The radiation dose, image quality, contrast agent dosage, and flow rate were statistically analyzed.

**RESULTS**

Age and heart rate in the two groups have no statistical significance (P> 0.05). The two groups of contrast agents were: (41.52±5.14) ml, (22.64±2.70) ml, and group B contrast was 45.5% less than that of group A. The flow rates in the two groups were: (3.45±0.43)ml/s, (1.90±0.21)ml/s, and group B was 44.9% lower than that of group A. ED was: (41.52±5.14) mSv in group A and (22.64±2.70) mSv in group B, group B dose was 41.0% lower than that of group A with statistical significant difference (P<0.05). There was no statistically significant difference in image quality subjective scores at the distal end (P>0.05).

**CONCLUSION**

Low-kVp, low-contrast, low-flow rate, low-dose, CT coronary artery imaging in wide-detectors is feasible. Image quality was not affected and the contrast agent dosage was reduced by 45.5%, the effective radiation dose was reduced by 41.0%, and the flow rate was reduced by 44.9%.

**CLINICAL RELEVANCE/APPLICATION**

The "four-low'scan scheme is feasible in coronary imaging without affecting the image quality. At the same time, the radiation dose, the contrast agent dose, and the injection rate of the contrast agent are greatly optimized and is recommended for clinical promotion.

**SSQ18-08**

**A Comparison of Lung and Breast Doses from CT Scans Using Organ-Based Tube Current Modulation (TCM) vs. Conventional Attenuation-Based TCM Using Monte Carlo Simulations**

Thursday, Nov. 29 11:40AM - 11:50AM Room: N228

Participants

Anthony Hardy, MS, Los Angeles, CA (Presenter) Nothing to Disclose

El Ne Chou, Los Angeles, CA (Abstract Co-Author) Nothing to Disclose

Rick R. Layman, PhD, Houston, TX (Abstract Co-Author) Researcher, Siemens AG

Dianna D. Cody, PhD, Houston, TX (Abstract Co-Author) In-kind support, General Electric Company; Reviewer, ACR CT accreditation program; Researcher, Gammex, Inc

Maryam Bostani, PhD, Los Angeles, CA (Abstract Co-Author) Nothing to Disclose

Christopher H. Cagnon, PhD, Los Angeles, CA (Abstract Co-Author) Nothing to Disclose

Michael F. McNitt-Gray, PhD, Los Angeles, CA (Abstract Co-Author) Institutional research agreement, Siemens AG; ; ; ; ;

**PURPOSE**

Organ-based Tube Current Modulation (TCM) was designed to reduce organ dose to anteriorly-located, radiosensitive organs such as the breast in CT exams. The purpose of this work was use Monte Carlo simulation techniques to compare lung and breast doses from chest CT exams using organ-based (TCM) to those using conventional TCM.

**METHOD AND MATERIALS**

Under IRB approval, raw projection and image data were collected from thirty-four patients (17 females, 17 males) who underwent CT chest/abdomen/pelvis (CAP) examinations employing organ-based TCM (XCARE + CAREDose4D, Siemens Healthineers). The actual organ based TCM schemes for the chest portion were extracted from the raw projection data for each patient. Lung and glandular breast tissue were semi-automatically segmented from patient image data for each case to create voxelized models of patient anatomy for use in a validated Monte Carlo (MC) transport code. Additionally, for these patients, TCM schemes from conventional, attenuation-based modulation only (CAREDose4D) were also estimated using a recently developed method that accounts for patient attenuation characteristics and scanner design. Absolute lung and breast doses for each TCM scenario were estimated for each patient model using MDCT source models in Monte Carlo simulations. The resulting lung and breast doses from each scheme were compared using within-patient percent difference using the from conventional TCM as the reference.

**RESULTS**

The differences of lung and breast dose from organ-based TCM across patients ranged from -35% to 73% and -53% to 45%, respectively. The mean female lung and breast dose differences were -11% and -21%, respectively. The average male lung dose difference was -21%. When pooled, on average, organ-based TCM reduces breast dose by 21% while dose lung dose remained nearly constant with a 5% increase.

**CONCLUSION**

Organ-based TCM may reduce breast dose while not incurring a substantial lung dose penalty when compared to conventional TCM. However, there can be some patients in which this may not be the case and may increase lung dose for men.

**CLINICAL RELEVANCE/APPLICATION**

On average, organ-based TCM may reduce breast dose relative to conventional TCM without increasing lung dose, but some patients may receive higher lung or breast from organ-based TCM.
Coronary CT Angiography Using a 70 kVp Protocol on 16cm Wide-Detector CT: Improved Vascular Enhancement with Reduction of Both Radiation and Contrast Agent Doses

Thursday, Nov. 29 11:50AM - 12:00PM Room: N228

Participants
Yuhuan Chen, MD, Xianyang, China (Presenter) Nothing to Disclose
Taipeing He, Xianyang, China (Abstract Co-Author) Nothing to Disclose
Jianying Li, Beijing, China (Abstract Co-Author) Employee, General Electric Company
Yong Yu, Xianyang City, China (Abstract Co-Author) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (Abstract Co-Author) Nothing to Disclose
Chaochen Li, Xianyang, China (Abstract Co-Author) Nothing to Disclose
Zhen Tang Liu, Xi'an, China (Abstract Co-Author) Nothing to Disclose
Zhijun Hu SR, Xi'an, China (Abstract Co-Author) Nothing to Disclose
Chaowen Li, Xianyang, China (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
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PURPOSE
To investigate image quality, radiation dose, and diagnostic efficiency of prospectively ECG-triggered coronary CT angiography (CCTA) on 16cm wide-detector scanner using 70 kVp with low contrast dose compared with routine 100 kVp CCTA protocol.

METHOD AND MATERIALS
Forty patients (29 men and 11 women; mean age, 55±14 years) received CCTA using either 70 kVp, noise index (NI) of 36HU, and at weight-dependent contrast dose of 16mgI/kg/s rate for 9s injection (Group A, n=20) or the conventional 100kVp, NI of 28HU, and at 25mgI/kg/s rate for 10s injection (Group B, n=20). Adaptive statistical iterative reconstruction (ASIR-V) was used with 80% strength for the 70 kV group and 60% strength for the 100 kV group. All CCTA image quality was evaluated by two experienced cardiovascular radiologists using a 5-point scale (5: best, 1: worst, >=3 scores diagnosable) and signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were calculated and compared. The volumetric CT dose index (CTDIvol) in mGy, dose-length-product (DLP) in mGy-cm of CT scan were recorded. The Mann-Whitney U-test was used to compare the subject image quality scores and the unpaired t-test was used to compare the continuous variables including CT value, SNR, CNR and radiation dose and contrast dose.

RESULTS
There was no significant difference in age, heart rate and body mass index (21.18±2.08kg/m² vs. 22.00±2.33kg/m²) between the two groups (all P>0.05); Mean CT values, SNR and CNR of the two groups were statistically the same(all P > 0.05). Subjective image quality showed no difference between the two groups (P=0.458) with good interobserver agreement (k=0.820). However, there was a significant difference in CTDIvol between Group A (2.20±1.0mGy) and Group B (9.03±5.50mGy) (P<0.05), resulting in 76.1% effective dose reduction for the 70kVp group (Group A) (0.43±0.20mSv vs. 1.80±1.28mSv, p<0.001). Moreover, the contrast dose for Group A was significantly lower than for Group B (22.01±3.11ml vs. 38.21±5.40ml) (P<0.001), a reduction of 42.4%.

CONCLUSION
Our proposed 70kVp CCTA protocol provides diagnostic information with substantial reduction in both radiation and contrast agent doses compared to the routine CCTA at 100 kVp.

CLINICAL RELEVANCE/APPLICATION
CCTA with 70kVp on a 16cm wide-detector CT that reduces both radiation and contrast agent doses while maintaining image quality compared with the routine 100 kVp CCTA protocol.
Hot Topic Session: Biomarker and Personalized Medicine in Lung Cancer Imaging

Thursday, Nov. 29 3:00PM - 4:00PM Room: E350

Participants
Patricia M. de Groot, MD, Houston, TX (Moderator) Nothing to Disclose

Sub-Events

SPSH52A Personalized Medicine and Lung Cancer Biomarkers: The Oncologist's Perspective
Participants
John V. Heymach, MD,PhD, Houston, TX (Presenter) Consultant, AstraZeneca PLC; Consultant, Boehringer Ingelheim GmbH; Consultant, Merck KGaA; Consultant, F. Hoffmann-La Roche Ltd; Consultant, Eli Lilly and Company; Consultant, Merck & Co, Inc; Consultant, Spectrum Dynamics Ltd; Consultant, Guardant; Consultant, Johnson & Johnson; Consultant, Novartis AG

LEARNING OBJECTIVES
1) Describe the goals and current state of personalized therapy for patients with non-small cell lung cancer. 2) Identify the lung cancer biomarkers now in clinical use as well as those in experimental trials. 3) Understand the barriers to optimal selection of individual patient therapy from the clinical and basic research perspective.

SPSH52B Imaging Biomarkers in Non-small Cell Lung Cancer
Participants
Brett W. Carter, MD, Houston, TX (Presenter) Editor, Reed Elsevier;

For information about this presentation, contact:
bcarter2@mdanderson.org

LEARNING OBJECTIVES
1) Identify the imaging manifestations and patterns of disease associated with specific non-small cell lung cancer genetic mutations such as EGFR and KRAS and rearrangements such as ALK on computed tomography (CT) and FDG positron emission tomography (PET)/CT. 2) Describe the role of established response criteria and emerging and novel imaging techniques on the assessment of treatment response in non-small cell lung cancer. 3) Understand the continuously evolving impact of radiogenomics, defined as the linking of medical images with the genomic properties of neoplasms, in predicting the presence of specific genetic alterations, response to therapy, and survival of patients with non-small cell lung cancer.

Honored Educators
Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Brett W. Carter, MD - 2015 Honored EducatorBrett W. Carter, MD - 2018 Honored Educator

SPSH52C Using Artificial Intelligence to Develop Non-invasive Biomarkers in Lung Cancer
Participants
Hugo Aerts, PhD, Boston, MA (Presenter) Stockholder, Sphera Inc

LEARNING OBJECTIVES
1) Learn about the motivation and methodology of AI technologies in lung cancer imaging. 2) Learn about scientific studies investigating the role of radiologic AI with other -omics data for precision medicine. 3) Learn about open-source informatics developments.
LEARNING OBJECTIVES

1) Understand the unique role that quantitative clinical imaging plays as costly, highly effective immunotherapies are increasingly approved by FDA for advanced cancer treatments and their dependence on imaging. 2) Learn the pitfalls confronting joint oncologist-imager teams can expect to encounter during the time course of cancer treatments and the need to modify existing intellectual models used by clinical cancer imagers. 3) By showing specific case examples that distinguish immune cancer treatments from conventional cytotoxic chemotherapies, attendees will comprehend the need to carefully exercise and reserve judgment when analyzing treatment care patterns.

ABSTRACT

Evidence is now accumulating on the use of functional imaging for evaluation of immunotherapy, once this is a treatment option for a wide range of FDG-avid tumors, including: melanoma, colorectal, breast, and lung cancers. New response patterns have arisen with the use of this treatment, which currently represent a challenge for conventional imaging and standard therapy assessment criteria. A delayed response and even a transient tumor enlargement are often seen, and can be misdiagnosed as disease progression. Moreover, unusual side effects may occur and these can be subtle or very difficult to recognize in regular anatomical images, such as CT or MRI. Especially in this scenario, PET/CT plays a pivotal role, since adverse events might be detected earlier, even preceding clinical symptoms. The most common immune-related adverse events such as pneumonitis, hepatitis, pancreatitis, colitis, and nephritis will be discussed. Another out-of-target tumor response is demonstrated, known as the abscopal effect, part of immunomodulation effect of check point inhibitors. This presentation will demonstrate initial assessment; response patterns following immunotherapy, and tumor recurrence using PET/CT illustrative cases. Perspectives on new imaging probes will be addressed as well.

LEARNING OBJECTIVES

1) Brief overview of basic concepts in immunotherapy. 2) To review key points of imaging response patterns according to IRECIST: partial response, complete response, pseudo-progression, and disease progression. 3) To illustrate PET-CT cases with emphasis in response patterns. 4) To recognize immune-related adverse events: pneumonitis, hepatitis, pancreatitis, colitis, and nephritis. 5) Others uncommon events: abscopal effect and sarcoid-like reaction.
For information about this presentation, contact:
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LEARNING OBJECTIVES
1) To understand basic principles of tumor immune responses. 2) To learn MR imaging approaches for the detection of tumor associated macrophages (TAM) in patients. 3) To learn, how to assess tumor response to TAM-modulating cancer immunotherapies.

ABSTRACT

Many malignant tumors, including breast cancer, lung cancer, colon cancer, pancreatic cancer, lymphomas, sarcomas and neuroblastomas (among many others) are associated with an anti-inflammatory tumor microenvironment, which is characterized by infiltration of leukocytes where increases in some leukocyte subsets parallels disease progression and worse clinical outcomes. Tumor-associated macrophages (TAMs) play a key role in this context. New therapeutic drugs that target TAM are currently being developed and are starting to enter the clinic. Therefore, it becomes increasingly important to identify patients whose tumors are heavily infiltrated by TAM. To serve this goal, an imaging test is advantageous over invasive biopsy because it is non-invasive, can cover the whole tumor and can interrogate treatment effects repeatedly in vivo, in patients. Unfortunately, existing clinical imaging tests do not provide a good method for evaluating response to immunotherapies because most immune modulating therapeutics do not cause changes in tumor size, at least not in the immediate post-treatment time period. This presentation will show how TAM can be detected with an immediately clinically applicable imaging approach, using the FDA-approved iron supplement ferumoxytol off label as an MR contrast agent. Our team showed that ferumoxytol nanoparticles exert an initial perfusion effect of the tumor tissue, followed by retention in the tumor via the 'enhanced permeability and retention (EPR) effect' and subsequent phagocytosis by TAM, which results in a marked negative (dark) signal effect on delayed T2-weighted MR images. This can be used to accurately and noninvasively track the degree of macrophage infiltration in a tumor tissue. This new TAM imaging test could represent a significant breakthrough for clinicians as a new biomarker for risk stratification and for monitoring tumor response to novel TAM-modulating immunotherapies. Ferumoxytol is particularly suited for tracking cancer immune responses due to its intrinsic pro-inflammatory effects on the cancer microenvironment.

URL
http://daldrup-link-lab.stanford.edu/

SPSH54D  Assessment of Tumor Dynamics beyond RECIST

Participants
Sean Khozin, MD, Silver Spring, MD (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.
**Imaging of Thoracic Neoplasms: Update 2018 (Interactive Session)**

Thursday, Nov. 29 4:30PM - 6:00PM Room: E450A

**Participants**
Edith M. Marom, MD, Tel Aviv, Israel *(Moderator)* Speaker, Bristol-Myers Squibb Company; Speaker, Boehringer Ingelheim GmbH;

For information about this presentation, contact:
edith.marom@gmail.com

**LEARNING OBJECTIVES**
1) Utilize MR for imaging lung cancer. 2) Evaluate tumor response. 3) Image thymoma. 4) Stage lung cancer with the 8th edition TNM staging.

**Sub-Events**

**RC701A**  **Lung Nodule Management**

Participants
Jin Mo Goo, MD, PhD, Seoul, Korea, Republic Of *(Presenter)* Research Grant, Samsung Electronics Co, Ltd; Research Grant, Lunit Inc

For information about this presentation, contact:
jmgoo@plaza.snu.ac.kr

**LEARNING OBJECTIVES**
1) List the major components in determining lung nodule management. 2) Compare the management guidelines for lung cancer screening and those for incidental nodules. 3) Describe how to measure lung nodules at CT.

**RC701B**  **Lung Cancer Staging: TNM 8th Edition**

Participants
Girish S. Shroff, MD, Houston, TX *(Presenter)* Nothing to Disclose

**LEARNING OBJECTIVES**
1) Review revisions to the TNM staging system. 2) Review how the new TNM staging system addresses lung adenocarcinoma.

**RC701C**  **Advances in MR Imaging of Lung Cancer**

Participants
Yoshiharu Ohno, MD, PhD, Kobe, Japan *(Presenter)* Research Grant, Canon Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Fuji Pharma Co, Ltd; Research Grant, Guerbet SA;

For information about this presentation, contact:
yosirad@kobe-u.ac.jp

**LEARNING OBJECTIVES**
1) Understand the appropriate MR sequence for answering each clinical question, especially lung cancer patients. 2) Identify the clinical relevance of MR imaging as compared with other modalities in not only lung cancer, but also pulmonary nodule and mass. 3) Recognize the potential of state-of-the-art MR imaging for thoracic oncologic patients.

**ABSTRACT**
Since the clinical application of MR imaging in thoracic diseases, numerous basic and clinical researchers reported technical advances in sequencing, scanners and coils, image acquisition and reconstruction techniques, contrast media utilization, and development of post-processing tools. As a result, state-of-the-art thoracic MR imaging now has the potential to be used as a substitute for traditional imaging techniques and/or play a complimentary role in patient management. In this lecture, I will have a lecture for 1) understanding the appropriate MR sequence for answering each clinical question, especially lung cancer patients, 2) demonstrating the clinical relevance of MR imaging as compared with other modalities in not only lung cancer, but also pulmonary nodule and mass, and 3) showing the potential of state-of-the-art MR imaging for thoracic oncologic patients.

**RC701D**  **Evaluating Tumor Response**

Participants
Tina D. Tailor, MD, Durham, NC *(Presenter)* Nothing to Disclose
LEARNING OBJECTIVES

1) Discuss the role of CT for tumor response assessment. 2) Discuss limitations for traditional CT response criteria, including WHO and RECIST. 3) Discuss therapy response in the setting of novel lung cancer therapies, including immunotherapy.

Active Handout: Tina Dinesh Tailor


RC701E Imaging of Thymoma

Participants
Edith M. Marom, MD, Tel Aviv, Israel (Presenter) Speaker, Bristol-Myers Squibb Company; Speaker, Boehringer Ingelheim GmbH;

For information about this presentation, contact:
edith.marom@gmail.com

LEARNING OBJECTIVES

1) Identify an incidental thymoma. 2) Apply the most appropriate imaging modality for the evaluation of thymoma. 3) Assign the newly proposed TNM stage to a newly diagnosed thymoma.

Active Handout: Edith Michelle Marom


Honored Educators

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LEARNING OBJECTIVES

1) Understand the patient preparation issues with performing PET/CT. 2) Review recommendations on patient preparation prior to performing PET/CT. 3) Review the issues in performing PET/CT scans on diabetic patients and learn ways to optimize the glucose level. 4) With the aid of challenging case examples, this activity aims improve PET-CT interpretation through recognition of pitfalls and variants. In addition, it aims to review typical as well as unusual examples of commonly encountered oncologic diagnoses. 5) Learn how to discriminate malignancy from benign FDG-avid changes caused by surgery and procedures, radiation, and chemotherapy.

Sub-Events

RC711A  Interpretive Pitfalls

Participants
Gary A. Ulaner, MD, PhD, New York, NY (Presenter) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd; Research support, Novartis AG

For information about this presentation, contact:
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RC711B  Impact of Patient Preparation

Participants
Don C. Yoo, MD, E Greenwich, RI (Presenter) Consultant, Endocyte, Inc

For information about this presentation, contact:
dyoo@lifesapn.org

RC711C  Effective Reporting and Communication

Participants
Eric M. Rohren, MD, PhD, Houston, TX (Presenter) Nothing to Disclose

For information about this presentation, contact:
Eric.Rohren@bcm.edu

ABSTRACT

F18-FDG PET/CT is a valuable tool for a variety of oncologic applications. The purpose of this educational activity is to discuss the importance of appropriate patient preparation prior to performing oncologic F18-FDG PET/CT scans. The recommendations from the American College of Radiology (ACR), the Society of Nuclear Medicine and Molecular Imaging (SNMMI), and the National Cancer Institute (NCI) for patient preparation will be discussed. Issues that will be discussed include fasting, limiting exercise, hydration, sedation, low carbohydrate meals, and diabetic patients. Patients are typically asked to fast for at least 4 hours before tracer injection for oncologic PET/CT scans. The ACR and SNMMI both recommend checking glucose levels on all patients prior to administration of F18-FDG. SNMMI guidelines recommend that patients with glucose of greater than 150-200 mg/dL should usually be rescheduled. Performing PET/CT scans in poorly controlled diabetic patients can result in a PET/CT scan with an altered biodistribution limiting interpretation of the study. In a poorly controlled diabetic patient with a glucose level of greater than 200 mg/dL, the study should usually be rescheduled if it does not critically affect patient care. Hyperglycemia will dilute the FDG uptake by tumors through competitive inhibition. Subcutaneous insulin should not be administered to a diabetic patient with high glucose within 4 hours of a PET/CT scan as insulin will stimulate FDG uptake by skeletal muscle resulting in an altered biodistribution which can severely limit interpretation.
1) With the aid of challenging case examples, this activity aims improve PET-CT interpretation through recognition of pitfalls and variants. 2) Aims to review typical as well as unusual examples of commonly encountered oncologic diagnoses.

ABSTRACT

Best practices in reporting are a critical aspect of a successful PET program. In this presentation, effective reporting methods will be demonstrated, along with common pitfalls in reporting that should be avoided. Emphasis will be placed on the eight ‘Cs’ of effective reporting: Correctness, Completeness, Consistency, Communication, Clarity, Confidence, Concision, and Consultation.

Honored Educators

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**RC711D Challenging Case Examples**

Participants
Esma A. Akin, MD, Washington, DC (Presenter) Nothing to Disclose

For information about this presentation, contact:
eakin@mfa.gwu.edu

LEARNING OBJECTIVES

1) Review challenging case examples of FDG PET-CT of the abdomen and pelvis with particular emphasis on genitourinary and gynecologic imaging.

ABSTRACT

FDG PET-CT is an effective modality for staging, restaging and treatment follow up of various malignancies. In this session, a review of challenging cases will be presented. Variants and pitfalls that may impact interpretation will be discussed with special emphasis on genitourinary and gynecologic imaging. Updates on imaging and interpretation parameters and guidelines will be reviewed.
Emerging Technology: Imaging of Dementias

Thursday, Nov. 29 4:30PM - 6:00PM Room: S505AB

CT  MR  NR  NM

AMA PRA Category 1 Credit™: 1.50
ARRT Category A+ Credit: 1.75

FDA  Discussions may include off-label uses.

Participants
Rathan M. Subramaniam, MD, PhD, Dallas, TX (Moderator) Consultant, Blue Earth Diagnostics Ltd; Speaker, Blue Earth Diagnostics Ltd

For information about this presentation, contact:
rathan.subramaniam@utsouthwestern.edu

LEARNING OBJECTIVES
1) To review the value of FDG and amyloid PET/CT in the diagnosis of dementia. 2) To review the value of MR imaging in the diagnosis of dementia. 3) To review the value of tau PET/CT in the diagnosis of dementia.

ABSTRACT
This session will review the importance and value of FDG PET, Amyloid PET, MRI and Tau PET imaging in the diagnosis of dementia.

Sub-Events

RC717A  Imaging Dementias 2018

Participants
Rathan M. Subramaniam, MD, PhD, Dallas, TX (Presenter) Consultant, Blue Earth Diagnostics Ltd; Speaker, Blue Earth Diagnostics Ltd

For information about this presentation, contact:
rathan.subramaniam@utsouthwestern.edu

LEARNING OBJECTIVES
1) To discuss the value of FDG brain PET/CT in differentiating various dementias in cognitive decline. 2) To discuss the value of Amyloid brain PET/CT in patients with cognitive decline and Alzheimer's disease.

RC717B  Imaging Dementias: FDG and Amyloid PET/CT

Participants
William A. Moore, MD, Dallas, TX (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Understand which FDA approved MR techniques are currently available for improving differential diagnosis in patients with dementia. 2) Improve basic knowledge of how MR results correspond to clinical dementia phenotypes. 3) Discuss recent technological advances including applications of dynamic susceptibility contrast (DSC) MR, arterial spin labelling (ASL) and resting state functional connectivity MRI (rs-fcMRI) in the setting of patients with dementia.

RC717C  Imaging Dementias: MRI

Participants
Kejal Kantarci, MD, Rochester, MN (Presenter) Data Safety Monitoring Board, Takeda Pharmaceutical Company Limited; Data Safety Monitoring Board, Pfizer Inc.; Data Safety Monitoring Board, Johnson & Johnson; Research funded, Eli Lilly and Company

For information about this presentation, contact:
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LEARNING OBJECTIVES
1) Describe the MRI techniques used in the imaging of cognitive impairment and dementia. 2) Understand the clinical utility. 3) Discuss the findings with pathologic confirmation.

RC717D  Imaging Dementias: Tau PET/CT

Participants
Val J. Lowe, MD, Rochester, MN (Presenter) Research Grant, General Electric Company; Research Grant, Siemens AG; Research Grant, Eli Lilly and Company; Advisory Board, Merck & Co, Inc
LEARNING OBJECTIVES

1) Describe the basic science principles behind tau PET/CT imaging. 2) Understand the utility of tau PET/CT imaging in neurodegenerative disease. 3) Identify the findings of a positive tau PET/CT scan.
**Participants**
Ehsan Samei, PhD, Durham, NC (Coordinator) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc
Lifeng Yu, PhD, Chicago, IL (Coordinator) Nothing to Disclose

**ABSTRACT**
CT has become a leading medical imaging modality, thanks to its superb spatial and temporal resolution to depict anatomical details. New advances have enabled extending the technology to depict physiological information. This has enabled a wide and expanding range of clinical applications. These advances are highlighted in this multi-session course. The course offers a comprehensive and topical depiction of these advances with material covering CT system innovations, CT operation, CT performance characterization, functional and quantitative applications, and CT systems devised for specific anatomical applications. The sessions include advances in CT system hardware and software, CT performance optimization, CT practice management and monitoring, spectral CT techniques, quantitative CT techniques, functional CT methods, and special CT use in breast, musculoskeletal, and interventional applications.

**Sub-Events**

**RC721A Practice Management**

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (Presenter) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Co-owner, LiteRay Medical LLC

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tszczykutowicz@uwhealth.org

**LEARNING OBJECTIVES**
1) Apply the master protocol concept to their CT fleet to obtain protocol performance uniformity. 2) Understand what information is needed to document a CT protocol and how it impacts the diagnostic utility of the resulting CT images and/or CT exam workflow. 3) Apply the CT protocol documentation template and team model discussed in the course to your own CT practice.

**ABSTRACT**
The talk will cover two CT protocol management strategies. The first is called the master protocol concept. The concept groups together phases of indications requiring similar: levels of image quality, body regions, scan times, and contrast enhancement. Once grouped, ‘master’ acquisition parameters can be defined for each master protocol. We will show how this simplifies protocol management across a diverse fleet of CT scanners. In other words, it changes a three phase abdomen CTA protocol from being thought of as composed of three unique sets of acquisition parameters into: abdomen CTA master, then 2 phases using the routine abdomen master. The second management strategy is CT protocol documentation. All parameters and instructions influencing the diagnostic utility and workflow of executing a CT order will be reviewed. This review will motivate a comprehensive definition of what constitutes a CT protocol. Example templates for efficiently documenting this information will be presented so the audience member can implement a CT protocol documentation strategy at their own institution.

**RC721B Practice Optimization**

Participants
Mannudeep K. Kalra, MD, Boston, MA (Presenter) Research Grant, Siemens AG; Research Grant, Canon Medical Systems Corporation

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**LEARNING OBJECTIVES**
1) Problems with practice optimization for CT protocols and radiation dose. 2) Role of personnel and processes for optimizing CT protocols and radiation dose. 3) Best practices in CT practice optimization with a 'regional-indication' based approach.

**RC721C Practice Monitoring**

Participants
Joshua Wilson, PhD, Durham, NC (Presenter) License agreement, Sun Nuclear Corporation
Ehsan Samei, PhD, Durham, NC (Presenter) Research Grant, General Electric Company; Research Grant, Siemens AG; Advisory Board, medInt Holdings, LLC; License agreement, 12 Sigma Technologies; License agreement, Gammex, Inc
LEARNING OBJECTIVES

1) Describe conventional radiation dose monitoring workflows and analytics. 2) Understand the limitations and future potential value of dose monitoring solutions. 3) Identify opportunities for improving clinical operations and consistency using dose monitoring.

ABSTRACT

Recent legislative and accreditation requirements have driven rapid development and implementation of radiation dose monitoring platforms. Multiple solutions are available that require financial commitment and oversight. How can institutions derive added-value, beyond minimum regulatory requirements, from their monitoring program by improving the quality of their clinical performance? Global alert thresholds, the standard in commercial products, naïve to system model and patient size have limited value. Setting a threshold presupposes a clinically-relevant level is known. For an arbitrary level, appropriately-dosed obese patients triggered false alerts, but over-dosed small patients were missed. Numerous study parameters must be retained because chronologic trends, the industry standard, are rarely useful without controlling for other moderators. Dashboards must be interactive enabling dynamic drill-down into cohorts. Dose databases require curation tools and maintenance, largely absent from all solutions, because wrong information will be inadvertently entered, and the utility of the analytics is entirely dependent on the data quality. Dose monitoring can satisfy requirements with global alert thresholds and patient dose records, but a program’s real value is in optimizing patient-specific protocols, balancing image quality trade-offs that dose-reduction strategies promise, and improving the performance and consistency of a clinical operation.
CT Radiation Dose Reduction: Techniques and Clinical Implementation

Friday, Nov. 30 8:30AM - 10:00AM Room: E253CD

Participants
Lifeng Yu, PhD, Chicago, IL (Coordinator) Nothing to Disclose

For information about this presentation, contact:
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LEARNING OBJECTIVES
1) Review techniques that are currently available for radiation dose reduction. 2) Understand general dose management and optimization strategies and how they are implemented in adult CT. 3) Understand strategies to optimize scanning protocols in pediatric CT.

ABSTRACT
This course will provide an overview of techniques and clinical implementations of radiation dose reduction in CT.

Sub-Events

RC823A Overview of Technology for Radiation Dose Reduction

Participants
Joseph W. Stayman, PhD, Baltimore, MD (Presenter) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc; Research Grant, Elekta AB; Research collaboration, Fischer Medical; Research Grant, Medtronic plc; Research collaboration, Koninklijke Philips NV; Research Grant, Siemens AG

LEARNING OBJECTIVES
1) Identify targets for radiation dose reductions in x-ray CT. 2) Gain an understanding of dose reduction strategies based on innovations in hardware design and development. 3) Gain an understanding of dose reduction strategies based on data processing chain improvements including iterative reconstruction methods. 4) Understand some of the trade-offs in dose reduction as well as limitations on dose reduction.

RC823B Dose Optimization Strategy and Clinical Implementation in Adult CT

Participants
Lifeng Yu, PhD, Chicago, IL (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Introduce dose management and optimization strategies in adult CT. 2) Describe how dose reduction techniques are clinical implemented in adult CT, including neuro, chest, abdominal, cardiovascular, and MSK.

RC823C Dose Reduction and Protocol Optimization in Pediatric CT

Participants
Robert MacDougall, MSc, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Recognize the important of clinical indication on CT protocol design. 2) Describe the different commercial implementations of kV and mA modulation algorithms and understand methods of standardizing image quality across platforms. 3) Understand the effect of reconstruction algorithms on acquisition parameter selection in pediatric CT.
International Symposium in Musculoskeletal Radiology (In Conjunction with Asian Musculoskeletal Society (AMS), European Society of Musculoskeletal Radiology (ESSR), German Society of Musculoskeletal Radiology (DGMSR), International Skeletal Society (ISS), Korean Society of Musculoskeletal Radiology (KSMR) and Society of Skeletal Radiology (SSR))

Friday, Nov. 30 9:30AM - 12:30PM Room: E450A

**CT**  **MR**  **MK**

**AMA PRA Category 1 Credits ™**: 3.00  
**ARRT Category A+ Credits**: 3.50

FDA Discussions may include off-label uses.

### Sub-Events

**SPIS61A**  **Top Tips in MSK Radiology: MSK Techniques**

Friday, Nov. 30 9:30AM - 10:30AM Room: E450A

Participants  
Laura W. Bancroft, MD, Orlando, FL (Moderator) Author with royalties, Wolters Kluwer nv; Speaker, World Class CME; Editor, Thieme Medical Publishers, Inc; Travel support, Thieme Medical Publishers, Inc 

For information about this presentation, contact:  
laura.bancroft.md@flhosp.org

**LEARNING OBJECTIVES**

1) Review the salient imaging features of some of the most commonly encountered musculoskeletal diagnoses.

**SPIS61B**  **Top Tips to Reduce Artifacts in MSK MRI**

Friday, Nov. 30 9:30AM - 9:45AM Room: E450A

Participants  
David A. Rubin, MD, Saint Louis, MO (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Recognize the source of common artifacts on MSK MIR images. 2) Anticipate artifacts before they occur. 3) Devise simple interventions to reduce or eliminate artifacts without sacrificing time or SNR. 4) Communicate with their technologists regarding MRI techniques.

**SPIS61C**  **Top Tips for Functional MRI**

Friday, Nov. 30 9:45AM - 10:00AM Room: E450A

Participants  
Won-Hee Jee, MD, Seoul, Korea, Republic Of (Presenter) Research Grant, Bayer AG

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**LEARNING OBJECTIVES**

1) Describe the role of functional MRI in MSK imaging. 2) Apply functional MRI to MSK imaging in clinical practice. 3) List the top benefits of functional MRI in MSK imaging.

**SPIS61D**  **Top Tips for MR/CT Arthrography**

Friday, Nov. 30 10:00AM - 10:15AM Room: E450A

Participants  
Reto Sutter, MD, Zurich, Switzerland (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Know and assess indications of MR and CT arthrography for different joints. 2) Identify the classic approaches for joint injections. 3) Compare the benefits of MR and CT arthrograms versus non-contrast MR and CT imaging. 4) Recognize diagnostic pitfalls of MR and CT arthrography.
**LEARNING OBJECTIVES**

1) Review the imaging characteristics of commonly encountered musculoskeletal entities with similar or overlapping features.

**Top Pitfalls in Fracture Diagnosis**
Friday, Nov. 30 10:30AM - 10:45AM Room: E450A

Participants
Mini N. Pathria, MD, San Diego, CA (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Develop a systematic approach to evaluating radiographs in the injured patient, focusing on soft tissue indicators of injury, articular alignment, and assessment of the bone cortex. 2) Detect patient characteristics (such as advanced age etc) and imaging limitations (poor positioning etc) that lead to interpretation errors. 3) Identify radiographic imaging findings that indicate underlying musculoskeletal injury and the need for further imaging.

**Active Handout:** Mini Nutan Pathria


**Top Pitfalls in Groin Pain**
Friday, Nov. 30 10:45AM - 11:00AM Room: E450A

Participants
Philip Robinson, MBChB, Leeds, United Kingdom (Presenter) Director, The LivingCare Group

**ABSTRACT**

Groin pain in the athlete is a complex process with different surgical and radiological researchers focusing on different structures in the hope of identifying the primary cause for chronic groin pain. There is a resulting confusion over terminology with, for example, osteitis pubis, adductor pain and sportsman's hernia encompassing many different potential conditions for different clinicians. In reality there is a lot of crossover with many or all of the anatomical region thought to be involved by chronic shearing forces acting through the symphysis pubis and surrounding soft tissues contributing to the development of groin pain. Research is also now increasingly showing that previous imaging findings thought to be pathognomonic for groin pain are found in asymptomatic kicking athletes. This talk will review such potential pitfalls and offer a reporting strategy.

**Top Pitfalls of Osteoporosis**
Friday, Nov. 30 11:00AM - 11:15AM Room: E450A

Participants
James F. Griffith, MD, Shatin, Hong Kong (Presenter) Nothing to Disclose

**Top Tips in MSK Radiology: MSK Pitfalls**
Friday, Nov. 30 10:30AM - 11:30AM Room: E450A

Participants
Jung-Ah Choi, MD, Seoul, Korea, Republic Of (Moderator) Research Grant, Bracco Group; Andrew J. Grainger, MRCP, FRCR, Leeds, United Kingdom (Moderator) Consultant, Levicept Ltd; Director, The LivingCare Group;

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andrewgrainger@nhs.net

**LEARNING OBJECTIVES**

1) Explain the biomechanics and functional anatomy of the anterior pelvis (groin) in relation to athletes. 2) Compare the theories and nomenclature for the pathogenesis of chronic groin pain in athletes. 3) Contrast the Imaging findings in symptomatic and asymptomatic athletes focussing on MR imaging. 4) Critique the interpretation of these findings and what research shows they relate to in terms of diagnosis, prognosis and decision making for treatment.

**Top Tips in MSK Radiology: MSK Research Trends**
Friday, Nov. 30 11:30AM - 12:30PM Room: E450A

Participants
James F. Griffith, MD, Shatin, Hong Kong (Moderator) Nothing to Disclose
Lawrence M. White, MD, FRCPC, Toronto, ON (Moderator) Nothing to Disclose

For information about this presentation, contact:
LEARNING OBJECTIVES
1) Review some of the common musculoskeletal research trends with current clinical applications in patient care.

**SPIS61L  Top Trends in Tumor Imaging**
Friday, Nov. 30 11:30AM - 11:45AM Room: E450A

Participants
Takatoshi Aoki, MD, PhD, Kitakyusyu, Japan (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Review the advanced techniques in musculoskeletal oncology. 2) Describe the radiomics for bone and soft tissue tumor imaging. 3) List the newly updated entities of bone and soft tissue tumors.

**SPIS61M  Top Trends in Marrow Imaging**
Friday, Nov. 30 11:45AM - 12:00PM Room: E450A

Participants
Frederic E. Lecouvet, MD, Brussels, Belgium (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Identify achievements, indications and future developments of whole skeleton MRI in oncology. Know new treatment paradigms and expectations from imaging in oncology. 2) Understand the growing importance of multiparametric approaches and radiomics in oncologic marrow imaging. 3) Differentiate various spontaneous epiphyseal lesions sharing bone marrow edema at MRI as common feature. 4) Understand the prognostic role of MRI. 5) Identify the upcoming technical developments and new indications of MRI and dual energy CT in bone marrow pathology.

**SPIS61N  Top Trends in Extremity Imaging**
Friday, Nov. 30 12:00PM - 12:15PM Room: E450A

Participants
Christine B. Chung, MD, La Jolla, CA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Identify current challenges and gaps in clinical practice for evaluation of musculoskeletal tumors, bone marrow and extremity pathology. 2) Apply novel imaging and post-processing techniques that improve diagnosis and characterization of musculoskeletal tumors, bone marrow and extremity pathology.

**SPIS61O  Discussion**
Friday, Nov. 30 12:15PM - 12:30PM Room: E450A
PARTICIPANTS

Grish S. Shroff, MD, Houston, TX (Moderator) Nothing to Disclose
Andrew J. Plodkowski, MD, Brookside, NJ (Moderator) Nothing to Disclose

SUB-EVENTS

SST02-01 Radiologist Variability in the Determination of the T-Size Descriptor Cutpoints in the Eighth Edition of the TNM Classification of Lung Cancer (TNM8)

Friday, Nov. 30 10:30AM - 10:40AM Room: E350

Participants

Julia Hine, MBBS, London, United Kingdom (Presenter) Nothing to Disclose
Anouchka Goldman, MBBS, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Jie-Ying Kowa, MBBS, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Sarah L. Sheard, MBBS, FRCR, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Konstantinos Stefanidis, MD, PhD, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Sisa Grubnic, MD, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Joanna Moser, MBChB, FRCR, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Ioannis Vlahos, MRCP, FRCR, London, United Kingdom (Abstract Co-Author) Research Consultant, Siemens AG Research Consultant, General Electric Company

PURPOSE

Based on pathological size TNM8 introduced additional T-descriptor size cutpoints at 1cm intervals impacting stage groups. Our aim was to determine whether radiological staging by different radiologists consistently classifies lesion size within this more detailed staging.

METHOD AND MATERIALS

4 thoracic radiologists (4-17yr experience) staged 180 consecutive new lung cancers, recording multiple parameters blinded to the study aim. Readers were provided with axial 2.5mm, 1mm, coronal and sagittal 3mm images and asked to stage the primary as per clinical practice. Readers recorded the solid component for subsolid lesions. 2 observers covertly recorded the image series used for review and measurement. Inter-rater consistency of primary lesion size and T-size determination was evaluated. The impact of reader recorded lesion characteristics on consistency was assessed.

RESULTS

Readers recorded lesions as solid in 78-87% of cases, part-solid in 11-17% and pure ground glass in 1-2% with a moderate mean inter-rater kappa (0.71). 176 lesions were considered measurable by at least 3 readers (median 38mm, 7-113mm), 95% evaluated by all 4 readers. Readers varied widely in measurement plane (2.5mm:20-90%, 1mm:2-54%, coronal:7-24%, sagittal:0-26%) and mean number of planes reviewed (1.1-3.0). For lesions the mean range of measurement about the consensus median size was 31% (3-175%). Increased reader range of measurement about the median size was associated with part solid (mean 43% v 29% solid, p<0.01 Mann Whitney U) and cavitory lesions (32 v 19%, p<0.05). Atelectasis and spiculation were not significant. Using median size to determine T-descriptors, only 42% of cases had 100% reader concordance (74% concordance for at least 67% of readers). Complete concordance was significantly lower for groups T1c-T3 (20-35%) and higher in the remaining groups (42-67%). Mean inter-rater T assignment kappa was 0.57 (moderate), but higher with weighted kappa (0.80, good).

CONCLUSION

There is considerable variation in tumor size determination by thoracic radiologists, influenced by lesion perceived morphology, and measurement choices that result in lower inter-reader concordance for the narrower range TNM8 T-size criteria.

CLINICAL RELEVANCE/APPLICATION

Pathological size data informed increased numbers of cutpoints in TNM8 to better predict survival but increases radiological stage uncertainty and inter-reader variance in clinical practice.

HONORED EDUCATORS

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Ioannis Vlahos, MRCP, FRCR - 2015 Honored Educator
A Novel Algorithm to Approach Multiple Lung Cancers with Multiple Pulmonary Sites of Involvement: Differentiation between Multiple Primary Lung Cancers and Intrapulmonary Metastasis

Friday, Nov. 30 10:40AM - 10:50AM Room: E350

Participants
Young Joo Suh, MD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Hyun-Ju Lee, MD, PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jiseon Oh, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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PURPOSE
To develop an differentiation algorithm in patients with multiple lung cancers, using clinical and imaging variables.

METHOD AND MATERIALS
We retrospectively included 112 lesions in 55 patients (57 pairs) with multiple lung cancers who received at least two separate surgeries between January 2007 and December 2016. Each pair of multiple lung cancers was classified into two categories with histopathologic findings as the standard reference: multiple primary lung cancer (MPLC) and intrapulmonary metastasis (IPM). We established five serial questions for differentiation; ‘Is either nodule pure ground-glass nodule on CT?’ or ‘Are both of the two lesions ground-glass dominant nodules?’ (Step1), ‘Does either nodule harbor air-bronchogram or irregular shape?’ (Step2), ‘Do both of the two nodules have the same or different grade of maximal standardized uptake values (SUVmax) on PET/CT?’ (Step3), and ‘Does either case harbor mediastinal LN or distant metastasis on preoperative work-up?’ (Step4). The SUVmax values were classified into grade 1(<2.5), grade 2(2.5-5.0), and grade 3(>5.0). At each decision step, each pair was classified as MPLC or IPM. The sensitivity, specificity, and accuracy of the differentiation algorithm were analyzed.

RESULTS
Among 57 pairs, 36 pairs (63.2%) were classified as MPLCs, and the other 21 pairs (26.8%) as IPMs of standard reference. In step1, 14 pairs were classified as MPLC. In step2, 10 pairs with absence of air-bronchogram or irregular contour on both lesions were classified as IPM. In step3, 8 pairs showing two grades of separate SUV were classified as MPLC. In step4, 3 pairs with mediastinal LN or distant organ metastasis were classified as IPMs and 22 pairs were considered MPLC. The sensitivity for MPLC (specificity for IPM), specificity for MPLC (sensitivity for IPM), and accuracy were 94.4%, 52.4%, and 78.9%, respectively. Accuracy for each step was 100% for step 1, 90% for step 2, 62.5% for step 3 and 68% for step 4, respectively.

CONCLUSION
Approach algorithm using comprehensive information and imaging variables can allow differentiation between MPLCs and IPMs in a substantial number of cases of multiple lung cancers with multiple pulmonary sites of involvement.

Risk of Occult Mediastinal Disease in Non-Small Cell Lung Cancer Patients with Radiographic N0 Disease according to Tumor Location

Friday, Nov. 30 10:50AM - 11:00AM Room: E350

Participants
Dongyoung Jeong, MD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Sun Hye Shin, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Yeonu Shin, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jiyeon Lee, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Lung cancer guidelines recommend invasive mediastinal staging for patients with centrally located tumors without evidence of nodal disease on imaging studies. However, there is no uniform definition of central tumor. This study aims to evaluate the risk of occult mediastinal disease in non-small cell lung cancer (NSCLC) patients with radiographic N0 disease according using several different definitions for central tumor.

METHOD AND MATERIALS
Of the patients who underwent curative-intent surgical resection or endobronchial ultrasound-guided transbronchial needle
aspiration between January 2014 and December 2015, 1,337 consecutive patients with radiographic N0 disease were identified. Based on the most proximal part of the tumor in computed tomography (CT) image, tumors were categorized using five different definitions; contact with hilar structure, located within inner one-third or two-thirds of hemithorax according to concentric or sagittal lines.

RESULTS
About 7% (93/1337) of patients had occult N2 disease and they had significantly larger tumor size and more solid tumors in CT image. All but inner two-thirds of hemithorax by sagittal line were associated with N2 disease. However, only inner one-third of hemithorax by concentric line remained significant after adjustment for tumor size and density in CT (adjusted odds ratio [95% confidence interval], 2.29 [1.28-4.11]).

CONCLUSION
We suggest using inner one-third of hemithorax by concentric line as indication of EBUS-TBNA in NSCLC with radiographic N0 disease.

CLINICAL RELEVANCE/APPLICATION
Using inner one-third of hemithorax by concentric line as indication of EBUS-TBNA in NSCLC with radiographic N0 disease.

SST02-04 Comparison of Computed Tomography and Clinical Findings Between Immune-Related Pneumonitis and Pneumonia by Pathogen in Patients Treated with Anti-Programmed Death-1 (PD-1)/Programmed Death Ligand 1 (PD-L1) Therapy

Friday, Nov. 30 11:00AM - 11:10AM Room: E350

Participants
Cherry Kim, MD, Ansan, Korea, Republic Of (Presenter) Nothing to Disclose
Mi Young Kim, MD, PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Chang-Min Choi, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Yeon Joo Kim, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

PURPOSE
Immune-related pneumonitis (IRP) is an uncommon but potentially fatal toxicity of anti-programmed death-1 (PD-1)/programmed death ligand 1 (PD-L1) therapy for intrathoracic malignancy including non-small cell lung cancer. The purpose of study was to compare CT and clinical findings between IRP and pneumonia by pathogen.

METHOD AND MATERIALS
A total of 154 patients who received anti-PD-1/PD-L1 therapy were identified from 2014 to 2017. Among these patients, IRP developed in 9 (5.8%) and pneumonia in 30 (19.5%), which were confirmed through multidisciplinary approach. CT findings (reticulation, consolidation, ground opacity [GGO], interlobular septal thickening, micro- [<10mm] and macro-nodules [>=10mm], bronchial wall thickening, bronchiectasis, pleural effusion, and lesion distribution/bilaterality) and clinical features (symptom, smoking history, cancer staging, laboratory findings, underlying disease, prior radiotherapy history) were compared between IRP and pneumonia. Grade and outcome of IRP were also investigated.

RESULTS
In chest CT, diffuse reticulation (44.4% vs.0%, P=0.02), patchy/diffuse GGO (100% vs. 50%, P=0.01), and interlobular septal thickening (66.7% vs. 10%, P=0.002) were significantly more frequent in IRP than in pneumonia, whereas macronodule (0 vs. 36.7%, P=0.033) was significantly more common in pneumonia than IRP. IRP significantly showed peripheral location (77.8% vs. 16.7%, P=0.001) and bilateral distribution (44.4% vs. 3.3%, P=0.007). However, there were no significant differences in clinical findings between IRP and pneumonia. Among the IRP patients, 66.7% (6 of 9) of cases were grade 3, and 66.7% improved with drug holding/steroid therapy. The median onset duration of IRP from the first prescription was 126 days (range, 40-669), the median time for improvement was 43 days (range, 21-45), and the median time to death due to IRP was 18 days (range, 11-55).

CONCLUSION
Several CT findings including diffuse reticulation, patchy/diffuse GGO, and interlobular septal thickening with bilateral and peripheral distribution were more frequent in IRP than pneumonia by pathogen. Clinical findings were overlapped.

CLINICAL RELEVANCE/APPLICATION
It is crucial to suspect IRP as opposed to pneumonia in routine practice. Radiologists should be familiar with those findings of IRP to avoid delayed diagnosis and serious drug related complication.

SST02-06 Growth Rates of Thymic Epithelial Tumor and Thymic Cyst: Is Differentiation Feasible?

Friday, Nov. 30 11:20AM - 11:30AM Room: E350

Participants
Hyungjin Kim, MD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Soon Ho Yoon, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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Kyung Won Lee, MD, PhD, Seongnam, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Ye Ra Choi, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jin Mo Goo, MD, PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Research Grant, Samsung Electronics Co, Ltd; Research Grant, Lunit Inc

PURPOSE
Growth Rates of Thymic Epithelial Tumor and Thymic Cyst: Is Differentiation Feasible?
To investigate the growth rate of thymic epithelial tumors (TETs) and thymic cysts to determine whether they can be differentiated, and to identify clinico-radiological predictors of interval growth and their differential implications.

METHOD AND MATERIALS
This retrospective study included 122 patients (male:female=64:58; mean age, 57.2 years) with pathologically proven thymic cysts (n=56) or TETs (n=66) who underwent 2 serial chest CT scans at least 8 weeks apart. Average diameters were measured, and volume-doubling times (VDTs) were calculated. Attenuation was also measured and clinical characteristics were recorded. VDTs were compared between the thymic cysts and TETs using the log-rank test. Predictors of growth were analyzed using the log-rank test and Cox regression analysis.

RESULTS
The frequency of growth did not significantly differ between TETs and thymic cysts (P=0.279). The VDT of the thymic cysts (median, 324 days) was not significantly different from that of the TETs (median, 475 days; P=0.808). Water attenuation (<=20 Hounsfield Unit) predicted growth in thymic cysts (P=0.016; HR, 13.2 [95% CI, 1.6-107.3]) and lesion size (>17.2 mm) predicted growth in TETs (P=0.008 for size and P=0.029 for size*time; HR=e^(-0.001×time+1.654)). Among the growing lesions, positive and negative predictive values of water attenuation for the thymic cysts was 93% and 80%, respectively.

CONCLUSION
The frequencies of interval growth and VDTs were indistinguishable between TETs and thymic cysts. Water attenuation and lesion size predicted growth in both thymic cysts and TETs, respectively. Among the growing lesions, the water attenuation was a differential feature of thymic cysts.

CLINICAL RELEVANCE/APPLICATION
Water attenuation (<=20 HU) indicates thymic cysts for the growing thymic lesions. Thus, CT follow-up, instead of surgical resection, can be recommended for the obvious cysts even if they show interval growth.

SST02-07 Cut-Off Value of MR Enhancement for Differentiating Benign Cysts from Solid Anterior Mediastinal Lesion: A Preliminary Observation

Friday, Nov. 30 11:30AM - 11:40AM Room: E350

Participants
Eui Jin Hwang, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Soon Ho Yoon, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jihang Kim, MD, Seongnam, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Ho Yun Lee, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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Munyoung Paek, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jeanne B. Ackman, MD, Boston, MA (Abstract Co-Author) Spouse, Stockholder, Everest Digital Medicine; Spouse, Consultant, Everest Digital Medicine; Spouse, Stockholder, Cynvenio Biosystems, Inc; Spouse, Scientific Advisory Board, Cynvenio Biosystems, Inc; Spouse, Consultant, PAREXEL International Corporation

For information about this presentation, contact:
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PURPOSE
To determine the optimal cut-off value of MR enhancement for the differentiation of benign cysts from solid lesions in the anterior mediastinum.

METHOD AND MATERIALS
The derivation dataset consisted of 19 consecutive patients with pathologically proven benign cysts (n=7) and solid lesions (n=12) in the anterior mediastinum who underwent a diagnostic contrast-enhanced MR from two institutions. We measured maximum diameters, T1 and T2 signal intensities (SI), apparent diffusion coefficients (ADCs) from diffusion-weighted images, and relative enhancement ratios (RERs). T1 and T2 SIs were normalized by SI of cerebrospinal fluid. RERs were obtained from the subtraction of axial pre- and post-contrast T1-weighted fat-suppressed images after the precise non-rigid image registration of the two images using a dedicated WIP software (MRI Arithmetic, Siemens Healthcare, Erlangen, Germany). After comparison of image variables between cysts and solid masses, the cutoff value of the most differential MR variable was determined based on a receiver operating characteristic curve. For validation, two separate datasets were utilized: 1) 15 patients with 8 cysts and 7 solid lesions from another institution (validation dataset 1); 2) 11 patients with MR-proven stable benign cysts more than 2 years (validation dataset 2). Diagnostic accuracies were calculated from validation datasets.

RESULTS
Normalized T2 SI (0.21-0.92 vs. 0.12-0.58; P=.013), ADC (1.76-4.09 vs. 0.66-2.93 10^-3 mm^2/s; P=.013), and RER (0.41-24.1% vs. 28.1-771.7%; P=.001) significantly differed between cysts and solid masses. RER of 26% or less was determined as the cutoff value for differentiation of cysts from solid masses. In validation dataset 1, the cutoff value showed sensitivity of 87.5% and specificity of 100%, the sensitivity of 90.9% was observed in validation dataset 2.

CONCLUSION
The assessment of RER with the cutoff value of 26% can appropriately differentiate benign cysts from solid anterior mediastinal masses.

CLINICAL RELEVANCE/APPLICATION
The differentiation of benign cysts from solid anterior mediastinal masses can be supported by quantitative measurement of RER, potentially reducing a futile thymectomy.

SST02-08 Primary Tumor Standardized Uptake Value (SUVmax) as Powerful Prognostic Factor for Early
Surgically Resected T1- and T2-Stage Esophageal Squamous Cell Carcinoma: T and N Staging Performance of EUS- and PET/CT

PURPOSE
We have previously shown that initial PET-SUVmax (Standardized uptake value) of early esophageal cancer helps both discriminating T1a and T1b stage esophageal squamous cell carcinoma (eSCC) from other eSCCs. In this study, we analyze the impact of PET-SUVmax for patient’s survival.

METHOD AND MATERIALS
This retrospective study was based on 435 patients with a surgically proven early T- (Tis or T1a [< T1a], T1b and T2) stage eSCC. We performed survival analysis by the Kaplan-Meier method and comparisons of survival using log-rank test.

RESULTS
131 < T1a, 234 T1b, and 70 T2 eSCCs were enrolled. Mean SUVmax value were 2.53 for < T1a eSCCs, 4.02 for T1b eSCCs and 9.69 for T2 eSCCs. With ROC curve analysis, cut off value of SUVmax 3.05 (AUC: 0.757; 95% CI, 0.710-0.803; P < .001) at PET provided sensitivity 74.8% (98/131), specificity 70.1% (213/304), respectively, for differentiating < T1a eSCCs from other cancers. Cut off value of SUVmax 5.65 (AUC: 0.897; 95% CI, 0.857-0.937; P < .001) provided sensitivity 77.1% (54/70), specificity 87.7% (320/365), respectively, for differentiating T1 (< T1b) eSCCs from T2 eSCCs. In multivariate analysis, both SUVmax and pathologic staging including tumor size and node involvement were significant predictors of survival (p < 0.01). Survival analysis and log-rank test showed significant difference for overall survival among groups based on proposed cut-off SUVmax values (p =0.008 for cut off value 3.05; p =0.001 for cut off value 5.65)

CONCLUSION
In early esophageal squamous cell carcinomas, SUVmax gives us powerful predictor of overall survival after resection.

CLINICAL RELEVANCE/APPLICATION
Pretreatment SUVmax of primary esophageal cancer shows powerful predictive values which can be comparable to pathologic T stage.

SST02-09 Surgically Resected T1- and T2-Stage Esophageal Squamous Cell Carcinoma: T and N Staging Performance of EUS- and PET/CT

PURPOSE
To demonstrate the frequency of nodal metastases and to disclose the diagnostic performance of endoscopic ultrasonography (EUS) and PET/CT in T and N staging in surgically resected early-stage esophageal squamous cell carcinomas (eSCCs).

METHOD AND MATERIALS
IRB approved this retrospective study with waiver of informed consent for reviewing medical record. We included 435 patients with an early T-stage (Tis or T1a [< T1a], T1b and T2) eSCC. The rates of metastatic lymphadenopathy were calculated. Then, the performance of EUS and PET/CT in subdividing T and N stages was assessed.

RESULTS
131 < T1a, 234 T1b, and 70 T2 eSCCs were identified. In discriminating < T1a from other cancers, the sensitivity, specificity and accuracy of EUS were 60.3% (79/131), 80.3% (244/304), and 74.3% (323/435), respectively. With ROC curve analysis, cutoff value of SUVmax 3.05 at PET provided sensitivity 73.3% (96/131), specificity 70.4% (214/304), and accuracy 71.3% (310/435) for differentiating < T1a eSCCs from others. Ten (7.6%) of 131 < T1a cancers had nodal metastasis. In discriminating N0 from node-positive disease, sensitivity, specificity and accuracy of EUS were 89.6% (267/298), 41.6% (57/137) and 74.5% (324/435), respectively, whereas those of PET/CT were 88.9% (265/298), 38.7% (53/137), and 73.1% (318/435), respectively.

CONCLUSION
In > 70% of patients with < T1a eSCCs, the tumor stage can be discriminated from higher stage cancers by using EUS or PET/CT, and substantial percentage (7.6%) of < T1a eSCC patients have nodal metastases, but the nodes are missed in more than half of the patients in clinical staging.
CLINICAL RELEVANCE/APPLICATION

Substantial percentage (7.6%) of < T1a eSCC patients have nodal metastases, and nodal metastasis rates increase as T stage increases (T1b [37.6%] and T2 [55.7%]). Moreover, more than half of nodal metastases were missed on PET/CT or EUS. Thus, after endoscopic surgery or even after curative surgical resection of < T1a eSCCs, adjuvant therapy is needed for those having nodal metastasis.
SST06-01 Liver/Spleen Scintigraphy: An Old Technique with a current Application

Friday, Nov. 30 10:30AM - 10:40AM Room: E261

Participants
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Ephraim E. Parent, MD,PhD, Ponta Vedra Beach, FL (Moderator) Research support, Blue Earth Diagnostics Ltd; Research support, Advanced Accelerator Applications SA
Andrew C. Homb, MD, Rochester, MN (Moderator) Nothing to Disclose

Sub-Events

SST06-02 The Diagnostic Accuracy of Brain-Lung Uptake and Whole-Body Uptake Derived from Technetium-99m-Labeled Macroaggregated Albumin (MAA) Lung Perfusion Scan for the Diagnosis of Hepatopulmonary Syndrome

Friday, Nov. 30 10:40AM - 10:50AM Room: E261

Scientists and Participants:
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PURPOSE

Cross-sectional imaging of the abdomen on occasion can demonstrate incidental pancreatic/peri-pancreatic lesions of unknown etiology. Although these lesions sometimes have the appearance of splenic tissue, situations arise where metastasis and/or primary pancreatic etiology are also on the differential. Scintigraphy with Tc99m Sulfur colloid or heat damaged RBC can be a useful diagnostic tool in identifying the presence of splenic tissue, suggesting a benign etiology for these lesions although the accuracy is uncertain.

METHOD AND MATERIALS

Retrospective review of all non-PET nuclear medicine studies in which a lesion in the upper abdomen were the cause of imaging from 1/2000 to 7/2017. Studies performed for hepatic artery perfusion or liver parenchyma lesion were excluded. Patients charts were reviewed, the date/results of the index study, subsequent imaging, clinical management, along with the last recorded encounter in our electronic medical record to establish benignity in the absence of pathology.

RESULTS

Initial review obtained 623 studies performed, a majority (74%) for hepatic artery perfusion. Liver lesion evaluation was performed in 7% of the cases (hemangioma or FNH). The remainder of the cases were done for evaluating splenic tissue in ITP (~5% of cases), ectopic splenic tissue (~9% after trauma or splenectomy) or to evaluate incidental pancreatic/peri-pancreatic lesions with potential neoplastic etiology (~5% cases, 34 cases total). Of these 34 cases, pathology was obtained in 12/34 patients. Imaging was correct in identifying non-splenic tissue in 11/12 cases (92%). One case was splenic tissue on path, but was not identified on imaging. For the patients that had imaging indicating splenic tissue without subsequent pathology (12/22), follow up of the patient occurred > 3-years.

CONCLUSION

Pancreatic/peri-pancreatic lesions of unknown etiology can present a diagnostic challenge with causes ranging from benign splenic tissue to a neoplastic process. Scintigraphy offers a unique ability to identify ectopic splenic tissue with a high degree of diagnostic accuracy, >90%, yielding a benign diagnosis and limiting the need of further workup.

CLINICAL RELEVANCE/APPLICATION

Liver/Spleen imaging with Tc99m Sulfur colloid or damaged RBC can accurately identify incidental pancreatic/peri-pancreatic lesions as ectopic splenic tissue not requiring further workup.
SST06-03  
Diagnosing Hepatobiliary Disease during Myocardial Perfusion Imaging Using Tc99m Methoxy Isobutyl Isonitrile
Friday, Nov. 30 10:50AM - 11:00AM Room: E261

Participants
He Zhao, Beijing, China (Abstract Co-Author) Nothing to Disclose
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PURPOSE
Technetium-99m-labeled macroaggregated albumin (MAA) lung perfusion scan is considered as a complementary tool for detecting intrapulmonary vascular dilations (IPVD), which is an essential criterion for diagnosing hepatopulmonary syndrome (HPS). The purpose of this study was to compare the diagnostic accuracy of brain-lung uptake and whole-body uptake for detecting IPVD.

METHOD AND MATERIALS
From December 2014 to October 2015, all patients with chronic liver disease and/or portal hypertension, undergoing interventional radiological procedures at our institution were eligible for inclusion in this prospective study. The brain-lung uptake was calculated using the geometric mean (GMT) of technetium counts around the brain and lung in the following formula: (GMTbrain / 0.13) / (GMTbrain / 0.13 + GMTlung). The brain-lung uptake was regarded as positive when the MAA shunt fraction was > 6%. The whole-body uptake was calculated using the GMT of technetium counts around the lung and whole body in the following formula: (1 - GMTlung / GMTwhole-body)

RESULTS
A total of 69 patients were included, IPVD was detected in 32 (46%) patients by contrast-enhanced echocardiography. Of these patients, 26 (38%) patients with elevated AaO2 were diagnosed as HPS. The brain-lung uptake was similar between those with or without IPVD [median, 3.5 (interquartile range (IQR), 2.6-5.8) % vs. 3.1 (IQR, 2.5-4.9) %; P = 0.245]. However, the whole-body uptake was significantly higher in the patients with IPVD than those without IPVD (48.0 ± 6.1 % vs. 40.1 ± 8.1 %; P = 0.001). Multivariable logistic regression showed that whole-body uptake was the only independent predictor that associated with the presence of IPVD [odds ratio (OR), 1.29; 95% CI, 1.07-1.55; P = 0.008]. The AUC values of the whole-body uptake for detecting IPVD were 0.75 (95% CI, 0.60-0.86). The optimal cut-off values of whole-body uptake for detecting IPVD was 42.5%. The sensitivity, specificity, and accuracy for detecting IPVD were 100%, 52%, and 74%, respectively.

CONCLUSION
Whole-body uptake could be a useful alternative to CEE and brain-lung uptake for detecting IPVD, especially in patients with mild or moderate HPS.

CLINICAL RELEVANCE/APPLICATION
Whole-body uptake derived from MAA lung perfusion scan could be a useful alternative to contrast-enhanced echocardiography and brain-lung uptake for detecting intrapulmonary vascular dilations.

SST06-03  
Diagnosing Hepatobiliary Disease during Myocardial Perfusion Imaging Using Tc99m Methoxy Isobutyl Isonitrile
Friday, Nov. 30 10:50AM - 11:00AM Room: E261

Participants
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PURPOSE
Tc99m Methoxy Isobutyl Isonitrile (MIBI) has been used for myocardial perfusion imaging (MPI) for the detection of ischemia. This study aimed to investigate the feasibility of effectively evaluating cystic duct patency, during routine visual analysis of the raw MPI and/or with the 3-D reconstructed data.

METHOD AND MATERIALS
A retrospective study of 91 patients undergoing cardiac Sestamibi scan for acute chest pain, and HIDA scan (within no more than 3 months) for suspected gallbladder obstructive disease (GBD). Gallbladder visualization during either the rest or stress portion of the MIBI study was indicative of cystic duct patency. These results were compared to those by the HIDA studies.

RESULTS
Ten patients had the MIBI and HIDA studies 4 days apart, both studies agreed 100% with the diagnosis of cystic duct patency. Sixteen patients had both studies between 4 days and 3 weeks and had an agreement of 87.5% with cystic duct patency. Sixty-one patients had both studies 3 weeks to 3 months apart and had an agreement of 80% with cystic duct patency.

CONCLUSION
The initial results of this study indicate that MPI with Tc99m MIBI is useful in detecting a patent cystic duct and should help in eliminating unnecessary additional Gallbladder testing.
CLINICAL RELEVANCE/APPLICATION
If the interpreting physician was made aware of the benefits of being able to diagnose cystic duct obstruction and gallbladder disease when using the Tc-99m cardiac sestamibi to evaluate myocardial perfusion, it would lead to earlier diagnosis and more efficient patient care; thus, decreasing the amount of imaging that patients need to go through to reach a diagnosis of gallbladder obstruction, which will lead to decreased cost.

SST06-04 Qualitative and Quantitative Analysis of 68Ga-DOTA-Peptide Uptake for Identifying Neuroendocrine Tumor in Uncinated Process of Pancreas

Friday, Nov. 30 11:00AM - 11:10AM Room: E261

Participants
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PURPOSE
68Ga-DOTA-peptide is a somatostatin analogue used for imaging neuroendocrine tumors (NET). Various organs demonstrate physiological distribution of which uncinate process of pancreas is a particular concern because uncinate is a common site for NET and great variability of tracer distribution at this location is making the interpretation difficult. Thus aim is to characterize 68Ga-DOTA-peptide distribution in uncinate process and useful hints for distinguishing pathology from physiological distribution.

METHOD AND MATERIALS
83 68Ga-DOTApeptide PET CT scans of 25 patients done between May 2009 and Oct 2014 were reviewed retrospectively. 66 scans from 20 subjects tumor involvement of uncinate process was excluded based on pathological, clinical, radiological evaluation and at least 1 year follow-up. 17 scans from 5 subjects neuroendocrine tumor involvement of the uncinate process was confirmed by histology and/or multimodality imaging. Statistical analyses univariable Generalized Estimating Equations was carried out for normal uncinate uptake features. Comparison of normal vs tumor uptake was carried out using Mann Whitley test.

RESULTS
There are 3 types of normal distribution in uncinate process diffuse, focal and multifocal. Average SUVmax for normal uncinate process is 5.88 +/-3.34 with highest to be 21.07. The average SUVmax for uncinate neuroendocrine tumor is 76.28 +/-44.72 with lowest to be 27. Tumor/spleen ratio is significantly higher than uncinate/spleen ratio (8.98 +/- 3.83 with lowest 3.67 vs 0.36 +/- 0.41 with highest 1.44). Strong positive correlation between uptake in normal uncinate process to that in pituitary and spleen (both P<0.0001) and the uptake is negatively affected by dose of peptide (p=0.0002).

CONCLUSION
Distribution pattern and uptake intensity in uncinate process vary greatly between patients and between scans. Pituitary and spleen uptake serve as references in judging the nature of uptake in uncinate. Low grade NET in uncinate process demonstrate significantly higher than normal uptake and greater than normal uncinate/spleen ratio.

CLINICAL RELEVANCE/APPLICATION
SUVmax and uncinate/spleen ratio is useful for differentiating normal versus tumor. SUVmax of 25 and uncinate/spleen ratio of 1.5 are recommended reasonable cutoff values for this purpose. But tumor involvement in uncinate process should be made by not only by presentation on PET scan but correlating with other imaging findings and/or biopsy result.

SST06-05 Hepatobiliary Scintigraphy versus Ultrasound in the Evaluation of Acute Cholecystitis: An Institutional Review

Friday, Nov. 30 11:10AM - 11:20AM Room: E261

Participants
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PURPOSE
Acute cholecystitis is a common entity. Hepatobiliary radionuclide scintigraphy (HIDA) is considered the gold standard for diagnosing cholecystitis, with sensitivity up to 97%. Ultrasound (US) is the preferred modality in the initial evaluation of acute cholecystitis, due to its availability, low cost, and short examination time, despite being less sensitive than HIDA. At our institution, US is the initial imaging study of choice, and a HIDA is subsequently obtained for equivocal studies. We aim to evaluate the concordance of US and HIDA, and to identify clinical and/or laboratory parameters which may correlate with equivocal US in order to better guide patient management.

METHOD AND MATERIALS
Following institutional IRB approval, MONTAGE was used to search our reporting database between October 2016 and October 2017. HIDA results were categorized as "positive" or "negative". US results were categorized as "negative", "positive", or "equivocal" for the assessment of acute cholecystitis. Clinical and laboratory data were also collected.

RESULTS
A total of 307 patients underwent both US and HIDA (n=307) with 43% (n=132) with an equivocal US. 35% (n=107) of these patients had discordant US and HIDA. Of the cases with an equivocal US, 43% (n=57) underwent cholecystectomy. At pathology,
51% (n=29) had acute cholecystitis with a positive HIDA and 4% (n=2) had acute cholecystitis with a negative HIDA. 14% (n=8) had chronic cholecystitis with a positive HIDA, and 32% (n=18) had chronic cholecystitis with a HIDA negative for acute cholecystitis. In patients with equivocal US, HIDA had a sensitivity of 93.6% and specificity of 69.2%.

CONCLUSION
Over one-third discordance between US and HIDA can have significant clinical implications. Given the high sensitivity of HIDA in patients with equivocal US, initial evaluation with HIDA may be more appropriate in patients in whom US is likely to be equivocal, possibly leading to decreased time to surgery and length of stay.

CLINICAL RELEVANCE/APPLICATION
Our results may elucidate factors influencing HIDA/US concordance, and whether US or HIDA is a more appropriate initial test. Imaging utilization may influence length of stay and time to surgery.

Identification and Characterization of Myocardial Metastases in Neuroendocrine Tumor Patients Using 68Ga-DOTATATE PET-CT

Friday, Nov. 30 11:20AM - 11:30AM Room: E261

Participants
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PURPOSE
Focal 68Ga-DOTATATE PET lesions within the myocardium of neuroendocrine tumor (NET) patients are observed in clinical practice. We determined the frequency and characteristics of lesions that are consistent with cardiac metastasis and assessed the lesion detection rate of conventional imaging.

METHOD AND MATERIALS
629 patients who underwent 68Ga-DOTATATE PET-CT at a supraregional comprehensive cancer center on NET were included from a consecutive registry. Inclusion criteria were: (1) focal 68Ga-DOTATATE tracer uptake within the myocardium in more than two sequential PET exams, and (2) contrast-enhanced CT. To determine the diagnostic accuracy of conventional CT imaging, a case-control cohort with a ratio of 1:3 was used. PET and CT were independently analyzed by two blinded readers. Cohen’s k was assessed for interreader agreement. Descriptive statistics were applied for frequencies and characteristics and group comparisons were analyzed using the Fisher’s exact test.

RESULTS
The prevalence of myocardial metastases related to the registry was 2.4% with 15/629 NET patients fulfilling the inclusion criteria and a total of 21 focal myocardial 68Ga-DOTATATE tracer uptakes detected. Myocardial lesions were most frequently located in the left ventricle (43%) and the septum (43%). No patient demonstrated a pericardial effusion. Patients with myocardial metastases did not differ in demographics, tumor grading, disease stage or circulating tumor markers compared to the overall registry (all p>0.05). The patient characteristics are shown in Table 1. Higher Ki67-Indices were observed (p=0.049) for patients with myocardial metastases. Interreader agreement for PET assessment was excellent (Cohen’s =1.0). CT reading showed a sensitivity of 19% (95% confidence interval: 6%-43%) at a specificity of 100% (95% confidence interval: 90%-100%). A patient example with a CT-detected cardiac metastasis is provided in Figure 1.

CONCLUSION
68Ga-DOTATATE PET enables detection of myocardial metastatic lesions in NET patients. In contrast, standard morphologic CT imaging provides very limited sensitivity.

Evaluation of [18F]-FDG PET/MR Enterography in the Assessment of Ileocolonic Inflammation in Crohn’s Disease - Which Surrogate Marker is Better? MaRIA, Clermont, PET, or PET-MR index?

Friday, Nov. 30 11:30AM - 11:40AM Room: E261

Participants
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Dynamic Study by PET/CT: Phantom Study and Clinical Trial on Sequential 26 Cases of Malignant Lesions of Uterus

Friday, Nov. 30 11:40AM - 11:50AM Room: E261

Participants
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PURPOSE
Dynamic study of PET/CT with 18F-FDG has not been reported up to now. The purpose of this study was to check the reliability of SUVmax on GE IQ PET/CT by phantom study, and to compare tumor 18F-FDG uptake between two phases of 30-second acquisition of dynamic deep-inspiration breath-hold PET/CT (BHPC) before and after 5 to 7 steps of 150-sec free-breathing PET/CT (FBPC). These sequence was named 'Dynamic study by PET/CT'.

METHOD AND MATERIALS
The PET/CT scanner was GE IQ with 26cm BGO crystal and PET images were reconstructed by patented new method of successive approximation (25-times). Before the clinical study, a phantom study was performed using an International Electrotechnical Commission body phantom set corresponding to the NU 2-2001 standard. The phantom set was consisted of a torso cavity and two spheres (inner diameters: 10, 13, 17, 22, 28, and 37 mm). The torso cavity was filled with water, and the 6 spheres were filled with 18F-FDG solutions of the same radioactivity concentration (25 kBq/mL). We studied sequential 26 patients, from 40 to 84 years old, with uterine malignant tumor including 11 cases of corpus carcinomas, 13 cases of cervical carcinomas, and 2 cases of uterus origin malignant lymphomas. On the basis of the phantom study, patients with uterine malignant tumors smaller than 13mm were excluded. Maximum tumor 18F-FDG SUV (SUVmax) was measured in FBPC and the two phases of BHPC.

RESULTS
Our phantom study revealed that BHPC was also reliable when the size of lesion was bigger than 13mm with the accuracy of one SD which was smaller than 2% of SUVmax. This reliability was markedly improved by one tenth in comparison with that of 10 years ago. On clinical study, the mean SUVmax was 18.56 with FBPC, 15.51 with the early phase of BHPC, whereas 18.15 with the delayed phase of BHPC. In dynamic study, 19.2% increase in SUVmax in delayed scan.

CONCLUSION
SUVmax obtained in the early and delayed phase of BHPC which had 15 minutes discrepancy showed a significant difference. BHPC before and after FBPC may contribute to distinguish benign lesions from malignant tumors, and this technique is feasible in the clinical setting with minimum increase in examination time.
Multiparametric Evaluation by 18F-Fluorocholine PET-CT and MRI Examinations in Patients with Prostate Cancer

Friday, Nov. 30 11:50AM - 12:00PM Room: E261

Participants
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PURPOSE
To evaluate the relationship between metabolic 18F-fluorocholine (FCH) PET-CT and functional parameters derived by Magnetic Resonance Imaging (MRI) in patients with prostate cancer (PC).

METHOD AND MATERIALS
Patients with proven PC who underwent FCH PET/CT and 1.5 T multiparametric MRI were included. FCH PET/CT consisted in a dual phase: early and late whole-body acquisition. A 12x5' - 3x30' time sampling was reconstructed from the first 150 seconds of the early acquisition. A freehand FCH PET/CT volume-of-interest (VOI) with a threshold of 40% of the maximum signal intensity was drawn on the late acquisition and projected onto the early static frame of 10 min and each frame of the dynamic reconstruction. For the kinetic analysis, an imaging-derived plasma input function was estimated from VOI placed within the largest arterial blood-pool structures available on the early PET image. The pharmacokinetic modeling was the reversible one-tissue compartment model. Kinetic parameter (K1 as influx) and static parameters (early SUVmean, late SUVmean and SUVmean retention index) were extracted. Concerning multiparametric MRI, axial diffusion-weighted imaging was obtained using three b values: 0, 50 and 1300 s/mm2. Dynamic contrast-enhanced studies were obtained with intravenous administration of gadolinium-based contrast agent with a 11x13' dynamic time sampling. Using co-registration of diffusion-weighting MRI with late whole-body FCH PET/CT, a freehand VOI was drawn to obtain the mean Apparent Diffusion Coefficient (ADC). VOI was projected onto the perfusion parametric maps to extract the mean transfer constant (ktrans) and the mean volume of the extracellular space (Ve) using the Tofts pharmacokinetic model. Spearman's correlation coefficients were calculated to compare imaging findings.

RESULTS
Thirteen patients were analysed. The median time interval between PET and MRI was 39 days. Concerning correlation analysis between PET and MRI parameters, K1 was significantly correlated with ktrans (r=0.59, p=0.035) and early SUVmean was significantly correlated with ADC (r=-0.58, p=0.04).

CONCLUSION
FCH influx using the reversible one-tissue compartment model is significantly correlated with the transfer constant of gadolinium-based contrast agent in prostate cancer.

CLINICAL RELEVANCE/APPLICATION
These results might be useful in the design of future clinical trials involving FCHOLINE-PET/DCE-MR for the assessment of prostate cancer.
**CONCLUSION**

The measured performances demonstrated that the inSpira HD SPECT scanner has high sensitivity, high resolution, and acceptable image quality and, hence, is well suited for high resolution static and dynamic SPECT neuroimaging studies.

**Background**

High-resolution SPECT imaging is of great interest for studying neurological pathologies. The objective of this study is to characterize the performances of high resolution inSpira HD SPECT scanner for neuroimaging applications.

**Evaluation**

inSpira HD is a dedicated high resolution SPECT scanner based on a rotating dual clamshell design that acquires data in dual-spiral geometry. The performance characteristics were evaluated in terms of spatial resolution, sensitivity, uniformity, and contrast. The spatial resolution was measured from images of a line source. System volume sensitivity (SVS) was calculated using large flood phantom filled with Tc-99m. ACR Small SPECT Phantom was used to evaluate the image quality in terms of uniformity and contrast. Brain phantom and patients images were acquired to access the system more realistically.

**Discussion**

Spatial resolution in terms of FWHM was 4.1 mm, 4.2 mm, and 4.3 mm for X, Y, and Z plane respectively. SVS was 9914.6 cts/sec/uc/ml. Integral uniformity for UFOV and CFOV were 4.8% and 2.1% respectively. Percent contrast for the five visible spheres with attenuation correction was 26%, 58%, 76%, 93%, and 99%. Brain phantom and patients images show fine details of brain regions.
increasing evidence for dose-effect relationships in RE with 90Y microspheres, the general consensus is that there is an urgent need for accurate dosimetry in patients undergoing RE treatment. This work aimed at estimating absorbed doses to lesions and normal liver in a novel anthropomorphic set-up.

**CONCLUSION**

In RE treatment planning the dose-kernel method proved to be more accurate with respect to deposition method based on full 3D dose distributions.

**CLINICAL RELEVANCE/APPLICATION**

Treatment planning in molecular radiotherapy is mandatory to obtain the most appropriate and effective treatment of patient. It is mandatory to validate dose quantification obtained by SPECT/CT imaging.

**SST09-03**  
**An Investigation Study of Deep Learning Convolutional Neural Network for Whole-Body PET Denoising**

Friday, Nov. 30 10:50AM - 11:00AM Room: E264

Participants
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**PURPOSE**

The goal of this study is to investigate the quantitative impact of deep residual convolutional neural network (DCNN) configurations for PET image denoising.

**METHOD AND MATERIALS**

We first compared deep residual networks constructed with different numbers of layers (5 vs 8 vs 10 layers). For the 8 layers network, we also compared two versions such that one has half the number of filters of the other. We trained our networks using 64 clinical datasets representing a range of acquisition and reconstruction protocols. We evaluated the performance of different networks on 4 different human 18F-FDG studies acquired for 4 minutes per bed position. Synthetic lung and liver lesions were generated using GATE simulation and inserted into the listmode data. The listmode data were further rebinned into 2-minute and 3-minute lists in order to test the robustness of networks against different noise levels. All images were reconstructed using OSEM with 3 iterations, 10 ordered subsets and applied with a Gaussian filter (GF) at 6 mm FWHM. Quantifications were assessed by measuring the lesion contrast recovery versus variability of the background liver uptake.

**RESULTS**

The 10 layers and 8 layers networks with the full number of filters resulted in comparable quantitative and qualitative performance. However, the 10 layers network used 2-fold the training time than the 8 layers network did. Reducing the layers to 5 resulted in reduced lesion contrast recovery and robustness to the noise levels in the input images. Reducing the number of filters in the 8 layers network also reduced quantitative performance compared to the full 8 layers network.

**CONCLUSION**

The network architecture plays an important role in the denoising performance of a DCNN network. While fewer layers fail to capture the full complexity of the noise distributions, too many layers result in over-parameterization and difficulties in training without substantial performance gain.

**CLINICAL RELEVANCE/APPLICATION**

A properly chosen denoising neural network architecture can significantly improve noise levels over alternative architectures and help improve clinical decisions made based on resulting images.

**SST09-04**  
**Large Scale Assessment of Detectability and Estimability Indices from ACR CT Accreditation Database: Report of an ACR-RSNA Collaboration**

Friday, Nov. 30 11:00AM - 11:10AM Room: E264

Participants
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**PURPOSE**

To assess the variability in a subset of image quality attributes of clinical CT systems using advanced task-based metrics, detectability and estimability, across the US through a collaboration between the ACR and the RSNA (QIBA).
The ACR CT accreditation program requires institutions to submit images using the Gammex 464 phantom. Through a collaboration between the RSNA QIBA and ACR, a set of 804 randomly-selected de-identified phantom data sets were analyzed using an automated image quality estimator. These data were not filtered with regard to ACR phantom pass/fail outcome. Basic image quality metrics, including HU numbers, CNR, and noise magnitude, were automatically extracted, as well as task-specific resolution (TTF) and noise power spectra. Two advanced task-based metrics that incorporate all the aforementioned metrics were also computed: detectability index ($d'$) and estimability index ($e'$) for CT volumetry, both with demonstrated correlation with human and machine performance. Results from each image set were binned into specific protocols. The data were analyzed in terms of variability across protocols.

RESULTS

For task-specific resolution, despite the wide spread of the frequencies for 0.5 TTF (f50) within each protocol, the median value was largely consistent across protocols (0.40–0.41 1/mm). Noise magnitude and CNR values, related to radiation dose, were highly dependent on the protocol. The $d'$ median values and distribution changed considerably with the task definition. Similar trends were also observed for $e'$. The $d'$ and $e'$ median values for polyethylene were 142.3, 168.1, 85.8, and 129.1; and 0.026, 0.035, 0.017, and 0.024 for adult abdomen, adult head, pediatric abdomen, and pediatric head, respectively.

CONCLUSION

Assessment of detectability and estimability indices from the ACR CT accreditation database was feasible. Phantom images can be used as a surrogate to ascertain variability across clinical operations. Such data could eventually be used in the development of future conformance assessment procedures.

CLINICAL RELEVANCE/APPLICATION

Analysis of reference phantom datasets across systems and institutions through the ACR Accreditation process enables granular assessment of multi-parameter variability across our national healthcare system enabling the development of key performance indicators, qualification of quantitative performance, and potential nation-wide image quality registries.

SST09-05 A Comprehensive Platform for Automated Analysis and Reporting of QC of Medical Imaging Modalities

Friday, Nov. 30 11:10AM - 11:20AM Room: E264

Participants
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CONCLUSION

This QC platform provides a tested, comprehensive solution for analysis and reporting of QC for most medical imaging modalities.

Background

Periodic testing of image quality is part of Quality Control (QC) of medical imaging devices. Implementation of QC testing is modality and model specific. If vendor-supplied QC is available, the details are not disclosed and exporting QC results is rarely possible. Those results are needed to spot drifts in system performance and to inform all users about the time and outcome of the latest QC. To aid implementation of a department-wide multi-modality QC program, the Society for Medical Physics of the Netherlands (NVKF) devised a community-driven, open source platform for automated analysis of medical images for quality control. The platform comprises a PACS, analysis modules, a database, and web based front-ends for administration and reporting. Analysis modules are available for most modalities, including MR, CT, MG, US, DX, RF and NM. In a normal workflow a user performs a QC test and sends the images to the QC PACS. Based on DICOM metadata, the platform runs the appropriate analysis modules and stores the results in the database. The web-based interface allows immediate access to the QC results.

Evaluation

This platform has been used since 2013 in several Dutch hospitals, successfully analyzing tens of thousands of datasets. Easy access to recent reports and trend plots of QC metrics were found beneficial for successful implementation of a QC program. Due to the open-source nature of the project, analysis modules are reviewed and improved continually.

Discussion

This platform is a community driven, open source project, with only open source third party software requirements. Its goal is a comprehensive solution for analysis and reporting of QC for all medical imaging modalities. Analysis modules were initially developed for specific models of modalities. Easy exchange of analysis modules and configurations between institutes resulted in a push from the user community towards generalizations to other models and brands. After extensive testing, the platform was publicly released.

SST09-06 An Embedded Pre-Screening Electrochemical Profile in Label-Free and Image-Free Quantified Tissue Behavioral Analysis

Friday, Nov. 30 11:20AM - 11:30AM Room: E264

Participants
Ali Zarafshani, Norman, OK (Presenter) Nothing to Disclose
RESULTS

The performance of the pre-screening tool has been verified by analysis of electrochemical profile using several breast tissue and phantom studies with different simulated tissue density levels at different sub-regions. The results indicated that the tool enabled to sensitively detect, quantify and distinguish the simulated breast tissue and local asymmetrical distribution. The testing results are also quite reproducible and can be offer as a personalized measurement analysis.

CONCLUSION

This research for the first time demonstrates a unique electrochemical sensing device coupled with a quantified behavioural analysis of breast tissue in an innovative pre-screening tool for label-free analysis of breast tissue bioelectrical features. In future human studies, it has potential to build a new low-cost and easy-to-use tool for pre-screening several types of cancers (i.e., breast cancer) to increase cancer detection yield and reduce false positive recalls in current screening methods.

CLINICAL RELEVANCE/APPLICATION

This a pre-screening tool can be used to increase cancer detection yield and reduce false-positive recalls (over-diagnosis) in current mammography screening.

SST09-07 Development and Initial Evaluation of a DaTscan Digital Reference Object

Friday, Nov. 30 11:30AM - 11:40AM Room: E264

Participants

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PURPOSE

The goal of this work was to design and evaluate 123I-Ioflupane DaTscan digital reference objects (DROs) and to create realistic projection datasets from a DRO to allow testing of DaTscan image reconstruction methods.

METHOD AND MATERIALS

The initial striatal brain DRO was created from an MRI image of an age-appropriate patient. The MRI was segmented to delineate structures of interest. Each structure was assigned a value according to expected Ioflupane uptake: CSF : background : right putamen : left putamen : caudate >= 0.33 : 1 : 5.5 : 3.25 : 5.5. This corresponds to a specific binding ratio (SBR) of 4.5 for the caudate and right putamen and an SBR of 2.25 for the left putamen. The initial, noise-free DRO was then smoothed using 6 mm and 10 mm Gaussian filters. The three versions were analyzed by four analysis packages. Next Monte Carlo simulation was used to model SPECT acquisition of the 123I-Ioflupane DRO. The simulation included multiple energy emissions and collimator/detector response modeling. After creation of a high count projection sinogram, Poisson-resampling was used to generate sinograms of different noise levels. Projection sinograms were reconstructed on a workstation. Images were then analyzed using DaTquant™ software.

RESULTS

An Ioflupane DRO developed for assessing DaTscan analysis software was tested. The SBR for the striatum varied from 2.53-3.19 (right, healthy) to 1.81-2.05 (left, diseased putamen) for the non-blurred DRO for the different analysis packages. The caudate SBRs varied from 2.4-3.6 (right) to 2.33-3.05 (left). The putamen SBRs varied from 2.56-2.7 (right) to 1.7-2.14 (left, diseased). There was similar variability for the blurred DRO images. The SBRs for the Monte Carlo simulated DRO projection images reconstructed on a vendor workstation were similar to SBRs from experimentally collected phantom data.

CONCLUSION

DROs with known 123I-Ioflupane activity distributions have been created from a patient MRI. Results reveal the variability in the...
calculated SBR for different analysis software. Monte Carlo simulation data sets have been created with full models of collimator detector response for testing DaTscan analysis packages and image reconstruction methodologies.

**CLINICAL RELEVANCE/APPLICATION**

DROs can be used to test/compare vendor analysis packages. Further, Monte Carlo simulations of DROs can be used to test/validate enhanced image reconstruction methods for 123I-Ioflupane brain imaging.

**SST09-08 Quantitative Iodine Maps from Spectral Detector Computed Tomography in Daily Practice: A Real World Study in 60 Patients**

Friday, Nov. 30 11:40AM - 11:50AM Room: E264

Participants
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**PURPOSE**

Iodine maps are available from spectral detector computed tomography (SDCT). They visualize the distribution of iodinated contrast media and allow for its quantification. While the accuracy of such maps has been investigated ex vivo in phantoms under optimized conditions, this study aimed to evaluate their accuracy in routine examinations.

**METHOD AND MATERIALS**

We designed a reference object consisting of 5 tubes filled with potassium iodide solutions of different concentrations (0.0, 0.8, 1.6, 3.2, 4.8 mg/ml). In 60 patients (31 male, mean age 65.2±11.4 years) who underwent routine SDCT of the abdomen, the reference object was positioned within the scan region at random positions/orientations. Iodine maps (IM) were reconstructed using the vendor provided algorithm. Two circular regions of interest were drawn in each tube, mean and standard deviation within each ROI were determined and averaged. Difference between IM and known iodine concentration was calculated. We performed a confounder analysis for BMI and radiation dose. In addition, we developed a software that allows for automatic measurement of the anterior-posterior and left-right diameter of each patient and further, computes a three-compartment model of the examined tissue (fat, bone, lean); all parameters were considered as possible confounders in statistic assessment.

**RESULTS**

Overall, iodine maps had a high accuracy as indicated by an offset of -0.01±0.12 mg/ml despite their random placement. The offset was found greater in low concentrations (relative offset in 0.8 and 4.8 mg/ml tubes: +6.5% and +1%, respectively). While smaller BMI tended to overestimate iodine content, greater BMI tended to underestimate iodine concentrations. Besides BMI, volume of bone was found to be a strong confounder regarding iodine quantification accuracy.

**CONCLUSION**

Iodine quantification using iodine maps from SDCT is technically feasible in routine examinations. When considering estimated concentrations for clinical decision making, increased caution is recommended in low concentrations, in skinny and obese patients and in images with presence of large amount of bone.

**CLINICAL RELEVANCE/APPLICATION**

Iodine quantification in daily practice is feasible with high accuracy using iodine maps from SDCT.

**SST09-09 Quantifying Liver Iron Content Using Photon-Counting Detector Based Computed Tomography**

Friday, Nov. 30 11:50AM - 12:00PM Room: E264

Participants
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**PURPOSE**

In a phantom, to quantify liver iron content using multi-energy photon-counting detector (PCD) CT and an image-based material decomposition technique.

**METHOD AND MATERIALS**

A wet liver analog was synthesized using dry liver extract (1:7 dilution of dry liver in water) to yield a base CT number enhancement of 50 HU at 140 kV, similar as that of normal human liver. Iron concentrations (iron III nitrate) were prepared at 1.8, 2.8 and 5.6 mg/ml with either wet liver or water as a solvent. Cylindrical vials containing approximately 10 mL of pure liver, iron-liver and iron-water solutions were placed inside a 20 cm multi-energy CT phantom (Gammex, Sun Nuclear, WI), and scanned using a whole-body PCD-CT system (Siemens Count, Forchheim, Germany) at 120 kV, 178 mAs (CTDIvol = 13 mGy) and energy thresholds of 25, 63 keV. Multi-energy PCD-CT images were reconstructed at [25, 120] keV, [63, 120] keV and [25, 63] keV energy ranges using a quantitative smooth kernel (D30). Quantitative iron maps were obtained using an in-house material decomposition
technique with the [25, 120] keV and [63-120] keV images assuming 3 base materials: liver, water and iron. The image domain material decomposition (MD) algorithm is based on spectral prior image constrained compressed sensing (MD-SPICCS) which combines material decomposition and denoising into a unified framework. The mean density (mg/mL) of iron content was estimated from the iron maps generated using MD-SPICCS. A linear regression analysis was performed to compare measured iron concentrations in liver background with known true concentrations.

RESULTS

MD-SPICCS was able to successfully detect and quantify iron from liver background in the phantom images. Liver background from the iron-liver mixtures was assigned to the liver map, while water background from the iron-water mixtures was assigned to water map. Linear regression showed excellent correlation between measured and true iron concentrations in the iron-liver mixtures (slope = 1.1, R² = 0.9997, RMSE =0.6 mg/mL).

CONCLUSION

We have demonstrated accurate iron quantification in a liver phantom scanned using the PCD-CT system and an image-based material decomposition technique. Measured iron concentrations showed excellent correlation with the ground truth.

CLINICAL RELEVANCE/APPLICATION

Diagnosing hemochromatosis characterized by liver iron overload using imaging methods requires accurate iron quantification to facilitate and monitor therapy.