Computed Tomography

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105th Scientific Assembly and Annual Meeting
December 1–6 | McCormick Place, Chicago
Automatic Quantitative Analysis of Kidney Tumor Using 3D Fully Convolutional Network

All Day Room: GU/UR Community, Learning Center Hardcopy Backboard

Participants
Chenglong Wang, Nagoya, Japan (Abstract Co-Author) Nothing to Disclose
Masahiro Oda, PhD, Nagoya, Japan (Abstract Co-Author) Nothing to Disclose
Yuichiro Hayashi, PhD, Nagoya, Japan (Abstract Co-Author) Nothing to Disclose
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Kensaku Mori, PhD, Nagoya, Japan (Presenter) Developer, Olympus Corporation; Developer, Cybernet System Inc; Developer, Morita Mfg Inc

TEACHING POINTS
The purpose of this exhibit is To learn fully-automated segmentation of the kidneys and kidney tumors from CT volume To learn fully-automated quantitative analysis method for kidney tumors To demonstrate deep learning-based analysis system for kidney tumors To show the internal relations between tumor morphology and treatment plan

TABLE OF CONTENTS/OUTLINE
Importance of pre-operative CT image diagnosis in partial nephrectomy How kidney tumor’s morphology affects treatment plan What can our assistance system do? Accurate kidney region and kidney tumor segmentation on CT image Extraction of kidney region and kidney tumors using 3D fully convolutional network Quantitative analysis of kidney tumors Analysis of relationship between tumor morphology and treatment Clinical application Deeper insight into relationship between kidney tumors and their treatment More standardized surgical plan for nephrectomy Demonstrate our computer-aided system Fully automated kidney and kidney tumor segmentation (Fig. 1) Calculation of statistical measures of tumors (Fig. 2 and 3) Interactive demonstration of results in 3D rendering and 3D printed model

Printed on: 10/29/20
Subtraction CT Angiography of Peripheral Artery with Orbital Synchronized Helical Scanning Using Characteristic of Organ-Based Tube Current Modulation

All Day Room: VI Community, Learning Center Digital Education Exhibit

Awards
Cum Laude

Participants
Satoshi Inada, Hiroshima, Japan (Abstract Co-Author) Nothing to Disclose
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Erika Tamai, Hiroshima, Japan (Presenter) Nothing to Disclose
Naohiro Yamagami, Hiroshima, Japan (Abstract Co-Author) Nothing to Disclose

TEACHING POINTS
Severe calcification complicates the diagnosis of the blood vessel lumen in CT angiography of peripheral artery. Subtraction CT angiography (SCTA) with the use of orbital synchronized helical scanning is beneficial for the diagnosis of peripheral arteries with vessel wall calcifications. Using the organ-based tube current modulation (organ dose modulation: ODM, GE Healthcare) for SCTA easily makes the orbital synchronized helical scanning possible. In addition, using the ODM for SCTA can inhibit the mis-registration of the SCTA image and visualizes only the lumen of the peripheral artery with severe calcifications. In this exhibit, we will illustrate the background of the SCTA with ODM, scanning methods, and clinical applications.

TABLE OF CONTENTS/OUTLINE
1. Technical points of the scanning method for the SCTA with ODM and the image processing, 2. Comparison of the image quality between the SCTA with ODM and SCTA without ODM. 3. Clinical images of SCTA with ODM, and comparison with digital subtraction angiography (DSA).

Printed on: 10/29/20
The Bleeding Point: Manifestations of Hemorrhage and Related Pathologies - With Mimics and Pitfalls

All Day Room: VI Community, Learning Center Digital Education Exhibit

Participants
Ghali Salahia, MD, Cardiff, United Kingdom (Presenter) Nothing to Disclose
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TEACHING POINTS

1. Describe optimal imaging strategies for evaluating active haemorrhage with schematic diagrams and multimodality imaging.
2. Review imaging appearances of haemorrhage and related pathologies, using cases drawn from an extensive archive at two tertiary interventional radiology centres.
3. Highlight important mimics of bleeding and interpretative pitfalls

TABLE OF CONTENTS/OUTLINE

1. Imaging strategies a. CT i. Utility of different contrast phases b. DSA c. Nuclear medicine
3. Miscellaneous

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Beginner Class: Classification Task (Intro)

Sunday, Dec. 1 10:30AM - 12:00PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIt Technologies, LLC; Stockholder, VoiceIt Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard and decent-sized screen. Having a Gmail account will be helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This class will focus on basic concepts of convolutional neural networks (CNNs) and walk the attendee through a working example. A popular training example is the MNIST data set which consists of hand-written digits. This course will use a data set we created, that we call 'MedNIST', and consists of images of 6 different classes: Chest X-ray, Chest CT, Abdomen CT, Head CT, Head MR and Breast MRI. The task is to identify the image class. This will be used to train attendees on the basic principles and some pitfalls in training a CNN. • Intro to CNNs • Data preparation: DICOM to jpeg, intensity normalization, train vs test • How do we choose the labels? Inconsistencies... Use Fast.AI routines to classify; Validation of results: Are the performance metrics reliable?; 'Extra Credit': if there is time, explore data augmentation options, effect of batch size, training set size.

Printed on: 10/29/20
To investigate the predictive value of 3D whole heart volume (WHV) for major adverse cardiovascular events (MACE) in patients with stable chest pain and nonobstructive coronary artery disease (CAD).

**METHOD AND MATERIALS**

Among participants of the Prospective Multicenter Imaging Study for Evaluation of Chest Pain (PROMISE), we included those with nonobstructive CAD on cardiac computed tomography (CT). WHV was defined as pericardial sac volume excluding the epicardial fat, measured on non-contrast cardiac CT, and indexed to body surface area (iWHV) (Figure A). We determined the association of iWHV with traditional cardiovascular risk factors, coronary artery calcium (CAC), and MACE (all-cause death, myocardial infarction, unstable angina) over a median follow-up of 26 months. In a subgroup, we correlated the iWHV with measures of left-ventricular (LV) function and morphology and systemic inflammation (IL-6).

**RESULTS**

In 1,134 patients (63±9 years; 43% women), the mean iWHV was 294.3±65.6 cm3/m2. Remarkably, smaller iWHV was associated with female sex and individual CV risk factors ($P<0.05$ for all) but not with CAC score (Figure B). Similarly, smaller iWHV was associated with MACE, an association that persisted after adjustment for cardiovascular risk and CAC (HR (per decrease of one standard deviation) = 6.7; 95%CI:2.1-19.9; $P=0.001$) (Figure C). In the subgroup analysis of mechanistic determinants, iWHV correlated moderately with end-diastolic volume (EDV) ($r=0.52$), stroke volume (SV) ($r=0.36$), LV-mass ($r=0.51$) and weakly with LV-ejection fraction (EF) ($r=0.14$), LV-mass/volume ratio ($r=0.07$) and inflammation (IL-6; $r=0.21$) (all correlations $P<0.05$). Notably, those with the smallest iWHV (i.e., first quintile) had preserved LV-EF (mean: 56.6±7.3%), no LV hypertrophy (mean iLV-
mass: 51.1±48.9 g/m2) or LV dilation (mean EDV: 57.2±12.0 ml/m2).

**CONCLUSION**

In patients with nonobstructive CAD and without clinical signs of heart failure, smaller iWHV was associated with MACE independent of traditional risk factors and CAC and correlated with smaller LV volumes, higher LV-mass/volume ratio, and increased inflammation.

**CLINICAL RELEVANCE/APPLICATION**

Given prior evidence linking nonobstructive CAD to coronary microvascular dysfunction and heart failure with preserved EF (HFpEF), we generate the hypothesis that iWHV may represent an early marker of HFpEF.

**SSA03-04**  **Coronary Atherosclerosis in Apparently Healthy Master Athletes Discovered During pre-PARTECIPATION Screening: Role of Coronary CT-Angiography (CCTA)**

**Participants**
- Riccardo Marano, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
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- Giancarlo Savino, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
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- Luigi Natale, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose
- Riccardo Manfredi, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To assess the role of Coronary CT-Angiography (CCTA) and non-invasive detection of coronary atherosclerosis (cATS) in the assessment and clinical management of master athletes (MA) during the pre-participation screening (PPS). To assess the role of Coronary CT-Angiography (CCTA) and non-invasive detection of coronary atherosclerosis (cATS) in the assessment and clinical management of master athletes (MA) during the pre-participation screening (PPS).

**METHOD AND MATERIALS**

We retrospectively examined 167 MA who underwent CCTA in our hospital since 2006, analyzing symptoms, stress-test ECG, cardiovascular risk profiles (SCORE) and CCTA findings.

**RESULTS**

Among the whole enrolled population, 153 (91.6%) MA underwent CCTA for equivocal/positive stress-test ECG with/without symptoms, 13 (7.8%) just for clinical symptoms, 1 (0.6%) for the family history. The CCTA showed the presence of cATS in 69 MA (41.3%), congenital coronary anomalies (anomalous origin or deep myocardial bridge) in 8 (4.8%), both in 7 (4.2%). A negative CCTA was observed in 83 MA (49.7%). The risk-SCORE (age, hypertension, hypercholesterolemia, smoking) was a good indicator for the presence of moderate/severe cATS on CCTA. However, mild/moderate cATS was present in 17.8% of MA clinically stratified at a low risk-SCORE.

**CONCLUSION**

CCTA may be helpful in the PPS of MA with an abnormal stress test ECG and/or clinical symptoms engaged in competitive sports with a high cardiovascular involvement, while the invasive coronary angiography is more indicated in athletes with positive stress-test ECG and high clinical risk. Age, gender, presence of symptoms and clinical risk-SCORE assessment may help sports-physicians/cardiologists to decide whether to request a CCTA or not.

**CLINICAL RELEVANCE/APPLICATION**

CCTA may be helpful in the PPS of MA with an abnormal stress test ECG and/or clinical symptoms engaged in competitive sports with a high cardiovascular involvement.

**SSA03-05**  **Impact of Diabetes on Coronary Artery Disease Progression in Selective Percutaneous Coronary Intervention-treated patients: Using Serial CCTAs**

**Participants**
- Rui Shi, Chengdu, China (Presenter) Nothing to Disclose
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- Ke Shi, Chengdu, China (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

Diabetes mellitus (DM) patients have been known to be susceptible to coronary artery disease (CAD). However, the impact of diabetes on plaque progression in CAD patients treated with selective percutaneous coronary intervention (PCI) has been rarely reported. Hence, the present study aimed to evaluate the impact of DM on CAD progression in selective PCI treated patients using serial coronary computed tomography angiography (CCTA), compared against non-diabetic patients.

**METHOD AND MATERIALS**
A total of 98 patients (age: 69.9 ± 11.0, 83.7% male) referred for selective PCI performed underwent serial CCTAs, which were arranged within one month before PCI and at least 6 month after PCI in our hospital were consecutively analyzed. All the subjects were categorized into diabetes group (36) and non-diabetes group (62). For all the CCTA scans, quantitative measures including segment involvement score (SIS), segment stenosis score (SSS) at baseline and follow-up CTA, and CCTA-verified plaque progression were evaluated blindly to clinical data and compared between the two groups.

RESULTS
No statistical differences were found in baseline SSS (DM:6(IQR:3.25-8) vs. Non-DM:4(IQR:2-10), P=0.195) or SIS(DM:3(IQR:2-4) vs. Non-DM:2(IQR:1-4), P=0.298). During the median 1.5 year inter-scan period, significant difference was observed in ΔSIS (DM: 0(IQR:0-1) Vs. non-DM: 0 (IQR:0-0.25), P=0.029), ΔSSS (DM:2(IQR:0-3) vs. Non-DM: 0 (IQR:0-2);P<0.001) and Anualised ΔSSS (0.64(IQR:0-1.83) vs. Non-DM:0 (IQR:0-0.75),P=0.004) between the two groups.At per-segment level, compared to non-diabetes, proximal segments(P=0.003), noncalcific plaques(P=0.014) and original normal segments(P=0.005) of diabetic patients were more susceptible to plaque progression(PP). Multivariate logistic regression showed that DM (OR:5.52; 95%CI:1.67-16.48, P=0.005) and chest pain at baseline (OR:5.24; 95%CI:1.67-16.48, P=0.008) were independently associated with CAD progression after adjusting for confounding factors.

CONCLUSION
In the present study, more CCTA-verified progressive plaques were found in diabetes patients after PCI. DM, combined with baseline chest symptom, can further enhance the ability to identify patients who require a therapeutic strategy to halt disease progression.

CLINICAL RELEVANCE/APPLICATION
The present study provides an important opportunity to advance the understanding of the relationship between diabetes and CAD progression in stented patients.

SSA03-06 Artificial Intelligence-Based Coronary CT Fractional Flow Reserve Applied to Triple-Rule-Out CT Angiography in Acute Chest Pain

Sunday, Dec. 1 11:35AM - 11:45AM Room: S105AB

Participants
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PURPOSE
In this study, we evaluated the additional value of noninvasive artificial intelligence (AI)-based CT-FFR, derived from triple-rule-out coronary computed tomography angiography (TRO-CTA) for acute chest pain (ACP) in the emergency department (ED) setting.

METHOD AND MATERIALS
This retrospective, HIPAA-compliant, single-center study was approved by the university's institutional review board. AI-based, deep-learning CT-FFR (Siemens Healthineers) from TRO-CTA datasets was obtained in 159 of 271 (59%) eligible patients (89 men; mean age 57.0±9.7 years) presenting to the ED with ACP. The agreement between CT-FFR (<=0.80) and stenosis on TRO-CTA demonstrated agreement in severity of CAD in 70% (111/159) of all cases. CT-FFR <=0.80 served as a better predictor for coronary revascularization and MACE in 70% (111/159) of all cases. CT-FFR <=0.80 served as a better predictor for coronary revascularization and MACE than >=50% stenosis on TRO-CTA (hazard ratio [HR] 4.1; 95% confidence interval [CI] 1.5-11.4 vs. HR 2.3; 95% CI 0.9-6.0) (p<0.01). Additional diagnostic cardiac testing was performed in 59% (94/159) of patients and included single-photon emission computed tomography (SPECT) (n=62), stress echocardiography (n=31), and stress magnetic resonance imaging (MRI) (n=1). In this subgroup there was higher agreement as to the presence/absence of significant disease with CT-FFR (55%; 52/94) than with coronary TRO-CTA (47%; 44/94) (p<0.01). Reserving downstream testing for patients with CT-FFR <=0.80 would have reduced the number of additional downstream cardiac examinations by 47%.

CONCLUSION
CT-FFR derived from TRO-CTA was a better predictor for coronary revascularization and MACE and showed better agreement with additional diagnostic testing than TRO-CTA. Therefore, CT-FFR may improve the specificity in identifying ACP patients with significant CAD in the ED setting and reduce unnecessary downstream testing.
**CLINICAL RELEVANCE/APPLICATION**

AI-based CT-FFR derived from TRO-CTA datasets provides additional diagnostic and prognostic value in the evaluation of patients presenting to the ED with chest pain may reduce subsequent downstream testing.

**SSA03-07 Combined Assessment of Myocardial Volume and Myocardial Blood Flow for Diagnosis of Obstructive Coronary Artery Disease in Cardiac Computed Tomography**

Sunday, Dec. 1 11:45AM - 11:55AM Room: S105AB

Participants
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**PURPOSE**
The purpose of this study was to evaluate the diagnostic performance of combined assessment of myocardial volume and myocardial blood flow (MBF) for detecting obstructive coronary artery disease (CAD) by cardiac computed tomography (CT).

**METHOD AND MATERIALS**
A total of 36 patients, who underwent coronary CT angiography (CTA), dynamic stress myocardial CT perfusion (CTP), and invasive coronary angiography (ICA) with invasive fractional flow reserve (FFR) measurement, were enrolled. 256-slice CT (Philips Healthcare, Cleveland, USA) was used in this study. Severe stenosis (stenosis >=70%) and moderate stenosis (50-69%) with FFR <=0.8 on ICA were defined as obstructive CAD. All CTP and CTA data were analyzed by a commercially available workstation (Synapse Vincent ver.5, Fujifilm Medical Systems, Japan). CT-MBF was calculated by deconvolution analysis from dynamic stress CTP images, and coronary artery-related left ventricular myocardial volume (LVMV) on CT was automatically segmented using Voronoi algorithm-based myocardial segmentation. Then, the stenosis-related CT-MBF and LVMV (stenosis >=50% on CTA) were quantified using the image fusion of CT-MBF and the coronary artery territory mapping. Diagnostic performance of the combined assessment of the stenosis-related CT-MBF and LVMV was assessed, and compared with that of stenosis-related CT-MBF alone using the area under receiver operating characteristic curve (AUC).

**RESULTS**
Of 108 vessels in 36 patients, 65 vessels were suspected of significant stenosis in CTA. Sensitivity and specificity for identifying obstructive CAD were 87% and 60% for stenosis-related CT-MBF, and 87% and 77% for combined assessment of the stenosis-related CT-MBF and LVMV, respectively. The AUCs were 0.79 for the stenosis-related CT-MBF, and 0.89 for combined assessment of stenosis-related CT-MBF and LVMV. The AUC of combined assessment of stenosis-related CT-MBF and LVMV was significantly higher than that of stenosis-related CT-MBF alone (p <0.05).

**CONCLUSION**
Stenosis-related LVMV could improve the diagnostic performance of CT-MBF for detecting obstructive CAD.

**CLINICAL RELEVANCE/APPLICATION**
The stenosis-related LVMV has influence on the severity of CAD as well as CT-MBF, and provides the incremental value for detecting obstructive CAD to the stenosis-related CT-MBF.

**SSA03-08 Myocardial Blood Flow Analysis of Stress Dynamic Myocardial CT Perfusion for Hemodynamically Significant Coronary Artery Disease Diagnosis: The Clinical Value of Relative Parameter Optimization**

Sunday, Dec. 1 11:55AM - 12:05PM Room: S105AB

Participants
Cheng Xu, Beijing, China (Presenter) Nothing to Disclose
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Wei Wu, Beijing, China (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**
To investigate the optimal relative parameter of quantitative myocardial blood flow (MBF) on dynamic myocardial CT perfusion (CTP) for the detection of hemodynamically significant coronary artery disease (CAD).

**METHOD AND MATERIALS**
A total of 86 patients who were prospectively recruited underwent adenosine triphosphate-stress dynamic myocardial CTP. The MBF value was measured by a manually drawn volume of interest (VOIs) on the MBF color-coded polar maps with perfusion defects of vessel-based territory. The relative MBF perfusion parameters were then calculated as Ratio1, Ratio2 and Ratio3 according to the three types of reference MBF values, respectively: 1) average segmental MBF value, 2) 75th percentile of the average segmental MBF value, and 3) highest segmental MBF value. All the data were derived from both the endocardial and transmural...
layers of the myocardium. Invasive coronary angiography and fractional flow reserve (ICA/FFR) were used as the reference standards for myocardial ischemia evaluation.

RESULTS

151 vessels of 60 patients (43 men and 17 women; 61.38±8.01 years) were enrolled in the analysis. The performance of endocardial layer was superior to that of the transmural layer (all P <0.05). The Ratio3 of endocardial myocardium (AUC=0.906, 95% CI: 0.857-0.954), for which the highest segmental value was selected as the reference MBF, was superior to both Ratio1 and Ratio2 for ischemia detection (AUC, 0.906 vs. 0.879, P <0.05; 0.906 vs. 0.891, P =0.18), and the sensitivity, specificity, PPV, NPV and diagnostic accuracy were 74.1%, 93.6%, 87.8%, 85.3% and 86.1%, respectively. The cutoff value of Ratio3 was 0.675.

CONCLUSION

The relative MBF parameter of the endocardial myocardium using the highest segmental MBF value as a reference provided optimal diagnostic accuracy for the detection of hemodynamically significant CAD.

CLINICAL RELEVANCE/APPLICATION

The relative MBF perfusion parameters are promising assessment in stress dynamic myocardial CT perfusion (CTP) for myocardial ischemia evaluation, the investigation of optimal relative MBF analysis method not only helps in improving the CTP diagnostic accuracy, but also can further promoting the standardization of CTP technology.
**Pulmonary Surface Irregularity as a Quantitative CT Biomarker for Idiopathic Pulmonary Fibrosis**

**Participants**
Jonathan D. Dodd, MD, Boston, MA (Moderator) Speaker, Boehringer Ingelheim GmbH;
Matthew J. Devries, MD, Omaha, NE (Moderator) Nothing to Disclose

**Sub-Events**

**SSA05-01 Pulmonary Surface Irregularity as a Quantitative CT Biomarker for Idiopathic Pulmonary Fibrosis**

**Awards**
Trainee Research Prize - Fellow

**Participants**
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Rafah Mresh, MD, Birmingham, AL (Abstract Co-Author) Nothing to Disclose
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Andrew D. Smith, MD, PhD, Birmingham, AL (Abstract Co-Author) CEO, AI Metrics LLC ; Owner, AI Metrics LLC ; CEO, Radiostics LLC; Owner, Radiostics LLC; CEO, Liver Nodularity LLC ; Owner, Liver Nodularity LLC ; Research Grant, General Electric Company; Speaker, Canon Medical Systems Corporation; Speaker, AlgoMedica, Inc

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**PURPOSE**
Idiopathic pulmonary fibrosis (IPF) causes peripheral fibrotic changes that lead to pulmonary surface irregularity (PSI). The purpose of this study was to assess the accuracy of a quantitative PSI score on high-resolution chest CT for predicting transplant-free survival in patients with IPF.

**METHOD AND MATERIALS**
For this IRB-approved HIPAA-compliant retrospective single-center observational pilot study, adult patients diagnosed with IPF (N=50; 25F/25M) were age and sex matched with a control group with no known lung disease (N=50; 25F/25M). While blinded to clinical data, three readers independently measured PSI on ten high-resolution axial CT images using custom semi-automated software (Liver Nodularity LLC, Hoover, AL). Patients' age, gender, and pulmonary function test (PFT) results were used to calculate the GAP index, a method for predicting mortality in IPF. A t-test was used to compare the PSI scores between cohorts. Multivariate cox regression analysis was used to associate PSI score and GAP index with transplant-free survival in the IPF cohort. Inter-observer agreement assessed by intraclass correlation coefficient (ICC).

**RESULTS**
There were zero (0/100) technical failures for measuring the PSI score. Median time to measure the PSI score was 4.7 min. A mean PSI score of 5.38 for the IPF cohort was significantly higher than 3.14 for the control cohort (p<0.001). The median (range) PSI score in the IPF cohort was 5.21 (3.05-9.33). The PSI score was independent of the FVC, DLCO and the GAP index (r=0.07, p=0.6), (r=-0.07, p=0.6), and (r=0.16, p=0.2), respectively. The median transplant-free survival for the IPF cohort was 3.6 years. In univariate analysis, patients with IPF and a high PSI score (>median) were 5 times more likely to die than patients with IPF and a low PSI score (HR:5.03; 95%CI:1.86-13.6). In multivariate analysis, only the PSI score was associated with transplant-free survival (HR:1.36 per unit increase; 95%CI:1.01-1.84). Inter-observer agreement for the PSI score among 3 readers was good (ICC:0.75; 95%CI:0.63-0.84).

**CONCLUSION**
Quantitative measurement of pulmonary surface irregularity on high-resolution chest CT images has good inter-observer agreement and is a strong independent predictor of transplant-free survival in patients with IPF.

**CLINICAL RELEVANCE/APPLICATION**
The pulmonary surface irregularity (PSI) score is a broadly applicable, quantitative CT biomarker that has high inter-observer agreement and is predictive of survival in patients with IPF and potentially many other forms of pulmonary fibrosis.

**Identification of Pathological UIP in Patients with an Alternative Diagnosis (to IPF) Pattern using Quantitative CT Analysis**

Sunday, Dec. 1 10:55AM - 11:05AM Room: E350
Participants
Jonathan H. Chung, MD, Chicago, IL (Presenter) Royalties, Reed Elsevier; Consultant, Boehringer Ingelheim GmbH; Speakers Bureau, Boehringer Ingelheim GmbH; Consultant, F. Hoffmann-La Roche Ltd; Speakers Bureau, F. Hoffmann-La Roche Ltd; Consultant, Veracyte, Inc;
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PURPOSE
New IPF guidelines support pursuing surgical lung biopsy in patients with an alternative diagnosis pattern on chest computed tomography (CT) scans. However, up to half of these patients will still have UIP on pathology. The purpose of this study was to determine if a commercially available quantitative imaging tool could be used to identify patients with an alternative diagnosis CT pattern who were highly likely to have a UIP histologically.

METHOD AND MATERIALS
Chest CT scans and lung biopsy specimens were available for review in 225 subjects who had undergone multidisciplinary diagnosis. In 92 of these subjects, their CT pattern was suggestive of an alternative diagnosis to IPF and these patients were included in the study. Non-contrast CT scans were analyzed using the Computer Aided Lung Informatics for Pathology Evaluation and Rating (CALIPER) program, which quantifies the amount of various abnormal CT patterns on chest CT. The resulting data was analyzed statistically using the student’s t-test or Mann-Whitney U test as appropriate. Multivariable analysis using logistic regression was performed.

RESULTS
The volume of low attenuation regions, reticulation, ground-glass opacity, honeycombing, or total lung volume did not predict the presence of UIP pattern on pathologic specimens. However, the total vessel related structures (VRS) volume on chest CT was significantly higher in subjects with UIP on pathology as opposed to those without UIP on pathology (182.8±18.3 cm³ versus 140.2±24.3 cm³, respectively; P<0.001). On multivariable analysis, VRS (P=0.032) and race (P=0.041) were significantly associated with UIP pathology. A VRS cut-off of 173 cm³ or greater was associated with a UIP pathology in 84.2% (32/38) of cases. VRS value less than 173 cm³ was associated with a UIP pathology in only 44.4% (24/54) of cases (P<0.001).

CONCLUSION
In subjects with an alternative diagnosis pattern on CT, a higher VRS is associated with a significantly higher proportion of UIP on pathology. At a threshold value of 173 cm³, the predictive accuracy for UIP on lung biopsy specimens approaches that reported for the probable UIP pattern on CT. Application of this to clinical practice could potentially minimize the need for performing lung biopsies for patients in whom a confident diagnosis could not be achieved.

CLINICAL RELEVANCE/APPLICATION
VRS may be an adjunct to HRCT in predicting pathology in patients with diffuse lung disease.

SSA05-03 Preliminary Result of Respiratory Change Analysis For Peripheral Normal-Appearing Lung Field By Dynamic-Ventilation CT: Comparison Between Idiopathic Pulmonary Fibrosis and Connective Tissue Disease Associated Interstitial Lung Disease

Sunday, Dec. 1 11:05AM - 11:15AM Room: E350

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PURPOSE
To compare cross-correlation coefficients (CCC) as an index of concordance of normal appearing lung fields in sub-pleural regions with those located in the center in regional density-based parameters on dynamic-ventilation CT between idiopathic pulmonary fibrosis (IPF) and interstitial lung disease of connective tissue disease (CTD-ILD).

METHOD AND MATERIALS
Five IPF and 5 CTD-ILD patients underwent dynamic-ventilation CT by using 320-row scanner (Aquilion ONE, Canon Medical...
Participants

Kyung-Hyun Byoung Soo Jooae

SSA05-05 Imaging biomarker for precise management of patients with IPF. Radiomic hyper-curvature features that are automatically calculated from lung CT images can provide an effective prognostic biomarker for predicting overall survival of patients with IPF.

CLINICAL RELEVANCE/APPLICATION

Effective imaging biomarker for predicting overall survival of patients with IPF. The RHC model yielded higher performance than that of GAP model in the prediction of overall survival. Thus, RHC can be an alternative for predicting survival of IPF.

CONCLUSION

Dynamic-ventilation CT demonstrated lower CCC for kurtosis in IPF indicative of temporal ventilation disproportion in sub-pleural normal appearing regions.

RESULTS

In total, CCCs for kurtosis in IPF were significant lower than those in CVD-ILD (IPF median: 0.636 IQR: 0.256-0.978, CTD-ILD median: 0.974, IQR: 0.934-0.985, p<0.0001). Similarly, CCCs for kurtosis in IPF were significant lower both in ventral and dorsal lung fields as compared with CTD-ILD (ventral area; median for IPF: 0.58, median for CTD-ILD: 0.976, p<0.021, dorsal area; median for IPF: 0.636, median for CTD-ILD: 0.972, p<0.0003). For mean, skewness of CT density histogram and estimated air volume calculated based on mean CT density in VOI were almost similar between IPF and CTD-ILD.

CONCLUSION

Dynamic-ventilation CT could be useful for detection early-stage IPF in combination with regional analysis of density-based parameters for sub-pleural normal area.

SSA05-04 Radiomic Hyper-Curvature Features for Predicting Survival of Patients with Idiopathic Pulmonary Fibrosis

Sunday, Dec. 1 11:15AM - 11:25AM Room: E350

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PURPOSE

To evaluate the comparative performance of a radiomic hyper-curvature (RHC) model of lung CT images in the prediction of the overall survival of patients with idiopathic pulmonary fibrosis (IPF).

METHOD AND MATERIALS

We retrospectively collected clinical and lung CT data of 172 IPF patients with pulmonary function tests from the Lung Tissue Research Consortium. The lung regions were extracted from the CT images using our previously developed method, after which the bronchi and aerated lungs were separated using histogram thresholding, region growing and mathematical morphology. To characterize patients' lungs, we computed 363 RHC features that characterize the principal curvatures, curvedness, light/dark blobs, lines and sheets, and curvature scales of the bronchi and the aerated lungs. An elastic-net penalty method was used to select and combine these RHC features with a Cox proportional hazards model for predicting the survival of the patient. Evaluation was performed by use of bootstrapping with 1,000 replications, where concordance index (C-index) was used as a measure of prediction performance. The performances of the RHC model was compared with the clinical biomarkers of gender and age, and gender, age, and physiology (GAP) index by use of two-sided t-test.

RESULTS

Bootstrap evaluation yielded the following C-index values: (a) age and gender: C-index 52.1%, [95% confidence interval (CI): 44.8, 59.3]; (b) GAP index: C-index 58.9%, [CI: 50.8, 67.2], P<0.0001 in comparison with (a); (c) RHC: 71.2% [CI: 65.6, 76.9], P<0.0001 in comparison with (b). Kaplan-Meier survival curves of patients stratified to low- and high-risk groups based on the RHC model showed statistically significant (P < 0.0001) difference.

CONCLUSION

The RHC model yielded higher performance than that of GAP model in the prediction of overall survival. Thus, RHC can be an effective imaging biomarker for predicting overall survival of patients with IPF.

CLINICAL RELEVANCE/APPLICATION

Radiomic hyper-curvature features that are automatically calculated from lung CT images can provide an effective prognostic imaging biomarker for precise management of patients with IPF.

SSA05-05 Diagnosis of Idiopathic Pulmonary Fibrosis (IPF) Applying the New Diagnostic Criteria of 2018 ATS/ERS/JRS/ALAT Guidelines

Sunday, Dec. 1 11:25AM - 11:35AM Room: E350

Participants

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PURPOSE

To evaluate the comparative performance of a radiomic hyper-curvature (RHC) model of lung CT images in the prediction of the overall survival of patients with idiopathic pulmonary fibrosis (IPF).

METHOD AND MATERIALS

We retrospectively collected clinical and lung CT data of 172 IPF patients with pulmonary function tests from the Lung Tissue Research Consortium. The lung regions were extracted from the CT images using our previously developed method, after which the bronchi and aerated lungs were separated using histogram thresholding, region growing and mathematical morphology. To characterize patients' lungs, we computed 363 RHC features that characterize the principal curvatures, curvedness, light/dark blobs, lines and sheets, and curvature scales of the bronchi and the aerated lungs. An elastic-net penalty method was used to select and combine these RHC features with a Cox proportional hazards model for predicting the survival of the patient. Evaluation was performed by use of bootstrapping with 1,000 replications, where concordance index (C-index) was used as a measure of prediction performance. The performances of the RHC model was compared with the clinical biomarkers of gender and age, and gender, age, and physiology (GAP) index by use of two-sided t-test.

RESULTS

Bootstrap evaluation yielded the following C-index values: (a) age and gender: C-index 52.1%, [95% confidence interval (CI): 44.8, 59.3]; (b) GAP index: C-index 58.9%, [CI: 50.8, 67.2], P<0.0001 in comparison with (a); (c) RHC: 71.2% [CI: 65.6, 76.9], P<0.0001 in comparison with (b). Kaplan-Meier survival curves of patients stratified to low- and high-risk groups based on the RHC model showed statistically significant (P < 0.0001) difference.

CONCLUSION

The RHC model yielded higher performance than that of GAP model in the prediction of overall survival. Thus, RHC can be an effective imaging biomarker for predicting overall survival of patients with IPF.

CLINICAL RELEVANCE/APPLICATION

Radiomic hyper-curvature features that are automatically calculated from lung CT images can provide an effective prognostic imaging biomarker for precise management of patients with IPF.
In 2018, the new diagnostic criteria has been proposed for diagnosis of idiopathic pulmonary fibrosis (IPF) from ATS/ERS/JRS/ALAT. This study was to evaluate the evolution of diagnosis of IPF by comparison of the new criteria to the previous 2011 guideline.

METHOD AND MATERIALS

This retrospective study included 535 patients with pathologically proven fibrosing interstitial pneumonia including usual interstitial pneumonia (UIP, n=339), nonspecific interstitial pneumonia (NSIP, n=97) and chronic hypersensitivity pneumonitis (HP, n=98). Three experienced chest radiologists who were blinded to the pathologic diagnosis classified the HRCT pattern of disease based on 2011 criteria (UIP, Possible UIP and Inconsistent with UIP) and 2018 criteria (UIP, Probable UIP, Indeterminate for UIP and Alternative diagnosis) for the diagnosis of UIP. Classification based on 2011 and 2018 criteria were compared and interobserver agreement was evaluated. In each classification, overall survival of patients was also evaluated.

RESULTS

Of the 535 cases, 177 (33.1%) had HRCT findings of UIP, 148 (27.7%) had probable UIP, 39 (7.3%) had indeterminate for UIP and 171 (32.0%) had alternative diagnosis. Of 184 cases with possible UIP based on 2011 criteria, 148 (80.4%) cases were categorized to probable UIP and 36 (19.6%) cases categorized to indeterminate UIP. Among those with probable UIP, 104 (70.3%) had pathologically UIP (concordant group), 33 (22.3%) had NSIP and 11 (7.4 %) had HP. 39 of those with indeterminate for UIP on HRCT had pathologically UIP in 28 cases (71.8%). Of the 339 patients with pathologically UIP, subjects with indeterminate for UIP showed significantly better survival compared to other groups based on 2018 criteria (log-rank test, P=0.001). Between 2011 and 2018 criteria, interobserver agreement did not showed significant difference (2018, κ = 0.512 for; 2011, κ = 0.546).

CONCLUSION

Applying the new diagnostic criteria for diagnosis of IPF, group of possible UIP based on 2011 criteria can be reclassified to two different categories, probable UIP and indeterminate for UIP based on 2018 criteria. The patients with indeterminate for UIP on HRCT showed better prognosis compared to the other groups based on new criteria.

CLINICAL RELEVANCE/APPLICATION

In the new CT criteria for diagnosis of IPF, group of possible UIP based on 2011 criteria can be reclassified to probable UIP and indeterminate for UIP, which seems to have different prognosis.

Deep Learning Enables Automatic Classification of Emphysema Pattern on Computed Tomography

Participants

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PURPOSE

Visual pattern of emphysema on chest CT, using the Fleischner Society classification scale, is associated with physiologic impairment and risk of death. We sought to determine whether subject-level emphysema pattern, classified using a deep learning (DL) method, could predict impairment and mortality.

METHOD AND MATERIALS

9652 subjects in the COPDGene study, with available baseline CT and visual emphysema scores, were partitioned into two non-overlapping sets (2507 for training and 7143 for testing). A DL algorithm was trained to classify pattern of parenchymal emphysema according to Fleischner criteria. We compared visual and DL emphysema scores with clinical parameters including pulmonary function tests (PFT). The Cox proportional hazard model was used to evaluate relationships between emphysema scores and survival. For independent verification the DL algorithm was also tested using 1962 subjects enrolled in the ECLIPSE study.

RESULTS

Emphysema classification by the DL method was associated with impairment on PFTs, six-minute walk distance and St. George's Respiratory Questionnaire (p < 0.0001 in each case). DL emphysema classification improved fit of linear mixed models in the prediction of these clinical parameters compared to visual scoring (p < 0.0001). Compared to subjects without emphysema, mortality was greater in subjects classified as having emphysema grade beyond trace (adjusted hazard ratios were 1.47, 1.64, 2.94, 5.27, and 9.67, respectively, for mild, moderate, confluent and advanced destructive, p<0.01). Testing in the ECLIPSE cohort showed comparable results.

CONCLUSION

Pattern of emphysema, scored automatically using DL, is associated with functional impairment and risk of mortality. Compared with visual scoring, DL provides additional information that can be used to predict diminished function and mortality risk.
**CLINICAL RELEVANCE/APPLICATION**

Standardized, objective assessment of radiologic images using DL could facilitate subject selection for clinical trials, and risk stratification in clinical practice or in lung cancer screening.

**SSA05-07  Structural Image-based Computational Model to Assess Pulmonary Ventilation in COPD Patients: A Comparison with Xenon-enhanced Dual-energy CT Imaging Data**

Sunday, Dec. 1 11:45AM - 11:55AM Room: E350

Participants

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**PURPOSE**

Thoracic computed tomography (CT) is an established technique routinely used to detect structural pulmonary abnormalities. The aim of this study was to demonstrate the CT-based full-scale airway network (FAN) flow model and to compare the modelled pulmonary ventilation with xenon-enhanced dual-energy computed tomography (Xe-DECT) derived pulmonary ventilation in chronic obstructive pulmonary disease (COPD) patients.

**METHOD AND MATERIALS**

A total of 9 COPD patients underwent Xe-DECT scanning. The virtual non-contrast (VNC) images and ventilation maps were coregistered without the influence of lung volume and evaluated using in-house software. The geometries of lobes and large airways were segmented from VNC images for the FAN flow modelling. Small airways were generated utilising the branch growing algorithm. To enhance the patient-specificity on the FAN model, pulmonary tissue density map extracted from CT images and the lung function tests were applied for the initial and boundary conditions of the model. The FAN model computed the dynamic characteristics of airway flow. In addition to the air flow, the model solved dynamic scalar transfer to simulate gas ventilation. Ventilation maps projected on a coronal plane and line profiles of ventilation were used for comparison of the FAN model and Xe-DECT images. The visual analysis with models and images was performed by experienced radiologists. Pearson correlation coefficients were calculated to assess their correlation.

**RESULTS**

The pulmonary ventilation calculated from the FAN model was visibly similar to the Xe-DECT images, and the Pearson correlations of the ventilation profiles on the projected plane between the model and images were statistically significant (r = 0.83 ± 0.13, P<0.001).

**CONCLUSION**

The CT-based FAN model showed visual and statistical significance when correlated with the Xe-DECT imaging data. The FAN model utilising structural data may provide additional ventilation information.

**CLINICAL RELEVANCE/APPLICATION**

The FAN model utilising structural CT data may be used to derive pulmonary ventilation maps and quantitative ventilation data.

**SSA05-09  Gender Differences in Airway Dimensions: A Study Based on Quantitative Computed Tomography**

Sunday, Dec. 1 12:05PM - 12:15PM Room: E350

Participants

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**PURPOSE**

The fairly high prevalence of more chronic obstructive pulmonary disease (COPD) in individuals who had never smoked and the increased risk in women raise important questions about the role of gender differences in the airway dimensions. However, there are limited data on non-smokers. Therefore, we investigated how quantitative high-resolution computed tomography (HRCT) measures of wall area percentage (WA%) vary with sex of non-smokers.

**METHOD AND MATERIALS**

We included 94 cases including 49 males and 45 females who underwent chest CT. All included subjects were non-smokers; without current or ex-chronic pulmonary disease (such as chronic obstructive pulmonary disease, asthma, bronchiectasis, lung cancer, chronic inflammation) and all underwent HRCT examination. The HRCT images were quantitatively assessed, providing airway dimensions. We compared the differences of inner diameter, wall area percentage (WA %) for each airway between males and females.

**RESULTS**

The median age was 64 in males and 68 in females. Internal diameter were smaller for women than men in all measured airway (3.51±0.90 VS 4.23±1.17 mm for segmental; and 2.64±0.43 vs 2.97±0.46 mm for subsegmental bronchi respectively, p < 0.001).
However, women had greater WA% in segmental and subsegmental bronchi (62.59±0.07 VS 56.27 ±11.42 for segmental; and 67.36±0.09 VS 57.97±0.16 for subsegmental bronchi, P<0.001.

CONCLUSION

We found significant differences in quantitative HRCT measures of WA% and internal diameter between varying sex of non smokers. Although gender and smoking are strong contributors to COPD, the differences found in this study may explain, in part, variations in disease prevalence-other factors also seem to be important.

CLINICAL RELEVANCE/APPLICATION

Quantitative high-resolution computed tomography (HRCT) measures of wall area percentage (WA%) vary with sex of non smokers.

Printed on: 10/29/20
PURPOSE
To assess the value of qualitative and quantitative radiomics features measured with MRI for noninvasive prediction of histopathologic and genomics characteristics, as well as outcomes of hepatocellular carcinoma (HCC).

METHOD AND MATERIALS
This retrospective study was IRB-approved and the requirement of informed consent was waived. Forty-eight patients with HCC (M/F 35/13, mean age 60y) who underwent hepatic resection or transplant within 4 months of abdominal MRI were included. Qualitative imaging traits, quantitative non-texture related and texture features were assessed in index lesions on contrast-enhanced T1-weighted and diffusion-weighted images. Advanced histopathological analysis was performed using multiplex immunohistochemistry. Gene expression analysis was performed on paraffin-embedded tissue blocks of the index HCC lesions. The association of imaging features with histopathologic and genomics features was assessed using binary logistic regression and correlation analyses. Binary logistic regression analysis was also employed to analyze the association of radiomics, histopathologic and genomics features with radiological recurrence of HCC at 12 months.

RESULTS
Qualitative (correlation coefficient r=0.41-0.40, P<0.042) and quantitative (r=0.52-0.45, P<0.049) radiomics features correlated with immunohistochemical cell type markers for T-cells (CD3), macrophages (CD68), and endothelial cells (CD31). MRI radiomics features also correlated with expression of immunotherapy targets PD-L1 at protein level (r=0.41-0.47, P<0.029) as well as PD1 and CTLA4 at mRNA expression level (r=-0.48-0.47, P<0.037). Follow-up imaging data up to at least 1 year after surgery was available for 43 patients, of whom 10 patients showed HCC recurrence within 1 year after surgery. Several radiomics features showed significant association with HCC recurrence (highest AUC =0.80, odds ratio=5.51, P<0.028), while histopathologic and genomics features did not (P>0.098).

CONCLUSION
We observed significant associations of MRI radiomics features with HCC histopathological and genomics characteristics and recurrence. We are currently validating these results in a prospective study.
CLINICAL RELEVANCE/APPLICATION

Our results suggest that MRI radiomics features may serve as noninvasive predictors of HCC biological properties and recurrence, providing potentially valuable information for treatment planning.

SSA08-02 Multi-Institutional Study using Radiomics and Machine Learning Model to Differentiate Benign and Malignant Focal Hepatic Lesions on Dual-Energy CT

Sunday, Dec. 1 10:55AM - 11:05AM Room: S104A

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PURPOSE
To assess the application of a machine learning (ML) model-based approach for differentiating benign and malignant focal hepatic lesions on post-contrast dual energy CT (DECT) using tumor analysis and radiomics prototypes (eXamine, Siemens Healthineers).

METHOD AND MATERIALS

Our included 174 adults from the US (Site-A: 103, 65 ± 15 years, 53M:50F) and India (Site-B=71, 48 ± 17 years, 46M:25F) with benign (Site-A=60;Site-B=35) or malignant (Site-A=43;SiteB=36) focal hepatic lesions on post-contrast dual source, DECT (Site-A: Siemens Force or Flash; Site-B: Siemens Flash). Most malignant lesions had histology; benign lesions had characteristic imaging features or were stable on follow-up CT. Low and high KV images in arterial phase (2-3mm) were de-identified, exported, and processed with the TA prototype to derive iodine concentrations and uptakes as well as 585 radiomic features within each lesion's volume and rim. ML model based statistical evaluation (Site-A: Training; Site-B: Test) was performed with the radiomics prototype. Random Forest Classifier was used to calculate the accuracy (AUC) for differentiating benign and malignant hepatic lesions.

RESULTS
Multivariate logistic regression demonstrated that 31 radiomic features enabled distinction between benign and malignant lesions (AUC 0.7-0.8; p=0.002-0.03; gldm, glszm, grlm, gszm, first order-kurtosis). With ML model based random forest classifier 12 inner rim radiomic features enabled lesion characterization (AUC=0.82, p<0.0001) with high specificity (97%) and positive predictive value (94%). Only 3/35 benign (flash-filling hemangioma) lesions was classified as malignant lesion (false positive). Compared to radiomics, accuracy was lower for normalized and total iodine uptake (AUC= 0.7; p=0.003; outer lesion rim).

CONCLUSION
With a ML model, the DECT based tumor analysis and radiomics prototypes enable accurate differentiation of benign and malignant hepatic lesions.

CLINICAL RELEVANCE/APPLICATION

Trained ML based predictive models can be generated and integrated with clinical workflow to characterize and classify focal hepatic lesions seen on dual-energy CT.

SSA08-03 Application of Radiomic MRI Features in Differentiation of Combined Hepatocellular Cholangiocarcinoma, Cholangiocarcinoma, and Hepatocellular Carcinoma Using Machine Learning

Sunday, Dec. 1 11:05AM - 11:15AM Room: S104A

Participants
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PURPOSE
Definitive morphological imaging features of combined hepatocellular-cholangiocarcinoma (cHCC-CC) have not been established. We aim to use radiomic features to predict diagnosis of cHCC-CC, cholangiocarcinoma (CC) and hepatocellular carcinoma (HCC) with machine learning.

METHOD AND MATERIALS

We conducted a retrospective review of pre-treatment gadolinium or gadoxetate disodium enhanced liver MRI performed between
2004 and 2018 in our institute for 86 patients with pathology proven cHCC-CC (n=38), CC (n=24) and HCC (n=24). Precontrast, arterial, portal venous, hepatic venous and 5 minutes delayed phases were included. Regions of interest (ROIs) were drawn around the largest diameter of the tumors, avoiding nearby normal tissues. 1370 radiomic features were extracted by standard library (PyRadiomics 2.1.2). Using Principle Component Analysis, they were fused to 20 first principle components that explain the majority of variance. These components were used in a 4-fold cross-validation by a Support Vector Machine (SVM) classifier to evaluate the performance of the predictive model for each MRI sequence using pathology diagnosis as endpoints.

RESULTS
We tested two endpoints predictions: 1. cHCC-CC vs. non cHCC-CC with the expectation of differentiating cHCC-CC from HCC and CC, given its unique pathology; 2. HCC vs. non HCC, due to the difference in management. For differentiation of cHCC-CC from HCC and CC, fused radiomic features from hepatic venous and precontrast phases demonstrated higher prediction value than other sequences, with AUC of 0.77 and 0.64 respectively. For the differentiation of HCC from cHCC-CC and CC, arterial, 5 min delayed, portal venous, and hepatic venous phases demonstrated highest prediction values, with AUC of 0.81, 0.80, 0.79, and 0.79 respectively.

CONCLUSION
CHCC-CC is a unique histological entity with treatment implications including liver transplantation due to poorer prognosis than either HCC or CC. Our results demonstrated fused MRI radiomic features in hepatic venous and precontrast phases are promising in differentiating cHCC-CC from HCC and CC. MRI of arterial and 5 min delayed phases have good predictive value to differentiate CHCC-CC and CC from HCC.

CLINICAL RELEVANCE/APPLICATION
The promising predictive value of radiomic MRI features in the differentiation of cHCC-CC, HCC and CC will help with improved preoperative imaging diagnosis and treatment planning including liver transplantation.

SSA08-04  A Radiomics Model Based on Preoperative Gadoxetic Acid-Enhanced MR Imaging for Predicting Liver Failure after Major Hepatectomy

Sunday, Dec. 1 11:15AM - 11:25AM Room: S104A

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PURPOSE
The clinical indexes are not sufficiently accurate in predicting the outcome of remnant liver function after surgery. The purpose of this study was to determine a radiomics model based on preoperative gadoxetic acid-enhanced MR imaging for predicting liver failure (LF) after major hepatectomy in cirrhotic patients with hepatocellular carcinoma (HCC).

METHOD AND MATERIALS
For this retrospective study, a radiomics-based model was developed based on 101 patients with HCC, with major liver resection between June 2012 and June 2018. Radiomic features were obtained from hepatobiliary phase of gadoxetic acid-enhanced MR images. The radiomics signature was built by using the least absolute shrinkage and selection operator method and multivariable logistic regression model was adopted to establish a radiomics nomogram. Nomogram performance for predicting liver failure was determined using its receiver operating characteristics curve, calibration curve and decision curve.

RESULTS
The radiomics signature, with radiomics score calculated consisting of 5 radiomics features, achieved favorable performance for predicting LF. The radiomics nomogram, which incorporated the radiomics signature and indocyanine green clearance rate at 15 minutes (ICG-R15), showed the highest performance for predicting liver failure (area under the curve [AUC], 0.894; 95% confidence intervals [CI], 0.823-0.964). The integrated discrimination improvement (IDI) analysis showed a significant improvement in the accuracy of LF prediction, especially when radiomics signature was added to the clinical prediction model (IDI = 0.117, P = 0.002).

CONCLUSION
A radiomics-based model of preoperative gadoxetic acid-enhanced MR images can be used for liver failure in cirrhotic patients with HCC after major liver resection.

CLINICAL RELEVANCE/APPLICATION
A radiomics-based model in predicting liver failure after major hepatectomy.

SSA08-05  Radiomic Analysis for Preoperative T-Staging in Patients with Rectal Cancer

Sunday, Dec. 1 11:25AM - 11:35AM Room: S104A

Participants
Wei Lu, Ningbo, China (Presenter) Nothing to Disclose
Pengfei Yang, Hangzhou, China (Abstract Co-Author) Nothing to Disclose
Hailan Zheng, Taizhou, China (Abstract Co-Author) Nothing to Disclose
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Sunday, Dec. 1 11:25AM - 11:35AM Room: S104A

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SSA08-05  Radiomic Analysis for Preoperative T-Staging in Patients with Rectal Cancer

Sunday, Dec. 1 11:25AM - 11:35AM Room: S104A

Participants
Wei Lu, Ningbo, China (Presenter) Nothing to Disclose
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CONCLUSION
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CLINICAL RELEVANCE/APPLICATION
A radiomics-based model in predicting liver failure after major hepatectomy.
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PURPOSE
The accurate preoperative assessment of tumor stage is critical for treatment and prognosis of rectal cancer. This study was aimed at constructing a radiomic prediction model to preoperatively assess the primary tumor (T) stage accurately in patients with rectal cancer.

METHOD AND MATERIALS
The magnetic resonance imaging (MRI) data of 349 patients with rectal cancer were collected from February 2011 to October 2017 in this study (T1, n=49; T2, n=79; T3, n=157; T4, n=64). The patients were divided randomly into training cohort (n=240) and validation cohort (n=109). The radiomic features were extracted from high-resolution T2-weighted imaging (HR-T2WI) and diffusion-weighted imaging (DWI) data, then selected to compose radiomic signatures. Incorporating the radiomic signatures and clinical independent risk factors, we constructed a radiomic assessment model by artificial neural network (ANN). The calibration, discrimination, and clinical utility of the radiomic models were assessed by independent validation.

RESULTS
The radiomic signature was significantly related to T stage of rectal cancer (p<0.01), and showed good preoperatively T-staging performance. The area under the curve (AUC) was 0.822, 0.733 and 0.779 in discriminating between early stages (T1 and T2 stage, T1/2) and advanced stages (T3 and T4 stage, T3/4), between T1 and T2 stages, and between T3 and T4 stages, respectively. Moreover, with combination of the radiomic signature and clinical independent risk factors, the radiomic assessment models showed improved performance. The AUC were 0.858, 0.801 and 0.815 discriminating between T1/2 and T3/4 stages, between T1 and T2 stages, and between T3 and T4 stages, respectively. And the performance was confirmed in an independent validation cohort (AUC, 0.842, 0.773 and 0.730).

CONCLUSION
The radiomic model has an excellent performance in preoperative assessment of T stage of rectal cancer. It can improve the accuracy of T staging in patients with rectal cancer.

CLINICAL RELEVANCE/APPLICATION
The radiomic prediction model can improve the accuracy of T-staging assessment in patients with rectal cancer.

SSA08-06  Radiomics Signature on Multiparameter MRI: Association with Disease-free Survival in Patients with Locally Advanced Rectal Cancer

Participants
Yanfen Cui, Taiyuan, China (Presenter) Nothing to Disclose
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PURPOSE
To develop a radiomics signature based on pre-treatment multiparameter MRI features to estimate disease-free survival (DFS) in patients with locally advanced rectal cancer (LARC) after receiving neoadjuvant chemoradiotherapy (CRT) and to establish a radiomics nomogram incorporating the radiomics signature and clinicopathological findings.

METHOD AND MATERIALS
142 consecutive patients with LARC (training: validation cohorts = 71:71) were enrolled in our retrospective study. 1188 imaging features were extracted from pre-CRT T2WI, contrast enhanced T1WI, and ADC images for each patient. Least absolute shrinkage and selection operator (LASSO) Cox regression was performed to select key features and build a radiomics signature in the training set, and the cutoff point of the radiomics signature to divide the patients into high- and low-risk groups was determined using ROC curve analysis. Kaplan-Meier analysis was used to determine the association of the radiomics signature and DFS. Combining clinicopathological factors, a radiomics nomogram was constructed to validate the radiomic signatures for individualized DFS estimation. Nomogram discrimination and calibration were evaluated.

RESULTS
Higher Rad-scores were significantly associated with worse DFS in both the training and validation cohorts (both P<0.05). The radiomics nomogram, incorporating the radiomics signature and ypN, tumor differentiation, and MRF, estimated DFS (C-index, 0.715; 95% confidence interval [CI], 0.67-0.79) better than the clinicopathological or Rad-score-only nomograms.

CONCLUSION
This study demonstrated that the radiomics signature is an independent biomarker for the estimation of DFS in patients with LARC. Combining the radiomics nomogram improved individualized DFS estimation.

CLINICAL RELEVANCE/APPLICATION
radiomics signature is an independent biomarker for the estimation of DFS in patients with LARC

SSA08-07  Reproducibility of Radiomics Features Using Single-Energy Dual-Source CT: Influence of Radiation Dose and CT Reconstruction Settings Within the Same Patient

Participants

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PURPOSE
Reproducibility of Radiomics Features Using Single-Energy Dual-Source CT: Influence of Radiation Dose and CT Reconstruction Settings Within the Same Patient

METHOD AND MATERIALS
142 consecutive patients with LARC (training: validation cohorts = 71:71) were enrolled in our retrospective study. 1188 imaging features were extracted from pre-CRT T2WI, contrast enhanced T1WI, and ADC images for each patient. Least absolute shrinkage and selection operator (LASSO) Cox regression was performed to select key features and build a radiomics signature in the training set, and the cutoff point of the radiomics signature to divide the patients into high- and low-risk groups was determined using ROC curve analysis. Kaplan-Meier analysis was used to determine the association of the radiomics signature and DFS. Combining clinicopathological factors, a radiomics nomogram was constructed to validate the radiomic signatures for individualized DFS estimation. Nomogram discrimination and calibration were evaluated.

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CONCLUSION
This study demonstrated that the radiomics signature is an independent biomarker for the estimation of DFS in patients with LARC. Combining the radiomics nomogram improved individualized DFS estimation.

CLINICAL RELEVANCE/APPLICATION
radiomics signature is an independent biomarker for the estimation of DFS in patients with LARC
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Daniele Marin, MD, Durham, NC (Abstract Co-Author) Research support, General Electric Company

PURPOSE
To investigate the impact of radiation dose and reconstruction CT settings on the reproducibility of radiomic features within the same patient, as well as to identify correction factors for mitigating these sources of variability.

METHOD AND MATERIALS
This is a retrospective study of 78 patients (33 women [mean age, 61 years; age range, 28-74 years] and 55 men [mean age, 60 years; age range, 34-81 years] with 151 metastatic liver lesions who underwent a single-energy dual-source contrast-enhanced dose split staging CT. By using the imaging raw datasets technique parameters were altered, resulting in 28 different CT datasets per patient which included different dose level, section thickness, kernel and reconstruction algorithms settings. Using a training dataset, reproducible intensity, shape and texture RFs (r2>0.95) were selected and correction factors were calculated by using a linear model to convert each RF to its estimated value under the reference technique. Using a test dataset, reproducibility of hierarchical clustering based on RFs measured under different CT techniques was assessed.

RESULTS
The percentage of RFs deemed reproducible for any variation of the different technical parameters was 11% (12/106). RFs in the shape category were the least likely to be affected by variability due to changes in technical parameters (87.5% [14/16]). Of all technical parameters, reconstructed section thickness had the largest impact on the reproducibility of RFs (12.3% [13/106]). The results of the hierarchical cluster analysis, showed improved clustering reproducibility when reproducible RFs without and with dedicated correction factors (Prob=0.62-1.0) where used.

CONCLUSION
Our patient study confirmed that many RFs are highly affected by CT acquisition and reconstruction settings to the point of being non-reproducible. By selecting reproducible RFs along with dedicated correction factors a significant improvement in the clustering reproducibility of RFs could be achieved.

CLINICAL RELEVANCE/APPLICATION
Radiomic features of databases with heterogeneous CT radiation dose and reconstruction settings are largely non-reproducible and thus, may be limited in their use for prognostic clinical studies.

SSA08-08 Prediction and Measurement of Treatment Response in Metastatic Liver Disease with Machine Learning Radiomics

Sunday, Dec. 1 11:55AM - 12:05PM Room: S104A

Participants
Leila Mostafavi, MD, MBA, Boston, MA (Presenter) Nothing to Disclose
Fatemeh Homayounieh, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
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PURPOSE
To assess if machine learning (ML) based-radiomics can predict and measure treatment response in patients with metastatic liver disease in patients with breast cancer.

METHOD AND MATERIALS
Our IRB approved study included 98 adult women (mean age 54±11 years) with metastatic liver disease from breast cancer. All patients underwent contrast abdomen-pelvis CT in portal venous phase at two timepoints - baseline (BL: pre-treatment) and follow-up (FU: between 3-12 months following treatment). Patients were subcategorized into three subgroups based on RECIST 1.1 criteria (Response Evaluation Criteria in Solid Tumors version 1.1): 32 with stable disease (SD), 32 with partial response (PR) and 34 with progressive disease (PD) on follow up CT. CT images from BL and FU were deidentified and exported to radiomics prototype (eXamine, Siemens Healthineers). The prototype enabled semiautomatic segmentation of the target liver lesions for extraction of first and high order radiomics. Statistical analyses with logistic regression and random forest classifiers was performed with the prototype to assess how well BL radiomics predicts treatment response, and whether radiomics can differentiate SD from...
PD and PR on the two timepoints.

RESULTS

BL radiomics differentiated SD from PR (AUC 0.718) and also SD from PD (AUC 0.797). There was no significant difference between the radiomics on BL and FU CT images of patients with SD (P= 0.998). Busyness (an NGTDM feature) and surface volume ratio (a shape feature) were the most powerful predictors of PD between the BL and FU exams (AUC 0.892). BL and FU radiomics were strong measures of PR (AUC 0.938; p= 0.026 with multivariate logistic regression) and random forest classification (AUC 0.78).

CONCLUSION

Radiomics can predict and measure treatment response in patients with metastatic liver disease.

CLINICAL RELEVANCE/APPLICATION

Machine-learning based radiomics has promise to help predict and differentiate stable metastatic liver disease from progressive disease and partial response to treatment.

SSA08-09  Preoperative Prediction of Early Recurrence in Advanced Gastric Cancer: A Radiomic Model Using Computed Tomography

Sunday, Dec. 1 12:05PM - 12:15PM Room: S104A

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

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PURPOSE

In the clinical management of advanced gastric cancer (AGC), preoperative identification of early recurrence after curative resection is essential. Thus, we aimed to create a Radiomic Model Using Computed Tomography to predict early recurrence in AGC patients preoperatively.

METHOD AND MATERIALS

Ethical approval was obtained for this retrospective analysis, and the informed consent requirement was waived. This study enrolled 521 consecutive patients (302 in the training set and 219 in the test set) with clinicopathologically confirmed AGC from our center. Radiomic features were extracted from preoperative diagnostic CT images. Machine learning methods were applied to shrink feature size and build a predictive radiomic signature. We incorporated the radiomic signature and clinical risk factors into a nomogram using multivariable logistic regression analysis. The area under the curve (AUC) of operating characteristics (ROC) and accuracy were assessed to evaluate the nomogram's performance in discriminating early recurrence.

RESULTS

A radiomic signature, including two hand crafted features and one deep learning feature, was significantly associated with early recurrence (p-value<0.0001 for both sets). The radiomic signature showed a good performance for discriminating early recurrence with AUCs of 0.820 (95% CI, 0.772-0.869) in the training set and 0.799 (95% CI, 0.741-0.857) in the test set. In addition, clinical N stage, clinical T stage, and carcinoembryonic antigen levels were considered independent predictors for early recurrence. The nomogram, combining all these predictors, showed powerful prognostic ability in both the training and test sets with AUCs of 0.851 (95% CI, 0.807-0.895) and 0.842 (95% CI, 0.791-0.894), respectively. The predicted risk yielded good agreement with the observed recurrence probability.

CONCLUSION

By incorporating a radiomic signature and clinical risk factors, we created a radiomic nomogram to predict early recurrence in patients with AGC, preoperatively, which may serve as a potential tool to guide personalized treatment.

CLINICAL RELEVANCE/APPLICATION

Radiomic nomogram may improve risk stratification and serve as a potential biomarker for guiding individual care in patients with AGC.
PURPOSE
The paradoxical lack of decreased mortality from renal cell carcinoma despite the increased incidental detection of renal masses demonstrates a need for risk stratification prior to intervention. As the most common and aggressive histologic subtype, identification of clear cell renal cell carcinoma (ccRCC) during radiologic evaluation would be valuable. Previous work has shown the predictive value of a clear cell likelihood score (ccLS) derived from multiparametric magnetic resonance imaging (mpMRI). Here we assess the prospective performance of ccLS for renal masses across all stages in clinical practice.

METHOD AND MATERIALS
We conducted a retrospective, multi-institution analysis of prospectively generated clinical data. The ccLS was incorporated into the clinical report of mpMRI at 2 different institutions in 06/2016. Prospectively assigned ccLS of renal masses evaluated between 06/2016 and 10/2018 were reviewed. ccLS were correlated with histologic diagnosis when available. Diagnostic performance for diagnosing ccRCC and post-test probabilities of ccLS were quantified by contingency table analysis.

RESULTS
634 mpMRIs were obtained for renal mass evaluation and prospectively assigned ccLS by 1 of 16 fellowship-trained radiologists. Of these, 255 renal masses (244 patients) had pathologic tissue diagnosis after the mpMRI via renal biopsy (34) or surgical excision (221) and represent the study cohort. Overall, 24% were ccLS 1-2, 12% ccLS 3, and 64% ccLS 4-5. 45.1% of the masses were clinical stage T1a, 24.7% T1b, 3.5% T2, 24.3% T3, 2.4% T4. The figure shows the distribution of histologic diagnosis across ccLS. The sensitivity and specificity of ccLS >=4 in diagnosing ccRCC are 87.8% and 80.2%, respectively. The sensitivity and specificity of ccLS >=3 in diagnosing ccRCC are 98.2% and 64.8%, respectively. Diagnostic accuracy improved in higher stage tumors (Cochran-Armitage trend test, p = 0.0025).

CONCLUSION
A non-invasive diagnosis of ccRCC in patients with renal masses using mpMRI can be achieved with reasonable clinical performance in a busy clinical practice with a large number of interpreting radiologists. ccLS performance improved in larger tumors.

CLINICAL RELEVANCE/APPLICATION
Implementation of ccLS in clinical practice can help reduce the number of renal biopsies prior to surgical resection (95.1% of ccLS 4-5 were malignant). Histologic prediction with mpMRI is improved in larger tumors.
Participants
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PURPOSE
To determine the prospective reporting rate of infiltrative features in radiologically identified renal masses and to evaluate the impact on patient outcomes.

METHOD AND MATERIALS
522 patients with renal tumors managed with partial or radical nephrectomy (2012-2014) with locally-advanced and/or aggressive histology were analyzed. Preoperative CT/MRI were retrospectively, independently reviewed by 2 radiologists. Infiltrative renal masses (IRM) were defined as having poorly-defined interface with parenchyma and non-elliptical shape in one or more distinct and unequivocal areas and features were identified as extensive or focal. Cancer-specific mortality (CSM) was estimated using Kaplan-Meier. Significant, independent predictors of CSM were evaluated using Cox-proportional-hazards analysis.

RESULTS
Image-review confirmed 133 IRMs (25%), including 103 RCCs, 59 with sarcomatoid or poorly-differentiated features on pathology. IRMs were larger and more often symptomatic compared to non-IRMs, and disseminated-disease was also more common (all p<0.001). Overall, 109 IRMs were imaged at our center; 42 were documented as IRM in preoperative radiology reports, while infiltrative features were not documented in 67 (61%). Only 4 (6%) of these 67 were documented as infiltrative by the surgical team. 2-year CSM was 29% and 6% for IRM and non-IRM patients, respectively (p<0.001, Figure A). CSM difference was found documented versus undocumented IRMs (p=0.04, Figure B) and both showed significantly increased CSM compared to non-IRMs (both p<0.001). Among IRMs, extensive infiltrative-features and disseminated-disease were associated with CSM, while documentation-status failed to associate. Among IRMs, extensive infiltrative-features and disseminated-disease were associated with CSM, while documentation-status failed to associate.

CONCLUSION
Twenty-five percent of locally-advanced and/or histologically-aggressive renal tumors exhibited infiltrative features, although many were not documented prospectively. Even within this high-risk population, infiltrative-features were independent predictors of CSM, whether documented or not.

CLINICAL RELEVANCE/APPLICATION
Infiltrative features in renal tumors have a strong impact on patient prognosis and should be routinely assessed and documented during radiologic evaluation of renal masses.

SSA11-03 Evaluating Distribution of Renal Tumor Growth Rate in Hereditary Cancers: A Single Center Study

Participants
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PURPOSE
To investigate the distribution of growth rate across different subtypes and sizes of renal tumors associated with hereditary renal cancers, using serial volumetric imaging.

METHOD AND MATERIALS
A registry of patients with hereditary renal cancers was retrospectively reviewed for patients with a minimum of two preoperative cross-sectional imaging. Longest diameter of the tumor was measured for all time points using less than 3 mm slice thickness CT in corticomedullary phase of high-resolution T2-WI MRI. Tumor growth rate between every two consecutive instances of imaging was calculated using the same modality (CT/MRI), and was used as a data point for statistical evaluation. Association between tumor size at each instance and its subsequent growth rate was analyzed using repeated-measures statistical models, which were also used to compare growth rates across renal tumor subtypes.

RESULTS
Images included 1142 CT scans and 734 MRI. Tumors included pathologically confirmed cases of Clear Cell renal cell carcinoma...
(ccRCC, n=197), Papillary type 1 (n=47), and Oncocytoma (n=12) from patients with Von Hippel-Lindau syndrome (n=75), Hereditary Papillary Renal Carcinoma (n=13), and Birt-Hogg-Dube syndrome (n=7). The number of pairs of consecutive measurements, their median growth rate (in mm per 365 days), and interquartile range were: n=777, median=2.35, IQR=(0.00, 6.67) for ccRCC; n=134, median=1.00, IQR=(0.00, 4.66) for Papillary Type 1; and n=27, median=1.44, IQR=(0.00, 4.89) for Oncocytoma. The data did not show any evidence of an association between tumor size at presentation and its subsequent growth rate, for any of the 3 subtypes. There was no evidence of average tumor growth rates being different between tumor subtypes in hereditary renal tumors. Based on all 3 subtypes combined (n=938), the median growth rate was 1.97 mm per 365 days, with an interquartile range of (0.00, 6.27).

CONCLUSION
The data analyzed showed no evidence of an association between renal tumor growth rate and tumor size in ccRCC, Papillary, and oncocytoma associated with hereditary renal syndromes, and showed no evidence of a difference in average growth rate among the 3 subtypes.

CLINICAL RELEVANCE/APPLICATION
Tumor size at presentation measured on serial images does not seem to be a reliable measure to estimate future growth, hence it is not suggested as a marker to schedule surveillance frequency of renal masses associated with hereditary renal cancers.

SSA11-04 The Arrowhead Sign (AS) a Novel, Reproducible Radiographic Indicator of Intramuscular Venous Branch Invasion (pT3a) in Patients with Renal Cell Carcinoma

Sunday, Dec. 1 11:15AM - 11:25AM Room: N230B

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PURPOSE
Accurate preoperative prediction of T3a disease in renal cell carcinoma (RCC) is a clinical challenge. Knowledge of renal intramuscular venous invasion can influence clinical decision-making regarding the suitability of nephron-sparing surgery. We report and validate the observation that tumors that exhibit invasion into the muscular branches of the veins vasculature form a 'beak-shaped' irregularity as they grow towards the renal sinus fat and resembles an 'arrowhead'. We sought to determine if the 'Arrowhead Sign (AS)' CT finding could be used as a preoperative predictor of proximal venous invasion on final histopathologic evaluation.

METHOD AND MATERIALS
We queried our IRB-approved, kidney cancer database and identified 174 patients with localized renal tumors who underwent surgical resection between 2009 and 2018 and had a pre-operative contrast imaging within 90 days of surgery. Two fellowship-trained junior abdominal radiologists and a senior radiologist with 25 years of experience blindly and independently reviewed the imaging. To evaluate for likelihood of tumor venous invasion on final histopathology, images were assessed for the following radiographic predictors of cT3a disease: sinus fat infiltration, perinephric invasion, and AS. Indicators were scored on a 1-4 scale according to reader's degree of confidence in the finding, with a score of 1 - definitely present, to 4 - definitely absent. Statistical analyses were performed.

RESULTS
Final pathologic staging revealed pT1=116 (66.6%), pT2=9 (5.1%), pT3a=48 (27.5%) and pT4a=1 (0.006%). The sensitivity and specificity of AS for predicting muscular venous invasion were 92% and 73%, respectively. Perinephric invasion had 62% sensitivity and 85% specificity, while sinus fat infiltration was 89% sensitive and 73% specific. Inter-reader agreement for AS was moderate (κ = 0.64).

CONCLUSION
The arrowhead sign is a novel and potentially clinically actionable predictor of muscular venous invasion in patients with RCC. Of the three indicators, it had the highest sensitivity and moderate intra-reader agreement. These initial findings justify further investigation.

CLINICAL RELEVANCE/APPLICATION
The ability to stage pT3a (RCC) with imaging can influence surgical management and eligibility for clinical trials. Of the three commonly reported imaging features the, 'arrowhead sign,' had the highest sensitivity and larger validation studies are warranted.

SSA11-05 Renal Mass Characterization with Dual-energy CT: Validation of a Dual-layer Spectral CT Platform in an Anthropomorphic Renal Phantom Model

Sunday, Dec. 1 11:25AM - 11:35AM Room: N230B

Participants
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METHOD AND MATERIALS

A custom renal phantom model consisting of three cylinders simulating unenhanced state (A) (0 mgI/mL), nephrographic (B) (7 mgI/mL) and excretory phases (C) of the kidneys (5 mgI/mL) was used. In addition, six rods were fabricated to mimic simple and hyperdense cysts (0 mgI/mL), unenhanced (0 mgI/mL) and contrast-enhanced minimally- (0.5 mgI/mL), moderately- (1 mgI/mL), and avidly-enhancing (3 mgI/mL) solid renal masses (labelled 1-6 respectively). Simulated kidneys with varying renal masses were inserted into an anthropomorphic human phantom (ATOM 701, CIRS Inc.) in three body sizes (small, medium, large) and scanned with 120 kV single-energy and dual-energy CT using a dual-layer spectral CT (IQon Spectral CT; Philips Healthcare). For each scan, full radiation dose and 40% radiation dose-reduced acquisitions were obtained. Single-energy, dual-energy 70 keV monochromatic and iodine maps were reconstructed and computed. The effect of body habitus and radiation exposure on renal mass characterization was also assessed.

RESULTS

Consistent and statistically significant attenuation differences were observed between the unenhanced, minimally-, moderately-, and avidly- enhancing lesions (p<0.05 for all comparisons) without variation between the small and medium body sizes. No statistically significant attenuation difference was found across the renal lesions when standard radiation dose was compared to 40% reduced dose with the exception of the moderately enhancing renal lesion in nephrographic phase in a small body size. Iodine quantification was variable with statistical significance between phase of contrast, body size and radiation dose.

CONCLUSION

Attenuation changes calculated from dual energy CT data using a dual-layer platform can be used to differentiate among different renal lesion types, without significant variation with different radiation dose levels. However, the iodine quantification technique shows significant variation as a function of study phase, body size and radiation dose.

CLINICAL RELEVANCE/APPLICATION

Radiation dose reduced acquisition can be implemented for renal mass characterization with DECT on a dual-layer platform. However, circumspection should be paid when using the iodine quantification with different study phases, body size and radiation dose levels.

SSA11-06 Cost-Effectiveness of Dual-Energy CT Versus MRI for Characterization of Small Incidental Indeterminate Renal Lesions

Sunday, Dec. 1 11:35AM - 11:45AM Room: N230B

Participants

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PURPOSE

To develop a Markov Monte Carlo decision-analytic model to estimate the cost effectiveness of dual-energy (DE) CT versus multiphasic single-energy (SE) CT and MRI for characterizing small incidentally detected indeterminate renal lesions.

METHOD AND MATERIALS

A decision analytic Markov model was constructed to estimate life expectancy and lifetime costs for otherwise healthy 64-year-old patients with small (<= 4 cm) incidentally detected, indeterminate renal lesions on routine imaging (e.g. ultrasound or single-phase CT). Three strategies for evaluating renal lesions for enhancement were compared: multiphase SECT (e.g. true unenhanced and nephrographic phase), multiphasic MRI, and single-phase DECT (nephrographic phase only in dual-energy mode). Model incorporated modality specific diagnostic performance, incidence and prevalence of incidental renal cell carcinomas (RCCs), effectiveness, costs, and outcomes. An incremental cost-effectiveness analysis was performed to identify strategy preference at a willingness-to-pay (WTP) thresholds of $50,000 and $100,000 per quality-adjusted life-year (QALY) gained. Deterministic and probabilistic sensitivity analysis were performed by using Monte Carlo simulations (100,000 runs).

RESULTS

Under the base-case assumptions, DECT was the dominant strategy as it was most cost-effective with a higher effectiveness (mean 0.95) and lower cost ($2108) compared to MRI (mean of 0.93 and $3105) and multiphasic SECT (0.93 and $2851). Results were robust to changes in model parameters based on sensitivity analysis. The probability that the single-phase DECT imaging strategy was cost-effective was 76% at a willingness to pay of $50,000/QALY.

CONCLUSION

Dual-energy CT is more cost-effective than multiphasic single-energy CT and MRI for characterizing small incidentally detected indeterminate renal lesions.

CLINICAL RELEVANCE/APPLICATION

Under the base-case assumptions, DECT was the dominant strategy as it was most cost-effective with a higher effectiveness (mean 0.95) and lower cost ($2108) compared to MRI (mean of 0.93 and $3105) and multiphasic SECT (0.93 and $2851). Results were robust to changes in model parameters based on sensitivity analysis. The probability that the single-phase DECT imaging strategy was cost-effective was 76% at a willingness to pay of $50,000/QALY.

CONCLUSION

Dual-energy CT is more cost-effective than multiphasic single-energy CT and MRI for characterizing small incidentally detected indeterminate renal lesions.
Incidental indeterminate renal lesions are commonly encountered and often warrant additional imaging workup. DECT is a more cost-effective than MRI and SECT to determine whether there is renal lesion enhancement and should be considered the preferred workup strategy.

**SSA11-07  Apparent Diffusion Coefficient Predicts Malignancy in T1-Hyperintense Small Renal Masses**

**Sunday, Dec. 1 11:45AM - 11:55AM Room: N230B**

**Participants**
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**PURPOSE**
Small renal masses (<4 cm) can be difficult to accurately classify as benign or malignant, particularly if they are T1 hyperintense on MRI. This intrinsic signal, potentially related to intralesional hemorrhage, may limit evaluation of contrast enhancement and signal intensity on other sequences. The purpose of this study was to test whether apparent diffusion coefficient (ADC) measurements may predict malignancy.

**METHOD AND MATERIALS**
This IRB-approved single-center retrospective study identified patients with a T1-hyperintense renal mass less than 4 cm on MRI. Malignant lesions were pathologically proven; a benign mass was established by a predefined hierarchy of pathologic proof, follow-up ultrasound, or follow-up imaging (MR/CT) showing more than 5 years of stability. T1 hyperintensity, defined as a signal intensity equivalent to or greater than the adjacent cortex, was confirmed by an abdominal radiologist with over 20 years of abdominal imaging experience. Two additional abdominal radiologists independently measured ADC values by drawing the largest region of interest within the lesion. This was normalized to the ADC of the ipsilateral background kidney (i.e. ADClesion / ADCipsilateral) and represented as ADCratio. (Figure). Inter-reader reliability was assessed using intra-class correlation coefficient (ICC). Multivariate binary logistic regression was used to control for lesion size.

**RESULTS**
There were 58 benign and 37 malignant renal lesions in 95 patients (51 [54%] males; age 61 ± 13 years; size 1.9 ± 0.9 cm). Inter-reader agreement for lesion and ipsilateral kidney was excellent (ICC of 0.94 [CI: 0.91, 0.96] and 0.84 [CI: 0.76, 0.89] respectively). ADCratio was significantly lower in malignant compared to benign lesions (0.65 ± 0.29 vs. 1.03 ± 0.32, p<0.001 [Figure]). Malignant lesions were significantly larger than benign lesions (2.7 ± 0.9 vs. 1.5 ± 0.6 cm, p<0.001). After controlling for lesion size, ADCratio remained a significant predictor of malignancy; each 0.1 unit decrease in ADCratio conferred a 1.49 times higher odds of malignancy (95% CI: 1.20, 1.84; p<0.001).

**CONCLUSION**
ADCratio is a significant predictor of malignancy in small T1-hyperintense renal lesions.

**CLINICAL RELEVANCE/APPLICATION**
Small renal masses with intrinsic T1 hyperintensity on MRI can be difficult to classify as benign versus malignant. ADCratio may serve as a useful differentiating feature.

**SSA11-08  Accuracy of Contrast-enhanced Ultrasound for Characterization of Complex Cystic Renal Masses and Its Agreement with CT for the Bosniak Classification**

**Sunday, Dec. 1 11:55AM - 12:05PM Room: N230B**

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**PURPOSE**
To evaluate the diagnostic accuracy of contrast-enhanced ultrasound (CEUS) for characterization of complex cystic renal masses according to Bosniak classification system and its agreement with CT.

**METHOD AND MATERIALS**
This prospective study approved by the Institutional Review Board comprised of 50 patients with complex cystic renal masses, detected on gray-scale ultrasound. All patients were evaluated by both CEUS and CT, after obtaining informed consent. CEUS was performed on a single ultrasound machine with a 1-6 MHz curvilinear using second generation contrast agent. Contrast CT was performed on the same 128-slice scanner in all patients. All patients were classified according to the Bosniak classification using both modalities. Imaging follow up was performed for Bosniak II and IIF lesions and histopathological diagnosis was obtained for Bosniak III and IV lesions. Mc Nemar test was used to compare sensitivity and specificity of the two methods. p value < 0.05 was considered statistically significant. Inter rater kappa agreement was used to find out agreement between CEUS and CT.
RESULTS
Out of 50 patients, 12 were female and 38 were male with ages ranging from 18 to 78 years. On CEUS, complex cysts were characterized as follows: 18 as Bosniak II, 18 as Bosniak IIF, 10 as Bosniak III and 4 as Bosniak IV. On CT, these complex cysts were characterized as follows: 20 as Bosniak II, 16 as Bosniak IIF, 12 as Bosniak III and 2 as Bosniak IV. CEUS upgraded two Bosniak II cysts into Bosniak IIF and two Bosniak III cysts into Bosniak IV. Mean septal thickness and mean number of septae was significantly higher on CEUS as compared to CT (p value < 0.05). Strength of agreement was excellent (k value of 0.818) between the two modalities for all categories of Bosniak classification.

CONCLUSION
CEUS has similar diagnostic accuracy to CT in characterization complex cystic renal masses for all categories of Bosniak classification.

CLINICAL RELEVANCE/APPLICATION
In patients with complex renal cysts, CEUS can be used as safer alternative to CT to prevent radiation exposure and for those with chronic kidney disease, where iodinated contrast is contraindicated.

SSA11-09 Morphometric Image Analysis Predicts Surgical Outcomes During Level II-IV Level Inferior Vena Cava Tumor Thrombectomy

Sunday, Dec. 1 12:05PM - 12:15PM Room: N230B

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PURPOSE
To assess if the scored morphometric analysis of renal vein and Inferior Vena Cava (IVC) tumor thrombus diameters and renal cell carcinoma (RCC) volume extracted from preoperative CECT and MRI can predict surgical outcomes and complications of level II-IV IVC tumor thrombectomy.

METHOD AND MATERIALS
In this IRB approved, HIPAA compliant retrospective study, we queried CECT and MRI imaging studies of 83 patients performed over a 10-year window (Nov 2007 - Dec 2017). Manual segmentation of the venous thrombus was performed by an experienced radiologist in Synapse 3D. The 3D regions of interest (ROIs) included IVC, renal vein, thrombus and renal mass. Segmental volumetric-analysis was performed separately on the suprarenal and infrarenal IVC, the caval thrombus volume included both tumor as well as bland thrombus. In all cases, maximum diameter of the IVC and renal vein, as well maximal bowing of the IVC and renal vein ostium diameter were measured. The radiological variables were compared to a measure of complications captured by Clavien-Dindo (CD) score. Random forest was used as the machine learning tool to build the composite prediction models with all candidate predictors. Leave-one-out procedure was used to assess the robust prediction accuracy. Area under the curve was used to assess the prediction accuracy for binary surgical outcome and R2 was used for continuous outcome.

RESULTS
Five composite prediction models were built using random forest. The leave-one-out validation showed that the composite prediction models using imaging-based morphometric predictors alone can achieve a robust and statistically significant AUROC=0.795% CI (0.58 0.81) in predicting CD. We also found that the models can robustly explain significant amount of total variance of natural log-transformed (ln) ln(Estimated Blood loss): 15% (p<0.01); ln(Number of units transfused): 7% (p=0.01); ln(Operation time): 6% (p=0.02) and ln(Trans): 5% (p=0.06).

CONCLUSION
Imaging-based morphometric models can be accurately used to predict surgical outcomes and complications. This can be used to assist with surgical planning and patient counseling.

CLINICAL RELEVANCE/APPLICATION
Radiologic morphometric analysis in patients with RCC with level II-IV IVC thrombus can help predict surgical outcomes and complications.
SSA14
Musculoskeletal (Bone Marrow and Neoplasms)

Sunday, Dec. 1 10:45AM - 12:15PM Room: E450B

CT MK

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
SSA14-01 Diagnostic Accuracy of Dual-Layer Detector CT Using Calcium-Suppressed Images for the Detection of Bone Marrow Edema in Wrist

Sunday, Dec. 1 10:45AM - 10:55AM Room: E450B

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PURPOSE
To evaluate the performance of calcium suppressed images (CaSupp) obtained by dual-layer detector computed tomography (DLCT) for the detection of bone marrow edema (BME) in patients with wrist pain.

METHOD AND MATERIALS
We retrospectively analyzed 49 patients with wrist pain (44 distal radius fractures, 2 carpal bone fractures, 2 scaphoid nonunion advance collapses, 1 Kienböck disease), who underwent both DLCT and MRI. Two blinded and independent readers evaluated CaSupp images for evaluating BME by using color-coded maps. Using MRI images as the reference standard, the sensitivity and specificity of CaSupp images were analyzed for detecting BME of radius, ulna, and carpal bones.

RESULTS
On MRI, 44 distal radius and 30 distal ulna fractures were found. In detecting BME of radius and ulna, two readers showed 100% of agreement. When CaSupp images were compared with MRI images, sensitivity and specificity for detecting BME were both 100% for radius, and 88% and 87.5% for ulna, respectively. For carpal bone, BME was found in 8 of 44 radius fractures and 5 of patients with only carpal bone abnormalities on MRI. Those carpal bone BMEs were detected on CaSupp images with following diagnostic accuracy: sensitivity, 92.8% for reader 1 and 64.2% for reader 2; specificity, 88.5% in both readers. For detection of carpal bone BME, two readers showed moderate agreement (agreement 75.5%, kappa value 0.43).

CONCLUSION
CaSupp images reconstructed from DLCT enabled detection of BME in fractured distal radius and ulna with substantially high diagnostic accuracy when compared to MRI images. However, CaSupp demonstrated limited performance in visualization of BME of carpal bone pathologies.

CLINICAL RELEVANCE/APPLICATION
CaSupp images showed similar performance in visualization and detection of BME in wrist, including incomplete fracture compared with MRI. CaSupp images is expected to be a promising technique to demonstrate BME in wrist.

SSA14-02 3D UTE Bicomponent T2* Analysis of Cortical Bone using a Novel Soft–Hard Composite Excitation Pulse

Sunday, Dec. 1 10:55AM - 11:05AM Room: E450B

Participants
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Distinguishing myelodysplastic syndromes (MDS) from aplastic anemia (AA) can be challenging because patients with these diseases share many clinical features, such as hypocellular bone marrow (BM). This research aimed to build an MRI-based predictive model to differentiate between these entities using a machine learning algorithm.

**METHOD AND MATERIALS**

Patients with histologically confirmed MDS (n=24) or AA (n=29) were retrospectively investigated. First, we used three machine-learning approaches including a logistic regression model for the classification task to differentiate the entities. We included mean ADC, indices calculated from the ADC histogram, perfusion indices, and fat fraction from ROIs within the BM of L1-L3, and whole blood test data, including the reticulocyte percentage, as inputs in the model. We used 10-fold cross-validation to prevent overfitting. Next, we compiled datasets of the lumbar MR images of T1WI. We fine-tuned a convolutional neural network (CNN) on our training dataset. The CNN with standard cross-entropy loss function and the Adam optimizer with an initial learning rate of 0.001 provided automated prediction of the diagnosis. Third, the diagnostic performances of a radiology fellow, experienced musculoskeletal radiologist, and senior hematologist with specific expertise in pancytopenia were calculated.

**RESULTS**

Of the 53 MRIs tested, the algorithm by conventional multiparametric MRI predicted diagnosis correctly by the logistic regression model with the highest accuracies of 77.4% for MDS and 77.4% for AA with a combination of features of age, fat fraction, and blood test data, including the reticulocyte percentage, as inputs in the model. We used 10-fold cross-validation to prevent overfitting. Next, we compiled datasets of the lumbar MR images of T1WI. We fine-tuned a convolutional neural network (CNN) on our training dataset. The CNN with standard cross-entropy loss function and the Adam optimizer with an initial learning rate of 0.001 provided automated prediction of the diagnosis. Third, the diagnostic performances of a radiology fellow, experienced musculoskeletal radiologist, and senior hematologist with specific expertise in pancytopenia were calculated.

**CONCLUSION**

The CNN provided better differentiation of MDS from AA than conventional multiparametric MRI or visual inspection by human observers. Age, fat fraction of lumbar BM, and platelet count in whole blood proved useful for differentiation of these two entities.
From a total of 1008 evaluated patients 763 (73.02%) were hematooncologic patients. A total of 104 rib lesions were found by

RESULTS

all ribs from 0 to 360°. The standard of reference was 18F-FDG-PET, Ga68-DOMITATE-PET/CT, bone scan or imaging follow-up processed to 3D unfolded ribs. The "unfolding" of the rib using the centreline as an axis allows a synchronous display and rotation of data sets of all patients were additionally directed from the scanner to a computational server where they were automated post-
data sets were used for "conventional" diagnosis including coronal reformates with 3mm slice thickness. 1mm slice thickness image section thickness 3mm and 1mm using a soft tissue spatial resolution kernel (I30f) and a sharp kernel (B70f). Both transversal image

METHOD AND MATERIALS

whole-body CT staging/restaging. The CT-protocol consisted of 120kV, 100 mAs, matrix 512x512, collimation 0.6mm, reconstructed

PURPOSE

To evaluate the performance of automated CT post-processing software generating unfolded rib images for improved detection of both benign and malignant rib lesions during routine diagnostic work-up of oncological patients.

METHOD AND MATERIALS

1008 in- and outpatients (63.66 ±14.25 years; range 18.67 to 95.67 years; 405 females and 603 males) undergoing chest-CT between 07/2018-1/2019 at our own institution were retrospectively evaluated. Patients underwent chest-CT alone or as part of a

RESULTS

From a total of 1008 evaluated patients 763 (73.02%) were hematooncologic patients. A total of 104 rib lesions were found by
transversal CT-image reading whereas the unfolded rib image reading detected 305 lesions. 89 were classified malignant and 202 were classified benign. Detection of malignant rib lesions proved significant both for <1cm diameter (p<0.02) and >1cm diameter (p<0.007). The sensitivity, specificity, PPV and NPV for detection of malignant rib lesions was 97.7%/98.5%/96.6%/99% for unfolding ribs and 76.4%/100/92.7%/90.5% for conventional (transversal) image reading. Detection of sclerotic rib lesions and lesions >1cm in diameter was significantly better (p<0.01) for the unfolding rib algorithm.

CONCLUSION
The 'unfolded rib' reformates are significantly superior for rib lesion detection compared to conventional transversal CT-scan reading and should be therefore used in all patients in particular in those with oncologic background.

CLINICAL RELEVANCE/APPLICATION
The 'unfolded rib' reformates are significantly superior for rib lesion detection and should be therefore used in all patients in particular in those with oncologic background.

SSA14-06 Convolutional Neural Networks versus Expert Radiologist Accuracy in Differentiating Benign and Malignant Soft Tissue Neoplasms

Sunday, Dec. 1 11:35AM - 11:45AM Room: E450B

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PURPOSE
To evaluate the accuracy of convolutional neural networks (CNNs) in differentiating pathologically-proven benign from malignant soft tissue musculoskeletal neoplasms as compared to that of experienced musculoskeletal radiologists.

METHOD AND MATERIALS
One hundred patients with histologically-confirmed soft tissue tumors were identified from the institutional medical record. T1W, fat-suppressed T2W (fsT2W), fat-suppressed T1W pre- (T1-Pre) and post-contrast (T1-Post) MR images were used to train four CNNs, each using data from one sequence. A fifth CNN was created using all images in combination. For image pre-processing, volumetric regions of interest (ROIs) corresponding to tumor boundaries were segmented on Horos software. PyOsinX was used to export images and ROI masks for later analyses. Patches of 201 x 201 pixels were generated in each tumor ROI. Five CNNs, each using data from one sequence. A fifth CNN was created using all imaging sequences in combination. For image pre-processing, volumetric regions of interest (ROIs) corresponding to tumor boundaries were segmented on Horos software. PyOsinX was used to export images and ROI masks for later analyses. Patches of 201 x 201 pixels were generated in each tumor ROI.

RESULTS
Each radiologist attained an accuracy of 0.66. The five CNNs achieved the following accuracies and AUCs, respectively: 0.69, 0.70 (T1W); 0.74, 0.80 (T1-Pre) 0.78, 0.76 (T1-Post); 0.70, 0.70 (fsT2W); 0.80, 0.82 (combined CNN). No significant difference was found between the accuracy of the combined CNN model and either radiologist (p>0.05). False positive rate for malignancy was significantly higher in both radiologists as compared to the combined CNN (p<0.05).

CONCLUSION
CNNs differentiate benign versus malignant soft tissue neoplasms with moderate accuracy using individual MR sequences and good accuracy using the full conventional MR imaging protocol. Overall accuracy is similar to expert radiologist interpretation.

CLINICAL RELEVANCE/APPLICATION
Machine learning approaches could serve as a valuable adjunct to clinical practice for physicians and non-musculoskeletal fellowship trained radiologists.

SSA14-07 Qualitative Evaluation of MRI Features of Lipoma and Atypical Lipomatous Tumors: Results from a Multi-Center Study

Sunday, Dec. 1 11:45AM - 11:55AM Room: E450B

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Morphologic changes in ASPS lesions at 3-months are strong predictors of durable response; while in isolated cases early and associated with lesion non-progression (p=0.04, 0.04, and 0.03, respectively). Of textural features, only decreases in kurtosis, entropy, and skewness were followed-up was highly associated with non-progressive disease (p=0.0004, Wilcoxon rank-sum), as were decreases in short axis and disappeared, 13 decreased by at least 30%, 3 remained stable, and 7 progressed by at least 20%. Decrease in Dmax at 3-month assessments. Baseline mean Dmax=2.6 cm, and volume=9.1 cc. Best individual lesion responses by Dmax were as follows: 5 lesions received axitinib and pembrolizumab combination therapy. Target lesions were chosen according to RECIST 1.1 guidelines. All target lesions were segmented on portal-venous phase CT using mint Lesion 3.4, and the following radiomics features were extracted: long axis, short axis, volume, entropy, kurtosis, skewness, mean of positive pixels (MPP), and uniformity of distribution of positive gray-level pixel values (UPP). Results were compared to maximum diameters at the lesional level.

The 28 lesions were followed for mean of 13 months (range 3 to 27 months); this yielded a total of 152 distinct lesional timepoint analyses. Axitinib/pembrolizumab has recently shown superior efficacy compared to historical controls in the treatment of alveolar soft part sarcoma (ASPS). We aimed to evaluate CT texture analysis of ASPS lesions treated with this novel immunotherapy regimen. This IRB-approved study included 28 lesions in 10 subjects with ASPS enrolled in a prospective phase 2 clinical trial. Patients underwent presurgical contrast-enhanced MRI. MRI was centrally read by a board-certified radiologist for site, depth (superficial/deep), architectural complexity, level of fat suppression, enhancement and septa. Significant features in univariate analysis were further studied using a logistic regression model with 1000-samples bootstrapped 95% confidence interval (CI). The radiologist’s impression was recorded as BL or ALT. A 4-point scale (1-4) reflecting the diagnostic confidence was also used, with 4 being the highest level of confidence. Histopathology (including MDM2) was used as the diagnostic reference standard.

RESULTS
71 ALTs were pathologically verified. Subjects with ALTs were significantly older (61±13 vs. 56±12yr) and presented with pain or discomfort. Multiple features were significantly associated with the pathologic diagnosis in univariate analysis, but in multivariate analysis only large tumor size (OR=1.08, 95%CI:1.01-1.16), deep location (OR=4.31, 95%CI:1.02-18.33), and incomplete fat saturation (OR=3.28, 95%CI:1.14-9.49), and increased architectural complexity (OR=9.44, 95%CI:3.51-25.44) were independent predictors of ALT. Overall radiologist impression was 80% sensitive (95%CI:69-89%) and 79% specific (95%CI:72-85%). 8/97 cases with a confidence score of 4 and 9/64 cases with a confidence score of 3 were misdiagnosed. Radiologist confidence score inversely correlated with the proportion of misdiagnosis (p=0.05).

CONCLUSION
The MRI features tumor size, depth, location, fat saturation and architectural complexity were independent predictors of ALT. Though these features may help in the differentiation of lipomatous lesions, several cases were misdiagnosed even when the radiologist expressed a high level of diagnostic confidence.

CLINICAL RELEVANCE/APPLICATION
MRI features can help differentiating lipomatous lesions, however, even when the radiologist’s confidence level is high, several cases were misdiagnosed. Clinician should be aware of the limitations of MRI features.

PURPOSE
Axitinib/pembrolizumab has recently shown superior efficacy compared to historical controls in the treatment of alveolar soft part sarcoma (ASPS). We aimed to evaluate CT texture analysis of ASPS lesions treated with this novel immunotherapy regimen.

METHOD AND MATERIALS
This retrospective multicenter study recruited a total of 247 (136 females) subjects (median age:59 years; range:23-92). All subjects underwent presurgical contrast-enhanced MRI. MRI was centrally read by a board-certified radiologist for site, depth (superficial/deep), architectural complexity, level of fat suppression, enhancement and septa. Significant features in univariate analysis were further studied using a logistic regression model with 1000-samples bootstrapped 95% confidence interval (CI). The radiologist’s impression was recorded as BL or ALT. A 4-point scale (1-4) reflecting the diagnostic confidence was also used, with 4 being the highest level of confidence. Histopathology (including MDM2) was used as the diagnostic reference standard.

RESULTS
71 ALTs were pathologically verified. Subjects with ALTs were significantly older (61±13 vs. 56±12yr) and presented with pain or discomfort. Multiple features were significantly associated with the pathologic diagnosis in univariate analysis, but in multivariate analysis only large tumor size (OR=1.08, 95%CI:1.01-1.16), deep location (OR=4.31, 95%CI:1.02-18.33), and incomplete fat saturation (OR=3.28, 95%CI:1.14-9.49), and increased architectural complexity (OR=9.44, 95%CI:3.51-25.44) were independent predictors of ALT. Overall radiologist impression was 80% sensitive (95%CI:69-89%) and 79% specific (95%CI:72-85%). 8/97 cases with a confidence score of 4 and 9/64 cases with a confidence score of 3 were misdiagnosed. Radiologist confidence score inversely correlated with the proportion of misdiagnosis (p=0.05).

CONCLUSION
The MRI features tumor size, depth, location, fat saturation and architectural complexity were independent predictors of ALT. Though these features may help in the differentiation of lipomatous lesions, several cases were misdiagnosed even when the radiologist expressed a high level of diagnostic confidence.

CLINICAL RELEVANCE/APPLICATION
MRI features can help differentiating lipomatous lesions, however, even when the radiologist’s confidence level is high, several cases were misdiagnosed. Clinician should be aware of the limitations of MRI features.

SSA14-08 CT Radiomics in Alveolar Soft Part Sarcoma Response to Novel Immunotherapy Regimen

Sunday, Dec. 1 11:55AM - 12:05PM Room: E450B

Participants
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PURPOSE
Axitinib/pembrolizumab has recently shown superior efficacy compared to historical controls in the treatment of alveolar soft part sarcoma (ASPS). We aimed to evaluate CT texture analysis of ASPS lesions treated with this novel immunotherapy regimen.

METHOD AND MATERIALS
This IRB-approved study included 28 lesions in 10 subjects with ASPS enrolled in a prospective phase 2 clinical trial. Patients received axitinib and pembrolizumab combination therapy. Target lesions were chosen according to RECIST 1.1 guidelines. All target lesions were segmented on portal-venous phase CT using mint Lesion 3.4, and the following radiomics features were extracted: long axis, short axis, volume, entropy, kurtosis, skewness, mean of positive pixels (MPP), and uniformity of distribution of positive gray-level pixel values (UPP). Results were compared to maximum diameters at the lesional level.

RESULTS
The 28 lesions were followed for mean of 13 months (range 3 to 27 months); this yielded a total of 152 distinct lesional timepoint assessments. Baseline mean Dmax=2.6 cm, and volume=9.1 cc. Best individual lesion responses by Dmax were as follows: 5 lesions disappeared, 13 decreased by at least 30%, 3 remained stable, and 7 progressed by at least 20%. Decrease in Dmax at 3-month follow-up was highly associated with non-progressive disease (p=0.0004, Wilcoxon rank-sum), as were decreases in short axis and volume (p=0.003 and 0.0003, respectively). Of textural features, only decreases in kurtosis, entropy, and skewness were associated with lesion non-progression (p=0.04, 0.04, and 0.03, respectively).

CONCLUSION
Morphologic changes in ASPS lesions at 3-months are strong predictors of durable response; while in isolated cases early and
predictive changes in image textural parameters were observed, in general these parameters do not substantially improve response prediction over Dmax at the 3-month time-point.

**CLINICAL RELEVANCE/APPLICATION**

In ASPS treated with this immunotherapy-based regimen, one-dimensional assessments at 3 months are sufficient to predict durable lesion response.

**SSA14-09  Organ Dose and Total Effective Dose of Whole-Body CT in Multiple Myeloma Patients**

Sunday, Dec. 1 12:05PM - 12:15PM Room: E450B

Participants
Robert Hemke, MD,PhD, Woerden, Netherlands (Presenter) Nothing to Disclose
Kai Yang, PhD, Boston, MA (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

Whole body low-dose CT (WBLDCT) plays an important role in the work-up of patients with plasma cell disorders and has recently been incorporated in the International Myeloma Working Group criteria for multiple myeloma (MM). However, data are lacking on the radiation exposure of such CTs. The purpose of this study was to evaluate organ dose and total effective dose of WBLDCT performed on different CT scanners in patients with MM and to compare it to the effective dose of a radiographic skeletal survey and typical diagnostic CTs. We hypothesized that the effective dose of WBLDCT would be lower than that of diagnostic CTs and higher than that of a skeletal survey.

**METHOD AND MATERIALS**

Our study was IRB approved and HIPAA compliant. We retrospectively analyzed data from 228 patients (47.4% females, mean age 67.9±10.4 years, mean weight 81.8±22.4 kg) who underwent WBLDCT for the work-up or surveillance of MM. Patients were scanned using one of our six multi-detector CT-scanners (Figure 1). Organ doses and total effective doses per scan were calculated using a commercially available dose management platform (Radimetrics, Bayer Healthcare, Leverkusen, Germany). The median effective dose was then compared to radiographic skeletal survey and representative diagnostic CTs performed in our institution.

**RESULTS**

The mean effective dose of our WBLDCT-protocol was 4.82 mSv. A significant higher effective dose was observed in females compared to males (4.95 mSv vs. 4.70 mSv, P=0.002). The mean organ dose ranged from 3.72 mSv (esophagus) to 13.09 mSv (skeleton). The mean effective dose varied amongst different CT-scanners (range 4.34-8.37 mSv) (Figure 1). The median effective dose of WBLDCT was more than twice the dose of a skeletal survey (4.82 vs 2.04 mSv), 23% higher than a diagnostic contrast-enhanced chest CT (3.9 mSv), 46% lower than a diagnostic contrast-enhanced abdomen/pelvis CT (9.0 mSv), and 45% lower than a lumbar spine CT (8.7 mSv).

**CONCLUSION**

WBLDCT in MM has a higher effective dose than a radiographic skeletal survey, but a lower effective dose than diagnostic CTs of the lumbar spine, abdomen and pelvis. This underlines the broad applicability of WBLDCT in the management of MM patients.

**CLINICAL RELEVANCE/APPLICATION**

The additional diagnostic value of low-dose whole-body CT in the management of MM patients outweighs the relatively limited additional radiation dose as compared to a radiographic skeletal survey.

Printed on: 10/29/20
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Sonya Y. Park, MD, Seoul, Korea, Republic Of (Moderator) Nothing to Disclose

Sub-Events
SSA16-01 AI Pipeline System for Detection of Bone Metastases on PET-CT

Participants
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PURPOSE
To develop a machine learning system for the detection of bone metastases from the data of CT based on ground truth generated from 18F-fluorodeoxyglucose (FDG) PET.

METHOD AND MATERIALS
In this study, 198 whole body PET-CT examinations (105 men and 93 women; mean age, 63.8 years ± 12.9 [standard deviation]) with one or more bone metastases were retrospectively evaluated. At first, an automated annotation generation tool for bone metastases was created to extract lesions from PET. A binary bone mask was obtained from CT and multiplied with the rescaled PET volume. This resulted in a PET volume with FDG uptake in bones only. A convolutional neural network (CNN), ResNet-50, was then used to discard high FDG uptake regions which did not correspond to bone metastases, such as brain or bladder. Each candidate of bone metastasis was assigned a unique lesion number before it was converted into slice-wise bounding boxes. Secondly, one of the authors labeled each automatically extracted lesion with osteoblastic metastasis, osteolytic metastasis, intertrabecular metastasis and other. The 198 examinations were split in 173 examinations for training and 25 examinations for validation. A Mask R-CNN model was trained on the training set using labeled bounding boxes as ground truth. Finally, prediction accuracy was measured on the validation set.

RESULTS
In a total of 198 examinations, 1263 lesions were detected with the annotation tool and composed of 364 osteoblastic metastases, 365 osteolytic metastases, 24 intertrabecular metastases, and 510 others such as normal lesions, postoperative lesions, degenerative changes, and inflammation. The sensitivity was 77.8% for osteoblastic metastases, 54.2% for osteolytic metastases, and 100% for penetrating metastases with a false positive per image of 0.701 in the validation datasets.

CONCLUSION
We successfully developed an AI pipeline system to detect bone metastases from the data of CT and FDG-PET. This is the first report on an AI-based automatic annotation system for PET-CT. Some limitations such as the low sensitivity for osteolytic metastases and too many false positives should be improved.

CLINICAL RELEVANCE/APPLICATION
Since the sensitivity for osteoblastic metastases was higher than that in the previous paper on human detection, our AI system can reduce the oversight of radiologists to detect bone metastases on CT.
Detection of Seminal Vesicle Involvement and Extra-Prostatic Extension of Primary Prostate Cancer by Fluciclovine PET-CT

Participants
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PURPOSE
To evaluate the diagnostic performance of fluciclovine PET-CT in determining the extent of primary prostate cancer specifically seminal vesicle involvement (SVI) and extra-prostatic extension (EPE).

METHOD AND MATERIALS
51 patients with high risk primary prostate cancer, without conventional imaging findings of systemic metastasis, deemed eligible for potential curative surgery were recruited and underwent fluciclovine PET-CT after obtaining informed consent. Image interpretation was performed by a board-certified nuclear medicine physician blinded to other clinical and imaging data. Abnormal or absent uptake indicating the presence or absence of SVI and EPE was recorded. Histologic findings of SVI and EPE were compared with preoperative imaging results. Measures of diagnostic performance of fluciclovine PET-CT were assessed. Equivocal interpretations were analyzed as negative.

RESULTS
44/51 patients with a mean ± SD PSA of 25.8 ± 31.1 ng/ ml underwent radical prostatectomy and extended lymph node dissection within 11.8 ± 9.9 days of imaging. The remaining 7 were excluded from the final analysis as they were either still awaiting surgery or considered unsuitable for curative surgery. 28/44 and 20/44 patients were interpreted as positive for SVI and EPE respectively on fluciclovine PET-CT. On histology, 20/44 and 36/44 were positive for SVI and EPE respectively. Consequently, sensitivity, specificity and positive predictive value (PPV) of fluciclovine PET-CT for determination of SVI were: 80%, 50% and 57.1% respectively. For assessment of EPE, sensitivity, specificity and PPV of fluciclovine PET-CT were: 50%, 75% and 90% respectively.

CONCLUSION
Fluciclovine PET/CT showed high sensitivity and moderate PPV in the detection of SVI in primary prostate cancer. It also demonstrated high positive predictive value and moderate specificity in the detection of EPE.

CLINICAL RELEVANCE/APPLICATION
Fluciclovine PET/CT may be of use in preoperative determination of tumor extent in primary prostate cancer and consequently choice of therapy. Further studies with PET/MR with better anatomic definition may therefore be beneficial.

Combined Hybrid Axumin (18F- Fluciclovine) PET/MRI Interpretation Compared to the Individual Interpretation of Axumin PET and Dedicated Prostate MRI in Evaluating for Prostate Cancer Local Recurrence

PURPOSE
To determine if evaluation for prostate cancer local recurrence with a combined reading of hybrid Axumin PET/MRI leads to more confident interpretation with fewer indeterminate results when compared to separate reading of Axumin PET and multiparametric prostate MRI (mpMRI).

METHOD AND MATERIALS
This is a retrospective study of 60 patients with biopsy-proven prostate cancer who have had definitive therapy with concern for recurrence, who underwent a hybrid Axumin PET/MRI. PET and MRI images were reviewed separately by a nuclear medicine and an abdominal imaging specialist, respectively, each blinded to the other. Lesions were assigned a likelihood of local recurrence score. Axumin PET/MRI images were then jointly interpreted and a consensus likelihood of local recurrence score was assigned. The scores were based on qualitative 5-point scales outlined by each reader prior to the study. Scores were compared between individual PET or MRI and combined PET/MRI interpretations using Chi-Square and linear-by-linear association tests.

RESULTS
We evaluated 60 Axumin PET-MRI exams with a total of 68 lesions. 39 (65%) patients had radical prostatectomy while 21 (35%...
had local therapy only. The average patient age was 69 years old (range 45-85). There is a significant difference in the interpretation scores between individual mpMRI and combined Axumin PET/MRI interpretation (p=0.006). Of the 24 lesions with scores of 2-4 on MRI, 9 (38%) lesions were downgraded to a score of 1 and 10 (42%) lesions were upgraded to a score of 5 on combined interpretation. There is a trend toward a significant difference between individual PET and combined PET/MRI, with a linear-by-linear association of 1.1 (p = 0.139). Of the 17 lesions assigned scores of 2-4 on PET, 5 (29%) lesions were upgraded to a score of 5 and 4 out of 43 lesions (9%) with a PET score of 1 were upgraded to a score of 5 on combined interpretation.

CONCLUSION

The combined interpretation of Axumin PET/MRI showed significantly more confidence in assessing for locally recurrent prostate cancer over interpretation of MRI alone and a trend toward significance in confidence over interpretation of PET alone.

CLINICAL RELEVANCE/APPLICATION

Combined reading of Axumin PET/MRI increases confidence in local recurrence detection, facilitating management in prostate cancer patients with clinical concern for recurrent disease after treatment.

SSA16-04  Tumor Foci Size but Not Lymph Node Size Affects 18F-fluciclovine PET/CT Detection of Metastatic Lymph Nodes in Primary Prostate Cancer

Sunday, Dec. 1 11:15AM - 11:25AM Room: S505AB

Participants
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PURPOSE

To determine the effect of sizes of lymph node (LN) and metastatic foci (MF) on the diagnostic performance of preoperative fluciclovine PET/CT for identifying LN metastasis (LNM) in patients with primary prostate cancer.

METHOD AND MATERIALS

51 patients with intermediate to high-risk prostate cancer underwent fluciclovine PET/CT (Dose: 366.3±22.2 MBq) prior to radical robotic prostatectomy (RP) with extended pelvic lymph node dissection (EPLND). LNs were excised according to 12 predefined templates and correlated to PET findings. Metastatic LNs and MF in LNs were measured bidimensionally by a board certified urologic pathologist. Sizes of metastatic LNs and MF in templates with positive and negative PET findings were compared using t-test. For every LN packet (LNP), the greatest long axis diameter of LN and MF were utilized as the most conservative surrogate for the LNP.

RESULTS

EPLND was performed in 45/51 patients with median PSA 18.0 ng/ml (range 0.58-147.03 ng/ml) and Gleason score (Grade group) 8 (4) within 7 days (range 1-41 days) after fluciclovine PET. Of these, 24/45 (53.3%) patients had histologically confirmed LNM. 508 LNPs (mean 11 packets per patient) were analyzed. LNM were detected in 82/508 (16.1%) LNPs on histology. Fluciclovine PET detected LNM in 36/82 (43.9%) LNPs (true positives) while 46/82 (56.1%) LNPs were either benign or not seen (false negatives) on fluciclovine PET. Of the remaining 426/508 LNPs, 3/426 (0.7%) were read as equivocal on PET but were benign on histology (false positives). There was no significant difference in the mean long axis diameters of true positives (15.1 mm [range 3.0-40.0 mm]) and false negatives (13.1 mm [range 3.0-52.0 mm]; p=0.13) LNPs. In contrast, the mean long axis diameters of MF within true positive LNPs (11.4 mm [range 1.0-40.0 mm]) were significantly higher than false negative LNPs (3.9 mm [range 0.4-14.0 mm]; p<0.01). 13/52 (25.0%) LNPs with MF <=7 mm were detected on fluciclovine PET while 23/30 (76.7%) LNPs with MF >7 mm were detected on fluciclovine PET.

CONCLUSION

Fluciclovine PET detection rate of LNM was influenced by the size of metastatic foci but not lymph node size. Metastatic foci >7 mm were more likely to be detected on fluciclovine PET than MF <=7 mm.

CLINICAL RELEVANCE/APPLICATION

The ability of preoperative fluciclovine PET/CT to detect lymph node metastasis in patients with primary prostate cancer is influenced by the size of the metastatic focus within the lymph node.

SSA16-05  Difference in the Spectrum of Metastatic Disease on 68Ga PSMA PET/CT after Radical Prostatectomy and after Radical Radiotherapy in Patients of Carcinoma Prostate with Biochemical Recurrence

Sunday, Dec. 1 11:25AM - 11:35AM Room: S505AB

Participants
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PURPOSE

To verify if the extent of disease, as measured by the presence of extrapelvic disease, differs after surgery and radiotherapy in patients of carcinoma prostate with biochemical recurrence.

METHOD AND MATERIALS

We evaluated 60 Axumin PET-MRI exams with a total of 68 lesions. 39 (65%) patients had radical prostatectomy while 21 (35%) patients underwent radical radiotherapy. The average patient age was 69 years old (range 45-85). There is a significant difference in the spectrum of metastatic disease on 68Ga PSMA PET/CT after surgery and after radiotherapy.

RESULTS

We compared the extent of disease with individual mpMRI and combined Axumin PET/MRI interpretation (p=0.006). Of the 68 lesions with scores of 2-4 on MRI, 23 (34%) lesions were downgraded to a score of 1 and 22 (32%) lesions were upgraded to a score of 5 on combined interpretation. There is a trend toward a significant difference between individual PET and combined PET/MRI, with a linear-by-linear association of 1.1 (p = 0.139). Of the 26 lesions assigned scores of 2-4 on PET, 7 (26%) lesions were upgraded to a score of 5 and 3 out of 46 lesions (7%) with a PET score of 1 were upgraded to a score of 5 on combined interpretation.
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PURPOSE
To determine the pattern of metastatic disease with 68Ga PSMA PET/CT in patients with biochemical recurrence after definitive treatment

METHOD AND MATERIALS
A retrospective analysis of subjects with carcinoma prostate, who had undergone definitive treatment (Radical prostatectomy or Radiotherapy) and presented with biochemical recurrence, was done by 68Ga PSMA PET/CT. The data collected was analysed to establish temporal occurrence and patterns of regional and distant metastatic disease in both the groups and correlated with serum PSA levels.

RESULTS
The study included 200 subjects with history of adenocarcinoma prostate. In the post radical prostatectomy group (n=144), median serum PSA was 1.8 ng/ml, the overall metastatic detection rate was 39.3% for PSA 0.2 to < 0.5 ng/ml, 47.3% for PSA 0.5 to < 1 ng/ml, 68.4% for PSA 1 to < 2 ng/ml and 93.1% for PSA >=2 ng/ml. In this group local recurrence was identified in 28.73 % and lymph nodal metastases in 65.1%, with the pelvic lymph nodal metastases being the most common site of metastasis followed by bone metastases. The mean time for serum PSA recurrence in the radical prostatectomy group was 49.77±44.44 months (range 2-184 months). In the post radiotherapy group, median serum PSA was 5.2 ng/ml, the detection rate was 88.8 % for PSA 2 to < 4 ng/ml and 100 % for PSA >= 4 ng/ ml. Local recurrence after radiotherapy was present in 79.5 % of the group and 63.6 % had lymph nodal metastases. The mean time for serum PSA recurrence following radiotherapy was 49.15± 24.32 months, (range 12-111 months).

CONCLUSION
Radical prostatectomy and Radical radiotherapy are the two standard treatment options for localized carcinoma prostate. Although the extent and patterns of recurrence differed in the two groups, the temporal occurrence of metastatic disease remained comparable.

CLINICAL RELEVANCE/APPLICATION
68Ga-PSMA has been suggested as a novel tracer for detection of prostate cancer relapse and metastases with high specificity and sensitivity.

SSA16-06 Correlation of Findings on 18F-Fluciclovine PET/CT with Failure-Free Survival of Salvage Radiotherapy in Post-Prostatectomy Patients with Biochemical Recurrence

Participants
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PURPOSE
To examine the impact of fluciclovine PET on failure-free survival (FFS) of radiotherapy (RT) ± androgen deprivation therapy (ADT) in recurrent prostate cancer patients post-prostatectomy.

METHOD AND MATERIALS
69 post-prostatectomy patients with biochemical recurrence in the experimental arm of a randomized controlled study (NCT01666808/NIH R01CA169188) underwent fluciclovine PET prior to RT±ADT. RT was based on PET and clinical findings: no
upset/prostate bed only uptake - RT to prostate bed only, pelvic nodal uptake - RT to prostate bed+pelvis, extrapelvic nodal uptake - no RT. RT (median 66.6 Gy in 1.8 Gy fractions) was initiated 17±10 days after PET scan. 21 patients received RT+short course ADT. 8 patients at 12 months and 3 additional patients at 18 months post-RT were censored due to lack of follow-up. Treatment failure was defined as either serum prostate-specific antigen (PSA) >=0.2 ng/mL+post-RT nadir followed by another higher value, a continued rise in the serum PSA despite RT, initiation of systemic therapy after completion of RT, or clinical progression. FFS based on fluciclovine PET findings were compared using Fisher's exact test.

RESULTS
53/69 (76.8%) patients had positive fluciclovine PET findings. 4/69 patients were ineligible for RT due to systemic disease, hence, FFS was assessed in 65 patients (median PSA 0.32 (range 0.02-9.79) ng/mL). FFS at 6, 12 and 18 months was 63/65 (96.9%), 52/57 (91.2%), and 43/54 (79.6%), respectively. In patients with no uptake, FFS was 16/16 (100%), 15/15 (100%), 12/13 (92.3%) at 6, 12, and 18 months, respectively. In patients with uptake in the prostate bed only, FFS was 27/27 (100%), 21/22 (95.5%), 18/21 (85.7%) at 6, 12, and 18 months, respectively. In patients with pelvic+prostate bed uptake, FFS was 20/22 (90.9%), 16/20 (80.0%), 13/20 (65.0%) at 6, 12, and 18 months, respectively. FFS trends did not reach statistical significance at any timepoint.

CONCLUSION
Findings on fluciclovine PET/CT correlate with failure-free survival, potentially reflecting metabolic tumor burden and may have prognostic value. Longer follow-up duration and comparison to a control group not undergoing PET, are required to fully evaluate the value of fluciclovine PET based radiotherapy.

CLINICAL RELEVANCE/APPLICATION
Findings on fluciclovine PET/CT correlate with failure-free survival of salvage radiotherapy and may have prognostic value in post-prostatectomy patients with biochemical recurrence.

SSA16-08 Significant Interval Decrease in Bone Mineral Density in Osteopenic Patients: A Notable Limitation of FRAX Analysis in Dual-energy X-ray Absorptiometry

Sunday, Dec. 1 11:55AM - 12:05PM Room: S505AB

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PURPOSE
Bone mineral density (BMD) evaluation, considered to be the standard measure for the diagnosis of osteoporosis and fracture risk assessment, is most commonly measured by dual-energy x-ray absorptiometry (DXA). For patients diagnosed with osteopenia, the Fracture Risk Assessment Tool (FRAX) was developed, which incorporates clinical factors to aid the clinician in patient management. If the FRAX score in an osteopenic patient predicts a fracture risk of less than 20% for a major osteoporotic fracture or 3% or greater for a hip fracture, therapy is warranted. However, any significant decline in BMD when compared to a prior DXA is not reflected in the FRAX analysis. Our goal was to determine the frequency with which there is a significant decline in BMD in patients diagnosed with osteopenia by DXA, but whose FRAX score predicts a fracture risk of less than 20% for a major osteoporotic fracture or less than 3% for a hip fracture.

METHOD AND MATERIALS
Over a period of 12 months, the number of patients diagnosed with osteopenia by DXA were counted, who (1) had a significant decrease in BMD when compared to a prior DXA and (2) the FRAX scores were both less than 20% for a major osteoporotic fracture and less than 3% for a hip fracture.

RESULTS
A total of 278 patients with osteopenia by DXA had a significant decrease in spine and/or hip BMD when compared to a previous DXA, yet the FRAX scores were both less than 20% for a major osteoporotic fracture and less than 3% for a hip fracture.

CONCLUSION
Fracture risk assessed by FRAX analysis is often underestimated in osteopenic patients whose BMD has significantly declined from a prior DXA. Therefore, in this clinical setting, a low FRAX score should not influence the therapeutic decision.

CLINICAL RELEVANCE/APPLICATION
The following sentence should be added to the DXA scan report in the above clinical scenario: "It should be noted that a significant decrease in BMD from a prior DXA is not reflected in the FRAX analysis."
PURPOSE

To determine if the detection of FDG-avid pelvic and para-aortic lymph nodes in early stage cervical cancer patients is dependent on tumor histology.

METHOD AND MATERIALS

Patients with IB1-2 cervical cancer who underwent pre-surgical FDG-PET between 1997-2018 were identified in a tertiary academic center database. All patients had radical hysterectomy with pelvic and para-aortic lymph node dissection. The detection of pelvic and para-aortic lymph nodes by FDG-PET vs. surgical dissection was compared. FDG-PET sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were determined and stratified by tumor histology. Freedom from relapse (FFR) was analyzed with Kaplan-Meier analysis and Cox proportional hazards models.

RESULTS

We identified 212 patients with early-stage cervical cancer (84% FIGO IB1, 16% IB2) who underwent pre-surgical FDG-PET; 137(65%) had squamous carcinoma and 75(35%) had adenocarcinoma. PET/CT was performed in 189(89%) patients and 23(11%) had PET only. Surgical dissection revealed positive pelvic and para-aortic lymph nodes in 25% and 3.3% of patients, respectively. For squamous carcinoma, the sensitivity, specificity, PPV and NPV of FDG-PET for pelvic nodal metastasis were 44%, 99%, 95% and 78%, respectively. For adenocarcinoma, the corresponding results for pelvic nodal metastasis were 25%, 99%, 67% and 92%, respectively. The overall sensitivity, specificity, PPV and NPV of FDG-PET for para-aortic nodal metastasis was 29%, 99%, 67% and 98%, respectively. With a median follow up of 9.3 years, the 5-year FFR for squamous carcinoma and adenocarcinoma was 83% vs. 96% (p=0.008), respectively.

CONCLUSION

Pelvic nodal metastasis was less likely to be detected by FDG-PET in patients with early-stage adenocarcinoma than with squamous carcinoma. Patients with adenocarcinoma had a better prognosis than those with squamous carcinoma.

CLINICAL RELEVANCE/APPLICATION

FDG-PET was half as sensitive for detecting pelvic lymph nodes in adenocarcinoma vs. squamous carcinoma.

Printed on: 10/29/20
Neuroradiology (Stroke 1)
Sunday, Dec. 1 10:45AM - 12:15PM Room: S501ABC

SSA17-01 A Deep Learning Algorithm for Detecting Challenging Cases of Acute Ischemic Stroke on Non-Contrast Brain CT

Participants
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Purpose
Improving the diagnostic accuracy for acute ischemic stroke (AIS) has the potential to reduce erroneous administration of tissue plasminogen activator (tPA) to patients presenting with stroke-like symptoms. Non-contrast CT is obtained in the acute setting to rule out intracranial hemorrhage but has poor sensitivity and specificity for AIS. Thus, the most ambiguous cases are referred to Diffusion Weighted MRI (DW-MRI) after administration of tPA for diagnostic confirmation. The aim of this study is to produce stroke annotations on non-contrast CT images based on corresponding DW-MRIs in these challenging cases, and then automatically detect and segment AIS directly from non-contrast brain CT images.

Method and Materials
8879 CT slices from 199 patients CT scans were collected and split into training (75%), validation (15%), and test (10%) sets. Out of 199 patients, 99 patients were confirmed to have stroke based on DW-MRIs (positive samples), and 100 patients had no evidence of AIS based on clinical follow up (negative samples). Board-certified radiologists annotated the CT for AIS on positive samples by comparing to corresponding DW-MRIs. The training dataset was then passed through a Mask R-CNN model with a ResNet-50 backbone with L2 Regularization. The loss function was optimized by stochastic gradient descent with momentum. The model was initialized with weights pretrained on the Common Objects in Context dataset. The validation set was used to tune hyperparameters.

Results
The model was assessed on the ability to identify a CT slice as containing a stroke and the ability to segment the regions of corresponding diffusion on MRI on the held-out test set. The model has a whole image classification specificity of 0.6849, sensitivity of 0.4792, F1 score of 0.1394, and accuracy of 0.6736. Additionally, the model demonstrated a promising ability to automatically segment AIS, achieving a mean average precision on true positive predictions of 0.3478 at an intersection-over-union of 10%.

Conclusion
Our Mask R-CNN model provides a promising means of detecting acute ischemic stroke on non-contrast CT.

Clinical Relevance/Application
The algorithm can be used to improve the diagnostic accuracy for AIS on non-contrast CT in emergency settings to improve patient selection for intravenous thrombolysis and mechanical thrombectomy.
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PURPOSE
We aim to determine whether a deep learning model trained on acute stroke patients can predict the 3-7 day infarcted region from baseline DWI/PWI MRI and to compare its prediction with state-of-the-art clinical thresholding methods.

METHOD AND MATERIALS
Patients with baseline DWI/PWI and 3-7 day T2-FLAIR imaging were selected from two large acute ischemic stroke trials. Six image channels from baseline imaging were used as model inputs (DWI, ADC, and from PWI: Tmax, CBF, CBV, and MTT). Ground truth was manually segmented on 3-7 day T2-FLAIR. The network structure was an attention-gated deep convolutional U-net with a composite loss function. The model outputs a map where each voxel represents the probability of being part of the lesion. Patients were grouped into unknown, minimal, partial, major reperfusion status. Area-under-the-curve (AUC), Dice score coefficient (DSC), and predicted lesion volume difference were analyzed. In minimal and major reperfusion, the model was compared to a thresholding method (RAPID) using Tmax>6 sec and ADC<620 x 10^-6 mm2/s by a paired sample Wilcoxon test, respectively.

RESULTS
182 patients were included (age 65±16 yrs, baseline NIHSS 15 [IQR 10-19]). For all patients, the model had a median AUC of 0.91 (IQR 0.87, 0.95); at 0.5 probability threshold, median DSC was 0.53 (IQR 0.31-0.68) and lesion volume differences were 9.1 ml (IQR -14.2-28.6) and 23.7 ml (IQR 11.4-50.1) (absolute difference). In minimal reperfusion patients, median AUC was 0.90 (IQR 0.85, 0.94) vs 0.78 (IQR 0.72, 0.82) for the Tmax model (p<0.001); in major reperfusion patients, median AUC was 0.93 (IQR 0.89, 0.96) vs 0.68 (IQR 0.62, 0.76) for the ADC model (p<0.001). In partial or unknown reperfusion patients, AUC was similar: 0.90 (IQR 0.86, 0.94) vs 0.78 (IQR 0.72, 0.82) for the Tmax model (p<0.001); in major reperfusion patients, median AUC was 0.90 (IQR 0.86, 0.96) and 0.92 (IQR 0.86, 0.96), respectively.

CONCLUSION
A deep learning model trained without reperfusion status performs better at infarct lesion segmentation compared to commonly-used threshold-based methods in minimal and major reperfusion patients, while also achieving high performance in partial or unknown reperfusion patients.

CLINICAL RELEVANCE/APPLICATION
A deep learning model without reperfusion information trained on acute images can achieve good performance at predicting imaging outcome at 3-7 days.

SSA17-03 Quantitative Evaluation of Multiphase Versus Single Phase Computed Tomography Angiography for the Detection of Distal Ischemic Stroke

Sunday, Dec. 1 11:05AM - 11:15AM Room: S501ABC

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PURPOSE
The aim of this investigation was to quantitatively evaluate the effects of the addition of peak and delayed venous phase imaging to arterial phase CTA for the detection of distal ischemic strokes. Changes in sensitivity, specificity, time required to render a final decision, and subjective level of diagnostic confidence were quantified.

METHOD AND MATERIALS
Four attending radiologists contributed as readers to this IRB-approved, HIPAA-compliant study. For each reader, two sessions were conducted; in each session, the reader retrospectively interpreted the CTA studies of 104 patients (52 positive, 52 negative) who underwent imaging for suspicion of acute ischemic stroke, resulting in a total of 832 interpretations. During the first session for each reader, only arterial phase images were available; during the second session, peak and delayed venous phase images were additionally available. The patients' images were randomized and de-identified, and the two reading sessions for each radiologist
RESULTS
The addition of venous phase images resulted in a significant 7.5% absolute increase in sensitivity (86.5% vs. 94.0%, p = .004) and an insignificant increase in specificity (98.2% vs. 99.0%, p = .387). No significant increase was observed in relative positive predictive value (97.2% vs. 98.1%, p = .511) but a small significant increase in relative negative predictive value was seen (87% vs. 91%, p = .001). A small but significant reduction in reading time was observed (66.7 seconds vs. 59.6 seconds, p = .001). A significant increase in diagnostic confidence was observed (2.26 vs. 2.58, p < .001). Inter-radiologist agreement (Kappa value) increased from 0.76 to 0.84.

CONCLUSION
The addition of peak and delayed venous phases to arterial phase CTA imaging for the detection of distal ischemic stroke significantly increases diagnostic specificity, reading speed, and reader confidence without incurring a corresponding reduction in specificity.

CLINICAL RELEVANCE/APPLICATION
By increasing sensitivity and reading speed at no cost to specificity, conducting multiphase imaging as a routine stroke protocol has the potential to improve diagnostic accuracy and patient outcomes.

SSA17-04 Deep Learning-Based Contrast Enhanced Time-Resolved Cone-Beam CT Angiography with IV Injection

Sunday, Dec. 1 11:15AM - 11:25AM Room: S501ABC

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PURPOSE
The purpose of this work was to develop a deep learning technique to generate time-resolved cone-beam CT angiography (TR-CBCTA) from cone-beam CT perfusion data sets.

METHOD AND MATERIALS
With IRB approval and written consent, 43 patients with acute ischemic stroke and a high NIH stroke scale scores (>5) were recruited in one-stop-shop C-arm cone beam CT stroke imaging clinical trial study. The recruited subjects received both diagnostic CT and C-arm cone-beam CT perfusion imaging. The C-arm cone beam CT perfusion data acquisitions consist of nine 5-seconds bidirectional rotational scans with 100 cc contrast medium injection intravenously followed by 50 cc saline flush. To generate TR-CBCTA, the acquired high quality diagnostic CT images were used to train our previously published deep learning angiography (DLA) neural network to extract vascular features from axial CT images. This trained deep neural network was transferred to learn TR-CBCTA from the acquired cone-beam CT perfusion data sets. To capture the spatiotemporal characteristics of TR-CBCTA, the trained DLA model was fine-tuned using images from the acquired cone-beam CT perfusion data sets. The trained model was then used to generate TR-CBCTA of other data sets from different patients. The generated TR-CBCTA images were subject to qualitative assessment of image quality of large arteries (i.e internal carotid artery - ICA, middle cerebral artery - MCA, anterior cerebral artery - ACA and the distal branches of the MCA and ACA) as well as the anatomy of the cerebral venous system. The presence/absence of residual bone and mis-registration artifacts was also evaluated.

RESULTS
All major arteries as well as venous drainage showed good to excellent image quality in time-resolved DLA images. No significant residual signal from osseous structures was observed.

CONCLUSION
A deep learning based method was developed to generate TR-CBCTA from cone-beam CT perfusion data sets with reduced mis-registration and residual bone artifacts induced by inter-sweep patient motion and known to be the major technical limitation.

CLINICAL RELEVANCE/APPLICATION
Time-resolved cone-beam CT angiography from cone-beam CT perfusion data sets may enable reliable use of c-arm based time-resolved CTA to directly visualize vascular occlusions and assess collaterals to ischemic stroke patients.

SSA17-05 Quantitative CT Perfusion: Do the CT Scanner Model and Variation in Vascular Flow Rate Affect Quantitative Measures of Parametric Maps?

Sunday, Dec. 1 11:25AM - 11:35AM Room: S501ABC

Participants
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Using a CT perfusion phantom, we sought to determine whether quantitative measurements on CT perfusion maps differed between CT manufacturers and scanner models and to determine if differences in simulated blood flow rates affect these quantitative measurements.

**METHOD AND MATERIALS**

A unique CT perfusion phantom comprised of 4 movable rods was used in this study. The phantom contains 2 rods designed to simulate arterial and venous flow rates and 2 rods replicating identical normal perfused brain tissue. The simulated arterial and venous contrast rods are designed to move at 5 distinct speeds, allowing acquisition of datasets at 5 different simulated blood flow rates. Scanning was performed using standard clinical protocols on 3 different CT scanner models at each of the speeds. The CT phantom was scanned 5 times for one of the phantom speeds to confirm reproducibility. Datasets from each scan were post processed using commercial perfusion software to create time attenuation curves and parametric perfusion maps for cerebral blood volume (CBV), cerebral blood flow (CBF) and mean transit times (MTT). Region of interest (ROI) measurements in the simulated brain tissue rods were obtained for 3 centrally located scan slices.

**RESULTS**

Quantitative ROI measurements revealed that CBF values increased, MTT decreased, and CBV did not change with increased phantom speed, as expected, for all three CT scanner models. The absolute values of CBV and CBF were different across CT scan manufacturers, although closer in range between two models of a single CT manufacturer, for a given phantom speed. For example, at a simulated flow rate of 1.5 mm/sec measured at a central phantom slice position, CBF(ml/100g/min) was 17.7 for Scanner 1 (mfgr 1), 14.0 for Scanner 2 (mfgr 1), and 36.0 for Scanner 3 (mfgr 2); CBV(ml/100g) was 4.9 for Scanner 1, 4.2 for Scanner 2, and 7.8 for Scanner 3; MTT(sec) was 16.7 for Scanner 1, 18.0 for Scanner 2, and 16.2 for Scanner 3.

**CONCLUSION**

Scanner manufacturers and models yield substantially different quantitative ROI values; therefore, one must be cautious when using absolute values for interpreting CT perfusion images, particularly when attempting to devise threshold values for CBF and CBV.

**CLINICAL RELEVANCE/APPLICATION**

Since quantitative values are not consistent across CT scanners, one must be cautious when using them for interpreting CT perfusion, particularly if attempting to devise threshold values for CBF and CBV.
CONCLUSION

CTP volume grew between 2017 and 2018 well in excess of ED presentations. Median time SLSW was different between the two study periods. Reduction in NNS may reflect patient selection for CTP and/or changed decision-making after CTP. In 2018 versus 2017, 199 more CTPs were performed for an additional 5 ECR patients to be discharged home.

CLINICAL RELEVANCE/APPLICATION

Broadened temporal criteria for endovascular clot retrieval (ECR) in acute stroke (AS) are associated with substantial increase in CT perfusion utilization per ECR patient discharged home.

SSA17-07 Amide Proton Transfer Magnetic Resonance Imaging of Cerebral Infarction: Correlation with Clinico-Radiological Findings

Sunday, Dec. 1 11:45AM - 11:55AM Room: S501ABC

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PURPOSE

Amide proton transfer (APT) imaging is a kind of chemical exchange saturation transfer imaging technique based on proton exchange between amides (-NH) and bulk water. As proton exchange rate depends on tissue pH, APT imaging could detect pH reduction in cerebral infarctions. The purpose of this study was to clarify correlations between APT-weighted signal (APTws) and clinico-radiological findings in patients with infarctions.

METHOD AND MATERIALS

In this retrospective study, 29 patients (13 males and 16 females; age range 9-91 y.o.; median 65 y.o.) were examined with a 3T MR system. The infarction etiology was cardioembolic in 11 cases, atherosclerotic in 5 cases and others in 13 cases. The range of time after ictus was 1.8 to 720 h. (median 52.3 h.). The range of lesion size was 19 to 132 mm (median 50 mm). The parameters of APT imaging were as follows: saturation pulse strength = 1.5 μT, saturation time = 2.0 sec, 25 offset frequencies (+4 ppm). MTR asymmetry at 3.5ppm was defined as APTws. Regions-of-interest (ROIs) were manually drawn around the infarction and contralateral normal-appearing white matter (CNWM) on diffusion-weighted images, then these were copied onto the APT images. We measured cumulative histogram parameters, including 10th, 25th, 50th, 75th, 90th percentiles of APTws in infarction and CNWMs. Histogram parameters were compared between infarction and CNWM using Wilcoxon signed-rank test. Those were also compared between cardioembolic infarction and the other subtypes of infarctions using Mann-Whitney U test. Correlation between 10th percentile of APTws (APT10th) and time after ictus, lesion size and 10th percentile of ADC (ADC10th) were evaluated using Spearman’s rank correlation coefficient.

RESULTS

APT10th of infarction was significantly lower than that of CNWM (-1.69±1.80 vs. -1.12±1.73 %, p = 0.0381). APT10th of cardioembolic infarction were significantly lower than those of the other infarction subtypes (-2.77±2.42 vs. -1.02±0.82 %, p = 0.0144). APT10th positively correlated with ADC10th (r = 0.49, p = 0.0065) and inversely correlated with lesion size (r = -0.43, p = 0.0216). There was no significant correlation between APTws and time after ictus.

CONCLUSION

APTws was reduced in cardioembolic infarctions, large infarctions and infarctions with low ADC values.

CLINICAL RELEVANCE/APPLICATION

APT imaging could be used to evaluate tissue acidosis in cerebral infarctions.

SSA17-08 High B Values for Diffusion-Weighted Imaging at 3 Tesla Improves the Sensitivity for Acute Ischemic Stroke Detection

Sunday, Dec. 1 11:55AM - 12:05PM Room: S501ABC

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PURPOSE

MRI may be performed in the setting of acute neurological deficits, in order to diagnose ischemic stroke, rule out alternative diagnoses and select patients for further treatment. The diagnosis is based on the demonstration of diffusion weighted high-signal intensity with decreased apparent diffusion coefficient (ADC) value. The optimum b factor to use at 3T has never been defined in the literature, varying between 1000 and 2000; hence, this study compares 2 b factors : b1000, b2000 s/mm2 in evaluating recent cerebral ischemic lesions at 3T MRI.

METHOD AND MATERIALS

227 patients with a recent ongoing or transient neurological deficit (< 24h) were included over 3 months. We performed b1000 and
b2000 MR diffusion sequences 3T MRI in an emergency setting. These acquisitions were quantitatively and independently analysed by 2 readers, specifying the presence of an ischemic lesion and their diagnostic confidence. Inter-reader agreement, sensitivity, specificity, and positive and negative predictive values were calculated.

RESULTS

Recent ischemic lesions were detected in 78/227 patients (34.4%). The sensitivity for b2000 was significantly higher than for b1000 at 3T (98.7% vs 93.7%, p=0.05), whereas the specificity was equivalent (99.3% vs 97.3%, p=0.18). There was no statistical difference for diagnostic confidence.

CONCLUSION

MR diffusion sequence with a b factor of 2000 s/mm² has a better sensitivity for the detection of recent ischemic lesions, compared to 1000 s/mm² at 3T.

CLINICAL RELEVANCE/APPLICATION

DWI with a b factor of 2000 s/mm² has a significantly higher sensitivity in diagnosing recent ischemic stroke compared to a b factor of 1000 s/mm² and is recommended in the emergency setting.

SSA17-09  High Performance of Deep-Learning (DL) based Segmentation Model of Acute Ischemia Stroke Lesions Evaluated with ASPECTs Score on Head CT

Sunday, Dec. 1 12:05PM - 12:15PM Room: S501ABC

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PURPOSE

In this study, we aim to develop a deep-learning (DL) based model to automatically segment signs of ischemia acute stroke lesions on head CT scans. By implementing the topographic scoring system (Alberta Stoke Program Early Score, ASPECTs), we evaluated the performance of the proposed model in the detection of patients with acute ischemic stroke.

METHOD AND MATERIALS

For this retrospective study, over 36,000 CT images were collected from 1,500 patients with and without ischemia stroke between 2012 and 2017. All patients had CT and MRI scan taken less than twenty-four hours apart for stroke diagnosis. The presence of ischemia stroke lesions as well as the corresponding ASPECTS score per region were labeled on CT scans by board-certified radiologists as ground truth on the review of MRI images and clinical reports. Using CT scans as input, a DL-based model was developed by using Dense UNet as the backbone, integrating DeepLab architectures. ASPECTs score was automatically calculated individually over all ASPECTS regions for the segmentation of ischemia stroke lesions.

RESULTS

In total, scans of 346 patients including 240 patients with acute ischemia stroke and 106 patients without acute ischemia stroke lesions were used in the evaluation of the model performance. Sensitivity, specificity and accuracy rate in an ASPECTs regions-based analysis were 39.80%, 98.02% and 96.37%, respectively.

CONCLUSION

The proposed automated model demonstrated a high performance in the prediction of ischemia stroke lesions in head CT scans as well as in regions like cerebellum and brainstem.

CLINICAL RELEVANCE/APPLICATION

Our proposed model could serve as a useful tool for early diagnosis of ischemia stroke lesions and has the potential to influence clinical decisions to treat patients with thrombolysis and thrombectomy.

Printed on: 10/29/20
PURPOSE
Assess the role of ADC in differentiating benign and malignant skull lesions and evaluate added value of ADC over conventional MRI alone, with HPE correlation as reference standard.

METHOD AND MATERIALS
53 patients (24 male, 29 female; age 3-75 years) with HPE proven skull lesions (24 malignant; 29 benign) were subjected to both conventional and DW MR imaging by using a single-shot SE EPI sequence with b-values of 0, 500 & 1000 s/mm² on 1.5T MR scanner. Margins of the lesion, number, soft-tissue component, local extension, periosteal reaction and enhancement pattern were the parameters used for differentiating benign & malignant lesions by conventional MRI. ADC values (mean of 3 ROIs over solid component) were calculated. Conventional MRI characteristics and ADC value of lesions were evaluated & compared using statistical analysis.

RESULTS
ADC cutoff value of 0.96 x 10⁻³ mm²/s obtained from ROC curve was found to have 75.47% accuracy, 87.5% sensitivity, 65.52% specificity, 67.74% PPV and 86.36% NPV for differentiating malignant from benign lesions. Statistically significant differences (p<0.05) were seen in the mean ADC values of malignant (0.64+/-0.42x10⁻³ mm²/s) and benign lesions (1.14+/-0.56x10⁻³ mm²/s). The sensitivity, specificity, PPV and NPV in differentiating benign & malignant skull lesions were found to be 58.33%, 62.07%, 56% and 64.29% respectively, with diagnostic accuracy of 60.38% on using conventional MRI alone and 75%, 72.41%, 69.23% and 77.78% respectively, with diagnostic accuracy of 73.58% on using conventional MRI with ADC. Hence, employing ADC values in addition to conventional MR sequences improved sensitivity, specificity, PPV, NPV and diagnostic accuracy by 16.67%, 10.3%, 13.23%, 13.49% and 13.2% respectively more than conventional MRI alone. High ADC in low-grade chondrosarcoma & chordoma, low ADC in eosinophilic granuloma and variable ADC in metastases are potential pitfalls for DWI.

CONCLUSION
ADC is promising non-invasive parameter that facilitate differentiation between benign and malignant skull lesions and potentially narrow differentials when conventional imaging features are indeterminate.

CLINICAL RELEVANCE/APPLICATION
Addition of DWI & ADC to conventional MRI avoids unnecessary surgical resection, helps monitor treatment response and distinguish between post-treatment changes and recurrent skull lesions. Also it is effective method with short imaging time, thus can be incorporated into routine imaging.
Post-Operative Recurrence in Patients with an Advanced Squamous Cell Carcinoma of the Tongue

Sunday, Dec. 1 10:55AM - 11:05AM Room: S404AB

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PURPOSE
To identify optimal modalities and machine-learning methods for radiomics-based prediction of recurrence in advanced squamous cell carcinoma (SCC) of the tongue, treated with primary tumor resection and neck dissection.

METHOD AND MATERIALS
A total of 81 patients with advanced SCCs of the tongue (cT3-4 or any nodal metastasis), who underwent both contrast-enhanced CT and MRI (homogeneous CT/MRI scanner and protocol) for preoperative staging between 1/2010-11/2017, were enrolled in this retrospective study. All the patients were treated with primary tumor resection and neck dissection with a follow-up at least 1 year after operation (39 patients developed recurrence, and the remaining 42 did not). A total of 1409 radiomic features were extracted from each modality of CT and MRI (2-weighted images (T2WI) and T1-weighted images using gadolinium-based contrast (Gd-T1WI)) with RadCloud platform for each patient. We used variance threshold, select K best, and LASSO algorithm to gradually select the optimal features. Computer-generated random numbers were used to assign 70% of the VOIs to the training data set and 30% of those to the validation data set for each imaging set. Classifications were made using six supervised learning classifiers (KNN, SVM, XGBoost, RF, LR, DT). ROC curve analysis was used to illustrate the prediction performance of the radiomic signature.

RESULTS
CT of 23 cases was excluded from this radiomic analysis due to metal artifacts, but MRI acquired sufficient VOIs in all the cases. For prediction of the postoperative outcome, AUC of the radiomics model based on the Gd-T1WI was the highest (0.854; 95% CI: 0.75 - 0.96, in training sets, and 0.827; 95% CI: 0.66 - 0.99, in validation sets) using KNN classifiers, compared to that using Contrast-enhanced CT (highest AUC was 0.667 in validation sets using SVM) and T2WI (the highest AUC was 0.654 in validation sets using KNN).

CONCLUSION
MRI (Gd-T1WI) may be optimum for building the radiomics model, especially using KNN methods, to predict the risk of postoperative recurrence in advanced SCCs of the tongue.

CLINICAL RELEVANCE/APPLICATION
MRI-based radiomics features could provide additional quantitative information on advanced SCCs of the tongue, which could be potentially used when considering post-operative adjuvant therapy.

Exploratory Study for Identifying Predictors for Persistent Disease and Tumor Reoccurrence After Treatment of Head and Neck Cancers

Sunday, Dec. 1 11:05AM - 11:15AM Room: S404AB

Participants
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PURPOSE
Laryngeal cancer is treated with organ preservation therapy or total laryngectomy. However, little is known about which tumors will persist or recur after definitive therapy. The objective of our study is to investigate the feasibility of using radiomic and perfusion features as predictors to determine tumors that will persist or recur at 1 year after treatment.

METHOD AND MATERIALS
Retrospective analysis of pre and post therapy CT neck scans was performed in 36 patients diagnosed with laryngeal cancer in this IRB approved study. Contouring of the tumors was performed by the computer and tumor features were generated on an internally developed/validated computer-aided detection (CAD) system. Twenty-six radiomic features including morphological and gray-level features were extracted from the computer. Five perfusion features including permeability surface area product (PS), blood flow (flow), blood volume (BV), mean transit time (MTT), and time-to-maximum (Tmax) were extracted from the computer. One year persistent/recurrent disease data were obtained from the time starting after the last treatment of definitive chemoradiation or after total laryngectomy surgery. We performed a two-loop leave one out feature selection using linear discriminant analysis classifier for radiomic and perfusion features. Receiver operator curves and standard deviation were generated.

RESULTS
All 36 lesions examined were primary laryngeal cancers. Out of the 36 patients, there were 10 patients (28%) that had reoccurrence/persistent disease at 1 year. Percent change in volume was the best predictive feature with an area under the curve (AUC) of 0.63 +/- 0.09. Selecting two features had a testing area under the curve (AUC) of 0.69 +/- 0.09. The best features selected were a combination of radiomic and perfusion features including percent change in volume and percent change in blood perfusion.

CONCLUSION
Our pilot study indicates that a combination of radiomic and perfusion features are good predictors of tumor reoccurrence/persistent disease after treatment with definitive radiation or total laryngectomy. Our next step is to expand our data set with additional patients.

CLINICAL RELEVANCE/APPLICATION
Predicting tumors that will recur or persist after traditional treatments is an important tool for head and neck cancer management. Good predictors can help providers determine prognosis and patients decide between therapeutic options.

SSA19-04 Diagnostic Performance of Post-Treatment Response Assessment FDG PET/CT Using NI-RADS in Head and Neck Cancer
Sunday, Dec. 1 11:15AM - 11:25AM Room: S404AB

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PURPOSE
To assess the diagnostic performance of response assessment FDG-PET/CT following definitive (chemo)radiotherapy in head & neck cancer using Neck Imaging Reporting and Data System (NIRADS).

METHOD AND MATERIALS
Pre and post-treatment response assessment FDG-PET/CT scans of 146 patients with squamous carcinoma of oropharynx & laryngo-arynx prospectively treated with image-guided intensity modulated radiation therapy were compared and classified as per NI-RADS template. NI-RADS category 1 indicates no evidence of recurrence; category 2 suggests low suspicion of recurrence; category 3 suggests high suspicion of recurrence; and category 4 is known or proven recurrence. The diagnostic performance of NIRADS criteria was evaluated using pathologically proven loco-regional recurrence as the reference standard.

RESULTS
For disease at primary site, 67%, 25% and 8% patients were scored as NI-RADS 1, 2 and 3 respectively. For NI-RADS 1 category at primary site (n=98), the rate of local recurrence within 2 years of therapy was 20.4% with a specificity of 100% and negative predictive value (NPV) of 79.6%. Rate of local recurrence for NI-RADS 2 and 3 were 38.8%, and 83% respectively. For neck nodal disease, 78%,10% and 12% patients were scored as NI-RADS 1, 2 and 3 respectively. For NI-RADS 1 category in the neck (n=114), rate of neck nodal recurrence within 2 years of therapy was 21% with a specificity of 100% and NPV of 80%. Rate of nodal recurrence for NI-RADS 2 and 3 were 53.3%, and 70.5% respectively. There was a strong association between NIRADS score and loco-regional disease status (p<0.001).

CONCLUSION
There is a strong association between NI-RADS score and loco-regional disease status in head and neck cancers. Although the specificity of NI-RADS 1 is excellent, its NPV is suboptimal precluding adoption in routine clinical practice.

CLINICAL RELEVANCE/APPLICATION
There is a strong association between NI-RADS score and loco-regional disease status and is recommended as a part of post treatment response assessment FDG PET/CT in head and neck cancers.

SSA19-05 Inter-Radiologist Reliability of NI-RADS on Post-Treatment PET/CECT in Head and Neck Squamous Cell Carcinoma
Sunday, Dec. 1 11:25AM - 11:35AM Room: S404AB

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CONCLUSION

FNAs and 16.7% of FNAs performed. A total of 2 biopsy or thyroidectomy-proven cancers were detected, representing 7.4% of all recommended FNAs). A total of 9 of the recommended FNAs were performed (44% of recommended FNAs). A total of 10% of the studies with nodules were given no recommendation. 12 of the recommended FNAs were performed (44% of recommended FNAs). A total of 2 biopsy or thyroidectomy-proven cancers were detected, representing 7.4% of all recommended FNAs and 16.7% of FNAs performed.

METHOD AND MATERIALS

Eighty HNSSC patient cases were uploaded to the American College of Radiology Cortex, with pre- and posttreatment PET/CECT studies. All images were scrubbed of all identifying information prior to upload. Each case provided a brief history of the patient, including age, sex, location of primary, staging, treatment, and timing of scan. Eight radiologists (5 neuroradiologists specialized in H&N, 1 general neuroradiologist and 2 neuroradiology fellows) independently evaluated each case and answered 4 multiple choice questions regarding the radiologic appearance of any primary or nodal disease and its associated NI-RADS category. Intraclass correlation coefficients (ICC) were calculated to assess inter-rater agreement.

RESULTS

The overall ICC for all readers for the primary site NI-RADS score (NS) was 0.58 (95% CI = 0.50 - 0.67) and for the nodal site NS was 0.65 (95% CI = 0.55 - 0.74). Among subspecialist readers, the ICC for the primary site NS was 0.61, and for the nodal site NS was 0.62. Non-specialists had an ICC of 0.55 for the primary site NS and 0.72 for the nodal site NS. The maximum pairwise kappa value was achieved between two specialist readers from different institutions who had never trained together, with an ICC of 0.72 for the primary site NS.

CONCLUSION

There was moderate agreement among the eight radiologists using NI-RADS in posttreatment HNSSC surveillance imaging. Disagreement among raters highlights the importance of training and standardization in the interpretation of post-treatment head and neck cancer surveillance imaging.

CLINICAL RELEVANCE/APPLICATION

This is the first study to examine the inter-rater reliability of NI-RADS, a standardized reporting template used in posttreatment HNSSC surveillance PET/CECTs.
The implementation of ACR-TIRADS resulted in an improved consistency of thyroid nodule description with an overall decrease in the number of recommended FNAs. This shows that by having a system to help radiologists stratify nodule risk based on a set parameter of characteristics, more appropriate recommendations can be made to guide referring providers. A limitation to our follow-up data collection resulted from patients being lost to follow-up or following-up outside our hospital system and is a possible explanation for the low percentage of recommended biopsies being performed. Additional limitations included adoption of the new reporting style to some of the senior attending radiologists and the frustration some referring providers voiced due to the increased length of the reports. The senior radiologists eventually adapted to the new style and began using it more regularly. Following the study period of TIRADS implementation, the TIRADS templates have been further revised to increase ease of interpretation for our referring clinicians while maintaining the consistency of TIRADS usage.

METHODS

Thyroid ultrasound reports for exams completed before the implementation of TIRADS reporting at the participating institution were reviewed for use of TIRADS nomenclature from 1/1/2017-12/31/2017. A standardized TIRADS template was created for the participating radiologists to ensure accurate, consistent, and appropriate use of TIRADS descriptors and recommendations post implementation from 4/1/2018-9/30/2018. Additionally, a TIRADS worksheet was developed for participating ultrasonographers, and these ultrasonographers were educated in the purpose and usage of the TIRADS criteria. Comparison was made between pre and post implementation usage of the 5 TIRADS nodule descriptors and follow-up recommendations. The hospital EMR was used to obtain information on patient follow-up and management by the referring provider.

SSA19-07 Effect of Ti-Rads Standardized Reporting Calculator on Radiologist Report Consistency and Recommendation for Thyroid Nodules Management

Sunday, Dec. 1 11:45AM - 11:55AM Room: S404AB

Participants
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PURPOSE

Thyroid nodules are a common imaging finding. Though the majority of are benign, there is overlap in the imaging appearance of benign and malignant nodules. Various systems have been published to guide radiologists for their appropriate management; till recently our practice utilized the 2015 American Thyroid Association (ATA) guidelines for this purpose. Though helpful, the use of this system as inconsistent, with anecdotaly high biopsy recommendation rates and an inability to classify some nodules making it difficult to provide specific recommendations. We recently adopted the American College of Radiology (ACR) Thyroid Imaging, Reporting, and Data System (TI-RADS), a newly-developed standardized system employed to unify lexicon and management recommendations for the ultrasound evaluation of thyroid nodules. In addition, a web-based calculator (Figure 1) that standardizes language, tallies scores and generates recommendations was implemented to streamline reporting and ease utilization of this system. The purpose of this project was to report effects of radiologists’ adherence to and reported recommendations before and after the adoption of ACR TI-RADS criteria at a large, multi-site academic practice.

RESULTS

We reviewed the data for radiologist adherence to the department approved recommendations (ATA vs TI-RADS), the rate of providing specific recommendations and compared the specific recommendations provided (biopsy vs follow-up vs no follow-up) before and after TIRADS adoption. Brief demographics of the final database were: 1651 studies with 2017 individual nodules. Of the 1651 patients, 1234 were female, comprising 75.7% of cases. Our outcomes were that 10.8% of nodules evaluated by TI-RADS were reported without a recommendation compared to 48.7% of nodules that used ATA and 63.8% that used No Scoring System (Table 1). With our intervention, the rate for appropriate recommendations was 86.1% for TI-RADS, 44.3% for ATA and 30.3% for when No Scoring system was utilized (Table 2).

CONCLUSION

The aim of the study was to implement TI-RADS as the departmental standard guideline for assessment of thyroid nodules on ultrasound to improve standardized reporting, guideline adherence, and the rate of providing actionable recommendations for reported thyroid nodules. Standardization in reporting lexicon and management recommendations was more prevalent when a radiologist was using TI-RADS along with a web based calculator. 10.8% of nodules evaluated by TI-RADS were reported without a recommendation compared to 48.7% of nodules that used ATA and 63.8% with No Scoring System, 37.9% less than the next closest system. In addition, based on our intervention, an increase in the reporting of appropriate management was significant for the TI-RADS scoring system compared to ATA and No Scoring System as it was 41.8% more than the next closest system. By having definitive recommendations established and consistent reporting of these recommendations, future patient care decisions can be made much more quickly and consistently, probably resulting in improved patient outcomes.

METHODS

Prior to its adoption, TI-RADS was internally reviewed by key radiology leaders and referring specialists including surgical endocrinology, discussed in department wide educational meetings including a journal clubs. The web-based calculator was created to streamline reporting, with a link embedded in the reporting templates. A “go-live” date was announced, at which point the system reporting templates were changed over to the new application. A power analysis was done with the basis on a change of length of the reports. The senior radiologists eventually adapted to the new style and began using it more regularly. The implementation of ACR-TIRADS resulted in an improved consistency of thyroid nodule description with an overall decrease in the number of recommended FNAs. This shows that by having a system to help radiologists stratify nodule risk based on a set parameter of characteristics, more appropriate recommendations can be made to guide referring providers. A limitation to our follow-up data collection resulted from patients being lost to follow-up or following-up outside our hospital system and is a possible explanation for the low percentage of recommended biopsies being performed. Additional limitations included adoption of the new reporting style to some of the senior attending radiologists and the frustration some referring providers voiced due to the increased length of the reports. The senior radiologists eventually adapted to the new style and began using it more regularly. Following the study period of TIRADS implementation, the TIRADS templates have been further revised to increase ease of interpretation for our referring clinicians while maintaining the consistency of TIRADS usage.

SSA19-08 Participants
Modified SHIN Classification for Grading Trachea Invasion on CT Imaging: Addressing the Resectability Issues in Thyroid Cancer

Sunday, Dec. 1 11:55AM - 12:05PM Room: S404AB

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PURPOSE

Evaluate the diagnostic value CT based modified SHIN Classification adapted from pathological SHIN grading for preoperative prediction of Tracheal invasion (TI) in patients with papillary thyroid cancer (PTC).

METHOD AND MATERIALS

Retrospective study from Jan 2012 to Dec 2016, 104 PTC patients who underwent total thyroidectomy were analysed. Preoperative CT were performed in all. TI was categorised based on contact of tumour with trachea on CT imaging. Grades of CT based SHIN Classification: I: disease abuts not invading external perichondrium. II: disease invades into the cartilage +/- destruction. III: disease extends into the tracheal mucosa with no elevation/penetration of mucosa. IV: disease is full-thickness invasion with expansion of the tracheal mucosa with a bulge. Other imaging features were: Angle of contact: grade I:0-89; II 90-179; III:180-269; IV:>270 Shape Score: I: horseshoe, elliptical, circular configuration; II: locally straightened wall; III: inward concave deformity. Grade of enhancement: None, similar, hyperenhancement Considering histopathology as the gold standard diagnostic performance of CT imaging for predicting TI.

RESULTS

84 patients (19 men, 65 women), 97 lesions (one tumor in 71 patients and two tumors in 13 patients). Mean maximum axial diameter of lesions was 3.5 ± 1.5 cm (one SD), ranging from 1.1 to 8.4 cm.CT based SHIN categories I- 39%, II- 25%, III- 21% and IV- 15%. More than 130-degree contact with trachea, soft tissue within the cartilage and score III shape were strong predictor of TI (P value < 0.05). Of the three factors, soft tissue in the cartilage was most accurate, 88% accuracy with 79% sensitivity. Intraluminal mass showed 100% specificity, the sensitivity was low 28%. SHIN showed good accuracy 93% with upwards of 90% sensitivity and specificity. Modified shin classification combined had a 96% accuracy.

CONCLUSION

CT based Modified SHIN classification has a very high negative predictive value for predicting TI and can help optimizing postoperative outcomes with efficient preoperative assessment.

CLINICAL RELEVANCE/APPLICATION

Presence Tracheal invasion (TI) alters the management plan. extensive local resection can improve survival rate and reduce local recurrence Vs. near-total tumor excision with adjuvant treatment has survival rate similar to that obtained with extensive resection. Hence, assessment of extent of TI with pre-op imaging is crucial in appropriate treatment planning.

Printed on: 10/29/20
A Dynamic Numerical Brain Simulation Model for CT Perfusion Optimization

**PURPOSE**
Recent research to extend the time window of thrombectomy for ischemic stroke has led to a growing need to understand and optimize the accuracy of CT perfusion (CTP) imaging. This work expands the XCAT brain phantom to model regional physiology and contrast agent kinetics for use in simulating and optimizing CTP studies.

**METHOD AND MATERIALS**
To enable spatially varying enhancement, the existing 3D NURBS vessels and brain regions were subdivided into smaller volumes. Brain tissue was divided using a physics and constraint solver to generate a 1:1 mapping between the terminal arteries (those without any subsequent branches in the vessel tree) and brain regions fed by each branch. Utilizing the region volume and prescribed tissue perfusion parameters, the flow required by each region is calculated. This determines the flow supplied by the feeding arterial branch and upstream arteries in the vessel tree. Once the flow is determined, the regional contrast agent concentration curves are calculated by propagating the input enhancement curve through the arteries, into the tissue, and drained to the veins. Projections of each dynamic object are simulated for a given acquisition geometry and protocol with CatSim, a CT system simulator. Using the calculated concentration curves, each projection is scaled to have the desired enhancement. The individual scaled projections are then combined to generate and reconstruct the image at each timepoint.

**RESULTS**
The updated brain phantom contains 78 gray matter regions, 117 white matter regions, 240 vein segments, and 400 artery segments. The framework enables structure specific contrast enhancement as a function of time with flow rates determined from first principles. By identifying individual tissue regions as healthy, ischemic, or infarcted, the model automatically updates the flow in the vasculature to simulate stroke physiology. The flow model combined with a CT simulator generates CTP images compatible with commercially available post-processing software.

**CONCLUSION**
We have incorporated methods to model the flow physiology of stroke cases to CTP simulations. This work will enable the quantitative assessment of CTP imaging protocols and post-processing techniques.

**CLINICAL RELEVANCE/APPLICATION**
The validation and optimization of CT perfusion will improve diagnostic tools for stroke patients and increase physicians’ ability to prescribe a plan of care driven by quantitative data.
To test a new deep learning image reconstruction technique for abdominal CT.

METHOD AND MATERIALS

An anthropomorphic abdomen phantom designed for qualitative and quantitative image quality assessment was scanned on a GE Revolution CT at 120 kVp, dose levels 5, 10 and 15 mGy CTDIvol and 40 mm collimation. All scans were reconstructed with 2.5 mm slice thickness, standard kernel, FBP (ASIR-V 0%), iterative reconstruction (IR) ASIR-V 50, 70 and 90% and deep learning based reconstruction (DLIR) (TrueFidelityTM, GE Healthcare) low (L), medium (M) and high (H). Image quality was evaluated for all reconstruction techniques using noise power spectrum (NPS), Noise texture deviations (NTD), modulation transfer function (MTF), contrast to noise ratio (CNR) and image noise.

RESULTS

Preliminary results show that image noise was reduced for both IR and DLIR reconstruction compared to FBP for all dose levels and noise reduction was independent of dose. Also, image noise was on the same level for DLIR L and ASIR-V 50%, DLIR M and ASIR-V 70% and DLIR H and ASIR-V 90%. However, the NPS peak frequency for all levels of DLIR reconstruction were higher than for the IR indicating less blotchiness and a finer image texture. Moreover, the NTD results indicated less artefacts using DLIR reconstruction (@5mGy: DLIR L/M/H ranges from 0.21-0.24 vs ASIR-V 50/70/90% 0.28-0.47, @10 mGy DLIR L/M/H ranges from 0.11-0.18 vs ASIR-V 50-90% 0.20-0.45, @15 mGy DLIR L/M/H ranges from 0.22-0.34 vs ASIR-V 50/70/90% 0.40-0.57). MTF @50% was at the same level independently of reconstruction techniques for all dose levels (3.5-3.8 @5mGy, 3.5-3.7 @10mGy, 3.79-3.89 @15mGy). CNR was improved using IR and DLIR reconstruction compared to FBP.

CONCLUSION

Both IR and the DLIR reconstruction techniques reduced image noise and improved image quality compared to FBP for all dose levels. In general, the DLIR reconstruction technique was superior to both FBP and IR reconstructions at all dose levels.

CLINICAL RELEVANCE/APPLICATION

New artificial intelligence reconstruction in CT improves image quality in abdominal CT; image texture, image noise, contrast noise ratio and artefact reduction.

SSA21-03 Low Noise, Thin-Slice Chest CT Imaging Using Prior Knowledge Aware Iterative Denoising

Sunday, Dec. 1 11:05AM - 11:15AM Room: E353B

Participants
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Purpose

The intrinsic trade-off between image noise and radiation dose hampers the adoption of thinner slice thicknesses for diagnostic tasks that could benefit from decreased volume averaging, such as chest CT. This work aimed to quantify the ability of prior-knowledge-aware iterative denoising (PKAID) to enable low-noise, thin-slice chest CT without increase radiation dose.

METHOD AND MATERIALS

PKAID exploits spatially redundant information along z-axis direction, using a prior image with a larger thickness to denoise a thinner-slice image. Phantom and patient studies were conducted to assess the performance of this technique. An anthropomorphic chest phantom was scanned on a 192-slice clinical CT system (Siemens Force). Images were reconstructed using a clinical kernel (Bv49) and 1024 matrix at two slice thicknesses (0.75/1.5 mm). The standard clinical image thickness (1.5 mm) was used as a prior by PKAID to process the 0.75 mm image. The modulation transfer function (MTF), slice sensitivity profile (SSP) and noise power spectra (NPS) were determined before and after PKAID. PKAID was applied to 3 patient cases and the image quality of critical anatomy and pathology was qualitatively assessed.

RESULTS

MTF and SSP showed that PKAID preserved in-plane and z-axis spatial resolution, maintaining the sharpness of 0.75 mm image. The shape of the NPS was preserved even though the amplitude was decreased, demonstrating that PKAID decreases image noise without altering noise texture. In patient cases, 0.75 mm PKAID images allowed better delineation of various pathologies compared to the clinical standard of 1.5 mm images, yet maintained the lower image noise level of the 1.5 mm images.

CONCLUSION

In this work, we demonstrate the ability to decrease image thickness in chest CT, without increasing image noise, by use of a technique that exploits spatial data redundancy in the z-axis direction to reduce image noise. Phantom and in vivo results showed that this technique preserved the spatial resolution and noise texture of 0.75-mm thick chest CT images while reducing the image noise to that of the clinical standard of 1.5 mm images, thereby improving the clarity of very fine anatomic detail in the lungs.

CLINICAL RELEVANCE/APPLICATION

PKAID may better delineate various anatomies and pathologies in chest CT by enabling low noise, thin-slice imaging. It may also be used to maintain a given spatial resolution at lower radiation dose.

SSA21-04 Radiation Dose and Contrast Dose Reduction in Combined Coronary CT Angiography and Iliac Artery
**CT Angiography with Personalized Scan Protocol for Preoperative Assessment of Renal Transplant Patients**

**METHOD AND MATERIALS**

A total of 77 patients needing assessment for coronary and iliac arteries before renal transplantation were prospectively enrolled. All patients underwent one-stop combined scans on a 256-row CT scanner with automatic tube current modulation, 50% pre-ASIR-V to control radiation dose. CCTA was performed first using one heartbeat axial scan mode with bolus tracking technique and iliac CTA was performed 1-5 seconds after CCTA using a spiral scan. Group A (n=40) used the standard protocol: 100kVp, 60 ml of 350 mgI/ml CM at the flow rate of 4.5 ml/s. Group B (n=37) used a personalized protocol: kVp: 80 (BMI<24) and 100 (BMI>=24) and CM: 19mgI/kg (BMI<18); 21mgI/kg (18<=BMI<24); and 22mgI/kg (BMI>=24). After scanning, all images were reconstructed with 50%ASIR-V.

**RESULTS**

There was no significant difference in patient demographic data. The contrast dose and radiation dose in the personalized protocol were significantly lower than that in the standard protocol (3.9mls vs. 4.5mls in flow rate, P<0.01; 31.16ml vs. 60ml in total volume, P<0.001 and 3.85±1.36mSv vs. 4.78±1.17mSv in effective radiation dose, p<0.05). The personalized group had better objective CCTA image quality than the standard protocol group (CNR: 27.37±15.47 vs. 15.47±3.86, P<0.01; SNR: 38.74±16.80 vs. 30.08±20.92, P=0.05). Mann-Whitney test showed that there was no significant difference in the subjective scores of arteries between the two scans (all P>0.05), except the left crown trunk where the standard scan protocol had a higher score (p=0.02).

**CONCLUSION**

Personalized scan protocol in tube selection and contrast medium selection can significantly reduce the radiation dose and contrast medium dose while maintaining diagnostic image quality for renal transplant patients.

**CLINICAL RELEVANCE/APPLICATION**

Preoperative assessment of coronary and iliac artery CTA in kidney transplant patients can be completed at a single dose with very low radiation dose and contrast agent dose.

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**X-ray CT Image Reconstruction Using Feature Aware Deep Learning Method**

**METHOD AND MATERIALS**

The entire framework of our proposed feature aware deep learning reconstruction method can be found in Fig. 1(a). DCNN takes the conventional filtered backprojection (FBP) image as input and outputs an image with desirable properties. The choice of training target is critical to DCNN. We propose to use a feature aware training target in Fig. 1(b). First, we need to obtain organ specific feature reconstruction. This can be done by reconstructing the image using different regularization parameters of MBIR. The number of feature images can vary depending on the number of anatomies required for clinical purposes. We combine these into a single image as the feature aware training target. We adopted the U-Net as our DCNN. Our training data consists of five dose patient scans. In order to handle different dose levels, for each full dose scans we simulated four low dose scans corresponding to 75%, 50%, 25% and 12% full dose. Then we extract a total number of two hundreds thousand training pairs. We ran 150 epochs in total to ensure effective convergence.

**RESULTS**

We evaluate our proposed method using two typical real low dose cases. We compare the proposed method to FBP and MBIR with a single adjustable regularization parameter. Fig. 2 shows the comparison for a low-dose pelvis scan. Fig. 3 shows another example of
a low dose chest scan.

CONCLUSION

The proposed method can generate consistent noise and resolution tradeoff which is suited for the specific organs compared to FBP and MBIR.

CLINICAL RELEVANCE/APPLICATION

The proposed method delivers noise consistent image reconstruction with a single reconstruction. Thus, it potentially improving CT work flow while still satisfying clinical diagnostic requirements.

SSA21-06  Assessment of Spatial Resolution as a Function of Focal Spot Size in an Ultra-High Resolution CT System with 6 Selectable Focal Spots

Sunday, Dec. 1 11:35AM - 11:45AM Room: E353B

Participants

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PURPOSE

Most conventional CT systems use two focal spots, but for a ultra-high resolution (0.150 mm pixel dimensions) CT system the focal spot plays a more important role in spatial resolution. The purpose of this study was to evaluate the spatial resolution using the MTF over a range of focal spot sizes and for both super high resolution "SHR" (0.25 mm nominal slice width) and normal resolution "NR" (0.50 mm nominal slice width ) modes.

METHOD AND MATERIALS

A ultra-high resolution CT scanner (Aquilion Precision, Canon Medical) was recently installed and evaluated as part of the commissioning process. A modular phantom was developed previously and used for this study, and specifically a series of thin air slits in PMMA were used to produce line spread functions (LSF). The phantom was placed near the isocenter of the system and imaged using all available focal spot settings in both NR and SHR modes. Sufficient mAs values were used at 120 kV to produce LSF images with low noise, and mA and rotation time settings were selected as a function of focal spot mode. A bone kernel was used for filtered backprojection reconstruction. Images were downloaded to a workstation for analysis using Matlab. The air slits were arranged at a slight angle relative to the image matrix to allow for oversampling the LSF to produce the pre-sampled MTF.

RESULTS

The MTF's showed monotonic improvement as the focal spot size got smaller, especially for the SHR mode (1024 matrix with zoom reconstruction) where 4 focal spot sizes were used. The MTFs for the NR mode (512 matrix) showed lower impact from the focal spot sizes, where 6 spots were used.

CONCLUSION

With the advent of high-resolution CT systems for whole body applications, the role of the focal spot dimensions is shown to be much more important than for previous normal resolution scanners.

CLINICAL RELEVANCE/APPLICATION

Because the focal spot size is a selectable parameter on this high resolution CT scanner, system operators need to fully understand the resolution capabilities and constraints of the various focal spot selections to achieve the full high resolution performance of the scanner.

SSA21-07  Detection of Myocardial Infarction Using a Spectral Imaging Method Derived from a Single KV Scan with Deep Learning

Sunday, Dec. 1 11:45AM - 11:55AM Room: E353B

Participants

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PURPOSE

Currently, to detect myocardial perfusion defects, nuclear medicine imaging methods are used in clinical practice. CT based imaging
methods such as CT myocardial perfusion and dual-energy CT are limited by confounding factors such as motion artifacts, radiation dose, and cumbersome clinical workflows. In this work, a deep learning based method was developed to generate iodine maps from a single kV scan and thus enable myocardial infarction detection from a single contrast-enhanced cardiac CT scan.

**METHOD AND MATERIALS**

A novel deep neural network architecture, referred to as deep spectral imaging network (DSI-Net), was designed and trained to generate two material basis maps from the projection data acquired from a single kV CT scan. To validate the quantitative accuracy of iodine concentration, an anthropomorphic phantom (Lungman) and iodine inserts were scanned using a clinical 64-slice MDCT scanner (Discovery CT750HD, GE Healthcare). The combination of 80kV and 140kV was used to perform the routine dual-energy decomposition to generate a reference iodine map. Iodine maps were then generated from the single 80kV data set and the trained DSI-Net. To demonstrate clinical feasibility, a swine model (N=8) with myocardial defects was scanned using myocardial perfusion CT imaging and PET imaging. The derived myocardial defect zones from these two modalities were compared against the myocardial defect detected by the developed DSI-Net.

**RESULTS**

Physical phantom studies show that the overall relative mean square error of iodine concentration quantification is 3.2% for the DSI-Net. Quantification of each iodine insert is summarized in the figure caption. As shown in the figure, the defect region derived from DSI-Net is highly correlated with that derived from the myocardial blood volume (MBV) and the defects diagnosed from PET images. The Dice coefficient of the affected territory between the MBV from MPI-CT and the iodine map from DSI-Net is 0.84.

**CONCLUSION**

It is feasible to use the deep learning based spectral CT imaging method from a single kV acquisition to generate quantitative iodine maps for myocardial perfusion defect detection.

**CLINICAL RELEVANCE/APPLICATION**

From a single kV CT acquisition, the developed deep spectral CT imaging can enable all of the currently available CT scans be used to generate spectral CT imaging information for quantitative diagnosis without modifications to the current scanner hardware or clinical workflow.

**SSA21-08 Phase-Locked Physiological Data for 4D CT: The Application of Standard Video Collection and Motion Enhancement**

Sunday, Dec. 1 11:55AM - 12:05PM Room: E353B

Participants
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**CONCLUSION**

Extracting cardiorespiratory signals from standard video recording is a promising technique for synchronizing and visualizing the physiological state of a patient during dynamic medical imaging.

**Background**

To facilitate precise interpretation of dynamic medical imaging, synchronized physiological parameters, such as cardiorespiratory phase, need be integrated into the collected dynamic images. While some aspects of this information may be visible during acquisition (e.g. respiratory gating in MRI, and EKG in MRI/CT), it is often difficult to obtain this raw data for post-processing. At our center, interpreting 4D airway scans critically requires the respiratory trace to be overlaid for each scan. Since the Force CT scanner has no ability to collect respiratory data or export cardiac signals, we developed a solution using simple video collection and Eulerian video magnification. Using enhanced motion and color data from video, we demonstrate the ability to generate automated physiological traces that can be integrated with CT images for clinical interpretation.

**Evaluation**

Eulerian video magnification functions to extract cardiorespiratory phase information by enhancing color and motion. This phase information is easily synchronized with the dynamic CT time-course to facilitate physiologically relevant interpretation. To validate derived data, anesthesia-monitor EKG and respiratory traces were compared to extracted video-signals. This approach has been demonstrated in infants and other patient groups with airway complications. In addition, the best-practice conditions for video capture and the limits of processing parameter choices will be presented.

**Discussion**

Standard video recordings are easy and inexpensive to obtain. Given the relative inability to collect or extract these signals on a broad range of imaging equipment, the exploitation of Eulerian video magnification and developed approach for re-integration of this data with the DICOM data-set, provides a roadmap for widespread use. Since audio data can be similarly processed, scenarios where this may be useful for artifact confirmation (e.g. crying) or diagnostic enhancement (e.g. linked laryngeal activity) will also be discussed.
High Temporal Resolution C-Arm Cone-Beam CT Perfusion Imaging

Sunday, Dec. 1 12:05PM - 12:15PM Room: E353B

Participants
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PURPOSE
C-arm cone-beam CT perfusion (CBCTP) imaging is key to enable one-stop-shop stroke imaging in angio-suite for ischemic stroke patients. Due to slow gantry motion, inadequate temporal resolution and temporal sampling in CBCTP acquisitions may limit the accuracy of the generated perfusion maps and thus limit accurate diagnosis of perfusion deficit in interventional suite. In this work, a new reconstruction technique was developed to achieve 30x improvement of temporal resolution for CBCTP perfusion imaging.

METHOD AND MATERIALS
With the SMART-RECON method, multiple CT volumes can be reconstructed from a single acquisition to achieve 4-5 temporal resolution improvement, however, in CBCTP acquisitions, multiple scans are performed by rotating the C-arm gantry in a back-and-forth manner. In this scheme, limited view artifacts demonstrate a strong intrinsic periodicity. In this work, this a priori knowledge of periodicity was incorporated into SMART-RECON, resulting in a significantly enhanced performance for SMART-RECON (eSMART-RECON). A digital anthropomorphic phantom was used to quantify the achievable temporal resolution of eSMART-RECON. The proposed method was also applied to human subject data to demonstrate clinical feasibility. Under IRB approval and written consent, each patient underwent both multi-detector CT perfusion (MDCTP) and CBCTP imaging. The MDCTP and CBCTP images were co-registered and processed with the same software to compute parametric perfusion maps.

RESULTS
The achievable temporal resolution of eSMART-RECON was quantified in the digital phantom as 7.5 fps. Given the gantry rotation speed of 4.2s (corresponding to approximately 0.25 fps), eSMART-RECON yields 30x temporal resolution improvement. The human subject studies demonstrate that eSMART-RECON can accurately capture the temporal variation of cerebral tissues as perfusion maps derived from eSMART-RECON CBCTP closely resemble MDCTP maps (see figure).

CONCLUSION
A new technique, eSMART-RECON, was developed and validated to achieve significantly improved temporal resolution to enable accurate CBCT perfusion imaging.

CLINICAL RELEVANCE/APPLICATION
With the ability to produce accurate perfusion maps in interventional suite, the workflow of endovascular treatment for acute ischemic stroke patients can be further optimized to reduce the time from stroke onset to treatment such that more brains can be saved since time is brain in ischemic stroke patient management.

Printed on: 10/29/20
SSA24

Vascular/Interventional (Liver Cancer Science)

Sunday, Dec. 1 10:45AM - 12:15PM Room: S404CD

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Sub-Events

SSA24-01 Safety of Shortened Observation Time Without Radiographic Follow-Up for Patients After CT-Guided Lung Biopsy

Participants
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PURPOSE
To determine safety of shortened observation without follow up chest X-ray (CXR) after CT-guided lung biopsy in patients without immediate post-procedural pneumothorax (PTX).

METHOD AND MATERIALS
Consecutive patients that underwent CT-guided lung biopsies under moderate sedation between 01/05/2015 and 06/19/2017 in a tertiary academic center were included in this IRB-approved HIPAA-compliant study. "Immediate post-procedure PTX" was defined as one detected by CT at the end of the biopsy; "observation PTX" and "delayed PTX" defined as pneumothorax detected by CXR during and after the post-procedural monitoring period, respectively.

RESULTS
441 lung biopsies for 409 patients (average age 68 ± 11yrs, 231 (56%) female patients) were performed; 76 biopsies were excluded due to immediate post-procedure PTX, 6 due to insufficient documentation in the electronic medical records and 6 due to lack of follow up after biopsy. Average duration of monitoring for outpatients (n=293) was 2.01 ± 0.74 hrs. In 20/353 (5.7%) biopsies, the patient became symptomatic (chest pain, shortness of breath) during post-procedural observation with 1/20 (5%) developing PTX. In 313/333 biopsies, the asymptomatic patients did not undergo CXR after the procedure, with 7/309 of these patients (2.3%) developing delayed PTX 2-10 days after the procedure (average 4.9 ± 4.0 days). In 24/333 biopsies (7.2%), the asymptomatic patients underwent CXR within 4 hours with no PTX detected and despite that 1/24 of these patients (4.2%) presented with delayed PTX 7 days after the procedure. When no immediate post procedural PTX was present, the rate of observation PTX and delayed PTX was 1/353 (0.3%) and 8/353 (2.3%), respectively.

CONCLUSION
Obtaining routine post-procedure CXRs in patients without immediate post-procedural PTX after CT-guided lung biopsies is not necessary given the low likelihood of PTX. Furthermore, shortening monitoring to 2 hour appears to be safe for these patients.

CLINICAL RELEVANCE/APPLICATION
A decrease in observation time for this subset of patients will allow improved utilization of hospital resources.

SSA24-02 Transthoracic Ultrasound Guided Lung Biopsy: Accuracy and Safety

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PURPOSE
Variables affecting performance of ultrasound-guided transthoracic needle biopsy (USG-TTNB) are not well established. The aim is to determine the clinical and imagery variables affecting sensitivity and rate of complications with USG-TTNB.

METHOD AND MATERIALS
From 2008 to 2017, a total of 542 consecutive USG-TTNB were reviewed. Mediastinal and chest wall lesions were excluded. 14 patients had incomplete data. Cubic splines were used to test the functional relationship between pleural contact length with sensitivity and complications. Multivariate logistic regression was used to account for possible confounding variables on that relationship.

RESULTS
Of the 528 biopsies, 312 diagnosis were obtained by USG-TTNB, including 285 malignant and 27 specific benign diagnosis, yielding a diagnostic accuracy of 59.2% (95%CI 54-62%) and sensitivity of 72.5% (95%CI 68-77%), respectively. Positive biopsies were associated with lesion size (p<0.001), pleural contact length (p<0.006), absence of pneumothorax (p=0.001), chest wall invasion (p=0.005) and core biopsy needle <=18G versus >18G (p=0.024). Graphical inspection of a cubic spline showed that the probability of positive biopsies rose sharply for increasing pleural contact length up to 30 mm, then a flattening of risk. A similar reverse relationship was observed for pneumothorax. After adjusting for lesion size, chest wall invasion, and core biopsy needle, there was a significant effect of increasing pleural contact length up to 30 mm predicting positive biopsy (HR 1.07 {1.02, 1.12}, p=0.002 per 1 mm) with a non-significant effect of pleural contact size past 30 mm. Pneumothorax occurred in 14.6% (95%CI 11.7-17.9%) and chest tube was placed in 1.7% (95%CI 0.8-3.2). Variables associated with pneumothorax were lesion size (p<0.001), pleural contact length (p<0.001) and upper/middle lobes (p=0.002). On multivariate analysis, none of the above were significant at 5% level. No variables were associated with hemorrhagic complications, which occurred in in 3.3% (95%CI 1.8-4.8).

CONCLUSION
Pleural contact length and target lesion size were the key variables predicting diagnostic accuracy and pneumothorax rate.

CLINICAL RELEVANCE/APPLICATION
Efficacy and safety outcomes are both affected by pleural contact length and lesion size. Therefore, choosing US-TTNB as a diagnostic procedure must consider these variables.

SSA24-03 Ultrasound- versus CT-Guided Peripheral Lung Biopsies: A Comparison of Safety, Effectiveness, and Wait Times

Sunday, Dec. 1 11:05AM - 11:15AM Room: S404CD

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PURPOSE
To compare the safety, effectiveness and wait times of CT-guided percutaneous lung biopsies with ultrasound (US) guidance for peripheral lung lesions that abut or arise from the pleura.

METHOD AND MATERIALS
Consecutive CT- and US-guided biopsies performed at our institution between January 2017-January 2019 were retrospectively reviewed. Lesion size, the degree of pleural contact, wait time for the procedure, the number of needle passes, procedure duration, complications and final pathology diagnosis were recorded. Chi-square and Mann-Whitney U tests were used for statistical analysis. Research ethics board approval was obtained.

RESULTS
A total of 228 imaging-guided lung biopsies were performed by 5 interventional radiologists. Of these, 117 were for peripheral or pleural-based lesions. US guidance was used for 38 cases (20 men, 18 women, mean age 71.1). CT guidance was used for 70 cases (39 men, 40 women, mean age 69.9). Overall, the mean maximum axial diameter of pulmonary lesions sampled under US guidance was greater than for CT (4.8±2.5 cm vs 3.7±1.8 cm, p = 0.007). Similarly, the length of pleural contact was also greater for US (4.1±2.4 cm) than CT (2.6±1.7 cm, p < 0.001). Procedure time was shorter for lesions localized with US than CT (28.7±16.9 min vs 36.6±20.2 min, p = 0.017). In contrast, the mean number of needle passes per lesion was less for CT than US (3.1±0.9 vs 3.5±1.1, p = 0.019). The adequacy of biopsy samples was determined to be equivalent for both modalities (97.4% for US and 97.5% for CT). The wait time for both procedures was not significantly different (11.7±8.3 days for US vs 14.9±8.0 days for CT, p = 0.059). Finally, the frequency of significant complications requiring chest tube insertion and/or hospital admission was similar between US and CT (2.6% vs 3.8%).

CONCLUSION
US-guided peripheral lung biopsies are safe and reliable with comparable results to CT-guided biopsies and similar wait times, but
US-guided peripheral lung biopsies are safe and reliable with comparable results to CT-guided biopsies and similar wait times, but shorter procedure times.

**CLINICAL RELEVANCE/APPLICATION**
US is relatively low cost, does not require ionizing radiation and allows for real-time needle visualization, making it a viable alternative to CT guidance for biopsy of peripheral lung lesions.

**SSA24-04 CT-Guided Percutaneous Biopsy of Ever Smaller Lung Nodules: Diagnostic Yield and Complication Rate as a Function of Nodule Size**

Sunday, Dec. 1 11:15AM - 11:25AM Room: S404CD

Participants
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**PURPOSE**
The number of CT-guided percutaneous lung biopsies performed is rapidly growing, in part due to the advent of lung cancer screening CT. However, not only are we performing more lung biopsies, but we are biopsying ever smaller nodules. Given that subcentimeter nodules have not routinely been biopsied, the diagnostic yield and complication rates are not known. The purpose of this project was to evaluate the diagnostic yield and complication rate of percutaneous lung biopsy as a function of nodule size.

**METHOD AND MATERIALS**
This IRB approved study involved retrospective review of 625 patients who underwent percutaneous, CT-guided lung biopsy. Patients were identified via search of our electronic medical records system (Montage). Biopsies were performed by one of fifteen attending radiologists specializing either in interventional radiology or body imaging. Data recorded included nodule size, distance from the pleura, needle type, number of passes performed, pneumothorax rate, chest tube rate, hospital admission rate, diagnostic yield as well as history of smoking or prior malignancy.

**RESULTS**
Overall, a diagnostic specimen was obtained in 91.5% of patients (572/625). However, diagnostic yield for lesions <1 cm was 80% compared to 92.1% for nodules > 1 cm (p < 0.05). For every 1 cm increase in lesion size, the odds of achieving a diagnostic specimen increased 21% (p < 0.05). Pneumothorax complicated 11% of biopsies (69/625) and 5.6% of patients (35/625) required chest tube placement. However, 22.5% of procedures were complicated by pneumothorax when lesions were <1 cm, compared to 10.3% of procedures when the nodule was >1 cm (p < 0.05). For every 1 cm increase in nodule size, the odds of pneumothorax decreased 24% (p < 0.05). Although there was no statistically significant difference in patients requiring chest tubes in the two groups, the odds of requiring a chest tube decreased 21% for every 1 cm increase in lesion size (p < 0.05).

**CONCLUSION**
Percutaneous CT-guided lung biopsy is a safe and effective procedure, however the diagnostic yield decreases and the complication rate increases as the size of the biopsy target decreases.

**CLINICAL RELEVANCE/APPLICATION**
As the number of CT-guided lung biopsies increases across the country it is crucial that physicians and patients understand that diagnostic yield and complication rates are directly related to nodule size.

**SSA24-05 Efficacy of Thermal Ablation versus Stereotactic Radiotherapy for Stage I Lung Cancer: Subgroup Analyses Based on Tumor Histology**

Sunday, Dec. 1 11:25AM - 11:35AM Room: S404CD

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**PURPOSE**
To assess the effectiveness of thermal ablation (TA) versus stereotactic body radiotherapy (SBRT) for stage I lung cancer depending on histology.

**METHOD AND MATERIALS**
The National Cancer Database was queried for patients with AJCC stage I lung cancer diagnosed from 2004-2015. Adenocarcinoma, squamous cell carcinoma (SCC), unspecified non-small cell lung cancer (NSCLC) and other histology (except carcinoid) were included. Treatment was stratified as TA (radiofrequency ablation, or grouped laser/cryo ablation) and SBRT (beam-based radiation of the lung). Patients age < 18yo, chemotherapy, and unknown survival/follow up were excluded. SBRT and TA patients were 5:1 propensity score matched to account for confounders, separately for each histology. Overall survival (OS) was compared in the matched cohort.
RESULTS

55,336 patients were included: n=68,693 receiving SBRT (97.3%) and n=1,836 receiving TA (2.7%). Histology was adenocarcinoma n=24,085 (35.1%), SCC n=20,736 (30.2%), NSCLC n=10,515 (15.3%), and other histology n=13,357 (19.4%). TA patients were more likely to be younger Caucasians with private insurance and more comorbidities and treated at academic centers in New England states for smaller adenocarcinomas. For each histology, a matched cohort was obtained with balanced distribution of confounders. TA and SBRT demonstrated comparable OS in all subgroups: adenocarcinoma (p=0.297; 1-year OS: 86 vs 86%; 3-year OS: 49 vs 52%), SCC (p=0.086; 1-year OS: 67 vs 67%; 3-year OS: 27 vs 30%), NSCLC (p=0.732; 1-year OS: 83 vs 83%; 3-year OS: 49 vs 47%), and other histologies (p=0.094; 1-year OS: 85 vs 83%; 3-year OS: 59 vs 50%).

CONCLUSION

Utilization of thermal ablation techniques for stage 1 lung cancer varies with tumor and patient variables. For adenocarcinomas, squamous cell carcinomas and tumors classified as unspecified NSCLC, overall survival was comparable for TA and SBRT. Future studies should prospectively evaluate optimal patient selection criteria in stage I lung cancer to offer individualized treatment approaches.

CLINICAL RELEVANCE/APPLICATION

Thermal ablation shows comparable OS to SBRT in stage I lung cancer and should be considered as an alternative treatment option, independent of histological subtype.

SSA24-06  Percutaneous Cryoablation of Lung Metastasis: 15 Year Experience of Feasibility, Safety and Recurrence Parameters

Sunday, Dec. 1 11:35AM - 11:45AM Room: S404CD

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PURPOSE

To report our long-term experience with CT guided percutaneous cryoablation using intensive freeze parameters for lung metastasis, including factors affecting complications and local recurrence rates.

METHOD AND MATERIALS

Following IRB approval under HIPAA compliance, 192 CT fluoroscopic-guided, percutaneous cryoablation procedures were performed for 262 masses in 107 outpatients. Primary sites of lung metastasis included colorectal (N=57), renal cell carcinoma (N=38), sarcoma (N=103), gynecologic (N=17), hepatobiliary (N=8) and other (N=24). Tumor size and location (central vs peripheral) with relationship to major vasculature. Hydrodissection and/or were utilized for protection of adjacent structures (i.e: esophagus). All complications were graded according to standardized CTCAE criteria. Patients were followed by CT and/or MRI at 1, 3, 6, 12, 18, 24 months and yearly thereafter.

RESULTS

Average tumor diameter of 2.0 cm was treated by average cryoprobe number of 3.1, which produced CT-visible ice ablation zone diameters averaging 4.1 cm. Grade >3 complications were 3.6% [N=7/192]. There were greater complications in tumors greater/less than 3 cm (9.8% vs. 2.0%; p=0.025). No deaths occurred in our series for ablation of metastatic lesions. Hydrodissection and/or warming catheter utilization was used in 7.8% (15/192). At a mean follow-up of 24 months, overall local tumor recurrence was 5.7%(15/262), but significantly greater for tumors above 3cm (i.e.,16% (7/44); p<0.005).

CONCLUSION

With appropriate pretreatment evaluation and PFT criteria, percutaneous lung cryoablation is safe and produces very low local recurrence rates, especially for tumors <3 cm.

CLINICAL RELEVANCE/APPLICATION

Appropriately delivered thoracic metastasis cryoablation is affected by tumor size yet still produces low recurrence and complication rates.

SSA24-07  Innovative Technique for CT-Guided Presurgical Lung Nodule Marking: High Efficacy and Safety

Sunday, Dec. 1 11:45AM - 11:55AM Room: S404CD

Participants
Hussein D. Aoun, MD, Dearborn, MI (Abstract Co-Author) Reviewer, Galil Medical Ltd
Peter J. Littrup, MD, Rochester Hills, MI (Abstract Co-Author) Founder, CryoMedix, LLC Research Grant, Galil Medical Ltd Research Grant, Endo International p/c Consultant, Delphinus Medical Technologies, Inc
Katie Heath, Detroit, MI (Presenter) Nothing to Disclose
Miguel Alvelo-Rivera, MD, Detroit, MI (Abstract Co-Author) Nothing to Disclose
Barbara A. Adam, Detroit, MI (Abstract Co-Author) Nothing to Disclose
Matthew Prus, BS, Detroit, MI (Abstract Co-Author) Nothing to Disclose
Frank Baciewicz, MD, Detroit, MI (Abstract Co-Author) Nothing to Disclose
ADC can evaluate early MWA efficacy in treatment of pulmonary tumors and Can predict tumor recurrence after treatment.
Palliative Role of Non-Selective Intra-Aortic Transarterial Chemoperfusion (TACP) in the Management of Inoperable Cases of Advanced Lung Cancer

Sunday, Dec. 1 12:05PM - 12:15PM Room: S404CD

Participants
Ahmed I. Ahmed, MBCHB, Assiut, Egypt (Presenter) Nothing to Disclose
Thomas J. Vogl, MD, PhD, Frankfurt, Germany (Abstract Co-Author) Nothing to Disclose
Duaa B. Thabet, Assiut, Egypt (Abstract Co-Author) Nothing to Disclose
Mostafa A. El-Sharkaway, Assiut, Egypt (Abstract Co-Author) Nothing to Disclose
Hossam M. Kamel, Assiut, Egypt (Abstract Co-Author) Nothing to Disclose
Nour-Eldin A. Nour-Eldin, MD, PhD, Frankfurt am Main, Germany (Abstract Co-Author) Nothing to Disclose
Nagy N. Naguib, MD, MSc, Frankfurt, Germany (Abstract Co-Author) Nothing to Disclose
Afaf A. Hassan, Assiut, Egypt (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
time_dr@yahoo.com

PURPOSE
To evaluate the initial tumor response, local control, and survival after the treatment of primary lung malignancies using non-selective intra-aortic transarterial chemoperfusion (TACP) in palliative intent.

METHOD AND MATERIALS
Forty-two patients (mean: 63±11 years; 19 females and 23 males) with advanced unresectable lung cancer (stage III=8 & stage IV=34), underwent repetitive TACP, as third- or further-line therapy, between November 2006 and January 2016. The mean number of sessions was 5.3±2.5. The treated pathologies were non-small cell lung cancer (n=29), small cell lung cancer (n=1) and 12 cases of bronchogenic carcinoma with unknown histology. Bilateral lung involvement was present in 61.9% of cases and the median number of lesions was four. Regional delivery was achieved by injecting the chemotherapeutic agents intra-aortic, as a bolus with maximum hand pressure, in close vicinity to the origins of the main tumor-supplying arteries. The treatment regimen included a combination of mitomycin C and Gemcitabine with (n=37) or without cisplatin (n=3). Two patients received other combinations after their oncologists’ recommendations. The treatment was performed in a palliative setting and patients who underwent subsequent ablation were excluded. The response was evaluated according to the revised RECIST criteria and local tumor progression and patient survival were analyzed using the Kaplan-Meier estimator.

RESULTS
Partial response (PR) was achieved in 4.8% (n=2), stable disease (SD) in 69% (n=29) and progressive disease (PD) in 26.2% (n=11). The estimated mean survival time (MST), median survival time and mean and median time to progression were 20±5.5, 9.5±0.6, 10.7±1.8 and 6.7±2.2 months, respectively. Technical success was achieved in all patients and no intervention-related complications were recorded.

CONCLUSION
Transarterial chemoperfusion is a feasible and well-tolerated treatment in patients with advanced lung cancer who failed prior systemic chemotherapy and have the potential to improve local control and survival, when compared to the published results of other third - and further-line therapies.

CLINICAL RELEVANCE/APPLICATION
TACP is a minimally invasive treatment option that can positively affect the local control and survival in patients with advanced lung cancer.

Printed on: 10/29/20
AI Theater: Japan's Startup Unlocking the Power of AI: Presented by LPIXEL, Inc.
Sunday, Dec. 1 11:00AM - 11:20AM Room: AI Showcase, North Building, Level 2, Booth 10724

Participants
Mariko Takahashi, DDS, Tokyo, Japan (Presenter) Nothing to Disclose

Program Information
LPIXEL is a University of Tokyo spin-off that hones its expertise in AI and medical imaging analytics. As the leading medical AI startup in Japan, LPIXEL has made significant progress in delivering its AI-driven medical image diagnostic technology, 'EIRL,' to hospitals and medical institutions across Japan and overseas. This session will touch on LPIXEL's key highlights of this year, which will include the most up to date information of its AI-powered diagnostic algorithms which focus on brain MRA/MRI, chest X-ray and CT, breast mammography, colonoscopy and more. Other highlights include participating in the Japan Medical Image Database (JMID) project for the development and implementation of the AI annotation tool, and receiving marketing certification in Japan for its diagnostic algorithms which target brain MR images. Join LPIXEL for even more, and how AI in medical imaging is leading the new generation of healthcare. For a personal demonstration of our algorithm, please visit our booth #11703.

Printed on: 10/29/20
**CT Protocol Management Across a Healthcare System**

Sunday, Dec. 1 11:00AM - 12:30PM Room: S406B

**Overview of CT Protocol Parameters and Protocol Management Pitfalls**

1) Understand the importance of CT protocol management to an imaging practice. 2) Identify tools that can be used to develop consistent protocols across multiple systems. 3) Develop awareness of the Management of Acquisition Profiles (MAP) IHE profile and features that should be requested from CT scanner vendors.

**Available Methods, Strategies, and Tools for CT Protocol Management**

1) Recognize the practical and regulatory requirements for protocol management. 2) Identify the technical and clinical parameters that may be included as part of a CT protocol. 3) Understand common difficulties in managing protocols across system vendors, models, and geographic locations.

**Details and Features of DICOM Protocol Storage and the IHE Management of Acquisition Protocols (MAP) Profile**

The talk will detail a CT protocol management strategy called the master protocol concept. The concept groups together phases of indication 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. We will also apply the same concept to reconstruction parameters. This allows the creation, for example, of identical lung field images across any protocol imaging the chest whether it is a dedicated thoracic protocol or a gated chest CTA. Lastly, we will survey current commercial and custom solutions for protocol management. The goal of the survey will be to inform the attendee on what options exist today to guide their selection of such a productivity/compliance informatics solution.

**Active Handout:** Timothy Peter Szczykutowicz

Participants
Kevin O'Donnell, Pacifica, CA (Presenter) Employee, Canon Medical Systems Corporation

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Segmentation

Sunday, Dec. 1 1:00PM - 2:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
George L. Shih, MD, New York, NY (Presenter) Consultant, MD.ai, Inc; Stockholder, MD.ai, Inc;

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This session will focus on the use of deep learning methods for image segmentation, applied to the challenge of CT or MR brain segmentation. While focused on this particular problem, the concepts should generalize to other organs and image types.

Printed on: 10/29/20
Lung Cancer Screening (Interactive Session)

Sunday, Dec. 1 2:00PM - 3:30PM Room: S402AB

Participants
Caroline Chiles, MD, Winston-Salem, NC (Moderator) Nothing to Disclose

Special Information
This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

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.

Sub-Events

RC101A Logistics of Screening
Participants
Jared D. Christensen, MD, Durham, NC (Presenter) Advisory Board, Riverain Technologies, LLC

LEARNING OBJECTIVES
1) Confirm compliance with screening guidelines, including patient eligibility, scanning protocols, radiation dose, CMS requirements, and National Lung Screening Registry.

RC101B Feasible Approaches to Shared Decision-making for Lung Cancer Screening
Participants
Robert Volk, PhD, Houston, TX (Presenter) Nothing to Disclose

RC101C Nodule Assessment and Lung-RADS™ Categories
Participants
Mylene T. Truong, MD, Houston, TX (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To review Lung-RADS categories and nodule management strategies. 2) To review how patient risk can impact nodule management.

RC101D Interesting Cases Encountered in a Screening Program
Participants
Brett M. Elicker, MD, San Francisco, CA (Presenter) Nothing to Disclose

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.

RC101E Incidental Findings on the Low-Dose CT
Participants
Carol C. Wu, MD, Houston, TX (Presenter) Author, Reed Elsevier

LEARNING OBJECTIVES
1) Describe the prevalence and significance of incidental findings on LDCT. 2) Apply the latest evidence-based management recommendations for various incidental findings on LDCT.

Printed on: 10/29/20
RC111A  **Fluciclovine PET/CT: Interpretation and Case Examples**

**Participants**
David M. Schuster, MD, Decatur, GA (Presenter) Institutional Research Grant, Nihon Medi-Physics Co, Ltd; Institutional Research Grant, Blue Earth Diagnostics Ltd; Institutional Research Grant, Advanced Accelerator Applications SA; Institutional Research Grant, Telix Pharmaceuticals Inc; Consultant, Syncona Ltd; Consultant, AIM Specialty Health, Inc; ;

**LEARNING OBJECTIVES**
1) Describe the mechanism of uptake of the PET radiotracer fluciclovine. 2) Identify normal biodistribution of fluciclovine. 3) Identify the FDA approved clinical indication of fluciclovine. 4) Discuss clinical interpretive criteria of fluciclovine PET.

For information about this presentation, contact:
thomas.hope@ucsf.edu

RC111B  **DOTATATE PET/CT: Interpretation and Case Examples**

**Participants**
Thomas A. Hope, MD, San Francisco, CA (Presenter) Research Grant, General Electric Company; Research Grant, Koninklijke Philips NV; Advisory Board, Ipsen SA; Researcher, Advanced Accelerator Applications SA

**LEARNING OBJECTIVES**
1) Define somatostatin receptor PET. 2) Examine the circumstances where somatostatin receptor PET should be used in imaging neuroendocrine tumor patients. 3) Describe the false positives and other issues with interpretation somatostatin receptor PET imaging. 4) Explain the use of 177Lu-DOTATATE peptide receptor radionuclide therapy and how imaging is used to select patients.

For information about this presentation, contact:
donyoo@brown.edu

RC111C  **Non-oncologic Applications for FDG-PET/CT**

**Participants**
Don C. Yoo, MD, Lexington, MA (Presenter) Consultant, inviCRO, LLC

**LEARNING OBJECTIVES**
1) Describe the role of PET/CT in evaluation of infection and inflammation. 2) Determine the role of PET/CT in evaluation of inpatients with fever without a source. 3) Describe the relative imaging costs of various radiopharmaceuticals that can be used for infection and inflammation.

RC111D  **Effective Reporting and Communication**

**Participants**
Eric M. Rohren, MD, PhD, Houston, TX (Presenter) Nothing to Disclose

Printed on: 10/29/20
**Peripheral Artery Disease: CTA and MRA (Interactive Session)**

Sunday, Dec. 1 2:00PM - 3:30PM Room: S404CD

CT  MR  VA

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

FDA  Discussions may include off-label uses.

Participants
Constantino S. Pena, MD, Key Biscayne, 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; Stephan Clasen, MD, Tuebingen, Germany (Moderator) Nothing to Disclose

For information about this presentation, contact:
stephan.clasen@med.uni-tuebingen.de

**Special Information**

This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

**LEARNING OBJECTIVES**

1) Describe techniques for acquisition, reconstruction, and image interpretation of peripheral CTA and MRA. 2) Discuss available data and evidence-based results for peripheral CTA and MRA, and expected impact on patient care. 3) Compare advantages and drawbacks of lower extremity CTA and MRA.

**Sub-Events**

**RC112A  Interventional Procedure Planning: Role for CTA and MRA**

Participants
Constantino S. Pena, MD, Key Biscayne, FL (Presenter) 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;

**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.

**RC112B  Peripheral CTA**

Participants
Stephan Clasen, MD, Tuebingen, Germany (Presenter) Nothing to Disclose

For information about this presentation, contact:
stephan.clasen@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.

**ABSTRACT**

Peripheral arterial disease (PAD) is a common cause of morbidity and mortality in developed countries. Traditionally, imaging for risk stratification and therapeutic planning involved catheter angiography. In recent years, cross-sectional imaging by CTA and MRA has proven a robust technique for non-invasive PAD assessment. Given ubiquity of CT scanning technology, CTA is widely available. High resolution datasets can be acquired rapidly, which facilitates assessment of clinically labile or trauma patients. To be optimally effective, CTA techniques require particular attention to contrast medium and scan protocol. With appropriate protocol design, data acquisition requires limited operator dependence. The acquired 3D dataset is rich with information, but requires careful scrutiny by the interpreting physician. Volumetric review of these datasets produces the most accurate results. Extensive small vessel calcification remains a potential barrier to full assessment of pedal vessels by CTA. Recent published data validates the clinical effectiveness of CTA for diagnosis of PAD and for the direction of treatment planning. Ongoing research aims to exploit the newest generation of CT scanners to acquire additional information, including dual energy data, time-resolved information, and radiation dose savings.

**RC112C  Peripheral MR Angiography**
Interventional Complications: Role for CTA and MRA

Participants
James C. Carr, MD, Chicago, IL (Presenter) Research Grant, Siemens AG; Advisory Board, Siemens AG; Travel support, Siemens AG; Advisory Board, General Electric Company; Speaker, General Electric Company; Research Grant, Bayer AG; Advisory Board, Bayer AG; Travel support, Bayer AG; Speaker, Bayer AG; Research Grant, Guerbet SA; Advisory Board, Guerbet SA; Travel support, Guerbet SA; Speaker, Guerbet SA; Consultant, Circle; Speaker, Circle

Charles Y. Kim, MD, Raleigh, NC (Presenter) Consultant, Medtronic plc; Consultant, Humacyte; Consultant, Galvani

For information about this presentation, contact:
charles.kim@duke.edu

LEARNING OBJECTIVES
1) Understand decision making for assessment of stent patency with CTA versus MRA. 2) Describe endovascular aneurysm repair with endografts as well as 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
Stents are used ubiquitously for the management of atherosclerotic lesions in peripheral arterial disease. While symptomology is an important metric, noninvasive imaging is also a crucial tool for more detailed assessment. Both CTA and MRA have been validated for the assessment of stent patency, although there are nuances for both modalities, and in certain circumstances, one may outperform the other. 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.

Printed on: 10/29/20
Emerging Technology: Imaging of Dementias and Movement Disorders Update 2019

Sunday, Dec. 1 2:00PM - 3:30PM Room: S504CD

CT  MR  NR  NM

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

Participants
Rathan M. Subramaniam, MD, PhD, Dunedin, New Zealand (Moderator) Nothing to Disclose

For information about this presentation, contact:
rathan.subramaniam@utsouthwestern.edu

LEARNING OBJECTIVES
1) To review the value of FDG and amyloid PET/CT in diagnosis of dementia. 2) To review the value of MR imaging in diagnosis of dementia. 3) To review the value of tau PET/CT in diagnosis of dementia.

ABSTRACT
This session will review the importance and value of FDG PET, Amyloid PET, MRI and Tau PET imaging in diagnosis of dementia.

Sub-Events

RC117A  Imaging Dementias: FDG and Amyloid PET/CT

Participants
Rathan M. Subramaniam, MD, PhD, Dunedin, New Zealand (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.

RC117B  Imaging Dementias - Tau PET/CT: Update 2019

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.

RC117C  Imaging of Movement Disorders: Update 2019

Participants
Kevin P. Banks, MD, Joint Base San Antonio, TX (Presenter) Nothing to Disclose

For information about this presentation, contact:
kevin.p.banks.civ@mail.mil

LEARNING OBJECTIVES
1) Understand the Parkinsonian Syndrome entities and their clinical features. 2) Analyze the role and efficacy of I-123 Ioflupane Brain SPECT in the diagnosis and management of PS. 3) Learn the essential steps of proper exam preparation and acquisition. 4) Comprehend the interpretation criteria for I-123 Ioflupane Brain SPECT and potential pitfalls.

Printed on: 10/29/20
Interactive Game: Cases in Body Oncologic Imaging that I Have Learned the Most From (Interactive Session)

Sunday, Dec. 1 2:00PM - 3:30PM Room: S102CD

CT  MR  OI  US

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

FDA Discussions may include off-label uses.

Participants
Deborah J. Rubens, MD, Rochester, NY (Moderator) Nothing to Disclose

For information about this presentation, contact:
Deborah_rubens@urmc.rochester.edu

Special Information
This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

Sub-Events

RC118A Ultrasound

Participants
Deborah J. Rubens, MD, Rochester, NY (Presenter) Nothing to Disclose

For information about this presentation, contact:
deborah_rubens@urmc.rochester.edu

LEARNING OBJECTIVES
1) Review some commonly performed examinations where US leads to oncologic diagnosis. 2) Identify those technical parameters which are critical to accurate ultrasound performance, especially color and spectral Doppler, as exemplified by pitfalls and ‘missed’ cases. 3) Explore the role of US in management of oncologic patients, including contrast enhanced ultrasound.

RC118B Computed Tomography

Participants
Christine O. Menias, MD, Chicago, IL (Presenter) Royalties, Reed Elsevier

For information about this presentation, contact:
menias.christine@mayo.edu

LEARNING OBJECTIVES
1) Review CT imaging features of challenging abdominal and pelvic oncologic cases encountered in clinical practice using case-based examples. 2) Highlight the imaging pearls and pitfalls that may impact diagnosis and treatment. 3) Discuss potential differential diagnoses and mimics of oncologic abdominal and pelvic cases.

RC118C Magnetic Resonance Imaging

Participants
Richard Kinh Gian Do, MD,PhD, New York, NY (Presenter) Consultant, Bayer AG; Author, Reed Elsevier; Spouse, Author, Wolters Kluwer nv; Spouse, Data Monitoring Committee, Alik Abello

For information about this presentation, contact:
dok@mskcc.org

LEARNING OBJECTIVES
1) Assess the role of diffusion weighted imaging in oncology. 2) Explain the presence of susceptibility artifacts on different MRI sequences. 3) Compare the use of extracellular and hepatobiliary contrast agents for liver MRI.

RC118D PET/CT

Participants
Luigi Aloj, MD, Cambridge, United Kingdom (Presenter) Nothing to Disclose

For information about this presentation, contact:
l398@cam.ac.uk
LEARNING OBJECTIVES

1) Biochemical characterisation of cancer through PET imaging. 2) How combinations of radiopharmaceuticals may be relevant to diagnosis. 3) Tumour heterogeneity as detected by PET and implications for patient management. 4) The role of PET/CT in theragnostics
Innovations in Hybrid Imaging

Sunday, Dec. 1 2:00PM - 3:30PM Room: E351

Participants
Osama R. Mawlawi, PhD, Houston, TX (Coordinator) Research Grant, General Electric Company Research Grant, Siemens AG

For information about this presentation, contact:
omawlawi@mdanderson.org

LEARNING OBJECTIVES
1) Become more proficient with the latest innovations in PET/CT imaging and their impact on scanner performance. 2) Learn about the challenges and opportunities in PET/MR image quantification and potential clinical applications. 3) Understand the various corrections necessary to generate a quantifiable SPECT image.

ABSTRACT
This session will cover the latest innovations in hybrid imaging. The session will have three speakers covering 3 different topics. The first talk will cover the latest in PET/CT imaging including silicon photomultiplier tubes, larger axial fields of view and the effects these innovations have on scanner performance. The second talk will focus on PET/MR imaging and discuss the challenges and opportunities of PET/MR image quantification and potential clinical applications. Finally, the third talk will focus on SPECT/CT image quantification while discussing the various correction factors and processes needed to generate a quantifiable SPECT image.

Sub-Events

RC121A Innovations in PET/CT

Participants
Osama R. Mawlawi, PhD, Houston, TX (Presenter) Research Grant, General Electric Company Research Grant, Siemens AG

For information about this presentation, contact:
omawlawi@mdanderson.org

LEARNING OBJECTIVES
1) List the latest advances in PET/CT imaging. 2) Understand the impact of these innovations on scanner performance and image quality. 3) Recognize the differences between commercial PET/CT systems with respect to these innovations.

ABSTRACT
This talk will focus on the latest innovations in PET/CT imaging. Topics covered will include silicon photomultiplier (SiPM) tubes, large axial PET scanners, data driven gating, and the impact these innovations have on scanner performance and image quality.

RC121B Opportunities in PET/MR

Participants
Thomas Beyer, PhD, Vienna, Austria (Presenter) Co-founder cmi-experts GmbH; Co-founder Dedicaid GmbH

For information about this presentation, contact:
thomas.beyer@meduniwien.ac.at

LEARNING OBJECTIVES
1) Appreciate benefits and challenges of quantification in PET. 2) Be made aware of the basic principles of fully-integrated PET/MR imaging systems. 3) Understand the fundamental challenges and potential of MR-guided PET quantification. 4) Be pointed to potential applications of fully-integrated PET/MR in clinical research, and possibly routine.

ABSTRACT
PET is a non-invasive imaging technique that provides reproducible and fully-quantitative information on preselected metabolic/signaling pathways. PET is highly sensitive, thus, requiring only small amounts of biomarkers to be used for visualization and quantification purposes. By comparison to high-resolution anatomical images PET images appear blurred, which is attributed to the positron range effects and the limited detector size of the PET ring systems. Today, clinical PET imaging systems are offered almost exclusively in combination with CT and MR systems. Combined PET/MR, in particular, offers a number of intrinsic methodological advantages over PET only. These include, the use of MR imaging (e.g., by means of MR navigators) to estimate involuntary patient motion as a pre-requisite for motion compensation, and, thus, subsequent improvement of PET image quality and quantification. Following appropriate motion compensation, PET data can be improved in quality and accuracy through the use of MR-guided partial volume corrections and image reconstruction. In this presentation we will highlight the most important advances of PET instrumentation and data processing that help facilitate fully-integrated PET/MR in the first place, and draw a
benefit from this integration for the PET data. This includes a brief discussion of the effect of the static MR field on positron range effects, in particular for higher-energetic positron emitters. Overall, increase volume sensitivity helps reduce the amount of radiotracer injected into patients or shorten the emission scan time, in combination with increased signal-to-noise in the emission images (thanks to the use of time-of-flight, a concept different from TOF-MR) it helps increase sensitivity and reader accuracy of PET images. Lastly, advances in image reconstruction have brought the level of PET, and the appearance of the PET images, closer to the common understanding of radiologically useful images.

RC121C  SPECT/CT Quantitation

Participants
Srinivas C. Kappadath, PhD, Houston, TX (Presenter) Research Grant, General Electric Company; Research Grant, BTG International Ltd; Consultant, BTG International Ltd; Consultant, ABK Biomedical Inc; Consultant, Terumo Corporation

For information about this presentation, contact:
skappadath@mdanderson.org

LEARNING OBJECTIVES

1) Identify the various correction factors applied to SPECT. 2) Understand the processes used for quantification of SPECT. 3) Describe the various approaches used commercially for SPECT quantitation.

Printed on: 10/29/20
## Dual Energy CT for Radiotherapy Applications

**Sunday, Dec. 1 2:00PM - 3:30PM Room: S504AB**

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**Participants**
Kristy K. Brock, PhD, Houston, TX (*Moderator*) License agreement, RaySearch Laboratories AB; Grant support, RaySearch Laboratories AB; Research support, Mirada Medical Ltd;  

**Sub-Events**

### RC122A  Clinical Need for Dual Energy CT in Proton Radiotherapy

**Participants**
Jon J. Kruse, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

**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.

### RC122B  State of the Art in Dual Energy CT Technology

**Participants**
Michael Lawless, PHD, Madison, WI (*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.

### RC122C  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.

Printed on: 10/29/20
Cardiac CT Mentored Case Review: Part I (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Dec. 2 8:30AM - 10:00AM Room: S406A

CA
CT

AMAPRA Category I Credits™: 1.50
ARRT Category A+ Credit: 1.75

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

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, Boston, MA (Presenter) Research Grant, Siemens AG

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.

Printed on: 10/29/20
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.

Sub-Events
RC201A Approach to Nodular Patterns
Participants
Daria Manos, MD, FRCP, Halifax, NS (Moderator) Nothing to Disclose
For information about this presentation, contact:
daria.manos@nshealth.ca

LEARNING OBJECTIVES
1) Use the traditional anatomic approach to 'micronodular' patterns on chest CT. 2) Understand the limitations to the anatomic approach and use additional strategies for a more refined differential diagnosis. 3) Be familiar with common diseases that result in a nodular pattern on chest CT.

RC201B Diffuse Airspace Disease: Practical Tips
Participants
Elsie Nguyen, MD, Toronto, ON (Presenter) Nothing to Disclose

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.

RC201C Cystic Lung Disease: What Are You Missing?
Participants
Judith L. Babar, MBChB, Shelford, United Kingdom (Presenter) Nothing to Disclose

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.

RC201D Fibrotic Lung Disease: Not Always UIP
Participants
Susan J. Copley, MD, FRCP, London, United Kingdom (Presenter) Nothing to Disclose

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.

Printed on: 10/29/20
**RC208**

**Emergency Cardiothoracic CT Angiography**

Monday, Dec. 2 8:30AM - 10:00AM Room: E450B

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

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**Participants**
Douglas S. Katz, MD, Mineola, NY (Moderator) Nothing to Disclose

**Sub-Events**

**RC208A** *Imaging of Venous Thromboembolism in Obesity: Pitfalls and Pearls*

Participants
Douglas S. Katz, MD, Mineola, NY (Presenter) Nothing to Disclose

For information about this presentation, contact:
douglasscottkatzmd@gmail.com

**LEARNING OBJECTIVES**

1) To provide some "pearls" for accurate interpretation of CT pulmonary angiography performed for suspected pulmonary embolism.
2) To review some potential "pitfalls" in the interpretation of CT pulmonary angiography for suspected pulmonary embolism, using examples from clinical practice, and to discuss strategies for avoiding falling into these potential pitfalls.
3) To briefly review the relevant imaging literature.

**RC208B** *CT Angiography of Acute Aortic Syndrome*

Participants
Constantine A. Raptis, MD, Saint Louis, MO (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Review the imaging findings of patients presenting with the acute aortic syndrome.
2) Identify imaging findings in patients with the acute aortic syndrome that can affect prognosis or management.
3) Discuss mimics and confounding imaging findings in cases of suspected acute aortic syndrome.

**RC208C** *Emergency Coronary CT Angiography*

Participants
Jeffrey M. Levsky, MD, PhD, Bronx, NY (Presenter) Nothing to Disclose

For information about this presentation, contact:
jlevsky@montefiore.org

**LEARNING OBJECTIVES**

1) Identify the landmark studies that form the evidence base for ED coronary CTA.
2) Contrast the levels of evidence supporting CTA use in different settings.
3) Differentiate between proven and speculative benefits and drawbacks of CTA.
4) Assess the appropriateness of development of ED coronary CTA programs.

Printed on: 10/29/20
Body Imaging Expert Panel: CTA or MRA?
Monday, Dec. 2 8:30AM - 10:00AM Room: S104A

Participants
Martin R. Prince, MD, PhD, New York, NY (Moderator) Patent agreement, General Electric Company; Patent agreement, Hitachi, Ltd; Patent agreement, Siemens AG; 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; Patent agreement, Toshiba Corporation

Sub-Events

RC212A  MRA
Participants
J. Paul Finn, MD, Los Angeles, CA (Presenter) Nothing to Disclose
Scott B. Reeder, MD, PhD, Madison, WI (Presenter) Nothing to Disclose
Robert R. Edelman, MD, Evanston, IL (Presenter) Research support, Siemens AG; Royalties, Siemens AG

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.

RC212B  CTA
Participants
Elliot K. Fishman, MD, Owings Mills, MD (Presenter) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc
W. Dennis Foley, MD, Milwaukee, WI (Presenter) Nothing to Disclose
Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Advisor, HeartFlow, Inc; Consultant, General Electric Company; Advisor, Boehringer Ingelheim GmbH; Advisor, Siemens AG;

For information about this presentation, contact:
dfoley@mcw.edu
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LEARNING OBJECTIVES
1) Discuss CTA and MRA methods and techniques for optimised 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.

Printed on: 10/29/20
RC221

Innovations in Cone-beam CT

Monday, Dec. 2 8:30AM - 10:00AM Room: E352

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

FDA
Discussions may include off-label uses.

Participants
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (Coordinator) Research Grant, Siemens AG; Advisory Board, Siemens AG; Research Grant, Medtronic plc; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health, Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;

For information about this presentation, contact:
jeff.siewerdsen@jhu.edu

LEARNING OBJECTIVES

Learn about the range of technologies and clinical applications of cone-beam CT in image-guided interventions (including surgery, interventional radiology, and image-guided radiation therapy) and specialty diagnostic imaging (such as breast imaging and orthopaedic / musculoskeletal imaging). Learn about the diversity of cone-beam CT imaging systems for image-guided interventions, including fixed-room and mobile C-arms, O-arms, and new embodiments. Learn about the image quality challenges in cone-beam CT, including image noise and artifacts. Learn about the methods being developed to address such challenges, including new detector types and 3D image reconstruction algorithms. Learn about the systems and methods being developed to further improve spatial resolution in cone-beam CT, offering to extend imaging performance for applications such as breast imaging (detection of microcalcifications) and orthopaedic imaging (visualization / quantification of fine skeletal detail). Learn about the methods by which cone-beam CT can give quantitative measures of pathophysiology, including quantitative imaging metrics related to musculoskeletal health in high-resolution orthopaedics imaging.

Sub-Events

RC221A Innovations in CBCT for Image-guided Interventions

Participants
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (Presenter) Research Grant, Siemens AG; Advisory Board, Siemens AG; Research Grant, Medtronic plc; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health, Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;

For information about this presentation, contact:

RC221B Innovations in CBCT for Breast Imaging

Participants
John M. Boone, PhD, Sacramento, CA (Presenter) Board of Directors and Shareholder, Izotropic Imaging Corporation; Co-author with royalties, Wolters Kluwer nv; Patent agreement, The Phantom Laboratory

For information about this presentation, contact:

RC221C Innovations in CBCT for Musculoskeletal/Orthopedic Imaging

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

For information about this presentation, contact:
wzbijewski@jhu.edu

LEARNING OBJECTIVES

1) To inform the audience of the overall design and use of a dedicated breast CT scanner. 2) To demonstrate the performance of the scanner as assessed using mathematical observers and other quantitative metrics. 3) To further demonstrate the performance of the scanner based upon radiologist-observer studies.

RC221C Innovations in CBCT for Musculoskeletal/Orthopedic Imaging

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

For information about this presentation, contact:
wzbijewski@jhu.edu

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.

Printed on: 10/29/20
Cardiac CT Mentored Case Review: Part II (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Dec. 2 10:30AM - 12:15PM Room: S406A

CA  CT

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

Participants
Jacobo Kirsch, MD, Miami, FL (Moderator) Nothing to Disclose

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; Advisor, HeartFlow, Inc; Consultant, General Electric Company; Advisor, Boehringer Ingelheim GmbH; Advisor, Siemens AG;

For information about this presentation, contact:
grubin@duke.edu

MSMC22B  Coronary Atherosclerosis II

Participants
Karin E. Dill, MD, Atlanta, GA (Presenter) Nothing to Disclose

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

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Beginner Class: Classification Task (Intro)

Monday, Dec. 2 10:30AM - 12:00PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIt Technologies, LLC; Stockholder, VoiceIt Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard and decent-sized screen. Having a Gmail account will be helpful. Here are instructions for creating and deleting a Gmail account. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This class will focus on basic concepts of convolutional neural networks (CNNs) and walk the attendee through a working example. A popular training example is the MNIST data set which consists of hand-written digits. This course will use a data set we created, that we call MedNIST, and consists of images of 6 different classes: Chest X-ray, Chest CT, Abdomen CT, Head CT, Head MR and Breast MRI. The task is to identify the image class. This will be used to train attendees on the basic principles and some pitfalls in training a CNN. • Intro to CNNs • Data preparation: DICOM to jpeg, intensity normalization, train vs test • How do we choose the labels? Inconsistencies... Use Fast.AI routines to classify; Validation of results: Are the performance metrics reliable? ‘Extra Credit’: if there is time, explore data augmentation options, effect of batch size, training set size.

Printed on: 10/29/20
**PURPOSE**

CAD-RADS (Coronary Artery Disease Reporting and Data System) is increasingly used to communicate findings at coronary computed tomography angiography (CTA) in a standardized fashion. The aim of this study was to investigate the impact of fractional flow reserve (FFR-CT) derived from CTA on CAD-RADS stratifications in patients presenting with acute chest pain.

**METHOD AND MATERIALS**

This observational, retrospective study was approved by the institutional review board. FFR-CT analysis was included in the diagnostic workup of 42 patients (mean age 63.6 ± 11.2 years) who presented to the emergency department (ED) with acute chest pain and were referred for CTA. We evaluated the rate of CAD-RADS reclassifications from initial interpretation of the CTA study alone to until after FFR-CT (HeartFlow, Redwood City, CA) results were revealed. Other recorded data included downstream resource use and 90-day clinical outcomes.

**RESULTS**

Four patients (10%) were initially classified as CAD-RADS 2 (i.e., mild stenosis not warranting further work-up), 29 (69%) as CAD-RADS 3 (i.e., moderate stenosis requiring functional assessment), and 9 (21%) as CAD-RADS 4 (i.e., severe stenosis requiring intervention), based on CTA alone. CAD-RADS 2 classifications (4 of 4) all remained concordant between CTA alone and with FFR-CT results added. Similarly, only limited reclassification (11%) occurred in CAD-RADS 4 patients, where CTA and FFR-CT results agreed in 8/9 patients. However, in patients with CAD-RADS 3, 55% (18/29) were reclassified to CAD-RADS 4 or CAD-RADS 2 after FFR-CT results were revealed. This assessment may have decreased the rate of additional diagnostic testing by 45%. No clinical events occurred in the group of patients with FFR-CT > 0.80 within 90 days.

**CONCLUSION**

Adding FFR-CT analysis in patients presenting with acute chest pain substantially decreases equivocality in CTA interpretation, drastically reduces CAD-RADS 3 classifications, and has potential to obviate unnecessary downstream testing. One should consider an update to the CAD-RADS classification to account for the availability of FFR-CT.

**CLINICAL RELEVANCE/APPLICATION**

Adding FFR-CT analysis in patients presenting with acute chest pain rationalizes patient management and has potential to obviate unnecessary downstream testing.
Participants
Joshua Bodreno, DO, Albuquerque, NM (Presenter) Nothing to Disclose
Chengcheng Hu, Tucson, AZ (Abstract Co-Author) Nothing to Disclose
Chris Schwemmer, Erlangen, Germany (Abstract Co-Author) Employee, Siemens AG
Heiko Schmedesekamp, PhD, Malvern, PA (Abstract Co-Author) Employee, Siemens AG
Ashish Pershad, MD, Phoenix, AZ (Abstract Co-Author) Nothing to Disclose
Michael F. Morris, MD, Scottsdale, AZ (Abstract Co-Author) Speakers Bureau, Medtronic plc

PURPOSE
Recent studies have demonstrated that a prototype machine learning based computed fractional flow reserve (ML-FFR) algorithm significantly boosts the diagnostic performance of coronary computed tomography (CTCTA). However, this data is based on results from a single CT vendor, limiting generalizability. We sought to determine the diagnostic performance of a prototype ML-FFR algorithm on CCTA datasets acquired from multiple CT vendors.

METHOD AND MATERIALS
This was a multicenter retrospective study of patients in a large integrated health system undergoing both CCTA and invasive FFR/IFR within 45 days. The study cohort consisted of 110 patients and a total of 120 vessels. Measurement of ML-FFR was performed using workstation-based software, with blinding to the invasive FFR/IFR results. CT scanners were dichotomized as either 'premium' or 'standard.' The 'premium' CT scanners included GE Revolution (n=18), Siemens Flash (n=17), and Siemens Force (n=8). The 'standard' CT scanners included Toshiba Aquilion 64 (n=56), Toshiba Prime 160 (n=2), and GE Lightspeed VCT (n=1).

RESULTS
Baseline characteristics of patients did not significantly differ between 'premium' and 'standard' CT scanners. Per-vessel ML-FFR results obtained on 'premium' CT scanners demonstrated significantly higher sensitivity (p=0.02) compared to ML-FFR from 'standard' CT scanners (Figure 1). There were no significant differences in the specificity (p=0.32) or accuracy (p=0.83) of ML-FFR between 'premium' and 'standard' CT scanners.

CONCLUSION
The sensitivity of a prototype ML-FFR algorithm performed on 'premium' CT scanners is significantly greater than 'standard' CT scanners, with overall similar specificity and accuracy. Future studies with larger number of patients should be performed to determine the reproducibility of these results.

CLINICAL RELEVANCE/APPLICATION
A prototype ML-FFR algorithm demonstrates significantly improved accuracy compared to standard coronary CTA. The sensitivity of the prototype ML-FFR algorithm performed on 'premium' CT scanners is significantly greater than 'standard' CT scanners.

SSC01-03 CTCA-Based Coronary FFR, Plaque Progression Prediction and Virtual Stenting: An All-Inclusive On Cloud Decision Support System for CAD Management

Participants
Antonis Sakellarios, Ioanna, Greece (Abstract Co-Author) Nothing to Disclose
Alberto Clemente, Massa, Italy (Presenter) Nothing to Disclose
Panagiota Siolekas, Ioanna, Greece (Abstract Co-Author) Nothing to Disclose
Savvas Kyriakakis, Ioanna, Greece (Abstract Co-Author) Nothing to Disclose
Vassiliki Kikla, Ioanna, Greece (Abstract Co-Author) Nothing to Disclose
Nenad Filipovic, Sestre Janjica, Serbia (Abstract Co-Author) Nothing to Disclose
Dante Chiappino, Massa, Italy (Abstract Co-Author) Nothing to Disclose
Danilo Neglia, Pisa, Italy (Abstract Co-Author) Nothing to Disclose
Silvia Rocciccioli, Pisa, Italy (Abstract Co-Author) Nothing to Disclose
Gualtiero Pelosi, Pisa, Italy (Abstract Co-Author) Nothing to Disclose
Dimitri Dimitri I Fotiadis, Ioanna, Greece (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
clemente@ftgm.it

PURPOSE
A comprehensive on cloud platform for clinical decision support (CDS) in stable coronary artery disease (CAD) has been developed within SMARTtool EU funded project, including several models and tools based on CT coronary angiography (CTCA) imaging.

METHOD AND MATERIALS
CTCA images are processed using an in-house 3D reconstruction tool which provides automatically the lumen, outer wall, calcified and non-calcified plaque of the coronary tree. The geometries are used for the non-invasive calculation of SmartFFR Index. The pathologic SmartFFR is taken as a marker of obstructive CAD requiring revascularization and the stenosed arteries are used for real-time virtual stenting simulation. Additionally, the reconstructed segments are used in a prognostic model including CTCA and computational modeling features as well as non-imaging patient data to predict patient/plaque-specific CAD progression.

RESULTS
The above implemented methodologies have been validated in SMARTtool clinical trial (263 stable CAD patients recruited at two time points with an interscan period of 6±1 years). Data from 27 patients were used for the validation of 3D reconstruction comparing results with manual annotations. The DICE coefficient and the Hausdorff distance are 0.72±0.08 and 1.95 ±0.45, respectively. The
SmartFFR methodology was validated using 88 coronary segments where invasive FFR was available ($r=0.86$, $p<0.0001$). Diagnostic performance of SmartFFR has 90.9, 88.9, 91.8, 82.8 and 94.9 for Accuracy, Sensitivity, Specificity, PPV and NPV, respectively. Virtual stenting methodology has also been proved to accurately simulate inflation and re-expansion of the stenotic segments, while the prognostic model based on the analysis of 480 coronary segments from 187 patients has 80% accuracy for plaque progression prediction.

**CONCLUSION**

The CTCA imaging-based models developed in SMARTool on cloud CDS empower current management of stable CAD patients. This work is partially funded by the European Commission: Project SMARTOOL, ‘Simulation Modeling of coronary ARTery disease: a tool for clinical decision support - SMARTool’ [GA number: 689068].

**CLINICAL RELEVANCE/APPLICATION**

SMARTool CDS is expected to enhance the diagnostic and prognostic yield of CTCA imaging and support stent implantation planning.

**SSC01-04** Comparison of Invasive FFR, CT-FFR, and Benchtop FFR Using 3D Printed Patient Specific Coronary Phantoms

*Presented by* Kelsey N. Sommer, East Amherst, NY
*Abstract Co-Author* Vijay Iyer, Buffalo, NY
*Abstract Co-Author* Erin Angel, PhD, Tuustin, CA
*Abstract Co-Author* Michael F. Wilson, Buffalo, NY
*Abstract Co-Author* Frank J. Rybicki III, MD, PhD, Sudbury, MA
*Abstract Co-Author* Dimitrios Mitsouras, PhD, Ottawa, MA
*Abstract Co-Author* Kanako K. Kumamaru, MD, PhD, Tokyo, Japan
*Abstract Co-Author* Cinpian N. Ionita, PhD, Buffalo, NY
*Abstract Co-Author* Ciprian N. Ionita, PhD, Buffalo, NY
*Abstract Co-Author* Imagia Cybernetics Inc
*Abstract Co-Author* Canon Medical Systems Corporation
*Abstract Co-Author* Grant, Canon Medical Systems Corporation;
*Abstract Co-Author* Director, Imagia Cybernetics Inc
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose
*Abstract Co-Author* Nothing to Disclose

**PURPOSE**

Diagnosis tools based on computational fluid dynamics, have been proposed to predict fractional flow reserve (FFR) in patients with coronary artery disease. These tools use segmented 3D geometry obtained via CT-angiography and various boundary conditions for flow. Regardless of the approach or computational particularities, tool validation and optimization is done using a reference standard invasive FFR. This development approach can be lengthy due to incomplete knowledge of all factors affecting the human physiology complexity. In this study we propose to determine whether it is feasible to use patient specific 3D printed patient specific coronary phantoms to validate a CT-FFR software.

**METHOD AND MATERIALS**

Using multi-material 3D printing capabilities, we built 33 patient specific cardiac phantoms from CCTA scans in patients who underwent clinically indicated elective invasive coronary angiography. Each phantom was used in a controlled flow system where patient specific flow conditions were provided by a programmable cardiac pump. Flow parameters were adjusted such that the aortic pressures were 100-120 mmHg and coronary total flow was 500mL/min. Each phantom had pressure sensors embedded in the main coronary arteries and the flow rate was monitored. The benchtop FFR was recorded between the aorta and distal to the stenosis. Benchtop FFR was compared with the invasive FFR and a CT-FFR research software (Canon Medical Systems).

**RESULTS**

The AUC for benchtop FFR and CT-FFR compared with invasive FFR as the 'gold standard' was 0.72 and 0.83, respectively, with less than or equal to FFR of 0.8 being true for diseased.

**CONCLUSION**

3D printed patient specific coronary phantoms can be used to replicate the human arterial anatomy as well as blood flow conditions. Above all they offer the unique opportunity to control and precisely measure physiological conditions which can be used to optimize and validate diagnostic software.

**SSC01-05** Diagnostic Performance of a Machine-Learning-Based Fractional Flow Reserve Derived from Coronary Computed Tomography Angiography for the Detection of Functionally Obstructive Coronary Artery Disease

*Presented by* Thamara C. Morais, MD, Sao Paulo, Brazil
*Abstract Co-Author* Antonildes N. Assuncao JR, MD, Sao Paulo, Brazil
*Abstract Co-Author* Carla F. Silva, Sao Paulo-sp, Brazil
*Abstract Co-Author* Caroline B. de Paula, BMedSc, Sao Caetano do Sul, Brazil
*Abstract Co-Author* Ana Paula T. Cardoso, MD, Sao Paulo, Brazil
*Abstract Co-Author* Ana Paula T. Cardoso, MD, Sao Paulo, Brazil
*Abstract Co-Author* Cintia d. Moraes, PhD, Sao Paulo, Brazil
*Abstract Co-Author* Roberto V. Torres, MD, Sao Paulo, Brazil
*Abstract Co-Author* Tiago A. Magalhaes, MD,PhD, Curitiba, Brazil
*Abstract Co-Author* Tiago Santos, Sao Paulo, Brazil
*Abstract Co-Author* Tiago Santos, Sao Paulo, Brazil

**PURPOSE**

Virtual stenting methodology was validated using 88 coronary segments where invasive FFR was available ($r=0.86$, $p<0.0001$). Diagnostic performance of SmartFFR has 90.9, 88.9, 91.8, 82.8 and 94.9 for Accuracy, Sensitivity, Specificity, PPV and NPV, respectively. Virtual stenting methodology has also been proved to accurately simulate inflation and re-expansion of the stenotic segments, while the prognostic model based on the analysis of 480 coronary segments from 187 patients has 80% accuracy for plaque progression prediction.

**CONCLUSION**

The CTCA imaging-based models developed in SMARTool on cloud CDS empower current management of stable CAD patients. This work is partially funded by the European Commission: Project SMARTOOL, ‘Simulation Modeling of coronary ARTery disease: a tool for clinical decision support - SMARTool’ [GA number: 689068].
For information about this presentation, contact: thamaramorais@hotmail.com

PURPOSE

To evaluate the diagnostic performance of a novel machine learning approach for computed tomography (CT) angiography-based fractional flow reserve (FFRCT), using different scanner profiles, in the detection of functionally obstructive coronary artery disease (CAD) assessed by invasive FFR (FFRi).

METHOD AND MATERIALS

This retrospective study comprised patients clinically referred to CT and subsequently to invasive coronary angiography with FFRi measurement for CAD assessment at Sino-Libanes Hospital, Sao Paulo, Brazil. CT acquisitions were performed using two scanner profiles: Siemens Somatom Definition Flash (75ms/0.30mm) and AS+ (150ms/0.30mm). On a dedicated software (cFFR version 3.0.0, Siemens Healthineers, Forchheim, Germany) installed in a standard desktop, FFRCT and the minimum luminal area (MLA) were calculated. Obstructive CAD was defined as CT with stenosis >50% and functionally obstructive CAD as FFRi <=0.8.

RESULTS

Ninety-three consecutive patients (152 vessels) were included. Bland-Altman analysis showed high agreement between FFRCT and FFRi, with mild systematic overestimation of FFRCT values (bias:-0.02; limits of agreement: 0.14-0.09) (Figure 1A). Images acquired in different CT’s did not modify the relationship between FFRCT and FFRi values (p for interaction=0.73) (Figure 1B). Compared with visual anatomically obstructive CAD by CT, both ALM (AUC 0.75 vs. 0.61, p<0.001) and FFRCT (AUC 0.93 vs. 0.61, p<0.001) demonstrated a higher performance. The best cutoff point using a Youden index was 0.84 for FFRCT (Sens 87%, Spec 85%, PPV 73%, NPV 93%), leading to a 76% reduction of false-positive when compared to obstructive CAD by CT.

CONCLUSION

FFRCT based on a machine learning algorithm can accurately identify patients with flow-limiting stenosis. This new tool is available for standard PC and seems to have consistent results even in CT with different profiles.

CLINICAL RELEVANCE/APPLICATION

FFRCT based on machine learning algorithms promises to speed up the clinical implementation of non-invasive functional CAD assessment. Given its reproducibility and diagnostic accuracy, it allows users to install dedicated software on a standard desktop, reducing post-processing time and providing functional information.
advanced techniques allowing low radiation dose, the innovative low-dose, one-stop CTP examination is clinically feasible for patients who need to receive a myocardial perfusion assessment.

**CLINICAL RELEVANCE/APPLICATION**

The CTP-derived SP-CTA improved the diagnostic value of CTP alone, which makes it clinically feasible to be applied as an innovative one-stop cardiac CT examination for patients with intermediate to high CAD risk, providing the convenience in clinical procedure and the advantage of dose and contrast media saving.

**SSC01-08  CT-FFR Profiles in Patients without Coronary Artery Disease**

**Monday, Dec. 2 11:40AM - 11:50AM Room: S402AB**

**Participants**

Marly van Assen, MSc, Charleston, SC (Abstract Co-Author) Nothing to Disclose
Carlo N. De Cecco, MD, Atlanta , GA (Abstract Co-Author) Research Grant, Siemens AG
Simon S. Martin, MD, Charleston, SC (Presenter) Institutional Research support, Siemens AG
Andreas Fischer, MD, Charleston, SC (Abstract Co-Author) Nothing to Disclose
Richard Bayer, Charleston, SC (Abstract Co-Author) Institutional Research support, Bayer AG; Institutional Research support, HeartFlow, Inc.; Institutional Research support, Siemens AG
Todd Hudson, MS, Charleston, SC (Abstract Co-Author) Nothing to Disclose
Rock Savage, Charleston, SC (Abstract Co-Author) Nothing to Disclose
Akos Varga-Szemes, MD, PhD, Charleston, SC (Abstract Co-Author) Research Grant and Travel Support, Siemens AG Research Consultant, Elucid Bioimaging
Matthijs Oudkerk, MD, PhD, Groningen, Netherlands (Abstract Co-Author) Nothing to Disclose
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**PURPOSE**

To evaluate the effect of measurement location and lumen area changes on CT-FFR values in patients without coronary artery disease (CAD).

**METHOD AND MATERIALS**

Patients who underwent calcium scoring (CACS) and CCTA with CT-FFR were retrospectively included. Patients were excluded if their CACS was not zero, there were elevated troponin levels, or any cardiac abnormality on the CCTA studies. On-site CT-FFR based on an artificial intelligence, deep-learning algorithm (Siemens Healthineers) was computed for each coronary artery at proximal, mid, and distal segments. At each measurement location, the lumen area and Hounsfield Unit (HU) value was measured.

**RESULTS**

A total of 106 patients were included. In 39 (37%) patients, the LAD had CT-FFR values <0.75, with a decrease in CT-FFR from 0.97 (SD 0.04) proximally to 0.62 (SD 0.10) distally in the abnormal patients. The Cx showed a limited number of patients with CT-FFR values <0.75 (n=16, 15%), with a decrease in CT-FFR values from 0.96 (SD 0.04) proximally to 0.65 (SD 0.09) distally in those patients. The RCA had 36 (34%) patients with CT-FFR <0.75, with distal CT-FFR values of 0.61 (SD 0.12) and proximal CT-FFR values of 0.98 (SD 0.02). 12 abnormal CT-FFR values were measured at mid segment, while all others were measured at distal segments. Lumen area was not significantly different between the abnormal and normal CT-FFR groups, while both HU and HU ratios were significantly lower in the abnormal CT-FFR group for all three major coronary arteries.

**CONCLUSION**

CT-FFR values in patients without coronary artery disease can become abnormal at a distal location without indicating flow-limiting stenosis, which depends strongly on HU values.

**CLINICAL RELEVANCE/APPLICATION**

CT-FFR values measured distally should always be interpreted in combination with the CCTA images in order to avoid false positives and over treatment.

**SSC01-09  Coronary Computed Tomography Angiography and CT-Fractional Flow Reserve for Heart Team Decision-Making in Multivessel Coronary Artery Disease: Syntax III Score**

**Monday, Dec. 2 11:50AM - 12:00PM Room: S402AB**

**Participants**

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**PURPOSE**

Coronary computed tomography angiography (CTA) has emerged as a non-invasive complex coronary artery disease remains to be
Coronary computed tomography angiography (CTA) has emerged as a non-invasive complex coronary artery disease remains to be investigated. The present study sought to determine the agreement between separate heart teams on treatment decision-making based on either coronary CTA or conventional angiography.

METHOD AND MATERIALS
Separate heart teams composed of a cardiologist, a cardiac surgeon, and a radiologist were randomized to assess the coronary artery disease with either coronary CTA or conventional angiography in patients with de novo left main or three-vessel coronary artery disease. Each heart team quantified the anatomical complexity using the SYNTAX score and integrated clinical information using the SYNTAX Score II to provide a treatment recommendations based on mortality prediction at 4 years. The primary endpoint was the agreement between heart teams on the revascularization strategy. The secondary endpoint was the impact of fractional flow reserve derived from coronary CTA (FFRCT) on treatment decision and procedural planning. Overall, 223 patients were included.

RESULTS
A treatment recommendation of CABG was made in 28% of the cases with coronary CTA and in 26% with conventional angiography. The agreement concerning treatment decision between coronary CTA and conventional angiography was high (Cohen's kappa 0.82, 95% confidence interval 0.74-0.91). The heart teams agreed on the coronary segments to be revascularized in 80% of the cases. FFRCT was available for 869/1108 lesions (196/223 patients). Fractional flow reserve derived from coronary CTA changed the treatment decision in 7% of the patients

CONCLUSION
In patients with left main or three-vessel coronary artery disease, a heart team treatment decision-making based on coronary CTA showed high agreement with the decision derived from conventional coronary angiography suggesting the potential feasibility of a treatment decision-making and planning based solely on this non-invasive imaging modality and clinical information.

CLINICAL RELEVANCE/APPLICATION
The addition of coronary CTA to standard medical therapy leads to an incremental benefit; in particular, reducing invasive angiography demonstrating no obstructive CAD and allowing for the appropriate immediate targeting of revascularisation strategies. To aid this process, a heart-team approach and clinical tools such as the Syntax Scores are advocated to objectively quantify CAD burden and clinical co-morbidity.

Printed on: 10/29/20
Impact of Interobserver Variability in Manual Segmentation of Non-Small Cell Lung Cancer (NSCLC) on Computed Tomography

METHOD AND MATERIALS
A public dataset of computed tomography (CT) imaging (NSCLC-Radiomics-Genomics- LUNG3) which contains 88 patients (61 males and 28 females) with NSCLC (adenocarcinoma (n=42), squamous cell carcinoma (n=32), and other NSCLC (n=12). For each CT, tumors were labeled in 3D using ITkSnap (ver 3.6.0). Segmentation was performed by three raters with differing levels of radiologic experience: an imaging analyst (BY;no formal experience), a radiology trainee (MH;5 yrs.) and a specialty-trained thoracic radiologist (SK;18 yrs.). For each tumor segmentation, 429 radiomic features (including grey-level intensity, co-occurrence, run-length, binary patterns, and wavelet features) were extracted. Principal component analysis was further performed on the extracted features. Interoberver variability in radiologic features between the 3 raters was then examined using the senior radiologist as the ground truth (GT). The Sørensen-Dice (SD) coefficient was used to evaluate spatial agreement of segmentations and the Pearson correlation was estimated between the first principal components of the extracted features from each rater's segmentations.

RESULTS
The SD coefficient between the BY-SK(GT) and MH-SK(GT) segmentations was indicated 0.894 (STD: ±0.25) and 0.839 (STD: ±0.20), respectively, showing high agreement. The corresponding PCs were also highly correlated with Pearson's correlations of 0.88 and 0.92, respectively.

CONCLUSION
Routine interobserver variability in tumor segmentation may not result in substantial spatial disagreement of 3D tumor delineation, while subsequently extracted radiomic features are also highly correlated.

CLINICAL RELEVANCE/APPLICATION
Radiomic feature extraction may be robust to interobserver variability in tumor segmentation from lung CT data, resulting in robust prognostic and predictive biomarkers of NSCLC.
To retrospectively assess the effect of CT slice thickness on the reproducibility of radiomic features (RFs) of lung cancer, and to investigate if convolutional neural network (CNN)-based super-resolution (SR) algorithms can improve the reproducibility of RFs obtained from different slice thicknesses.

METHOD AND MATERIALS
CT images from 100 pathologically proven lung cancers acquired between July 2017 and December 2017 were evaluated, including 1, 3, and 5 mm slice thicknesses. CNN-based SR algorithms using residual learning were developed to convert thick-slice images into 1 mm slices. Lung cancers were semi-automatically segmented and a total of 702 RFs (tumor intensity, texture, and wavelet features) were extracted from 1, 3, and 5 mm slices, as well as the 1 mm slices generated from the 3 and 5 mm images. The stabilities of the RFs were evaluated using concordance correlation coefficients (CCCs).

RESULTS
All CT scans were successfully converted to 1 mm slice images at a rate of 2.5 s/slice. The mean CCCs for the comparisons of original 1 vs 3 mm, 1 vs 5 mm, and 3 vs 5 mm images were 0.41, 0.27, and 0.65, respectively (all, P<0.001). Tumor intensity features showed the best reproducibility and wavelets the lowest. The majority of RFs failed to reach reproducibility (CCC>0.85; 3.6%, 1.0%, and 21.5%, respectively). In terms of nodule type, GGNs had better reproducibility than solid nodules in all RF classes and in all slice-thickness pairings (P < 0.001 for 1 vs 3 mm and 1 vs 5 mm, and P = 0.002 for 3 vs 5 mm). After applying CNN-based SR algorithms, the reproducibility significantly improved in all three pairings (mean CCCs: 0.58, 0.45, and 0.72; all, P<0.001). This improvement was also observed in the subgroupings based on the classes of RFs and nodule types. The reproducible RFs also increased (36.3%, 17.4%, and 36.9%, respectively).

CONCLUSION
The reproducibility of RFs in lung cancer is significantly influenced by CT slice thickness, which can be improved by the CNN-based SR algorithms.

CLINICAL RELEVANCE/APPLICATION
On the basis of the findings of our study, the comparisons of radiomics results derived from CT images with different slice thicknesses may be unreliable. As our convolutional neural network-based image conversion algorithm is easily applicable and reliable, this algorithm may be used for enhancing reproducibility of radiomic features when the CT slice-thicknesses are different.

SSC03-03 Correlation-Incorporated Hierarchical Clustering of High-Dimensional Radiomic Features for Prognostic Phenotype Identification of EGFR-Mutated Non-Small Cell Lung Cancer

Participants
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PURPOSE
We propose a correlation-incorporated unsupervised hierarchical clustering algorithm and evaluate it in identifying computed tomography (CT) radiomic phenotypes of EGFR-mutated non-small cell lung cancer (NSCLC) in association with patient overall survival.

METHOD AND MATERIALS
The NSCLC-radiogenomic dataset publicly available from the National Cancer Institute's Cancer Imaging Archive (TCIA) was analyzed, including 204 patients (age range: 69 [±11], male/female: 132/72, event: death [41], adenocarcinoma/squamous cell carcinoma/ unspecified: 166/34/4, EGFR mutation status: wild-type/mutant/unknown: 125/42/37). Tumor regions were verified by an experienced radiologist and segmented in 3D using the ITKSnaps semi-automated toolkit. A total of 429 radiomic features were extracted (grey-level intensity, co-occurrence, run-length, binary patterns, and wavelets) using the pyRadiomics toolkit. An unsupervised method was applied based on a correlation-incorporated hierarchical clustering algorithm (CHCA) to determine the truncation distance in the resulting dendrogram and assign features to robust cluster groups. Low-rank dimensionality reduction
was further performed by principal component analysis (PCA) to estimate the first principal component (PC) of each feature cluster and create a radiomic signature for each tumor. Differences between radiomic signature scores and EGFR mutation status was evaluated using Student’s t-test. Survival probabilities across the extracted PCs were evaluated using Kaplan-Meier curves, and a Cox proportional hazards (CPH) model was fitted based on the estimated PCs.

RESULTS
Using CHCA, dimensionality was reduced from 429 to 67 PCs for a dendrogram truncation distance of 0.1. Three significant radiomic phenotypes were identified, which were associated with EGFR mutation status (p-value < 0.05). The best multivariable CPH model had a C-statistic of 0.71 based on the 67 PCs. Combining radiomic signatures with all available clinical covariates (age, sex, histology, EGFR mutation) yielded a C-statistic of 0.78.

CONCLUSION
CHCA effectively reduces the high dimensionality of radiomic features while allowing for robust identification of CT-based phenotypes of EGFR-mutated NSCLC that are associated with patient survival.

CLINICAL RELEVANCE/APPLICATION
Radiomic phenotypes of EGFR-mutated NSCLC, efficiently extracted by CHCA, could aid in identifying NSCLC patients likely to benefit from targeted EGFR inhibitor therapy.

PURPOSE
We aimed to establish an effective radiomics-based prognostic nomogram for the prediction of progress-free survival (PFS) in stage IV non-small cell lung cancer (NSCLC) treated with platinum-based chemotherapy.

METHOD AND MATERIALS
A total of 308 stage IV NSCLC patients without an EGFR-sensitizing mutation or ALK gene rearrangement were enrolled and divided into a discovery cohort (n=159) and a validation cohort (n=149). All patients had received at least 2 cycles of platinum-based chemotherapy as first-line treatment. 1182 radiomics features were extracted from pre-treatment CT images of each patient. Then, radiomics signature was constructed using LASSO Cox regression analysis based on discovery cohort, and was validated in validation cohort. Furthermore, an individualized prognostic nomogram incorporating the radiomics signature and clinicopathologic risk factors was proposed.

RESULTS
The established signature consisted of 14 features showed good discrimination for classify patients with high-risk and low-risk progression treated by platinum-based chemotherapy. On the multivariable Cox regression, independent factors for PFS were radiomics signature, PS, and N stage, which were all selected into the nomogram. The calibration curve for probability of PFS showed good satisfactory. The C-index of the nomogram for predicting PFS was 0.721(95%CI:0.713-0.729), which was statistically higher than clinicopathologic-based model (C-index: 0.641, 95%CI:0.631-0.651). Decision curve analysis revealed that the nomogram significantly outperformed the clinicopathologic-based model in terms of clinical usefulness.

CONCLUSION
This study establishes a radiomics-based prognostic nomogram that can be conveniently used to achieve individualized prediction of PFS probability for stage IV NSCLC patients treated with platinum-based chemotherapy, which holds promise of guiding the personalized pre-therapy of stage IV NSCLC.

CLINICAL RELEVANCE/APPLICATION
The developed radiomics-based prognostic nomogram could be conveniently used to achieve individualized prediction of PFS probability for stage IV NSCLC patients treated with platinum-based chemotherapy.
**PURPOSE**
Spread through air space (STAS), a novel invasive pattern of lung adenocarcinoma, is a risk factor for recurrence and worse prognosis of patients with early stage adenocarcinoma who underwent limited resection. Therefore, preoperative prediction of STAS in lung adenocarcinoma can facilitate surgeons’ treatment decision making. The aim of this study is to develop and validate a CT-based radiomics model for preoperative prediction of STAS in lung adenocarcinoma.

**METHOD AND MATERIALS**
This retrospective study was approved by institutional review board and included 437 patients with pathological confirmed lung adenocarcinoma, which consisted of 186 males and 251 females with a mean age of 58.2 years. Two experienced radiologists retrospectively reviewed the tissue sample slices in consensus to determine whether there was STAS in lung adenocarcinomas. Two experienced radiologists segmented and extracted radiomics features on preoperative thin-slice CT images using the 3D Slicer with Pyradiomics extention (www.slicer.org) independently. Intra-class correlation coefficients (ICC) and Pearson’s correlation were used to roll out those low reliability (ICC<0.76) and redundant (r>0.9) features. Univariate logistic regression was used to select radiomics features and clinical metrics which were associated with STAS. Multivariate logistic regression analysis was used to develop a predictive model. The diagnostic performance of the model was measured by area under curve (AUC) of receiver operating characteristic (ROC) and calibrated with five-fold cross-validation.

**RESULTS**
STAS was identified by the pathologists in 85 patients (19.5%). At univariate analysis, 26 radiomics features and age were found to be associated with STAS. Multivariate logistic regression showed that age and one radiomics feature (Skewness) were independent predictors for STAS. The CT-base radiomics model achieved a AUC of 0.81 with a sensitivity of 0.737 and a specificity of 0.838 for predicting SATS (Figure. 1).

**CONCLUSION**
CT-base radiomics model can preoperatively predict STAS in lung adenocarcinoma with high diagnosis performance, which provide guides for patients therapeutic decision making.

**CLINICAL RELEVANCE/APPLICATION**
The result of present study showed CT-based radiomics model could preoperatively predict STAS in lung adenocarcinomas with high diagnosis performance which could facilitate surgeons' operation decision making.

**SSCO3-06 Can DECT Quantitative and Radiomics Features Differentiate Benign and Malignant Lymphadenopathy?**
Monday, Dec. 2 11:20AM - 11:30AM Room: E451A

**Participants**
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**PURPOSE**
Dual Energy CT tumor analysis prototype (DE-TA, eXamine, Siemens) was developed to evaluate DECT quantitative and DECT radiomics features. We assessed the accuracy of these features for differentiating benign and malignant lymph nodes on DECT of the chest and abdomen using histology as reference.

**METHOD AND MATERIALS**
With IRB approval, we identified 80 adult patients (mean age 62 ± 15 years; 42 men, 38 women) from our Radiology Information System who had lymph nodes > 1 cm in short axis and had a tissue biopsy of the lymph nodes. All patients had contrast enhanced, dual-source DECT (SOMATOM Flash or Force, Siemens) of the chest and abdomen using histology as reference. The result of present study showed CT-based radiomics model could preoperatively predict STAS in lung adenocarcinomas with high diagnosis performance which could facilitate surgeons' operation decision making.
Development of Predictive Models for Lymph Node Metastasis in Pre-Surgical Stage IA Patients with Non-Small Cell Lung Cancer

PURPOSE

To develop and validate predictive models by use of clinical/CT findings, radiomics features and combination of the both for lymph node metastasis (LNM) in pre-surgical stage IA patients with a non-small cell lung cancer (NSCLC).

METHOD AND MATERIALS

This retrospective study included 649 pre-surgical stage IA patients with NSCLC from September 2017 to January 2019 in our hospital. All patients had a thin-section venous CT scan before surgery. There were 138 (21%) of the 649 patients who had LNM after surgery. A training group included 455 patients (97 with and 358 without LNM) and a test group included 194 patients (41 and 153, respectively). Clinical/CT features (such as age, gender, smoking status, size, vacuole sign, marginal spiculation, marginal lobulation, and pleural indentation) were identified by a study radiologist, selected by Mann-Whitney U test and χ² test, and used to develop a clinical model. A total of 396 radiomics features were extracted from venous CT scans. Mann-Whitney U test and univariate analysis of variance were used for radiomics feature dimension reduction. The least absolute shrinkage and selection operator (LASSO) algorithm was used for radiomics feature selection. Three models (a clinical model, a radiomics model, and a combined model) were developed to predict LNM in the early-stage NSCLC. The receiver operating characteristic (ROC) curve was used to evaluate the performance in LNM classification by use of the three models.

RESULTS

The area under the curve (AUC) value of radiomics model based on seven best features in predicting LNM was 0.898 (95% CI, 0.890-0.906) in the training group, compared with 0.851 in the test group. The AUC values of the clinical model (main based on size and spiculation) were 0.739 (95% CI, 0.725-0.753) and 0.614, respectively, in the training and test group. The AUC values of the radiomic-clinical model were 0.911 (95% CI, 0.904-0.918) and 0.860, respectively, in the two groups.

CONCLUSION

A radiomics-clinical model in venous CT was superior for predicting LNM in pre-surgical Stage IA patients with NSCLC than that models developed by radiomics and clinical features only.

CLINICAL RELEVANCE/APPLICATION

Approximately 20% of pre-surgical Stage IA patients with NSCLC may have LNM; a radiomics-clinical model has the potential to predict the LNM and may help to improve treatment plans.
After retrospective chart review, we trained a radiomic model to predict recurrence for 316 ES-NSCLC pts. using 124 radiomic
textural features from the Gabor, Laws, Laplace, Haralick, and Collage feature families extracted from a 0-3 mm annular ring
immediately adjacent to the nodule-Peritumoral(PT) features. The radiomics model had an AUC=0.74(p<0.01) in predicting
recurrence. Among 70 pts in this cohort, we had available tissue derived PD-L1 expression as well as H&E stained Whole slide
images (WSIs). In order to build the radiomic-histologic-molecular phenotype of the tumor habitat, we also extracted 242
Quantitative Histomorphometric (QH) features related to the nuclear shape, texture, orientation, spatial architecture of TILs and
features quantifying TI-cancer nuclei interaction. Unsupervised clustering of the top 20 most discriminative features from 0-3mm
outside the tumor was done, and correlations of the clusters were calculated for QH and PDL-1 expression.

RESULTS
We obtained two significant clusters corresponding to high-risk and low-risk patients based on their risk of recurrence. The two
clusters had significant disease-free survival(DFS) differences based on Kaplan-Meier analysis(p<0.05). The two clusters were also
correlated with nuclear morphology features(p<0.05) and spatial architecture of TIL patterns (p<0.05) as well as PD-L1
expression(p<0.001). We found that the high-risk cluster had increased PD-L1 expression and increased intensity of the QH
features

CONCLUSION
We built a radio-histo-molecular phenotype of the tumor habitat stratified according to the risk of recurrence in ES-NSCLC. We
found that radiomic tumor habitat features were strongly correlated with TIL-cancer nuclei interaction and PD-L1 expression.

CLINICAL RELEVANCE/APPLICATION
The prognostic usefulness of radiomics of the tumor habitat can be complemented by understanding the underlying morphology in
the tissue patterns which lead to the expression of these features, which we have shown in this work.

SSC03-09 CT-Based Analysis Using Radiomics for Predicting Pathological Response after Preoperative
Chemotherapy in Patients with Locally Advanced Esophageal Cancer

Participants
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Takashi Hiyama, MD, Kashiwa, Japan (Abstract Co-Author) Nothing to Disclose
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PURPOSE
To investigate the application of radiomics in a group of patients with locally advanced esophageal cancer (LAEC) and distinguish
those who will respond to preoperative chemotherapy from those who will not, using histopathologic results as the reference
standard.

METHOD AND MATERIALS
For this retrospective study, a radiomics model was developed based on a primary cohort of 133 patients with LAEC, who
underwent contrast-enhanced CT from October 2013 to November 2018, followed by preoperative chemotherapy. All patients
underwent surgery after chemotherapy and were divided into two groups based on the pathological evaluation of surgically
resected specimens; a poor response group (Grade 0/1) and a good response group (Grade 2/3). A total of 1409 quantitative
imaging features were extracted from the CT images using Radcloud platform. We used variance threshold, SelectKBest and LASSO
algorithm methods to gradually select the most optimal features and reduce their dimensionality. Six machine learning algorithms
(KNN, SVM, XGBoost, RF, LR, DT) were adopted to establish a radiomics nomogram. The predictive performances of the radiomics
signature were evaluated by ROC curve analysis in both cohorts: training (n=99 VOIs) and validation (n=41 VOIs).

RESULTS
Out of 1409 features, 6 optimal ones were selected using the LASSO method. The area under the ROC curve (AUC) of the XGBoost
model used for predicting the good response in a group was 0.893 (95% CI; 0.79 - 0.99) in the training cohort and 0.761 (95% CI; 0.65 - 0.87)
in the validation cohort.

CONCLUSION
A radiomics model derived from CT imaging could be potentially useful for predicting the effect of preoperative chemotherapy in
patients with LAEC.

CLINICAL RELEVANCE/APPLICATION
CT-based radiomics features could provide additional quantitative information on disease progression and may help to improve
clinical decision making for the preoperative management of LAEC patients.

Printed on: 10/29/20
PURPOSE
To evaluate the incidence of venous air embolism (VAE) incidence with or without implementation of preflushing before connecting a power injector to a patient's catheter, aiming to reducing the VAE in contrast-enhanced CT angiography (CTA)

METHOD AND MATERIALS
The control group underwent the conventional injection procedure. In the preflushing group, the injector tubes were flushed at high speed (10 ml/s) with saline before being connected to the patients' indwelling catheters. The locations, number and sizes of VAE were analyzed. The difference in the incidence of VAE between the 2 groups was compared.

RESULTS
A total of 4900 adults (control/preflushing, 2190/2710) were included. A total of 228 (4.65%) patients were found to have 318 VAEs (285 bubbles and 33 gas-liquid plane VAEs). The incidence of VAE in the preflushing group (3.21%) was lower than that in the control group (6.44%); a similar trend was observed for multiple VAEs (P<0.05). VAEs occurred in the following locations from high to low frequency: right atrium>pulmonary artery trunk>superior vena cava>right ventricle>left brachial vein>right brachial vein. There was no significant difference in the location, shape or diameters (P=0.19) of VAEs between the two groups.

CONCLUSION
The proposed preflushing procedure is simple yet effective in reducing the incidence of VAE by 50.16% in patients with CTA thus improving safety during power injection.

CLINICAL RELEVANCE/APPLICATION
The first reported effective measure of preflushing power injector tubing at a high flow rate with saline can significantly reduce the incidence of VAE.
**SSC04-04** Combination of Rapid Scanning with Wide-Detector and Adaptive Statistical Iterative Reconstruction-V Algorithm in Low Dose Chest CT for Unconscious Patients

**Monday, Dec. 2 11:00AM - 11:10AM Room: S102CD**

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**PURPOSE**
To explore the value of combining rapid scanning with wide-detector and new adaptive statistical iterative reconstruction (ASIR-V) in low dose chest CT for unconscious patients.

**METHOD AND MATERIALS**
Prospectively randomized 46 unconscious patients for chest CT into 2 spiral-scan groups: Group A (n=23) with 80mm collimation and 0.28s gantry rotation speed; Group B (n=23) with 40mm collimation and 0.5s speed to simulate conventional scan protocol. Both groups used the 120kV and AutomA technique (10-500mA) and 50% pre-ASIR-V to obtain a noise index of 14HU. The 0.625mm images were reconstructed with 50%ASIR-V and different kernels. Standard deviations of the antero-subcutaneous fat and back muscle of different scan modes and reconstructions were measured and compared with LSD-t test. The maximum diaphragmatic displacements were measured on sagittal images of the lung-kernel reconstruction and compared. Two radiologists performed 4-level subjective assessments of image quality and motion artifact. The Wilcoxon test and Kappa test was used for image goodness and score consistency, respectively.

**RESULTS**
The mean scan time in Group A was 1.17s, 70% faster than the conventional protocol (3.91s) resulting in better overall image quality and no measurable diaphragmatic displacement in Group A, compared with the 4.70±5.29mm in Group B (p<0.05). There was no difference in radiation dose (1.33 vs. 1.48mSv) and image noise between the two scan groups.

**CONCLUSION**
The combination of fast scanning with 80mm collimation, 0.28s rotation speed and ASIR-V significantly reduces motion artifacts and image noise in low-dose chest CT for unconscious or uncooperative patients.

**CLINICAL RELEVANCE/APPLICATION**
The use of 80mm wide-detector and fast rotation speed combined with ASIR-V can significantly reduce motion artifacts and maintain image quality at low radiation dose, and is more suitable for the chest CT examination for unconscious or uncooperative patients.

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**SSC04-05** Comparison of Baseline, Bone-Subtracted, and Edge-Enhanced Chest Radiographs for Detection of Pneumothorax

**Monday, Dec. 2 11:10AM - 11:20AM Room: S102CD**

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**PURPOSE**
To assess detectability of pneumothorax on unprocessed baseline (Up), bone-subtracted (B-), and edge-enhanced (E+) frontal chest radiographs (CXR).

**METHOD AND MATERIALS**
Our retrospective IRB approved study included 202 patients (mean age 53 ± 24 years; 132 men, 70 women) who underwent frontal CXR and had trace (<5mm), moderate (>=5mm, <3cm), large (>=3cm), or tension pneumothorax. All patients (except those with tension pneumothorax) had concurrent chest CT performed within 1-7 days of CXR for clinically indicated reasons. Two radiologists reviewed the CXR and chest CT for pneumothorax on Up CXR (ground truth). All Up CXR were processed to generate B- and E+ images (ClearRead X-ray, Riverain Inc). Two separate thoracic radiologists (R1, R2) sequentially assessed the Up, B- and E+ images and separately recorded the presence of pneumothorax (side, size and confidence for detection) for each image type. Area under the curve (AUC) was calculated with ROC analyses to determine the accuracy of pneumothorax detection.

**RESULTS**
There were 120 right, 95 left, and 13 bilateral pneumothoraces with 53 trace, 87 moderate, 29 large, and 46 tension pneumothoraces. B- images had the lowest accuracy for detection of pneumothorax compared to Up and E+ images (p<0.01). With B-, the sensitivity dropped from 91% to 84% on the right side and 83% to 77% on the left for R1 but remained relatively unchanged for R2 (87% vs 86%). Highest detection rates, and confidence was noted for the E+ images (empirc AUC for R1 and R2 0.95-0.99). No false positive pneumothorax was noted on either B- or E+ images.

CONCLUSION
Enhanced CXRs are superior to bone subtraction and unprocessed radiographs for detection of pneumothorax.

CLINICAL RELEVANCE/APPLICATION
Enhanced CXRs improve detection of pneumothorax over unprocessed images; bone subtracted images must be cautiously reviewed to avoid false negatives.

SSC04-06 FFR-CT in the Evaluation of Acute Chest Pain - Concepts and First Experiences

Monday, Dec. 2 11:20AM - 11:30AM Room: S102CD

Participants
Richard Bayer, Charleston, SC (Presenter) Institutional Research support, Bayer AG; Institutional Research support, HeartFlow, Inc; Institutional Research support, Siemens AG
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PURPOSE
Fractional flow reserve derived from coronary CTA (FFR-CT) is becoming rapidly established in the evaluation of patients with chronic stable angina in an elective setting. However, the utility of FFR-CT in the work-up of patients presenting to the Emergency Department (ED) with acute chest pain (ACP) is insufficiently studied. We evaluated the hospital course and treatment decisions along with the 30-day rate of major adverse cardiovascular events (MACE) in ACP patients undergoing cCTA and FFR-CT in the ED.

METHOD AND MATERIALS
Patients between the ages of 18-95 years who presented to our ED with ACP and underwent clinically indicated cCTA and FFR-CT were included, if their cCTA interpretation showed coronary artery stenosis between 30-90% luminal narrowing. cCTA was acquired using 3rd generation dual-source CT and FFR-CT was performed using the commercially available computational fluid dynamics approach (HeartFlow®, Redwood City, CA). Subjects were evaluated for patient management decisions, 30 day MACE, repeat presentation to the ED, and 30 day additional testing for evaluation of chest pain. They were subsequently compared to a control group of patients who also presented to the ED with ACP, but underwent alternative evaluation strategies.

RESULTS
The average turnaround time for completing FFR-CT analyses was 3h 22min. 16/31 patients (52%) with stenosis grade of 30-90% by cCTA had negative FFR-CT (>0.80), of whom 9 (56%) were discharged from the ED and 2 of whom underwent invasive coronary angiography (ICA) during the index ED visit, with 1 being revascularized. In comparison, 10/15 patients with FFR-CT <0.80 underwent ICA. Out of the 16 patients without functionally significant coronary artery disease (CAD) by FFR-CT, 15 (93%) did not undergo revascularization and did not experience MACE during the 30-day follow-up. One patient was referred for ICA in the setting of severe stenosis on cCTA, albeit with negative FFR-CT, where ICA showed severe multivessel disease prompting subsequent revascularization. Conversely, 3 patients with FFR-CT <0.80 experienced MACE during follow-up. Within 30-days 2 patients with FFR-CT <0.80 were readmitted, versus none in the FFR-CT>0.80 group. Overall, a negative FFR-CT analysis translates into a high negative predictive value to exclude 30-day MACE occurrence of 94% in this preliminary cohort.

CONCLUSION
These preliminary data suggest that FFR-CT could be utilized for a more rational risk stratification and disposition of patients who present to the ED with ACP than with cCTA alone, helping to differentiate those who would benefit from admission and further invasive management versus those who could be safely discharged. While prior studies have demonstrated utility in the stable chronic stable angina in an elective setting. However, the utility of FFR-CT in the work-up of patients presenting to the Emergency Department (ED) with acute chest pain (ACP) is insufficiently studied. We evaluated the hospital course and treatment decisions along with the 30-day rate of major adverse cardiovascular events (MACE) in ACP patients undergoing cCTA and FFR-CT in the ED.

METHOD AND MATERIALS
Patients between the ages of 18-95 years who presented to our ED with ACP and underwent clinically indicated cCTA and FFR-CT were included, if their cCTA interpretation showed coronary artery stenosis between 30-90% luminal narrowing. cCTA was acquired using 3rd generation dual-source CT and FFR-CT was performed using the commercially available computational fluid dynamics approach (HeartFlow®, Redwood City, CA). Subjects were evaluated for patient management decisions, 30 day MACE, repeat presentation to the ED, and 30 day additional testing for evaluation of chest pain. They were subsequently compared to a control group of patients who also presented to the ED with ACP, but underwent alternative evaluation strategies.

RESULTS
The average turnaround time for completing FFR-CT analyses was 3h 22min. 16/31 patients (52%) with stenosis grade of 30-90% by cCTA had negative FFR-CT (>0.80), of whom 9 (56%) were discharged from the ED and 2 of whom underwent invasive coronary angiography (ICA) during the index ED visit, with 1 being revascularized. In comparison, 10/15 patients with FFR-CT <0.80 underwent ICA. Out of the 16 patients without functionally significant coronary artery disease (CAD) by FFR-CT, 15 (93%) did not undergo revascularization and did not experience MACE during the 30-day follow-up. One patient was referred for ICA in the setting of severe stenosis on cCTA, albeit with negative FFR-CT, where ICA showed severe multivessel disease prompting subsequent revascularization. Conversely, 3 patients with FFR-CT <0.80 experienced MACE during follow-up. Within 30-days 2 patients with FFR-CT <0.80 were readmitted, versus none in the FFR-CT>0.80 group. Overall, a negative FFR-CT analysis translates into a high negative predictive value to exclude 30-day MACE occurrence of 94% in this preliminary cohort.

CONCLUSION
These preliminary data suggest that FFR-CT could be utilized for a more rational risk stratification and disposition of patients who present to the ED with ACP than with cCTA alone, helping to differentiate those who would benefit from admission and further invasive management versus those who could be safely discharged. While prior studies have demonstrated utility in the stable chest pain population, to our knowledge this represents the first reported experience in the ACP, ED setting.

CLINICAL RELEVANCE/APPLICATION
cCTA with subsequent FFR-CT demonstrate potential for accurate and safe evaluation of CAD in patients presenting to the ED with ACP.

SSC04-07 Comparison of ASPECTS by Human Observers and Automated ASPECTS in Prediction of Final Infarct Volume in Anterior Circulation Emergent Large Vessel Occlusion

Monday, Dec. 2 11:30AM - 11:40AM Room: S102CD

Participants
John P. Walsh, MBCHB, Vancouver, BC (Abstract Co-Author) Nothing to Disclose
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We propose that this model can be useful for screening and triaging emergency patients with various intracranial diseases by detecting anomalies on CT. We suggest that unsupervised learning of GANs using healthy dataset can be used to detect various intracranial diseases on brain CT scans.

RESULTS

Substantial correlation with final ASPECTS was found for human NCCT ASPECTS ($r=0.713$, $p<0.001$) and human CTA ASPECTS ($r=0.718$, $p<0.001$) readings. The correlation was good for automated ASPECTS ($r=0.543$, $p<0.001$). Good interobserver agreement was seen for NCCT ASPECTS (kappa = 0.628) and CTA ASPECTS (kappa = 0.611).

CONCLUSION

Compared to automated ASPECTS, the ASPECTS by human observers correlates better with final infarct volume in anterior circulation emergent large vessel occlusion. NCCT ASPECTS and CTA ASPECTS show good agreement among the human observers.

CLINICAL RELEVANCE/APPLICATION

ASPECTS is a valuable prognostic marker and important tool to make clinical decisions in acute ischemic stroke. Ongoing validation of machine learning based research applications is important.

SSC04-08  Unsupervised Detection of Various Intracranial Diseases on Brain CT Using Generative Adversarial Networks (GANs)

METHOD AND MATERIALS

CT studies at presentation of consecutive patients ($n=98$) presenting with emergent large vessel occlusion in the anterior circulation (terminal ICA, M1, proximal M2) were reviewed. ASPECTS readings were made by two radiologists on non-contrast CT and CT angiography studies independently in a blinded fashion. The observers were blinded from each other, other imaging studies and clinical and patient data. Automated ASPECTS readings were recorded from a research based software package. The observers later made consensus ASPECTS readings on follow-up CT or MRI performed within 7 days of presentation. Spearman’s rank correlation was performed. Kappa statistic was calculated to test inter-observer agreement among the human readers.

RESULTS

Total per-slice sensitivity was 89.0% (89/100) and total per-lesional sensitivity was 87.2% (102/117). For each disease group, sensitivity was 91.3% (21/23) for hemorrhage, 85.2% (23/27) for acute infarction, 96.8% (30/31) for tumor and 78.9% (15/19) for other diseases. Evaluation for other performance characteristics was limited due to difficult quantification and calculation of non-pathologic false positive detections.

CONCLUSION

We suggest that unsupervised learning of GANs using healthy dataset can be used to detect various intracranial diseases on unseen data and has high sensitivity to detect anomalies.

CLINICAL RELEVANCE/APPLICATION

We propose that this model can be useful for screening and triaging emergency patients with various intracranial diseases by detecting anomalies on CT.
PURPOSE
To evaluate the diagnostic accuracy of a dual-energy computed tomography (CT) virtual non-calcium (VNCa) technique for the depiction of traumatic bone marrow edema of the calcaneus.

METHOD AND MATERIALS
Data from 62 patients with acute tarsal trauma who had undergone third-generation dual-source dual-energy CT and 3-T magnetic resonance imaging (MRI) within seven days between January 2017 and July 2018 were retrospectively analyzed. Five radiologists, blinded to clinical and MRI information, independently assessed conventional grayscale dual-energy CT series for the presence of fractures; after at least eight weeks, readers re-evaluated all cases using color-coded VNCa reconstructions for the presence of bone marrow edema for four calcaneal regions. Quantitative analysis of CT numbers on VNCa reconstructions was performed by a sixth radiologist. Two additional experienced radiologists (32 and 20 years of experience in musculoskeletal imaging), blinded to clinical and CT information, assessed MRI series in consensus to define the reference standard. Sensitivity, specificity and the area under the curve (AUC) were the primary indices for diagnostic accuracy.

RESULTS
MRI revealed a total of 62 areas with focal posttraumatic bone marrow edema in 39 patients. Fractures were present in 11 patients. In the qualitative analysis, VNCa showed high overall sensitivity (286/310 [92%]), specificity (899/930 [97%]), positive predictive value (286/317 [90%]), negative predictive value (899/923 [97%]) and accuracy (1185/1240 [96%]) for the depiction of bone marrow edema. Inter-reader agreement was excellent (κ=0.84). CT numbers obtained from VNCa were significantly different in areas with or without edema (p<.001). The overall AUC was 0.98. A cut-off value of -53 Hounsfield units (HU) provided a sensitivity of 82% (51/62) and specificity of 95% (176/186) for differentiating bone marrow edema.

CONCLUSION
In both quantitative and qualitative analyses, dual-energy CT VNCa reconstructions show excellent diagnostic accuracy for the depiction of traumatic calcaneal bone marrow edema compared to MRI by enabling direct color-coded visualization.

CLINICAL RELEVANCE/APPLICATION
Bone marrow edema may be visualized using color-coded VNCa reconstructions during dual-energy CT performed for detection of fracture in patients with acute tarsal trauma, potentially replacing MRI in patients with contraindications.
SSC12-01  
Coronary Calcium Scoring Using Tin Filtration to Dramatically Reduce Radiation Dose

**Participants**
- Kai Yang, PhD, Boston, MA (Moderator) Nothing to Disclose
- Sarah E. McKenney, PhD, Stanford, CA (Moderator) Nothing to Disclose
- Baojun Li, PhD, Iowa City, IA (Moderator) Research Grant, General Electric Company

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**PURPOSE**
The purpose of this work is to evaluate the ability of tin (Sn) filtration to dramatically reduce radiation dose for CT calcium (Ca) scoring to dose levels comparable to a few chest x-rays.

**METHOD AND MATERIALS**
Chest phantoms emulating small/medium/large patients were scanned on a dual-source CT (Definition Force, VB10, Siemens). A piece of pork was placed at the center of the phantoms, which contained three cylindrical hydroxyapatite (HA) inserts (diameter/length = 5 mm, HA concentration = 200/400/800 mg/mL) emulating coronary calcifications. Phantoms were scanned at 100 kV and 600 mAs/rot using a Sn filter to remove low-energy photons that increase patient radiation dose but do not substantially contribute to image quality. The same phantoms were then scanned using a standard Ca scoring protocol at 120 kV, with mAs determined by a clinical technique chart designed for different patient sizes. Images were reconstructed using a specially designed reconstruction kernel (Sa36 kernel), which accounts for the different attenuation of Ca materials due to different x-ray spectra of Sn100 and 120 kV, and generates 120 kV-like images. The CT numbers of pork and a 200 mg/mL HA insert were measured, the Ca scores were calculated using commercial software, and the results compared between 120 kV and Sn100 kV scans.

**RESULTS**
Radiation dose was reduced from 2.3/6.8/14.3 at 120kV to 1.5/1.5/1.5 mGy at Sn100 kV for the small/medium/large phantoms, yielding a 34%/78%/90% dose reduction. CT numbers of soft tissue and HA measured from Sn100 kV images were consistent with those of 120 kV images (max differences < 7/15 HU for tissue/Ca, respectively). Ca scores of HA inserts measured from Sn100 kV images were consistent with those of 120 kV images for the small/medium phantoms (max difference < 16). Larger differences (40-140) were observed for the large phantom.

**CONCLUSION**
Ca scoring using a Sn filtered x-ray beam was found to achieve 34-78% dose reduction compared to the standard 120 kV technique while yielding consistent Ca scores for small/medium patients. However, it may not be suitable for large patients due to considerable score elevation.

**CLINICAL RELEVANCE/APPLICATION**
The evaluated technique can reduce patient dose from coronary calcium screening to levels comparable to a few chest x-rays.

SSC12-02  
Impact of Imaging Conditions on Localizer-Based Water Equivalent Diameter Estimation and on Dose Modulation

**Participants**
- Shengzhen Tao, Rochester, MN (Presenter) Nothing to Disclose
- Emily Sheedy, Rochester, MN (Abstract Co-Author) Nothing to Disclose
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- Bernhard Schmidt, PhD, Forchheim, Germany (Abstract Co-Author) Employee, Siemens AG
- Eric E. Williamson, MD, 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) Nothing to Disclose

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**PURPOSE**
The purpose of this work is to evaluate the impact of imaging conditions on localizer-based water equivalent diameter estimation and on dose modulation.
Individual reader's scores showed stable high values with average of 4.8 up to a CTDIvol of 0.9 mGy. For the lower doses, primarily on 10 patients, an optimized protocol was defined and employed with means of an automatic segmentation tool and multiple ROI evaluations. Both noise and tube current profiles were compared varying the acquisition parameters with a relative CTDIvol range of 0.3 – 1.5 mGy. For each slice, a noise analysis was performed along z axis in each acquisition. Some phantom details were identified as potential simulation of pathologic bone and assumed as reference for a subjective evaluation by three radiologists (5-point Likert scale). An optimized protocol was defined and employed primarily on 10 patients.

RESULTS
Calibration slope and intercept depends on localizer kV on all CTs. E.g., on a Canon A-One CT, slope changed from 1.47 to 1.64 for localizers from 80 to 135 kV. Using calibration of 120kV localizers, we simulated errors in WED estimation caused by using unmatched calibrations: WED from 80kV– 135kV-localizers deviated from the truth by 1-5% for the CTDI phantom and 1-7% for the ACR phantom. Localizer mA and directions have small impacts on calibrations and WED results. Calibration also depends on localizer kernels for Canon CTs. For the A-One, WED calibration slopes under Sharp- and STD-kernels were identical (diff. < 0.01%) but differed from the Soft-kernel slope by 55%. Using the Sharp-kernel calibration, WED from Soft-kernel localizers deviated from the truth by 35% for the CTDI phantom and 42% for the ACR phantom. Localizer kV affected dose modulation performance. On a GE CT750HD, comparing to the CTDIv (11.65 mGy) of a baseline condition (120kV-localizer), CTDIv from the same helical scans after 80kV-, 100kV-, 140kV-localizers were 12.43 (+7%), 11.98 (+3%), and 11.41 mGy (-2%). Localizer mA did not affect dose modulation.

CONCLUSION
Localizer kV and image kernels have stronger impacts on WED calibration and dose modulation than other factors.

CLINICAL RELEVANCE/APPLICATION
Using the same kV and image kernel for localizers may improve consistency of dose modulation and WED estimation.

SSC12-03 Protocol Optimization of Whole-Body Low-Dose CT in Patients with Multiple Myeloma: How Low is Too Low?

PURPOSE
Water equivalent diameter (WED) is a sound patient-size descriptor, and CTs use localizers to determine WED and to guide dose modulation. Localizer-based WED estimation requires a calibration to relate localizer pixel values to attenuation. We investigated how imaging conditions affect the WED calibration and dose modulation performance.

METHOD AND MATERIALS
We acquired localizer and axial images of ACR and body CTDI phantoms on 11 CT models from GE, Siemens, Philips, and Canon. We estimated calibration parameters (slope and intercept) by associating axial images with the corresponding localizer lines using custom built software. Experiments were conducted under combinations of kV, mA, orientation, and imaging kernel of localizer radiographs, and axial kV. In separate experiments, the ACR phantom and body CTDI phantom (iso-centered) were imaged together on table top. We repeatedly acquired 120kV-helical scans with dose modulation, after taking localizers at varied kV and mA levels, to examine their impact on dose modulation.

RESULTS
Using the same kV and image kernel for localizers may improve consistency of dose modulation and WED estimation.
Individual reader’s scores showed stable high values with average of 4.8 up to a CTDIvol of 0.9 mGy. For the lower doses, significant lower average scores were observed (4.2 for CTDIvol of 0.5 mGy and 3.2 for CTDIvol of 0.3 mGy, p<0.01). The minimum CTDIvol without loss of diagnostic information was achieved with different combinations of exposure parameters, and among these, a maximum image quality rank was obtained with a scan performed with 140 kV and a percentage of ASIR-V of 80 %. The overall corresponding medians of automatic noise measurements for the phantom were 49 HU (range 22 - 67) with a sharp convolution kernel and 13 HU (range 7 - 21) with a standard kernel. Using the optimized protocol, the median effective dose for ten patients was estimated 0.7 mSv.

CONCLUSION
Routine submillisievert WBLDCT can be performed on latest generation CT scanner with a proper balance between tube current modulation parameters and iterative reconstruction strength.

CLINICAL RELEVANCE/APPLICATION
Assessing the lowest achievable dose for WBLDCT with phantom studies and image quality metrics can be useful to optimize this imaging modality in accordance with the ALARA principle.

SSC12-06 The Presence of Contrast Agent Increases Absorbed Organ Radiation Dose in Contrast-Enhanced CT

Participants
Mahta Mazloumi, MA, Brussels, Belgium (Abstract Co-Author) Nothing to Disclose
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PURPOSE
Although intravenous iodinated contrast agents are being used in 50 to 60 % of all computed tomography (CT) scans, their presence is not considered in patient dosimetry calculations. The aim of this study is to investigate the impact of contrast agent on absorbed radiation dose in the venous phase of abdominal CT scans.

METHOD AND MATERIALS
10 female and 10 male abdominal contrast-enhanced dual energy computed tomography (DECT) scans were retrospectively selected from our patient database. Organ and tissue doses were calculated by an ad-hoc Monte Carlo (MC) simulation model (ImpactMC) that was experimentally validated (accuracy<5.5%) for the scanner geometry (GE Revolution CT) and acquisition parameters including tube current, tube voltage, beam shape filter, and collimation were modeled. MC simulations were performed in the presence and in the absence of contrast agent using the contrast-enhanced and virtual-unenhanced dataset of DECT as patient models. The simulated dose volumes were segmented (3D slicer) to obtain the dose in the liver, liver parenchyma, left kidney, right kidney, aorta, and spleen. We calculated the relative dose increase due to contrast as (DI-D0)/D0 where DI is the dose in the presence of contrast agent and D0 is the dose in the absence of contrast agent. The iodine concentrations in the simulations were estimated using iodine content calculated by DECT.

RESULTS
The average iodine concentrations among 20 patients are 7.16 ± 1.51 mg I/ml for left kidney, 6.98 ± 1.58 mg I/ml for right kidney, 5.62 ±0.04 mg I/ml for aorta, 3.76 ± 1.03 mg I/ml for spleen, 3.22 ± 0.97 mg I/ml for liver, and 2.95 ± 0.87 mg I/ml for liver parenchyma. Compared to a non-contrast scan, the relative doses increase in the liver (21 ± 5 %), liver parenchyma (20± 5 %), aorta (34 ± 6 %), right kidney (37 ± 7 %), left kidney (39 ± 7 %) and spleen (26 ± 3 %).

CONCLUSION
In abdominal CT, organ radiation doses increase due to the presence of contrast agents. On average, doses increase by 29 %. The highest increase is observed in kidneys, then in aorta, spleen, liver, and lowest in liver parenchyma.

CLINICAL RELEVANCE/APPLICATION
The presence of contrast agents should be considered in patient dosimetry calculations.

SSC12-07 Paradoxical Increase in Eye Lens Dose When Using Automatic Exposure Control During Non-Contrast Head CT and Mitigation by Organ-Based Tube-Current Modulation

Participants
Sean Wo, MD, Seattle, WA (Presenter) Nothing to Disclose
Thomas M. Anderson, MD, PhD, Seattle, WA (Abstract Co-Author) Nothing to Disclose
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Kalpana M. Kanal, PhD, Seattle, WA (Abstract Co-Author) Nothing to Disclose

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PURPOSE
In CT scanning, tube current modulation techniques aim to maintain image quality over a variable anatomy. We examined eye lens...
dose and image noise when activating a combination of automatic exposure control (AEC, current modulated based on anatomic attenuation measured on localizer) and organ-based tube-current modulation (OBTCM, current decreased over anterior portion of tube arc).

**METHOD AND MATERIALS**

We performed CT scans of an adult anthropomorphic head phantom on 2 scanners (SOMATOM Force and SOMATOM Definition AS+, Siemens Healthcare) using 4 acquisition modes: 1) fixed mAs; 2) AEC (CARE Dose 4D) only; 3) OBTCM (X-CARE) only; 4) and both AEC and OBTCM active. For both scanners, we used 2 protocols: ‘trauma’ with 310 and ‘follow-up’ with 250 effective mAs or quality reference mAs, as applicable. We maintained a constant kV of 120. For each of 6 replicates at each acquisition mode, we placed an optically stimulated luminescence (OSL) dosimeter in each orbit to measure absorbed dose. We averaged OSL doses at each mode to obtain generalized lens dose and characterized image noise (σ) from 4 ROIs placed at the level of the sella on subtraction images derived from consecutive scans with the least interscan motion. We used Student’s t-test and distribution to test for significance and to calculate confidence intervals.

**RESULTS**

For the Force trauma, Force follow-up, AS+ trauma, and AS+ follow-up protocols, respectively, fixed current technique produced average lens doses of 35.8, 28.0, 32.1 and 25.5 mGy. As compared to the benchmark fixed technique, AEC alone paradoxically increased eye lens dose (+11%, +21%, +22%, +21%), while OBTCM decreased lens dose (-33%, -33%, -29%, -35%), and combining both techniques decreased lens dose (-21%, -21%, -21%, -20%). Every acquisition mode produced a significant change from the benchmark (p<0.05). Noise measurements revealed a roughly inverse linear relationship between o and vdose (R² = 0.88 and 0.72 for Force and AS+, respectively).

**CONCLUSION**

Compared to the standard fixed technique, activating AEC on non-contrast head CT paradoxically causes a significant increase in eye lens dose. Conversely, OBTCM with or without AEC significantly decreases lens dose.

**CLINICAL RELEVANCE/APPLICATION**

In designing non-contrast CT head protocols, use of AEC requires careful consideration because it may increase eye lens dose despite reducing overall dose. Adding OBTCM to AEC can mitigate this effect.

**SSC12-08 kV Independent Coronary Calcium Scoring: A Phantom Evaluation of Score Accuracy and Potential Radiation Dose Reductions**

Monday, Dec. 2 11:40AM - 11:50AM Room: S504AB

**Participants**

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**PURPOSE**

Because of the use of a fixed CT number threshold in the Agatston calcium (Ca) scoring method, and the dependence of CT numbers on photon energy, coronary Ca CT exams are required to be performed at a fixed tube potential (120kV). Here, we determine the accuracy of a kV-independent Ca scoring technique and its potential to reduce radiation dose by using tube potentials below 120kV.

**METHOD AND MATERIALS**

Three hydroxyapatite (HA) cylinders (5 mm diameter and length; 200, 400, 800 mg HA/mL) were inserted into a piece of pork and placed within anthropomorphic chest phantoms representing small, medium, and large adults. Phantoms were first scanned at 8 tube potentials (70-140kV) to compare CT numbers and Ca scores. Next, phantom scans were performed with automatic exposure control (AEC) and automatic kV selection (CareDose4D QR=180/150/120/90mAs, CareKV setting = 4) to evaluate potential dose reduction. A dedicated reconstruction kernel (Sa36) was used to create 3-mm-thick 120kV-like images every 1.5 mm, from data acquired at other kVs, by appropriately scaling CT numbers above a soft tissue threshold. Phantoms were also scanned at 120kV using our clinical size-dependent mA chart. CT numbers were measured from images at different kVs, and Agatston scores calculated using commercial software.

**RESULTS**

Absolute CT number differences at different kVs (relative to 120kV) were small (tissue <4 HU; HA/Ca <5 HU for kV > 80 and < 18 HU for kV <= 80). The differences in Ca scores for kV >= 90 (relative to 120kV) were < 13.8 (8%) for 200/400 mg HA/mL, and < 22 (7%) for 800 mg HA/mL cylinders. The use of AEC and lower tube potentials reduced CTDIvol from 4.1/10.0/20.8 mGy (120kV, small/medium/large phantoms) to 2.1/4.4/5.6 mGy (for QR=90mAs), yielding 48/56/73% reduction in CTDIvol and Ca score difference (for 400 mg HA/mL insert) < 13 (8%) in relative to 120 kV.

**CONCLUSION**

kV independent Ca scoring methods, coupled with AEC and lower tube potentials, provide a 48-73% reduction in CTDIvol and Ca scores that are consistent with those at 120 kV.

**CLINICAL RELEVANCE/APPLICATION**

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**PURPOSE**

Because of the use of a fixed CT number threshold in the Agatston calcium (Ca) scoring method, and the dependence of CT numbers on photon energy, coronary Ca CT exams are required to be performed at a fixed tube potential (120kV). Here, we determine the accuracy of a kV-independent Ca scoring technique and its potential to reduce radiation dose by using tube potentials below 120kV.

**METHOD AND MATERIALS**

Three hydroxyapatite (HA) cylinders (5 mm diameter and length; 200, 400, 800 mg HA/mL) were inserted into a piece of pork and placed within anthropomorphic chest phantoms representing small, medium, and large adults. Phantoms were first scanned at 8 tube potentials (70-140kV) to compare CT numbers and Ca scores. Next, phantom scans were performed with automatic exposure control (AEC) and automatic kV selection (CareDose4D QR=180/150/120/90mAs, CareKV setting = 4) to evaluate potential dose reduction. A dedicated reconstruction kernel (Sa36) was used to create 3-mm-thick 120kV-like images every 1.5 mm, from data acquired at other kVs, by appropriately scaling CT numbers above a soft tissue threshold. Phantoms were also scanned at 120kV using our clinical size-dependent mA chart. CT numbers were measured from images at different kVs, and Agatston scores calculated using commercial software.

**RESULTS**

Absolute CT number differences at different kVs (relative to 120kV) were small (tissue <4 HU; HA/Ca <5 HU for kV > 80 and < 18 HU for kV <= 80). The differences in Ca scores for kV >= 90 (relative to 120kV) were < 13.8 (8%) for 200/400 mg HA/mL, and < 22 (7%) for 800 mg HA/mL cylinders. The use of AEC and lower tube potentials reduced CTDIvol from 4.1/10.0/20.8 mGy (120kV, small/medium/large phantoms) to 2.1/4.4/5.6 mGy (for QR=90mAs), yielding 48/56/73% reduction in CTDIvol and Ca score difference (for 400 mg HA/mL insert) < 13 (8%) in relative to 120 kV.

**CONCLUSION**

kV independent Ca scoring methods, coupled with AEC and lower tube potentials, provide a 48-73% reduction in CTDIvol and Ca scores that are consistent with those at 120 kV.
The reported technique benefits patients undergoing coronary Ca scoring CT by considerably reducing radiation dose while maintaining accurate Ca scores.

**SSC12-09** Exploring the Limits of Size-Specific Dose Estimates (SSDE) as an Estimate of Organ Dose from Routine Chest and Abdomen/Pelvis CT Examinations

Monday, Dec. 2 11:50AM - 12:00PM Room: S504AB

Participants
Anthony Hardy, MS, Los Angeles, CA (*Presenter*) Nothing to Disclose
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**
Size-Specific Dose Estimate (SSDE) adjusts scanner-reported CTDIvol to account for patient size and should be widely available on future scanners. While not intended to represent organ doses, the purpose of this work was to explore the ability of SSDE to provide a reasonable estimate of organ doses in routine chest and abdomen/pelvis exams across a wide range of patient sizes.

**METHOD AND MATERIALS**
Raw projection data and patient protocol pages for 133 routine chest (71 women, 62 men) and 82 routine abdomen/pelvis (40 women, 42 women) CT exams performed with tube current modulation (TCM) were gathered from two Siemens MDCT scanners (Sensation 64 and Definition AS64, Siemens Healthineers, Forchheim, Germany). Image data were reconstructed and were semi-automatically segmented to identify lung and glandular breast tissues in chest exams and liver, spleen, and kidneys in abdomen/pelvis exams. Segmented image data were used to create voxelized models of chest and abdomen/pelvis anatomy. TCM data was extracted from the raw projection data to describe the tube current values as a function of gantry angle and table location. Voxelized patient models and TCM data were incorporated into a validated Monte Carlo (MC) simulation engine to estimate absolute lung, breast, liver, spleen, and kidney dose using MDCT source models. Normalized lung (nDlung), breast (nDbreast), liver (nDliver), spleen (nDspleen), and kidney (nDkidney) doses were obtained by dividing respective absolute doses by the CTDIvol values from the patient protocol pages. SSDE values were acquired using AAPM Report 204 and the water equivalent diameter (Dw) from the image data. Normalized doses were then compared to SSDE f-factors.

**RESULTS**
The relative bias of nDlung, nDbreast, nDliver, nDspleen, and nDkidney to the SSDE f-factors was observed to be 17.4%, 35.4%, 16.2%, 17.9%, and 17.1%, respectively. SSDE overestimates organ dose in small and large patients.

**CONCLUSION**
SSDE may serve as a reasonable estimate lung, liver, spleen, and kidney dose across patient size within 20%, but may overestimate dose in small and large patients. For breast, SSDE may serve as a reasonable estimate within 36%.

**CLINICAL RELEVANCE/APPLICATION**
SSDE may provide reasonable estimates of organ dose for routine chest and abdomen/pelvis CT exams for most organs; however, estimates of breast dose may require wider tolerances.

Printed on: 10/29/20
3D22

3D + AV Theater: Overcoming Funding Challenges to Scale 3DP at the Point-of-Care. Lessons from an Innovation Lab: Presented by Formlabs

Monday, Dec. 2 11:30AM - 11:50AM Room: 3D Printing and Advanced Visualization Theater, North Building, Level 3, Booth 6563

Participants
Gaurav Manchanda, Somerville, MA (Presenter) Nothing to Disclose
Sarah A. Flora, ARRT, Danville, PA (Presenter) Nothing to Disclose

Program Information
Join us to hear trends, observations, and perspectives from Formlabs, the market-leader for professional-grade 3D printers, as well as best practices, common challenges, and lessons learned from Geisinger Health System. Formlabs has deployed over 50,000 SLA printers to date and has a presence in over 80% of the medical schools, medical device companies, and Level I/II trauma centers that have adopted 3D printing. 3D Printing at the Point-of-Care is not new, however, justifying a hospital 3D print program and achieving sustainability without ongoing philanthropy is rare. In this presentation, Sarah Flora, Program Director of the 3D Print Lab at Geisinger Health System, will discuss the route she took to build the business case for fully funding her program as well as discuss use cases and tools she has learned along the way. Geisinger is a 14+ hospital health system spread throughout Pennsylvania and New Jersey that includes two simulation centers, a medical school, and its own health insurance plan. Geisinger uses 3d printed medical models to aid in presurgical planning, patient and learner education, surgical simulation, and surgical aid tools. In the last 4 years, Geisinger's 3D Print lab has provided over 600+ medical models for these purposes at no cost to the patient or physician.

Printed on: 10/29/20
Cardiac CT Mentored Case Review: Part III (In Conjunction with the North American Society for Cardiovascular Imaging) (Interactive Session)

Monday, Dec. 2 1:30PM - 3:00PM Room: S406A

CA CT

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

Participants
Karen G. Ordovas, MD, Seattle, WA (Moderator) Advisor, Arterys Inc;

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
Carole J. Dennie, MD, Ottawa, ON (Presenter) Nothing to Disclose

For information about this presentation, contact:
cdennie@toh.ca

**MSMC23B  Coronary Atherosclerosis III**

Participants
U. Joseph Schoepf, MD, Charleston, SC (Presenter) Research Grant, Astellas Group; Research Grant, Bayer AG; Research Grant, Bracco Group; Research Grant, Siemens AG; Research Grant, Heartflow, Inc; Research support, Bayer AG; Consultant, Elucid BioImaging Inc; Research Grant, Guerbet SA; Consultant, HeartFlow, Inc; Consultant, Bayer AG; Consultant, Siemens AG; ;

For information about this presentation, contact:
Schoepf@musc.edu

Printed on: 10/29/20
Basic Physics Lecture for the RT: Radiation Safety Refresher Course

Monday, Dec. 2 1:30PM - 2:45PM Room: S402AB

Participants
Scott J. Emerson, MS, Royal Oak, MI (Moderator) Nothing to Disclose
Rebecca M. Marsh, PHD, Aurora, CO (Presenter) Nothing to Disclose

For information about this presentation, contact:
Rebecca.Marsh@ucdenver.edu

LEARNING OBJECTIVES

1) Understand and describe the risks and benefits associated with patient shielding.
2) Critically evaluate common radiation safety practices.
3) Apply current data about radiation risk from diagnostic imaging exams to clinical practice.

Printed on: 10/29/20
LEARNING OBJECTIVES

1) Explain the role of model-based dose calculation algorithms and their affects for several anatomic site. 2) provide an in-depth understanding on the application of brachytherapy for prostate, gynecological, breast, and skin diseases. 3) Clarify emerging technologies such as electronic brachytherapy, clinical modalities, and intensity-modulated brachytherapy.

ABSTRACT

The Symposium will cover the highlights from the 2017 AAPM Summer School on Clinical Brachytherapy Physics. Presentations by the School Program Directors will include the experiences from experts on eight key aspects of clinical brachytherapy physics: model-based dose calculations, prostate brachytherapy, gynecological brachytherapy, skin brachytherapy, breast brachytherapy, electronic brachytherapy, intensity modulated and anisotropic brachytherapy sources, and early clinical advancements in 3D printing, tracking technologies, and robotic brachytherapy.

SPPH22A Overview of Commercial Algorithms: Needs and Availability

Participants
Luc Beaulieu, PhD, Quebec, QC (Presenter) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Understand the need for advanced dose calculation algorithms in brachytherapy. 2) Provide an overview of the basis of the underlying algorithms used in brachytherapy commercial treatment planning systems. 3) Know the key strength and limitations of each algorithm.

ABSTRACT

Brachytherapy is a very efficient cancer treatment modality, essentially due to a best in class dose deposition kernel dominated by 1/r^2 spearing tissue at a distance from the source. Furthermore, the energy deposition from the ionizing photons emitted by brachytherapy sources can be calculated, in theory, with very high accuracy. Until recently, the field of brachytherapy relied on a factor-based approach, TG-43, to deal for dose calculation. While TG43 is extremely fast for dose computation and optimization, its accuracy is limited to specific conditions, often not met in clinical situations. This presentation will provide an overview of these different situations and provide ballpark estimates of the expected differences. We will further look at alternatives to solve this issue and briefly described the approaches chosen by the major vendors in providing the next generation of dose calculation engines in their treatment planning system offering. We will finally describe how these new algorithms performed under various scenarios, highlighting both their strength and weakness.

SPPH22B Emphasis on MBDC A Commissioning Infrastructure and Process

Participants
Luc Beaulieu, PhD, Quebec, QC (Presenter) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Review the commissioning requirements set forth in TG186. 2) Provide an overview of the existing infrastructure and resources available to the clinical medical physicists. 3) Understand the various steps necessary in the commissioning of model-based dose calculation algorithms.

ABSTRACT

With the publication in 2012 of the AAPM/ESTRO/ABG TG-186 report, early adopters were provided with a set of guidelines to help in the integration of advanced dose calculation algorithms in brachytherapy, beyond TG43, and ensuring safe and efficient use of the new features that are enabled by these new algorithms. However, the commissioning aspects were minimal in that report. In the following, the work from a subsequent working group, established to tackle this issue, will be presented. It is intended to provide the clinical users (the clinical medical physicists) with a set of comprehensive commissioning guidelines as well as to provide the necessary information for resources that are available to the community in making the transition from TG43 to TG186.

SPPH22C Prostate Brachytherapy: Real-time Intra-operative

Participants
Luc Beaulieu, PhD, Quebec, QC (Presenter) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;
LEARNING OBJECTIVES
1) Underline the system components of a real-time prostate brachytherapy program. 2) Understand the possible workflows of real-time ultrasounds based prostate brachytherapy. 3) Understand the difference between real-time LDR and HDR prostate brachytherapy workflows.

ABSTRACT
Prostate brachytherapy is a highly effective treatment option for localized prostate cancer. For low-risk prostate cancer patients, LDR seed implants has proven its long-term efficacy. For intermediate risk and high risk localized prostate cancer, both LDR and HDR brachytherapy boost combined to EBRT (either 3D-CRT or IMRT/VMAT) are providing compelling clinical outcomes. Both approaches deliver very high local dose to the cancerous regions while providing enhanced dose sparing to the organs at risk. The move to real-time intra-operative prostate brachytherapy further enables simplified treatment options to patients, in many cases performed as a single day outpatient procedure while improving the overall treatment accuracy by limiting the uncertainties due to moving the patients from the OR to imaging to finally the treatment room. This presentation will look at the key components of an efficient real-time intra-operative as well as the associated workflows.

SPPH22D  Prostate Brachytherapy: Post-implant Evaluation Using CT or MR

Participants
Mark J. Rivard, PhD, Providence, RI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Learn the importance of post-implant dosimetric analysis. 2) To convey how to evaluate prostate brachytherapy implants using CT or MRI. 3) Be able to utilize modern techniques for post-implant evaluation of prostate brachytherapy implants.

SPPH22E  Gynecological Brachytherapy: MRI Guidance and Targeting

Participants
Bruce R. Thomadsen, PhD, Madison, WI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To understand the rationale for MR targeting in gynecological brachytherapy. 2) To become familiar with techniques and difficulties in MR targeting.

ABSTRACT
Cervical brachytherapy has changed greatly over the last few years. The conventional techniques that served well for the last six decades provided many cures; however, failures still plagued the higher staged disease. The challenges to improving outcomes rested with two issues: 1. Visualizing, localizing and assessing the disease, and 2. Adequately treating the disease once it is demarcated. This presentation will address the first of the challenges, imaging and targeting the disease.

Active Handout: Bruce Robert Thomadsen

SPPH22F  Gynecological Brachytherapy: Applicators

Participants
Bruce R. Thomadsen, PhD, Madison, WI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To understand the evolution of brachytherapy applicators for treatment of cervical cancer. 2) To become familiar with the latest generations of cervical brachytherapy applicators.

ABSTRACT
This presentation continues addressing the challenges for cervical brachytherapy, looking at recent developments in applicator design to facilitate treating the target tissues.

SPPH22G  Gynecological Brachytherapy: Comparisons with Conventional

Participants
Bruce R. Thomadsen, PhD, Madison, WI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To understand the differences in dosimetry between the conventional approach and the MR-guided approach to cervical brachytherapy. 2) To appreciate the benefits to patients of the newer approach.

ABSTRACT
This presentation completes the discussion of cervical brachytherapy by comparison of the newer approaches with the conventional treatments, reviewing the dosimetry and outcomes.

SPPH22H  Skin Brachytherapy

Participants
Mark J. Rivard, PhD, Providence, RI (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Develop a sense for the physics concerns surrounding skin brachytherapy. 2) Convey how to dosimetrically evaluate skin brachytherapy treatment plans. 3) Learn several methods for delivering skin brachytherapy.
LEARNING OBJECTIVES

1) To understand the geometry, dosimetry and nature of applicators used in breast brachytherapy.

ABSTRACT

Breast brachytherapy has been shown to be a highly effective treatment with very low toxicity. Many types of applicators have been developed to perform the procedure, each with strength and limitations. This presentation will discuss the various applicators and how they apply to applications.

Active Handout: Bruce Robert Thomadsen

1) To understand what should be checked during a treatment plan review for breast brachytherapy. 2) To understand the quantities used in performing the reviews.

ABSTRACT

Review of a treatment plan serves to help improve quality and prevent errors in treatment. Plan evaluations are crucial for breast brachytherapy. This presentation will discuss the techniques used, and quantities evaluated during a treatment plan review.

1) Understand the radiological physics differences between electronic brachytherapy and radionuclide-based brachytherapy. 2) Describe several different systems, contrasting and comparing them. 3) Learn how electronic brachytherapy is used clinically.

1) Comprehend the designs and goals for intensity modulated and anisotropic brachytherapy sources. 2) Explain how intensity modulated and anisotropic brachytherapy sources can provide improved dose distributions over conventional brachytherapy sources. 3) Learn how to evaluate and commission intensity modulated and anisotropic brachytherapy sources.

LEARNING OBJECTIVES

1) Understand the potential role of 3D printing in brachytherapy. 2) Have an overview of various tracking technologies that can be integrated into catheters, needles and applicators. 3) Discuss envisioned usage in the brachytherapy clinical workflow.

ABSTRACT

This portion of the AAPM summer school was dedicated to an outlook of the use of novel technologies tot her field of brachytherapy. First, brachytherapy relies heavily on applicators in which one or more sources can travel. As such, custom-made applicators derived from patient-specific 3D imaging or any other relevant information constitute a potential use of 3D printing technology. Second, to proceed with an optimal treatment the location in space of one or more applicators as well as the full 3D path (called channels in brachytherapy) the source will be traveling needs to be known with precision. Tacking technology can simplify the acquisition and validation of this information, thus simplifying the overall clinical workflow. This presentation will look at the various technologies involved with both the steps described above and how they could impact the current clinical workflows. Prerequisites for clinical use will also be discussed.

LEARNING OBJECTIVES

1) To understand some of the principles of robotics in brachytherapy. 2) To learn about some of the robots, their designs and limitations.
ABSTRACT

As with much of medicine, and life in general, automation is improving consistency and ability. Robots have become part of the surgical landscape and are found in most large pharmacies. Robots are just coming into brachytherapy but promise to improve dose distributions and access to procedures. This presentation will review the current, dynamic state of robotic brachytherapy.

Active Handout: Bruce Robert Thomadsen

Printed on: 10/29/20
Contrastes y Trazadores: Estado del Art-Session del Colegio Interamericano de Radiologia (CIR) en Español/Contrast Agents and Radiopharmaceuticals: State of the Art-Session of Interamerican College of Radiology (CIR) in Spanish

LEARNING OBJECTIVES

1) Conocer el uso actual, ventajas y desventajas de los medios de contraste en diferentes modalidades y en diversas situaciones clínicas. 2) Conocer los diversos trazadores, además de FDG, analizando su metabolismo normal y las indicaciones más frecuentes.

1) Understand the current indications, benefits and limitations of the use of contrast agents for various imaging modalities. 2) Review the various types of radiotracers available today for PET Imaging, along with their normal metabolism and common indications for their use.

Sub-Events

SPSP21A  Bienvenida/Welcome

Participants
Jose L. Criales, MD, Huixquilucan, Mexico (Moderator) Nothing to Disclose
Jorge A. Soto, MD, Boston, MA (Moderator) Royalties, Reed Elsevier

For information about this presentation, contact:
jorge.soto@bmc.org
jcriales@att.net.mx

LEARNING OBJECTIVES

1) Review the general principles and technique of using CEUS in the abdomen. 2) Discuss the role of CEUS in the diagnosis and characterization of masses in the liver and kidney. 3) Briefly discuss other applications of CEUS including guiding interventional procedures and monitoring of therapy.

ABSTRACT

Contrast-enhanced ultrasound (CEUS) continues to gain traction as a technique that complements traditional B-mode and Doppler ultrasound in the evaluation of the liver and other organs. Because the micro-vasculature can be visualized with CEUS and real-time imaging of tissue perfusion can be performed, imaging with this technique yields supplementary information, including flow and perfusion kinetics. The contrast agent used in CEUS is comprised of microbubbles, which are injected into a peripheral vein. The microbubble composition varies depending on the agent used, but the agent typically consists of an inert gas encased by a stabilizing shell composed of phospholipid, galactose, or albumin. The microbubbles circulate in the bloodstream and oscillate irregularly at low mechanical index settings within the acoustic field, creating nonlinear reflections that resonate at diagnostic ultrasound frequencies (3-5 MHz) and increase the signal produced. Proper technique and optimization of contrast-enhanced ultrasound require a balance between maintaining the integrity of the microbubble contrast agent and preserving the ultrasound signal. Established and emerging applications in the liver include diagnosis and characterization of focal lesions, aiding ultrasound-guided intervention, monitoring of therapy, and aiding surgical management.

For information about this presentation, contact:
clbonini@hotmail.com
**LEARNING OBJECTIVES**

1) Medios de contraste hepatospecíficos por MR. 2) Estructura molecular y su interacción a nivel celular. 3) Indicaciones actuales. 4) Ventajas y desventajas en comparación con los contrastes convencionales. 5) Contraindicaciones / 1) Hepatospecific contrast by MR. 2) Molecular structure and interaction at the cellular level. 3) Current indications. 4) Advantages and disadvantages compared to conventional contrasts. 5) Contraindications.

**PET-CT: Radiotrazadores Más Allá de FDG/PET-CT: Beyond FDG**

Participants
Belen Rivera Bravo, MD, Mexico City, Mexico (Presenter) Nothing to Disclose

For information about this presentation, contact:
brivera@unam.mx

**LEARNING OBJECTIVES**

1) Identify PET/CT radiopharmaceuticals other than FDG, used in clinical practice. 2) Describe the uptake mechanism of each radiopharmaceutical. 3) Diferentiate the normal biodistribution of each radiopharmaceutical by reading the images of the study. 4) Recognize the clinical indication of each radiopharmaceutical based in the uptake mechanism. 5) Al final de esta actividad, los participantes deberán ser capaces de. 2) Identificar radiofármacos de PET/CT diferentes al FDG utilizados en la práctica clínica. 3) Describir el mecanismo de concentración de cada radiofármaco. 4) Diferenciar la biodistribución habitual de cada radiofármaco al observar las imágenes del estudio. 5) Reconocer la indicación clínica de cada radiofármaco basado en su mecanismo concentración.

**Oral Contrast for Abdominal CT: Never, Always or Sometimes?**

Participants
Antonio Jose B. Madureira, MD, Porto, Portugal (Presenter) Nothing to Disclose

For information about this presentation, contact:
cvarelaubilla@gmail.com

**LEARNING OBJECTIVES**

1) To understand the rationale for the use of oral contrast agents in CT examinations. 2) To become familiar with the major indications of oral contrast use. 3) To discuss the benefits and drawbacks of their use.

**ABSTRACT**

There has been a gradual decline in the last years in the use of oral contrast agents in CT examinations. In spite of these there are some clinical scenarios in which their use is of great benefit as it can clearly establish a diagnosis. In the emergency setting and in patients suspected of high-grade bowel obstruction their use is not warranted and may even be contraindicated. Oral contrast agents administration still has a role in CT imaging and every radiologist should be familiar with their indications and benefits in specific clinical situations.

**Daño Renal Agudo por Contraste Iodado: Conceptos Actuales/Iodine Contrast Induced Acute Kidney Injury: Current Concepts**

Participants
Juan E. Gutierrez, MD, Medellin, Colombia (Presenter) Speakers Bureau, Bayer AG

For information about this presentation, contact:
juanes65@gmail.com

**LEARNING OBJECTIVES**

1) Define the classification of GBCAs based on molecular structure and other physicochemical properties. 2) Discuss current
literature regarding deposition of gadolinium in the brain (Clinical - Pre Clinical). 3) Describe the relationship between the type of contrast agents and gadolinium deposition in brain. Describe FDA, ACR, and European Medicines Agency (EMA) guidelines for GBCA usage.

ABSTRACT

Gadolinium Based Contrast Agents (GBCA) had been part of MRI environment for three decades with great benefits on the development of imaging as well as helping radiologists to achieve a better knowledge of the human body and its diseases. So far more than 500 million injections of GBCA’s have been applied Worldwide, initially and for many years GBCA’s were believed to be a harmless solution, to the point of being used as contrast for DSA and also in double or triple dose for MRI, however, in 2006 evidence of Gadolinium retention in tissues was published proving its link with Nefrogenic Systemic Fibrosis (NSF) in renal impaired patients. This situation triggered multiple academic and regulatory evaluations, involving the pharma industry to define the risk benefit of using GBCA’s depending on its safety profile, plus new warning regulations and classification for this agents issued by the FDA, EMA and ACR. New evidence of Gadolinium deposition in the brain, specifically locate at Dentate Nucleus and Globus Pallidus, after multiple GBCA’s injections in patients with normal kidney function was recently published (2014), and gives again new evidence of the potential harmful effect of Gadolinium in tissues. This situation brought a new regulatory environment with different approach by the FDA and EMA, as well as a new challenge for the MRI practice worldwide.

Participants
Jose L. Ciales, MD, Huixquilucan, Mexico (Presenter) Nothing to Disclose
Jorge A. Soto, MD, Boston, MA (Presenter) Royalties, Reed Elsevier

For information about this presentation, contact:

jorge.soto@bmc.org

Printed on: 10/29/20
CS24

Advances in MR & CT Imaging: Emphasis on Artificial Intelligence: Presented by the Institute for Advanced Medical Education (IAME), educational grant provided by Canon Medical Systems USA, Inc.

Monday, Dec. 2 2:00PM - 3:00PM Room: S101AB

Participants
Garry E. Gold, MD, Stanford, CA (Presenter) Research support, General Electric Company
Mathias Prokop, PhD, Nijmegen, Netherlands (Presenter) Speakers Bureau, Bracco Group Speakers Bureau, Bayer AG Research Grant, Canon Medical Systems Corporation Speakers Bureau, Canon Medical Systems Corporation Research Grant, Siemens AG Speakers Bureau, Siemens AG Departmental spinoff, Thirona Departmental licence agreement, Varian Medical Systems, Inc

PROGRAM INFORMATION

MR and CT imaging are advancing at a rapid rate with new scanner and software technology finding its way into advanced imaging systems each year. Artificial Intelligence (AI) is playing a major role in this expansion. In this one-hour CME accredited symposium, Dr. Gold and Dr. Prokop will provide insight into how they are using new AI tools in their everyday practice and explain how these new tools are providing better patient care and throughput.

CME

Yes, CME credit is available through a third-party provider. Information on claiming credits will be provided at the end of the symposium.

RSVP Link
https://www.appliedradiology.org/Rsna1/default.aspx

Printed on: 10/29/20
Enhancing Patient Care in CTEPH through Imaging Innovation: Presented by Bayer and Siemens Healthineers

Monday, Dec. 2 2:00PM - 3:30PM Room: S105D

Participants
Deepa Gopalan, MRCP, FRCR, Cambridge, United Kingdom (Presenter) Nothing to Disclose
Narinder S. Paul, MD, Toronto, ON (Presenter) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc
Martine J. Remy-Jardin, MD, PhD, Lille, France (Presenter) Research Grant, Siemens AG; Speaker, Siemens AG

PROGRAM INFORMATION
Through the use of case examples, we will walk through imaging techniques currently used by radiologists to identify and diagnose CTEPH, so that the radiological signs seen in respective modalities are not missed. We will explore the role of AI in CTEPH diagnosis and how it will benefit radiologists and patients in the near future.

CME
This course does not offer CME credit.

Printed on: 10/29/20
AI Theater: Practical Experience with Production Deployment of AI: Presented by Zebra Medical Vision and Intermountain Healthcare

Monday, Dec. 2 2:30PM - 2:50PM Room: AI Showcase, North Building, Level 2, Booth 10724

Participants
John Logioco, Shefayim, Israel (Presenter) Nothing to Disclose
Benjamin H. Gordon, MD, Murray, UT (Presenter) Nothing to Disclose

Program Information
Intermountain Healthcare, one of the premier healthcare providers in the U.S., and Zebra Medical Vision, the leading Deep Learning Imaging Analytics company, announced in 2016 their partnership to integrate machine learning into the medical imaging analysis of the premier healthcare provider to enhance patient care. Zebra-Med's Analytics Engine receives imaging data and analyzes millions of clinical imaging data in real time, detecting medical indications that are used by Intermountain to identify patients at risk and optimize care. As Zebra-Med's engine grows with new insights it will provide increasingly comprehensive reports that will allow more accurate, cost effective treatment. Intermountain Healthcare has been pleased to receive over 100,000 AI insights on CT scans from Zebra-Med. The healthcare provider has undertaken a pilot to create structured radiology reports and to automatically integrate Zebra AI insights, within the routine radiology reporting workflow. The result is a more comprehensive report with discrete observations that provide downstream benefits including enabling appropriate care within the EMR. The valuable partnership continues to grow, along with the growing number of FDA approvals of Zebra-Med's automated All-In-One (AI1) solutions, providing excellent outcomes while transforming patient care. Zebra Medical Vision: Zebra-Med was founded in 2014 by Eyal Toledano, Eyal Gura, and Elad Benjamin and funded by Khosla Ventures, Marc Benioff, Intermountain Investment Fund, OurCrowd Qure, Aurum, aMoon, Nvidia, J&J, and Dolby Ventures. Zebra Medical Vision has raised $50 million in funding to date, and was named a Fast Company Top-5 AI and Machine Learning company. www.zebra-med.com Intermountain Healthcare: Intermountain Healthcare is a Utah-based not-for-profit system of 22 hospitals, 185 clinics, a Medical Group with about 1,500 employed physicians and advanced practitioners, a health plans group called SelectHealth, and other medical services. Intermountain is widely recognized as a leader in transforming healthcare through high quality and sustainable costs. www.intermountainhealthcare.org

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Generative Adversarial Networks (GANs)

Monday, Dec. 2 3:00PM - 4:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIt Technologies, LLC; Stockholder, VoiceIt Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This course describes a more recent advance in deep learning known as Generative Adversarial Networks (GANs). GANs are a deep learning technology in which a computer is trained to create images that look very 'real' even though they are completely synthetic. Getting 'large enough' data sets is a problem for most deep learning applications, and this is particularly true in medical imaging. This may be one way to address the 'data shortage' problem in medicine. GANs have also been created that can convert MRIs to CTs (e.g. for attenuation correction with MR/PET).

Printed on: 10/29/20
SSE05
Chest (Radiomics and Machine Learning)
Monday, Dec. 2 3:00PM - 4:00PM Room: S102CD

OBJECTIVE
The aim of this prospective, internal review board approved study was to investigate the possibility of fully automatic, machine-learning-based prediction of the development of acute respiratory distress syndrome (ARDS) in polytraumatized patients based on the initial computed tomography (CT) scan of the chest.

METHOD AND MATERIALS
Over a timeframe of four years, polytraumatized patients, 18 years or older, with an Injury Severity Score (ISS) greater than 15, were included in the study. Exclusion criteria were: death within 48 hours, burning injury and known oncologic or chronic inflammatory lung disease. All scans were conducted on the same scanner and all scans were conducted within one hour of the accident. ARDS was defined by the Berlin definition. We performed deep-learning-based segmentation of the lungs including pleural effusions. Within the masks we densely sampled 83 radiomics features on locations throughout the lung and learned a spatio-visual vocabulary of radiomics feature expressions. Subsequently, we used the histogram of spatio-visual words of each lung to train a Support Vector Machine (SVM) classifier for prediction of ARDS and compared the algorithm to commonly used scores for prognosis estimation (ISS and abbreviated injury score of the thorax (AIS)). We performed 40-fold stratified cross validation to split training and test sets.

RESULTS
123 patients met the inclusion criteria. 101 of the polytraumatized patients had a thoracic AIS of 3 or greater (indicating severe thoracic injury). 40 out of 123 patients (32.5%) developed ARDS. The machine learning-based ARDS risk-score yielded an AUC of 0.78 (ISS: 0.66; AIS: 0.68). At a cutoff at 0.3, the radiomics risk-score yields a precision of 0.59, recall of 0.73 and an f1-score of 0.65 for ARDS prediction.

CONCLUSION
Machine-learning-based radiomic features of the lung in polytraumatized patients are able to predict ARDS at a higher level than common clinical scores in the same collective.

CLINICAL RELEVANCE/APPLICATION
Clinical decision support regarding the development of ARDS may be supported by extracting and analysing imaging data that is routinely available in polytraumatized patients at their admission to the hospital.

SSE05-01 Radiomics-Based Prediction of Acute Respiratory Distress Syndrome in Chest Computed Tomography of Polytraumatized Patients at Admission

Participants
Brett W. Carter, MD, Houston, TX (Moderator) Nothing to Disclose
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Sub-Events
SSE05-01 Radiomics-Based Prediction of Acute Respiratory Distress Syndrome in Chest Computed Tomography of Polytraumatized Patients at Admission

Awards
Trainee Research Prize - Resident

Participants
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PURPOSE
The aim of this prospective, internal review board approved study was to investigate the possibility of fully automatic, machine-learning-based prediction of the development of acute respiratory distress syndrome (ARDS) in polytraumatized patients based on the initial computed tomography (CT) scan of the chest.

METHOD AND MATERIALS
Over a timeframe of four years, polytraumatized patients, 18 years or older, with an Injury Severity Score (ISS) greater than 15, were included in the study. Exclusion criteria were: death within 48 hours, burning injury and known oncologic or chronic inflammatory lung disease. All scans were conducted on the same scanner and all scans were conducted within one hour of the accident. ARDS was defined by the Berlin definition. We performed deep-learning-based segmentation of the lungs including pleural effusions. Within the masks we densely sampled 83 radiomics features on locations throughout the lung and learned a spatio-visual vocabulary of radiomics feature expressions. Subsequently, we used the histogram of spatio-visual words of each lung to train a Support Vector Machine (SVM) classifier for prediction of ARDS and compared the algorithm to commonly used scores for prognosis estimation (ISS and abbreviated injury score of the thorax (AIS)). We performed 40-fold stratified cross validation to split training and test sets.

RESULTS
123 patients met the inclusion criteria. 101 of the polytraumatized patients had a thoracic AIS of 3 or greater (indicating severe thoracic injury). 40 out of 123 patients (32.5%) developed ARDS. The machine learning-based ARDS risk-score yielded an AUC of 0.78 (ISS: 0.66; AIS: 0.68). At a cutoff at 0.3, the radiomics risk-score yields a precision of 0.59, recall of 0.73 and an f1-score of 0.65 for ARDS prediction.

CONCLUSION
Machine-learning-based radiomic features of the lung in polytraumatized patients are able to predict ARDS at a higher level than common clinical scores in the same collective.

CLINICAL RELEVANCE/APPLICATION
Clinical decision support regarding the development of ARDS may be supported by extracting and analysing imaging data that is routinely available in polytraumatized patients at their admission to the hospital.

SSE05-02 The Incidental Thyroid Nodule on Chest CT: Application of CT Texture Analysis in the Prediction of Ultrasound Classification

Participants
PURPOSE
To explore the value of CT texture analysis (CTTA) in predicting subsequent ultrasound (US) classification of incidentally detected thyroid nodule on chest CT.

METHOD AND MATERIALS
A total of 117 incidental thyroid nodules (>=1cm in the longest diameter) on the chest CT scan of 107 patients were enrolled. CTTA parameters (mean value of positive pixels (MPP), kurtosis, entropy, skewness) were extracted using commercial software (TexRAD) with soft, medium and coarse spatial filters. CT texture features were correlated with the Korean Thyroid Imaging Reporting and Data System (K-TIRADS) classification on recent thyroid US within 1 month. All of the single texture features were compared between benign (K-TIRADS 2; n=21) and suspicion (K-TIRADS 3, 4, 5; n=96) nodules by Mann-Whitney U test. Combinations of significant texture features were entered as predictors in logistic regression models for predicting suspicion nodule and the performance of logistic regression model was analyzed by area under receiver operating characteristic curve (AUROC).

RESULTS
The mean values of MPP of benign nodule were significantly lower than suspicion nodule at all filter levels (all, p<0.05). Entropy of benign nodule was significantly lower than suspicion nodule at fine and coarse filters (p=0.018, 0.040, respectively), besides kurtosis of benign nodule was significantly lower than suspicion nodule at medium filter (p=0.002). Skewness of benign nodule were slightly higher than suspicion nodule at medium and coarse filters (both, p=0.074). A logistic regression analysis with combination of kurtosis, mpp and skewness at medium filter showed the best performance for the prediction of suspicion nodule with AUROC of 0.841 (p<0.001, sensitivity 84.4% and specificity 81.0%). The logistic regression model correctly classified 85.7% benign and 84.3% suspicion nodules.

CONCLUSION
CTTA features of ITN were significantly associated with systematic US classification and can accurately discriminate between benign (K-TIRADS 2) and suspicion (K-TIRADS 3, 4, 5) nodule.

CLINICAL RELEVANCE/APPLICATION
Quantitative CT texture analysis of ITN has the potential to predict benign or suspicion nodule on subsequent ultrasound and can be used to direct further workup of ITN on CT images.

SSEE05-04  Deep Learning (DL) Based Interpretation of Frontal Chest Radiographs: Assessing Accuracy of the DL Algorithm

Participants
Ramandeep Singh, MBBS, Boston, MA (Presenter) Nothing to Disclose
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Mannudeep K. Kalra, MD, Lexington, MA (Abstract Co-Author) Research Grant, Siemens AG; Research Grant, Riverain Technologies, LLC;
Jo-Anne O. Shepard, MD, Boston, MA (Abstract Co-Author) Editor with royalties, Reed Elsevier
Sebastian Vogt, PhD, Malvern, PA (Abstract Co-Author) R&D Director, Siemens AG; Stockholder, Siemens AG;
Eli Gibson, MSc, Princeton, NJ (Abstract Co-Author) Employee, Siemens AG

PURPOSE
Deep learning-based algorithm can improve the workflow and turnaround of interpretation of chest radiographs which are one of the most commonly performed imaging exams in hospital settings. The purpose of our study was to assess accuracy of deep learning based algorithm for detection of radiographic findings on frontal chest radiographs (CXR).

METHOD AND MATERIALS
A DL prototype (DNetLoc, Siemens) was trained for detecting and classifying radiographic abnormalities on 112,120 CXRs from the CXR14 data (NIH) and 185,421 CXRs belonging to the PLCO data (Prostate, Lung, Ovarian, and Colon Cancer). Five hundred unidentified CXRs (47 PA and 453 AP projection radiographs; 280 males, 220 female; mean age 64 ± 18 years) belonging to the CHEXpert data (from Stanford) were processed with the DL prototype. The prototype processed the CXRs and provided prediction statistics and scores for consolidation, pneumonia, atelectasis, pulmonary edema, pleural effusion, and enlarged cardiac silhouette. Statistical analysis was performed with receiver operating characteristics (ROC) to determine the area under the curve (AUC).

RESULTS
Distribution of findings on CXR included 320 pleural effusions, 242 pulmonary edema,183 consolidation, 126 atelectasis, 66 enlarged cardiac silhouette, and 54 pneumonia. Of the included CXR, 183/500 (37%) had multiple radiographic findings, 169/500 (34%) had single radiographic finding per CXR, and 148/500 (30%) CXR had no radiographic abnormality. The estimated sensitivity, specificity, and AUC values for different findings were: pleural effusions (0.68, 0.77, 0.91), pulmonary edema (0.73, 0.80, 0.82),183 consolidation (0.87, 0.76, 0.89), atelectasis (0.87, 0.70, 0.84), enlarged cardiac silhouette (0.70, 0.80, 0.86), and 54 pneumonia (0.78, 0.75, 0.84).

CONCLUSION
DL based prototype can accurately detect radiographic findings such as consolidation, pneumonia, atelectasis, pleural effusion, and...
enlarged cardiac silhouette (maximum AUC of 0.91 for pleural effusion). Performance of the prototype may have been limited by the JPEG image format and 8-bit compression of DICOM data.

**CLINICAL RELEVANCE/APPLICATION**

Deep learning based prototype can accurately detect and classify radiographic findings on frontal chest radiographs.

**SSE05-05 Improving Diagnostic Performance of Deep Learning Radiographic Localization by Injecting Expert Knowledge**

Monday, Dec. 2 3:40PM - 3:50PM Room: S102CD

Participants
Brian Hurt, MD,MS, San Diego, CA (Presenter) Consultant, Arterys Inc; Consultant, IBM Corporation
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**PURPOSE**

We explored a semantic segmentation approach to localize suspected foci of pneumonia and endotracheal tube placement, and
tested the hypothesis that additional anatomic contextual information may further improve performance.

**METHOD AND MATERIALS**

A public data set comprised of 29K frontal chest radiographs was used to train multiple multi-channel U-net neural networks. Foci of pneumonia were represented by bounding box coordinates and converted to probability maps for model training. We developed custom software to draw free-form annotations as a method of injecting expert radiologist knowledge into model training. Pneumonia localization were trained on 25K and tested on 4K frontal radiographs. Two pneumonia models were trained: (a) without and (b) with thoracic cavity annotations. Endotracheal/Tracheostomy tube segmentation models were trained on 771 from the above dataset and tested on 291 private radiographs. Two models for tube tip and carina localization were trained: (a) without and (b) with central airways and tube annotations. Annotations and model training were performed by a physician post-doctoral research fellow. Pneumonia classifications and subsequent ROC/AUC values are derived from predicted heat maps. Points corresponding to the carina and tube tip are extracted from predicted heat-maps, and distance error between prediction and hand-labeled points are calculated.

**RESULTS**

AUC for detection of pneumonia was 0.861 and improved to 0.906 with concurrent training with the thoracic cavity annotation. Inclusion of central airways and tube entirety improved tube detection AUC from 0.610 to 0.894. Further, mean error in tube tip and carina localization were 19.7 and 13.3 mm, and improved to 10.2 and 6.4 mm with concurrent training with the central airways and the entirety of the tube.

**CONCLUSION**

Semantic segmentation is a feasible approach to localize anatomy, pathology, and hardware. Injecting concurrent anatomic contextual information using a multi-channel strategy can improve localization performance. This approach may enable radiologists to further improve performance of deep learning algorithms for use in clinical practice.

**CLINICAL RELEVANCE/APPLICATION**

Multiple deep learning approaches have been proposed to assist interpretation of chest radiographs. Deep learning-based semantic segmentation provides natural model transparency and may enable radiologists to inject expert knowledge.

**SSE05-06 The Combination of Deep Learning Based Denoising and Iterative Reconstruction on Ultra-Low-Dose Chest CT: Image Quality and Lung-RADS Evaluation**

Monday, Dec. 2 3:50PM - 4:00PM Room: S102CD

Participants
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Noriko Kikuchi, Suita, Japan (Abstract Co-Author) Nothing to Disclose
Mitsuko Tsuamoto, MD, Suita, Japan (Abstract Co-Author) Support, Canon Medical Systems Corporation

**PURPOSE**

To assess the effect of the combination of the deep learning based denoising (DLD) and iterative reconstruction (IR) on the image quality and the Lung-RADS results on ultra-low-dose chest CT.

**METHOD AND MATERIALS**

Forty-one patients with 252 nodules were evaluated retrospectively. All patients underwent standard-dose CT (SDCT: 6.46 ± 2.28 mSv) and ultra-low-dose CT (ULDCT: 0.19 ± 0.01 mSv). SDCT was reconstructed using hybrid IR. ULDCT was reconstructed using hybrid IR (hIR) and model-based iterative reconstruction (MBIR). Post-processing DLD was performed on ULDCT images (hIR+DLD and MBIR+DLD). Two independent radiologists subjectively evaluated 4 ULDCT image sets (hIR, hIR+DLD, MBIR, and MBIR+DLD) on a
5-point scale (1=worst<2<3<4<5=best) in terms of noise, streak artifact, the visibility of nodule edge, the clarity of small vessels, the homogeneity of normal lung parenchyma, and overall image quality. In addition, two radiologists independently evaluated the nodules according to the LungRADS using the SDCT image set and the two post-processed ULDCT image sets (hIR+DLD, MBIR+DLD). The subjective scores were analyzed using the Wilcoxon signed-rank test with the Bonferroni correction. The intra-observer agreement for the LungRADS category between SDCT and ULDCT was evaluated using weighted kappa coefficients.

RESULTS

In subjective image quality analysis, ULDCT images with DLD showed significantly better scores than those without DLD (p <= 0.001) in terms of all items for both readers. MBIR+DLD showed the best scores among the ULDCT images in terms of all items except for the homogeneity (p < 0.001). In the LungRADS evaluation, hIR+DLD showed moderate agreement (κ = 0.420 for reader1 and κ = 0.423 for reader2) and MBIR+DLD showed moderate or good agreement (κ = 0.591 for reader1 and κ = 0.663 for reader2).

CONCLUSION

DLD improved the image quality of both hybrid IR and MBIR images on ULDCT. MBIR was more advantageous than hybrid IR in terms of image quality and LungRADS evaluation even using DLD.

CLINICAL RELEVANCE/APPLICATION

Both deep learning based denoising (DLD) and MBIR may contribute to the clinical practice by the improvement of image quality on ultra-low-dose chest CT.

Printed on: 10/29/20
Radiogenomics for Epigenomic Data: Estimated Serum MicroRNA-1246 From Contrast-Enhanced CT Can Predict Prognosis of Esophageal Squamous-Cell Carcinoma

**PURPOSE**

Radiogenomics is a new field that provides clinically useful predictions of prognosis by linking the molecular characteristics such as genetic aberrations of malignant tumors with medical images. On the other hand, abnormal expression of serum microRNA has been reported as a prognostic factor of malignant and is thought to be a new biomarker. Using the technique of radiogenomics, we attempted to infer the degree of expression of microRNA in the serum of esophageal squamous-cell carcinoma (ESCC) patients.

**METHOD AND MATERIALS**

Serum miR-1246 expressions in 92 ESCC patients were evaluated by qRT-PCR. A radiologist delineated the volume of interest (VOI) within each tumor region on contrast-enhanced CT images. Using morphology, histogram and texture analyses, 45 imaging features (IF) in the VOIs were extracted. Features were selected according to correlation analysis between miR-1246 and each IF. A prediction model for miR-1246 was constructed using linear regression of selected feature with 10-fold cross-validation. A threshold of miR-1246 dividing into high and low expression groups was defined with ROC analysis. Survival analyses were performed using the log-rank test and Cox regression.

**RESULTS**

SHAPE_Compacity and NGLDM_Coarseness were selected as IF correlated with the expression of miR-1246 (real_miR-1246) (r = 0.29 and 0.30; p = 0.004 and 0.003) and were used to construct a prediction model. When applying the calculated threshold of Real_miR-1246 (≥15.0) for the estimated miR-1246 expression (est_miR-1246), there was a significant difference between high and low expression groups (p=0.003) as well as real_miR-1246 (p=0.001). Real_miR-1246 was an independent predictor for overall survival on the multivariate test, whereas est_miR-1246 was also the same.

**CONCLUSION**

The close relation between expression levels of miR-1246 and IF such as SHAPE_Compacity and NGLDM_Coarseness were observed. Est_miR-1246 had similar power to predict prognosis of ESCC.

**CLINICAL RELEVANCE/APPLICATION**

Radiogenomic can predict genomic/epigenomic data strongly related to prognosis with low cost. This approach might proceed to accomplish precision medicine.

**SSE08-02**

**Esophageal Cancer: Dual-Energy Spectral CT Quantitative Parameters for Preoperative Diagnosis of Metastatic Lymph Nodes**

**Participants**

Jian Zhou, Guangzhou, China (Presenter) Nothing to Disclose
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PURPOSE
To evaluate the diagnostic performance of quantitative parameters derived from dual-energy CT for the preoperative diagnosis of metastatic lymph nodes in patients with esophageal cancer.

METHOD AND MATERIALS
For this prospective study, dual-phase contrast agent-enhanced CT was performed in participants with esophageal cancer from June 2016 to May 2018. Quantitative dual-energy CT parameters were compared between metastatic and non-metastatic lymph nodes. The optimal cutoff value of metastatic node was determined using the receiver operating characteristic (ROC) curve analysis.

RESULTS
This study included 99 participants. A total of 51 lymph nodes were diagnosed as metastatic lymph nodes, and 45 lymph nodes were diagnosed as non-metastatic lymph nodes. Quantitative dual-energy CT parameters including iodine concentration (IC), normalized iodine concentration (ICN), slope of the spectral Hounsfield unit curve (λHu), normalized slope of the spectral Hounsfield unit curve (λHu-N) measured at venous phase were higher in metastatic than in non-metastatic lymph nodes (P < 0.01). The combined diagnosis was the best predictor of metastatic lymph nodes, with a threshold of 0.558, thus demonstrating 88.2% sensitivity, 93.2% specificity, and 90.5% accuracy (P < 0.001), with the area under ROC curve of 0.943.

CONCLUSION
Dual-energy CT is a complementary means for the preoperative identification of lymph nodes metastases in participants with esophageal cancer.

CLINICAL RELEVANCE/APPLICATION
Dual-energy CT could be used for the preoperative identification of lymph nodes metastases in participants with esophageal cancer.

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PURPOSE
To evaluate the diagnostic potential of real-time MRI for assessment of gastroesophageal reflux disease in patients with GERD-like symptoms compared to pH-metry and impedance.

METHOD AND MATERIALS
Patients who underwent real-time MRI and pH-metry between 2015-2018 were included in this study. Real-time MRI at 3 Tesla was achieved by highly undersampled radial FLASH acquisitions with iterative image reconstruction by regularized nonlinear inversion. Real-time MRI visualized transit of pineapple juice through the gastroesophageal junction at rest and during Valsalva maneuver. MRI results were compared to 24-hour pH-metry to assess acid reflux (following Lyon Consensus guidelines), as well as to impedance to assess non-acid reflux. A standard 2x2 table was chosen to calculate diagnostic performance measures.

RESULTS
Of 93 eligible patients, 91 patients with GERD-like symptoms fulfilled inclusion criteria (male n=49; female n= 42; median age 55y). One patient was excluded due to pH-metry probe defect and one due to diagnosis of achalasia on real-time MRI. All MRI studies were successfully completed without adverse events at a median examination time of 15 minutes. Using real-time MRI, reflux was detected in 60 patients (66%). pH-metry revealed reflux in 41 patients (45%), and impedance in 54 patients (59%). Compared to pH-metry as reference, real-time MRI demonstrated sensitivity 0.82 (0.67, 0.93), specificity 0.47 (0.33, 0.62) and PPV 0.55 (0.42, 0.68). Due to the high number of false positive readings in this setting, a second scenario with assessment of acid as well as non-acid reflux was considered. Here, the reference standard was either positive reflux on pH-metry (indicating acid reflux) or a high number of reflux episodes during impedance (indicating non-acid reflux). In this scenario, real-time MRI sensitivity was 0.78 (0.66, 0.87), specificity 0.67 (0.45, 0.84) and PPV 0.87 (0.75, 0.94).

CONCLUSION
Real-time MRI is a fast and safe imaging method for assessment of gastroesophageal reflux in patients with GERD-like symptoms. Considering its high positive predictive value, real-time MRI can accurately identify patients in which further invasive testing with pH-metry and impedance might be considered.
Stratification of Gastrointestinal Stromal Tumors: Evaluation of Data Mining and Radiomics Features

Monday, Dec. 2 3:30PM - 3:40PM Room: S404AB

Participants
Isabella Martini, Rome, Italy (Abstract Co-Author) Nothing to Disclose
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Federica Landolfi, MD, Rome, Italy (Abstract Co-Author) Nothing to Disclose

PURPOSE
To develop and validate a decision tree model, based on texture features extracted from contrast enhanced multi detector computed tomography (MDCT), to discriminate between high and low risk gastrointestinal stromal tumors (GISTs) according to Miettinen's classification.

METHOD AND MATERIALS
A population of 53 patients with proven GIST and subjected to MDCT of the abdomen were selected. All patients underwent surgical resection and histopathology was the gold standard. 30 texture features were extracted from MDCT images and 8 morphological features were identified by two expert radiologists. The population was split in two cohorts, one for training (32 patients) and one for validation (21 patients) of a random forest (RF) classifier. The training model was obtained after 100 iterations. All patients were stratified as higher risk (Miettinen's class moderate and high risk) or lower risk (Miettinen's class no risk, very low risk and low risk).

RESULTS
The model based on RF classifier algorithm correctly classified 16 (80%) patients (validation cohort) with a mean absolute error of 0.34%. The AUC for the identification of higher risk patients was 0.845 while for lower risk was 0.815. True positive rate was 80% while false positive rate was 20% for both classes (Higher and lower risk).

CONCLUSION
The RF model developed using texture and morphological features, obtained from MDCT images, provided a high accuracy (80%) for the identification of higher and lower risk patients according to Miettinen's classification. This approach can be considered as a potential tool for the non invasive staging of GISTS.

Noninvasive Evaluation of Esophageal Varices with Spleen Hemodynamics in Cirrhotic Patients: A Dual-Energy CT Study

Monday, Dec. 2 3:40PM - 3:50PM Room: S404AB

Participants
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PURPOSE
To evaluate noninvasively the degree of esophageal varices in cirrhotic portal hypertension patients with spleen hemodynamic parameters obtained using dual energy CT.

METHOD AND MATERIALS
Fifty patients with portal hypertension due to cirrhosis were retrospectively selected. These patients all had esophageal varices (EV) confirmed by endoscopy. Fifteen liver transplant donors were selected retrospectively as the control group. All patients underwent contrast-enhanced dual energy CT (DECT) scans. The iodine content in spleen (IC-S) in the portal venous phase, the splenic volume (Vol-S), and the diameters of splenic vein (D-SV) were obtained by two experienced radiologists on a DECT post-processing workstation and the iodine volume of spleen (IV-S) was calculated using the following formula: IV-S=IC-S×Vol-S. EV was classified into three groups according the results of endoscopy. The degree of Spearman correlation analysis was used to analyze the correlation between the EV degree and the above parameters. ANOVA was used to compare the differences of the above parameters among different EV groups. The ROC curve was used to analyze the diagnostic efficiency of the correlated parameters. P<0.05 was considered statistically significant.

RESULTS
There were positive correlations between the EV degree and Vol-S, D-SV, and IV-S, with the correlation coefficient between EV degree and IV-S the highest (R=0.627, P<0.05) among the three spectral CT parameters. The differences of the Vol-S, D-SV and
IV-S among different EV degree groups were statistically significant (all P<0.05). The ROC analysis showed that the area under the curve (AUC) with Vol-S, D-SV and IV-S were large. The diagnostic sensitivity and specificity were high using these parameters. The diagnostic specificity of using Vol-S was 96%.

CONCLUSION
The parameters, Vol-S, D-SV and IV-S, obtained in DECT, could be used to evaluate the severity of EV noninvasively.

CLINICAL RELEVANCE/APPLICATION
DECT parameters can be used to indicate the EV degree, predict the esophageal varices bleeding and learn the visceral hemodynamics.

SSE08-06 Is Surveillance CT or Ultrasound Necessary for the Detection of Extragastric Recurrence After Curative Surgery for Early Gastric Carcinoma?
Monday, Dec. 2 3:50PM - 4:00PM Room: S404AB

Participants
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Joon Koo Han, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

PURPOSE
To evaluate the yield of follow-up abdomen CT and ultrasound (US) for the detection of extragastric recurrence after curative surgery for early gastric cancers (EGCs).

METHOD AND MATERIALS
In this single-institutional retrospective study, we enrolled 407 patients who underwent radical surgery for EGCs between January and December 2010 and who underwent post-operative surveillance with CT, US, and/or gastroscopy. All patients were followed up until February 2019. The primary outcome was post-operative CT or US detection of extragastric recurrence (i.e., distant or lymph node metastasis) which was not discovered with endoscopy. The secondary outcome was CT and/or endoscopic detection of gastric recurrence.

RESULTS
Mean and median follow-up periods were 64.1 ± 28.1 months and 66.0 months (range, 0-106 months), respectively. From a total of 3808 post-operative CT (2351 examinations) and US (1457 examinations), extragastric recurrence was detected only in two patients, with an incidence of 0.5% (2/407). One patient had extragastric recurrence at duodenal stump which was detected on CT at 23 months after subtotal gastrectomy for EGC (pT1bN0, poorly differentiated). The other patient had liver metastasis which was detected on CT at 10 months after subtotal gastrectomy for EGC (pT1bN0, moderately differentiated). There was no gastric recurrence detected with post-operative CT or US examinations. From a total of 1901 post-operative endoscopic examinations, two gastric recurrences were detected. These two gastric recurrences were detected at 18 and 61 months after subtotal gastrectomy, respectively. One gastric recurrence developed remote to the anastomosis site and the other recurred tumor was detected around the anastomosis site. Both gastric recurred lesions showed identical histologic types to those of the initial tumors.

CONCLUSION
Extragastric recurrence after curative surgery for EGC was very rare (0.5%, 2/407), but exclusively developed in patients with pT1b cancers. Therefore, post-operative surveillance with CT or US should be selectively performed in patients with a higher risk of recurrence.

CLINICAL RELEVANCE/APPLICATION
Considering a radiation risk and cost-effectiveness, post-operative surveillance with CT or US in patients who received gastrectomy for EGCs should be selectively performed in patients with a higher risk of recurrence.

Printed on: 10/29/20
PURPOSE
Quantitative MRI of the liver based on corrected T1, T2* and PDFF enables characterisation of liver state by providing information about fibro-inflammation, iron, and liver fat. This is often difficult and time-consuming challenge to the Radiologist, not least because heterogeneous disease and artefacts such as motion and field inhomogeneities. With of non-alcoholic fatty liver disease, this is increasingly more important, and in order to achieve a high throughput we have developed a machine learning pipeline to generate and automatically analyse quantitative MRI scans of the liver.

METHOD AND MATERIALS
We acquired 1347 MRI scans from 15 sites world-wide, including all major vendors at both 1.5T and 3T. All of the images were processed manually by trained clinical analysts who both performed manual delineation of the liver and selected regions of interest (ROIs) to quantify liver T1, T2* and PDFF. Using these manually generated segmentation masks, we trained a U-Net based deep learning method to automatically delineate the liver. Regions that exhibited poor model fit and artefacts in the MRI image were automatically identified and excluded. Next, in order to mimic ROI analysis performed manually, the unsupervised mask-SLIC algorithm with a trained classifier was used to define and detect the best regions based on quality metrics. In each case, the automatically calculated T2* value for the liver was used to produce an iron corrected T1 (cT1) map. Finally, a triaging step is used to identify low confidence cases for closer manual review.

RESULTS
The manually-placed ROIs were compared to those placed automatically. The difference between manual and automatic was -0.02+/−4.8 ms (T2*), 0.0+/−63 ms (cT1) and -0.1+/−1.9 % (PDFF). By automatically detecting poorer cases with triaging, the CI is reduced to -0.3+/−3.0 ms (T2*), -5.8+/−30.1 ms (cT1) and -0.2+/−1.1 % (PDFF). These results were similar to the inter-rater variability measured in a smaller trial (-0.6+/−2.12 ms (T2*), 3.68+/−41.3 ms (cT1) and 0.48+/−1.77 % (PDFF)).

CONCLUSION
The automatic processing pipeline (based on machine learning) yields results that compare closely to those generated by manual processing.

CLINICAL RELEVANCE/APPLICATION
Automated analysis of quantitative maps has the potential to hugely increase the efficiency of evaluating challenging quantitative results, and to increase the viability of quantitative MRI analysis in standard clinical workflows.
SSE09-02  Development and Validation of a Deep Learning-Based Algorithm for Detecting Malignant Hepatic Lesions on Multi-Phase CT in Patients at High Risk for Hepatocellular Carcinoma

Monday, Dec. 2 3:10PM - 3:20PM Room: N230B

Participants
Dong Woek Kim, MD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Geun Lee, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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Seung Soo Lee, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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Seong Ho Park, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Research Grant, Central Medical Service Co, Ltd
Yoon Jin Lee, MD, Seongnam, Korea, Republic Of (Abstract Co-Author) Stockholder, Coreline Soft, Co Ltd; Stockholder, Anymedi, Inc
Namkug Kim, PhD, Seoul, Korea, Republic Of (Abstract Co-Author) Stockholder, Coreline Soft, Co Ltd; Stockholder, Anymedi, Inc

PURPOSE
To develop and validate a deep-learning model for automatic detection of malignant hepatic lesions on multi-phase CT in patients at high risk for hepatocellular carcinoma (HCC).

METHOD AND MATERIALS
In this retrospective study, 1350 multi-phase CT image series including pre-, arterial-, portal-, and delayed-phases in 1320 patients at high risk for HCC (1054 men and 296 women; mean age, 56.76 years; age range, 20-87 years) obtained between 2007 and 2016 were included. Focal hepatic lesions were labeled and annotated by five board-certified radiologists. Final diagnosis of focal hepatic lesions was confirmed either by pathologic results for suspicious malignant lesions or by follow-up imaging studies for benign lesions. The CT images were randomly split into a development set (761 CT series) and a validation set (589 CT series). The development set was further divided into 568 CT scans for training the deep learning based malignant hepatic lesion detection model and 193 CT scans for finding the operational parameter by using the jackknife alternative free-response receiver-operating characteristic (JAFROC) figure of merit (FOM) for per-lesion-based analysis. Diagnostic performances of the developed model were tested in the validation set as sensitivity and false positive (FP) rate per case.

RESULTS
A total of 1348 focal hepatic lesions (462 benign lesions and 886 malignant nodules including 825 HCCs and 61 non-HCC malignancies) in the development set and 809 focal hepatic lesions (415 benign lesions and 394 malignant nodules including 377 HCCs and 17 non-HCC malignancies) in the validation set were labeled. The operational parameter was selected by the JAFROC FOM and applying less than 3 FPs criteria. The detection performance of malignant hepatic lesions was 89 % of sensitivity and 2.54 FP rate in the validation set.

CONCLUSION
The deep learning-based system showed high diagnostic performance for detecting malignant hepatic lesions.

CLINICAL RELEVANCE/APPLICATION
Deep-learning based detection system has potential to be a promising tool to help radiologists to accurately detect focal hepatic malignancies on multi-phase CT.

SSE09-03  Evaluating Appropriate Role of Artificial Intelligence in Preoperative Abdomen CT Assessment for Living Donor Liver Transplants (LDLT)

Monday, Dec. 2 3:20PM - 3:30PM Room: N230B

Participants
Abhishek Agarwal, MD, New Delhi, India (Presenter) Nothing to Disclose
Suthirth Vaidya, BEng,MENG, Bengaluru, India (Abstract Co-Author) Stockholder, Predible Health
Digvijay S. Mahra, BEng, Bengaluru, India (Abstract Co-Author) Stockholder, Predible Health
Adarsh Raj, BEng, Bengaluru, India (Abstract Co-Author) Stockholder, Predible Health
Krishna Chatyana Kaluva, BEng,MENG, Bangalore, India (Abstract Co-Author) Employee, Predible Health
Abhijith Chunduru, MENG, Bengaluru, India (Abstract Co-Author) Stockholder, Predible Health
Bharat Aggarwal, MBBS, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose

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PURPOSE
In LDLT, assuring appropriate graft size via evaluation of liver and segmental volumes is a major predictor of safe, successful outcomes. The analysis comprises of two key steps: 1. Segmentation of liver and hepatic vascular structures, and 2. Liver Resection to calculate graft and remnant volumes. Here we aim to study preoperative LDLT assessment using 3 different approaches: A: Fully Manual (Hepatic anatomy is segmented by manual contouring followed by manual resection), B: AI with Manual Resection (Hepatic anatomy is automatically segmented using AI and a radiologist resects manually), and C: Fully Automated (Hepatic anatomy is automatically segmented and resected by AI with no radiologist intervention).

METHOD AND MATERIALS
Our developed AI system comprised of 3 CNN models trained on 324 triphasic contrast-enhanced CTs and validated on 100 CTs from multiple institutions for liver and veins segmentation and middle hepatic vein (MHV) classification. For automated resection (C), we sample points from the MHV and IVC to draw a resection plane and return the graft and remnant volumes. 100 retrospective abdomen CT scans with preoperative analysis done were extracted from a large tertiary hospital. 6 studies were excluded due to incomplete information. On the remaining 94 CTs, the graft and remnant volumes were generated for A, B, and C. Intraoperative surgical weights were collected for comparison as ground truth.
RESULTS

We measured the variance of graft volume for A, B, and C against intraoperative surgical weight. B has the least overall variance of 9.14%, followed by C (9.32%) and A (10.62%) on 94 cases. A close correlation (variance < 5%) with the weight was seen in 40 cases using C as compared to 39 cases using B and 32 cases using A. Fig 1 shows the boxplot of the variance of A, B, and C.

CONCLUSION

Amongst the 3 approaches for LDLT analysis, AI with Manual Resection (B) and Fully Automated (C) give the best results, with B displaying the least overall variance.

CLINICAL RELEVANCE/APPLICATION

While AI can automate routine mundane tasks such as hepatic structure segmentation, an AI system coupled with expert intervention is poised to deliver better outcomes in Liver Transplant Planning.

SSE09-04  AI For Detecting Serrated Polyps in CT Colonography

Participants

Janne J. Nappi, PhD, Boston, MA (Presenter) Royalties, Hologic, Inc Royalties, MEDIAN Technologies
Tomoki Uemura, MS, BA, Boston, MA (Abstract Co-Author) Nothing to Disclose
Perry J. Pickhardt, MD, Madison, WI (Abstract Co-Author) Stockholder, SHINE Medical Technologies, Inc; Stockholder, Elucent Medical; Advisor, Bracco Group;
David H. Kim, MD, Middleton, WI (Abstract Co-Author) Shareholder, Cellebtr Biosciences, Inc; Shareholder, Elucent Medical;
Hiroyuki Yoshida, PhD, Boston, MA (Abstract Co-Author) Patent holder, Hologic, Inc; Patent holder, MEDIAN Technologies;

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PURPOSE

To evaluate the performance of AI in automated detection of serrated polyps in CT colonography (CTC).

METHOD AND MATERIALS

A total of 101 CTC cases with biopsy-confirmed serrated polyps were collected from a prospectively acquired database of patients enrolled in a CTC screening program. The patients were prepared for the CTC examination with saline laxative and fecal tagging by 250 ml barium sulfate and 60 ml of iodine-based diatrizoate. The CTC data were acquired using a section collimation of 1.25 mm with 1-mm reconstruction interval, noise index of 50, 30-150 mA, and 120 kVp. Polyps were detected from the CTC datasets automatically by use of an AI algorithm that was designed to detect the contrast-coating phenomenon of serrated polyps in combination with a 3D-convolutional neural network. For pilot evaluation, the detection accuracy of the AI algorithm was evaluated by use of 10-fold per-patient cross validation.

RESULTS

There were 144 serrated polyps >=6 mm in size: 76 polyps were >=10 mm and 68 polyps were 6-9 mm in size. Sixty-six (46%) of the polyps were flat lesions. Contrast coating was visible on 131 (91%) of the polyps. The average per-polyp detection sensitivity was 93±7% at 0.8±1.8 false-positive (FP) prompts per patient on average. The average per-patient sensitivity for polyps >=10 mm (for polyps 6-9 mm) was 94±9% (96±7%) at 0.1±0.2 (0.6±1.9) FPs per patient on average.

CONCLUSION

The contrast coating of serrated polyps provides an effective biomarker for AI to detect serrated polyps at a high sensitivity in CTC.

CLINICAL RELEVANCE/APPLICATION

Serrated polyps were recently discovered to represent a new pathway into colorectal cancers. Current CADe systems have not been designed to detect serrated polyps.

SSE09-05  Machine Learning-Based Ultrasomics Improved Diagnostic Performance in Differentiating Focal Nodular Hyperplasia and Atypical Hepatocellular Carcinoma

Participants

Wei Li, PhD, Guangzhou, China (Abstract Co-Author) Nothing to Disclose
Bo-Wen Zhuang, Guangzhou, China (Abstract Co-Author) Nothing to Disclose
Wei Wang, MD, Guangzhou, China (Presenter) Nothing to Disclose
Xiao-Yan Xie, Guangzhou, China (Abstract Co-Author) Nothing to Disclose
Ming de Lu, MD, Guangzhou, China (Abstract Co-Author) Nothing to Disclose
Xin Li, Shanghai, China (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To investigate whether machine learning-based ultrasomics of contrast enhanced ultrasound (CEUS) can improve the diagnostic performance in differentiation of focal nodular hyperplasia (FNH) and atypical hepatocellular carcinoma (aHCC).

METHOD AND MATERIALS

A total of 226 focal liver lesions, including 107 aHCC and 119 FNH underwent CEUS, were reviewed retrospectively. For machine
learning-based ultrasonics, 3,132 features were extracted from images of baseline, arterial and portal phases respectively. An ultrasonics signature was generated by using the least absolute shrinkage and selection operator (LASSO) logistic regression model. Predictive model was developed using the support vector machine trained with following groups: (i) ultrasonics features, (ii) radiologist’s score, (iii) combination of ultrasonics and radiologist’s score. The area under the curve (AUC) of operating characteristic was used to explore their performances. The clinical usefulness was assessed by decision curve analysis (DCA).

RESULTS

Fourteen ultrasonics features were selected to build an ultrasonics signature, and they presented good performance in the differentiation of FNH and aHCC with an AUC of 0.860, sensitivity of 76.6%, and specificity of 79.0%. The model trained with combination of ultrasonics and radiologist’s score had a significantly higher AUC (0.927) than radiologist’s score (AUC: 0.840, P < 0.001). Adding an ultrasonics signature into radiologist’s feature score significantly improves the accuracy of the model in differentiating FNH from aHCC. DCA demonstrated that the combination of ultrasonics and radiologist’s score model had the highest net benefit compared with both the other models.

CONCLUSION

The machine learning-based ultrasonics is as good as the staff radiologist in predicting the differential diagnosis of FNH and atypical HCC. Incorporating ultrasonics signature into radiologist’s score improves the diagnostic performance in FNH and aHCC.

CLINICAL RELEVANCE/APPLICATION

Adding an ultrasonics signature into radiologist’s feature score can significantly improve the accuracy of the model in discrimination of FNH and aHCC.

SSE09-06 Texture Analysis and Machine Learning for Quantification of Liver Fibrosis in MRI: Correlation with MR Elastography and Histopathology

Monday, Dec. 2 3:50PM - 4:00PM Room: N230B

Participants

Khoschy Schawkat, MD, Boston, MA (Presenter) Nothing to Disclose
Alexander Ciritsis, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose
Sophie von Ulmenstein, Zurich , Switzerland (Abstract Co-Author) Nothing to Disclose
Hanna Honcharova-Biletska, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose
Christoph Jungst, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose
Achim Weber, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose
Christoph Gubler, Zurich, Switzerland (Abstract Co-Author) Nothing to Disclose
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Caecilia S. Reiner, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To assess the diagnostic accuracy of texture analysis (TA) derived parameters of T1w in-phase (ip) and T2w fat-saturated (fs) images in comparison to MR elastography (MRE) for the diagnosis of liver fibrosis using a machine learning approach.

METHOD AND MATERIALS

Routine liver MRIs including MR elastography (MRE) of 79 patients (mean age 48 years, range 18 - 71) with suspected or known chronic liver disease, performed between 2015 and 2018, were retrospectively analyzed. Two readers performed TA measurements using an open-source software (MaZda, v. 3.20). Gray-level normalization was performed with the TA software by rescaling the histogram data to fit within µ-gray-level mean ± 3 standard deviations. The regions-of-interest were set manually on axial T1w ip and T2w fs images according to the MRE analysis by two independent readers. Histopathology of liver biopsy (n=78) or resection (n=1) served as reference standard. The patients were categorized into no or low grade fibrosis (0-2) and advanced fibrosis (3-4) groups. The data was split in a 2/3 ratio of model derivation and 1/3 ratio for validation. Machine learning based prediction of liver fibrosis was evaluated by calculating the AUC using a support vector machine (SVM) combined with previously implemented principal component analysis (PCA).

RESULTS

For feature selection, TA features with an intraclass correlation coefficient < 0.8 were excluded from further analysis. For further dimensional reduction PCA with two principal components was implemented. On axial T1w ip, a classification accuracy of 92% and 75% for fibrosis groups 0-2 and 3-4 was achieved, respectively, with K=10 folds using an SVM radial basis function (RBF) kernel. On axial T2w fs, a classification accuracy of 62% for both fibrosis groups (0-2 and 3-4) was achieved. The AUC for TA on T1w ip was similar to MRE (0.82 vs. 0.92, P=0.4066), while the AUC for T2w fs was significantly lower compared to MRE (0.57, p=0.0075).

CONCLUSION

Liver fibrosis levels can be assessed with TA-derived parameters of T1w ip images using a TA and machine learning approach with similar accuracy compared to MRE.

CLINICAL RELEVANCE/APPLICATION

T1w ip images, which are part of routine liver MRI, can serve as an alternative to assess liver fibrosis levels when MRE is not available.

Printed on: 10/29/20
**MSMC24**

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

Monday, Dec. 2 3:30PM - 5:30PM Room: S406A

**Participants**
Phillip M. Young, MD, Rochester, MN (Moderator) Consultant, Arterys Inc

**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

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**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
Linda B. Haramati, MD, MS, New Rochelle, NY (Presenter) Spouse, Board Member, Kryon Systems Ltd

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**LEARNING OBJECTIVES**
1) To recognize complex congenital heart disease on chest CT scans performed for other indications. 2) To tailor cardiac CT protocols and reconstructions to answer specific clinical questions for patients with treated congenital heart disease. 3) To provide information that guides therapy related to longstanding complications of congenital heart disease and its treatment.

**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 imagingsurveillance 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

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**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.

Printed on: 10/29/20
Controversy Session: MR Elastography versus US Elastography of Liver

Tuesday, Dec. 3 7:15AM - 8:15AM Room: E350

Participants
Bachir Taouli, MD, New York, NY (Moderator) Research Grant, Bayer AG; Research Grant, Takeda Pharmaceutical Company Limited; Research Grant, Regeneron Pharmaceuticals, Inc; Consultant, Alexion Pharmaceuticals, Inc; Consultant, Bayer AG; Anthony E. Samir, MD, Boston, MA (Moderator) Consultant, Pfizer Inc; Consultant, General Electric Company; Consultant, PAREXEL International Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Siemens AG; Research Grant, Canon Medical Systems Corporation; Research Grant, General Electric Company; Research Grant, Samsung Electronics Co, Ltd; Research Grant, Analogic Corporation; Research support, SuperSonic Imagine; Research support, Hitachi, Ltd; Research contract, Koninklijke Philips NV
Laura Kulik, MD, Chicago, IL (Presenter) Speaker, Eisai Co, Ltd; Speaker, Dova; Speaker, Gilead Sciences, Inc; Consultant, Bristol-Myers Squibb Company; Consultant, Bayer AG; Consultant, Exelixis, Inc; Consultant, Eisai Co, Ltd; Consultant, CE Outcomes
Paul S. Sidhu, MRCP, FRCR, London, United Kingdom (Presenter) Speaker, Koninklijke Philips NV; Speaker, Bracco Group; Speaker, Hitachi, Ltd; Speaker, Siemens AG; Speaker, Samsung Electronics Co, Ltd; Advisory Board, Samsung Electronics Co, Ltd; Advisory Board, Itreas Ltd
Scott B. Reeder, MD, PhD, Madison, WI (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Review the current uses and diagnostic performance of ultrasound and MR elastography of the liver. 2) Review and compare advantages, pitfalls and limitations of ultrasound and MR elastography of the liver.

ABSTRACT
The use of elastography has altered the management of chronic liver disease, and modified the patient pathway. The ability to assess the degree of fibrosis within the accepted classification, either the METAVIR or Ishak scoring systems, allows for clinical disease management. The establishment of elastography in both MR imaging and US imaging has become established, with standards measured against liver biopsy. The number of liver biopsies for assessment of liver fibrosis has predictably declines as a result. Both imaging techniques have advantages and disadvantages. Advocates of MR imaging indicate the global nature of the measurement, speed of aquisition, whereas the proponents of US based elastography suggest the rapid, cost effective methodology is superior. However the need to image an increasing patient population will require a rapid, portable and acceptable method. This debate will highlight the two techniques, the accuracy, acceptance and reproducibility and allow the audience to come to a conclusion of the usefulness of each technique.

Printed on: 10/29/20
Participants
Katherine A. Zukotynski, MD, PhD, Ancaster, ON (Moderator) Nothing to Disclose

Sub-Events

**MSCC31A  Brain FDG and Amyloid PET/DAT Scans**

Participants
Phillip Kuo, MD, PhD, Tucson, AZ (Presenter) Research Grant, Astellas Group; Research Grant, Blue Earth Diagnostics Ltd; Consultant, Novartis AG; Consultant and Speaker, General Electric Company; Consultant, Konica Minolta, Inc; Consultant, Imaging Endpoints

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**LEARNING OBJECTIVES**

1) Apply a systematic approach to interpretation of PET imaging in dementia. 2) Explain the optimal performance and interpretation of dopamine transporter imaging. 3) Describe the complementary roles of amyloid, FDG and dopamine transporter imaging in the assessment of neurodegenerative diseases.

**MSCC31B  Neck**

Participants
Rathan M. Subramaniam, MD, PhD, Dunedin, New Zealand (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) To review best clinical practices in Head and Neck PET/CT and case review.

Printed on: 10/29/20
HRCT of Interstitial Lung Disease: Interactive Read with the Experts

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S406A

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

LEARNING OBJECTIVES
After participating in the HRCT of Interstitial Lung Disease session the participants will acquire:
1. Capacity to identify key imaging features of interstitial lung disease that lead to a useful categorization.
2. Capacity to describe the most recent Fleischner criteria for the diagnosis of Idiopathic pulmonary fibrosis.
3. Capacity to analyze the key imaging features of diffuse lung disease that lead to pulmonary fibrosis including: organizing pneumonia, idiopathic pulmonary fibrosis, acute interstitial pneumonia/ARDS, cigarette smoke related fibrosis and sarcoidosis.
4. Capacity to better manage and contribute to a multi-disciplinary conference (MDD) that focuses on diffuse lung disease.

ABSTRACT
The assessment of fibrotic diffuse lung injury is difficult and radiologists are a key member of multidisciplinary conferences (MDD) that are recommended for a more accurate diagnosis of the underlying disease. This session is designed to help the radiologist understand the strengths and weaknesses of the MDD. Ten cases of diffuse lung injury will be presented to 4 experienced chest radiologists. The complete DICOM set of images will be displayed to both the panelists and the participants. This will allow the 4 panelists to describe the key features that support a diagnosis. The design of the session will also allow the participants to gauge the degree of agreement between experienced chest radiologists. The chief of pulmonary pathology at the Joint Pathology Center in Silver Spring will also participate giving a more accurate picture of the MDD. The case review session will begin with short presentation explaining the current Fleischner criteria for idiopathic pulmonary fibrosis provided by David Lynch from National Jewish Health in Denver. Additionally, there will be a short presentation providing a general approach to the imaging features of fibrotic lung disease by Jeffrey Galvin from the University of Maryland and the American Institute for Radiologic Pathology. The unknown cases can also be viewed on your internet enabled phone, tablet or computer.

Active Handout: Jeffrey R. Galvin

Sub-Events
RC301A Introduction
Participants
Jeffrey R. Galvin, MD, Baltimore, MD (Presenter) Nothing to Disclose

RC301B Fleischner Criteria for IPF
Participants
David A. Lynch, MBBCh, Denver, CO (Presenter) Research support, Siemens AG; Research Consultant, Siemens AG; Research Consultant, PAREXEL International Corporation; Research Consultant, Boehringer Ingelheim GmbH; Research Consultant, F. Hoffmann-La Roche Ltd; Research Consultant, Veracyte, Inc; Research Consultant, Acceleron, Inc;

LEARNING OBJECTIVES
1) Apply Fleischner Society criteria for diagnosis of idiopathic pulmonary fibrosis. 2) Identify features of definite UIP, probable UIP, indeterminate fibrosing interstitial pneumonia, and suggestive of an alternative diagnosis.

RC301C Brief Overview to Approach and Management
Participants
Jeffrey R. Galvin, MD, Baltimore, MD (Presenter) Nothing to Disclose

Active Handout: Jeffrey R. Galvin

RC301D Panel
Participants
Gerald F. Abbott, MD, Boston, MA (Presenter) Nothing to Disclose
H. Page McAdarre, MD, Durham, NC (Presenter) Consultant, MedQIA Imaging Core Laboratory; Author, Reed Elsevier; Author, Wolters Kluwer nv; Research Consultant, F. Hoffmann-La Roche Ltd; Research Consultant, Boehringer Ingelheim GmbH; Research Consultant, Novartis AG
David A. Lynch, MBBCh, Denver, CO (Presenter) Research support, Siemens AG; Research Consultant, Siemens AG; Research Consultant, PAREXEL International Corporation; Research Consultant, Boehringer Ingelheim GmbH; Research Consultant, F.
LEARNING OBJECTIVES

1) To discuss ILD cases and establish differential diagnosis and key points.
Applications of AI for Cardiovascular Imaging

Tuesday, Dec. 3 8:30AM - 9:00AM Room: E350

Participants
Karen G. Ordovas, MD, Seattle, WA (Moderator) Advisor, Arterys Inc;
Gautham P. Reddy, MD, Seattle, WA (Moderator) Researcher, Koninklijke Philips NV
Albert Hsiao, MD, PhD, La Jolla, CA (Moderator) Founder, Arterys, Inc; Consultant, Arterys, Inc; Shareholder, Arterys, Inc; Speaker, Bayer AG; Research Grant, Bayer AG; Speaker, General Electric Company; Research Grant, General Electric Company;
Michael K. Atalay, MD, PhD, Providence, RI (Moderator) Nothing to Disclose

Sub-Events

RC303-01 Applications of AI for Cardiovascular Imaging

Tuesday, Dec. 3 8:30AM - 9:00AM Room: E350

Participants
Albert Hsiao, MD, PhD, La Jolla, CA (Presenter) Founder, Arterys, Inc; Consultant, Arterys, Inc; Shareholder, Arterys, Inc; Speaker, Bayer AG; Research Grant, Bayer AG; Speaker, General Electric Company; Research Grant, General Electric Company;

LEARNING OBJECTIVES

1) Identify the recent innovations that have enabled a resurgence of interest in applying artificial intelligence (AI) in medical practice. 2) Identify potential applications for AI in the acquisition, analysis and interpretation of cardiovascular CT and MRI. 3) Apply concepts of analytical validity, clinical applicability, to become knowledgeable consumers of AI.

RC303-02 Deep-Learning Quantification of Coronary Calcium on CT and Mortality in the National Lung Screening Trial (NLST)

Tuesday, Dec. 3 9:00AM - 9:10AM Room: E350

Participants
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PURPOSE

Coronary artery calcification (CAC) is quantifiable on low-dose chest CT and can guide statin therapy. Quantification is not routinely performed due to time and equipment limitations. We developed a deep-learning algorithm that automatically quantifies coronary calcium on standard lung screening CT and evaluated prognostic value in 14,959 National Lung Screening Trial (NLST) participants.

METHOD AND MATERIALS

The deep learning algorithm was developed in 1,600 cardiac CTs from with manual CAC measurement as the reference. The deep learning calcium score was categorized as: High (CAC>300), Moderate (CAC: 101-300), Low (CAC: 1-100), and Very Low (CAC: 0). The association of the deep learning calcium score with all-cause and cardiovascular mortality was then tested in 14,999 heavy
smokers aged 55–74 having lung cancer screening chest CT at 33 US sites in NLST. The intraclass correlation coefficient (ICC) between automated and human manual CAC was assessed in 396 NLST chest CTs.

RESULTS

All-cause (7.3% (1,092/14,959)) and cardiovascular (1.9% (288/14,959)) mortality was assessed over median follow-up of 6.5 years. There was a significant association between deep learning calcium score and all cause mortality: High: HR 2.9 (95%CI: 2.4-3.5), Moderate: 1.9 (1.5-2.3), Low: 1.3 (1.1-1.6), all p<0.01 compared to Very Low; as well as for cardiovascular mortality: High: HR 6.6 (4.3-10.3), Moderate: 3.8 (2.3-6.1), Low: 2.2 (1.4-3.6), all p<0.001 compared to Very Low. The ICC between manual and automatic calcium classes was 0.858 (95%CI: 0.830-0.882).

CONCLUSION

The automated deep learning algorithm quantified CAC on lung screening CT. Automated CAC corresponded closely to human readers and was strongly associated with all-cause and cardiovascular mortality in a large multicenter cohort of NLST participants having lung screening.

CLINICAL RELEVANCE/APPLICATION

Automated quantification of coronary calcium using existing lung screening CTs identifies persons at high and low risk to guide cardiovascular prevention.

PURPOSE

The Agatston calcium score quantifies the severity of coronary artery disease (CAD) and is typically measured on an EKG-gated cardiac CT. The purpose of this study was to assess the ability of deep convolutional neural networks (DCNNs) to estimate Agatston scores on chest radiographs (CXRs).

METHOD AND MATERIALS

Our dataset was comprised of 471 patients who had undergone a cardiac CT and a PA and lateral CXR in the same year. CT-derived Agatston scores were considered ground truth and used as labels for DCNN training on radiographs. Radiographs were split into 70% training and 30% testing, balancing the distribution of Agatston scores. Weighted augmentation was performed on images to increase data size and balance class distribution. An attention-based network architecture was built on a variety of standard DCNNs such as VGG-16, pretrained with ImageNet weights, and used for (1) binary classification of Agatston scores at variable thresholds and (2) linear regression prediction of absolute calcium scores. Classifier performance was measured using area under the curve (AUC) and regression assessed with the mean absolute error. Attention maps were produced to highlight areas of decision-making and results were additionally compared to radiologist mention of CAD on CXR reports.

RESULTS

Binary classification performed best for discrimination of Agatston scores greater than 75 with AUC of 0.73 (Fig. 1a). Best performing regression algorithms predicted Agatston scores with a mean absolute error of 159. DCNNs trained on PA radiographs outperformed those on lateral radiographs. Attention maps primarily localized to the cardiac silhouette (Fig. 1b), with highest performing binary algorithms additionally including the aortic arch and other vessels in predictions. Of the radiographs with calcium scores >75, none of the reports included mention of CAD.

CONCLUSION

DCNNs on CXRs may have utility in estimating calcium scores and predicting clinically-significant CAD, a finding not often reported by radiologists on radiographs. These results provide proof-of-concept in the promise of deep learning to extract additional information that may not typically be noted on human review.

CLINICAL RELEVANCE/APPLICATION

We illustrate the potential for deep learning to estimate Agatston calcium scores and predict the severity of coronary artery disease on chest radiographs.

Participants
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Participants
Jonathan Nadjiri, MD, Munich, Germany (Presenter) Nothing to Disclose
Spectral CT-coronary angiography (SCCTA) with a dual-layer detector allows for quantitative determination of iodine uptake with high accuracy with just one scan. In this pilot project we sought to prospectively evaluate this quantitative method to measure iodine uptake in coronary plaques as a possible surrogate for inflammation.

**PURPOSE**

To assess the feasibility of 'one-stop' coronary and aortic examination with low contrast agentss by using spectral imaging technique.

**METHOD AND MATERIALS**

From Oct. 2017 to Apr. 2018, 96 consecutive patients undergoing both coronary and aortic CT angiography (CTA) examination in hospital were randomly divided into two groups. Conventional group (group A): Single-beat prospective electrocardiogram (ECG)-gated coronary CTA examination was followed by aortic CTA. The coronary artery axial scanning was performed before the spiral scanning. The whole scanning process was completed altogether with one-time injection of contrast agent, and the contrast agents was used for 0.85ml/kg. The Spectral group (group B): Single-beat prospective ECG-gated coronary CTA examination was followed by aortic spectral CTA. The contrast agents used 0.55ml/kg. The routine axial CCTA scanning was performed, and the spectrum of aorta was scanned after CCTA. All data were transferred to AW workstation for post-processing and measurement. The coronary artery and the best monochromatic images were processed by workstation. The contrast agent used 0.55ml/kg and recorded the CT values of, descending aortic root in both 120kV and 50keV images were calculated. The radiation dose and the contrast agents dosage was recorded. The image quality of the two groups were evaluated by two radiologists by using 5-point scale. The student t test was used to evaluate continuous variables and the Mann-Whitney U test for image quality evaluation.

**RESULTS**

In the study population 18 non-calcified plaques were found in SCCTA. Mean density was 70 ± 56 HU. Mean Iodine uptake was 2.4 ± 2.1mg/ml, respectively. There was significant correlation between iodine uptake and density of coronary plaques; r = 0.9, p < 0.001. 11 patients underwent ICA; in these group 11 non-calcified plaques were found by SCCTA. For all of those plaque formations a correlate in OCT was found. For low-attenuation plaques (<90HU) there was no significant correlation between density and iodine uptake. In these plaques variance of iodine uptake was very high (standard deviation was 155% of mean) while in plaques with higher density (>90 HU) variance was small (standard deviation was 33% of mean).

**CONCLUSION**

In our pilot study we found that in general non-calcified plaques iodine uptake corresponds to the density of the plaques and we found a correlate of every non-calcified plaque detected by SCCTA in OCT. However, there is relevant difference in iodine uptake of coronary plaques with similar HU in very low attenuation plaques (HU < 90) indicating additional information through determination of quantitative iodine uptake.

**CLINICAL RELEVANCE/APPLICATION**

Coronary plaque characterization in CT is known to stratify a patient’s individual risk for cardiovascular events beyond clinical risk scores, calcification and stenosis. However, a gap in predicting outcomes remains. This gap might be closed by more information about the plaque and its composition. Measuring iodine content as proposed in this abstract might be one of the missing parts to further close the prognostic gap of cardiac CT which has to be evaluated in further outcome studies.

Can Spectral Imaging Technique Reduce Agents Dosage in "One-Stop" Coronary and Aortic CT Angiography?

**Tuesday, Dec. 3 10:00AM - 10:10AM Room: E350**

**Participants**

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**PURPOSE**

To assess the feasibility of 'one-stop' coronary and aortic examination with low contrast agentss by using spectral imaging technique.
RESULTS
There was no significant difference in the image quality and radiation dose between the two groups (p>0.5).
(Aortic: 4.6±0.5:4.4±0.6, RCA: 7.4±0.5:4.8±0.6, LAD: 6.4±0.4:4.5±0.5, LCX: 4.7±0.5:4.6±0.5, z=1.76, 1.38, 0.77, 0.97) . Compared with the conventional group, the contrast agent was compared: (38.0±4.3:57.6±8.3) ml, and the use of contrast agent was reduced in group B. The ED in Group A was not different from the combined ED in Group B and C (2.1±0.6:1.9±0.5) mSv.

CONCLUSION
The "one-stop" coronary CTA and aortic spectral CTA is the feasible examination with low contrast agents dosage.

CLINICAL RELEVANCE/APPLICATION
"One-stop" CTA examination with low contrast agents dosage, is a suitable method for the patients with renal function impairment.

RC303-07  Valvular Flow Quantification with Phase Contrast Imaging
Tuesday, Dec. 3 10:20AM - 10:50AM Room: E350

Participants
Michael Markl, PhD, Chicago, IL (Presenter) Institutional research support, Siemens AG; Consultant, Circle Cardiovascular Imaging Inc;

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.

RC303-08  4D Flow MRI Before and After Bicuspid Aortic Valve Sparing Surgery: Assessment of Aortic Flow Patterns for Monitoring of Successful Repair
Tuesday, Dec. 3 10:50AM - 11:00AM Room: E350

Participants
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PURPOSE
To assess the feasibility of 4D flow MRI for evaluation of aortic flow patterns in patients with congenital aortic valve disease before and after aortic valve sparing surgical repair.

METHOD AND MATERIALS
20 patients (median age 34.5 years, IQR 29-47; 16 male) with severe aortic regurgitation [15 bicuspid aortic valves (BAV) and 5 unicuspid aortic valves (UAV)] underwent 4D flow MRI at 3T before and after valve sparing aortic repair. Analysis planes were placed at the aortic valve, sinotubular junction, mid-ascending aorta, and proximal arch. The aortic regurgitant fraction (%) was estimated. The degree of helical and vortical flow was evaluated according to a 3-point scale. Relative flow displacement (FD) as a measure of flow eccentricity and wall shear stress (WSS) were estimated. Results before and after surgery were statistically compared using a paired t-test or a Wilcoxon matched-pairs test.

RESULTS
All patients underwent successful aortic valve surgery (17 isolated aortic valve repairs, 3 aortic root procedures with a significant reduction of the aortic regurgitant fraction (27±13% vs. 6.4±3, P=0.001). The degree of both helical (1.6±0.6 vs. 0.9±0.5, P=0.001) and vortical flow (1.2±0.8 vs. 0.5±0.6, P=0.007) were significantly reduced after surgery. Both FD (0.3±0.1 vs. 0.1±0.1, P=0.003) and WSS (0.6±0.2 vs. 0.4±0.2, P=0.007) were significantly reduced after surgery at the level of the mid-ascending aorta.

CONCLUSION

CLINICAL RELEVANCE/APPLICATION
4D flow MRI allows to evaluate the success of valve repair surgery and may optimize surgical procedures in the future.

RC303-09  Cardiac Magnetic Resonance with 4D Flow Imaging for Mitral Regurgitation Severity Assessment
Tuesday, Dec. 3 11:00AM - 11:10AM Room: E350

Participants
Marco Guglielmo, Milan, Italy (Abstract Co-Author) Nothing to Disclose
Giuseppe Muscogiuri, MD, Milano, Italy (Presenter) Nothing to Disclose
Cardiac involvement is common in neuromuscular diseases (NMDs), and is a major cause of progressive heart failure. Subclinical cardiac involvement in NMDs is however difficult to detect. The aim of this study was to investigate the diagnostic value of native MR T1/T2 mapping parameters to detect cardiac involvement in NMDs.

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**PURPOSE**

Cardiac Magnetic Resonance (CMR) has recently emerged as a technique more accurate than echocardiography in assessing the severity of mitral regurgitation (MR). Standard method for mitral regurgitation determination with CMR is measuring the regurgitant volume (RV) as the difference between the LV stroke volume obtained with SSFP (Steady state free precession) cine imaging and the forward flow obtained with phase contrast (PC) imaging. It has already been demonstrated that there is a strong correlation between post-surgical left ventricle (LV) remodeling and MR severity as assessed by CMR SSFP - PC. More recently, time-resolved phase contrast CMR with velocity encoding along all three flow directions and three-dimensional (3D) anatomic coverage (also termed ‘4D flow’) has been developed. The purpose of this study was to compare CMR 4D flow and SSFP imaging for the assessment of MR severity using the degree of left ventricular (LV) remodeling after surgery as the reference standard.

**METHOD AND MATERIALS**

10 consecutive patients (age: 59 ± 10) with indication to mitral valve plasty for severe mitral regurgitation were enrolled. MR severity was assessed using both CMR SSFP - PC imaging and CMR 4D flow imaging without the use of contrast agents. The pre-surgical estimate of regurgitant severity was correlated with the postoperative decrease in LV end-diastolic volume.

**RESULTS**

Agreement between CMR SSFP-PC imaging and CMR 4D flow imaging for MR regurgitant volume (RV) was excellent for both pre (r = 0.8, p<0.05, mean difference 5.1 mL) and post surgery (r = 0.9, p<0.05) evaluations. There was a strong correlation between post-surgical LV remodeling and MR severity as assessed by CMR 4D flow imaging (r=0.81, p <0.005) that was comparable to CMR SSFP-PC (r=0.78, p<0.005). The average time for MR assessment with CMR SSFP and PC imaging evaluation was 10 minutes, 2 minutes with CMR 4D flow imaging.

**CONCLUSION**

CMR 4D flow imaging without contrast agents allows an accurate and quick evaluation of MR regurgitant volume. There is a strong correlation between MR severity assessed with CMR 4D flow imaging and post-surgical LV remodeling. Indeed, CMR 4D flow imaging may represent an alternative method for MR severity assessment.

**CLINICAL RELEVANCE/APPLICATION**

4D flow approach can be extremely helpful for the management of patients with mitral regurgitation.

**RC303-10 Multi-parametric Myocardial MR Mapping (T1, T2, T2*)**

Tuesday, Dec. 3 11:10AM - 11:40AM Room: E350

Participants
Kate Hanneman, MD, FRCPC, Toronto, ON (Presenter) Medical Advisory Board, sanofi-aventis Group

**LEARNING OBJECTIVES**

1) Describe analysis approaches for T1/T2/T2* parametric maps. 2) Discuss clinical role of T1/T2/T2* parametric mapping. 3) Identify findings of common diseases on T1/T2/T2* parametric maps.

**RC303-11 Tissue Heterogeneity in Native MR T1/T2 Map Helps Diagnose Cardiac Involvement in Neuromuscular Diseases**

Tuesday, Dec. 3 11:40AM - 11:50AM Room: E350

Participants
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**PURPOSE**

Cardiac involvement is common in neuromuscular diseases (NMDs), and is a major cause of progressive heart failure. Subclinical cardiac involvement in NMDs is however difficult to detect. The aim of this study was to investigate the diagnostic value of native MR T1/T2 mapping parameters to detect cardiac involvement in NMDs.
Sixty subjects (41±14y) diagnosed as NMDs, including 40 idiopathic inflammatory myopathy, 20 non-inflammatory myopathies, and 20 age and gender-matched healthy controls were enrolled in this study. NMDs patients with abnormal ECG or LGE or reduced LVEF/ RVEF were categorized as the cardiac involvement subgroup. All subjects underwent a CMR exam on a 3T MR scanner (Skyra, Siemens Healthcare, Erlangen, Germany), including short-axis SSFP cine, LGE, native T1 and T2 mapping, covering the whole heart. Endocardial and epicardial contours of the left ventricle were manually drawn on short-axis T1 and T2 maps. Six parameters, including mean, median, minimum, maximum and entropy, were calculated from the T1 and T2 map.

RESULTS
Forty-one NMDs patients were categorized as the cardiac involvement subgroup, and the remaining 19 were categorized as the non-involvement subgroup. Compared to the controls, T1 mean, median, SD and entropy, as well as T2 mean, median, and entropy of the cardiac involvement subgroup all elevated significantly (P<0.05 for all 8 parameters), while in the non-involvement subgroup, only native T1 mean and median increased (P<0.05 for both). The heterogeneity parameters, namely, the native T1/T2 SD and entropy, were all significantly higher in the cardiac involvement subgroup compared to then non-involvement subgroup (P<0.05 for all). A multi-variate regression model including all heterogeneous parameters exhibited a diagnostic accuracy of 83% (AUC 0.81, 95%CI: 0.67-0.94) to detect cardiac involvement in NMDs patients.

CONCLUSION
Tissue heterogeneity in the native MR T1/T2 map showed high diagnostic value, without use of contrast agent.

CLINICAL RELEVANCE/APPLICATION
Early detection of cardiac involvement in NMDs can help prevent overt heart failure. Tissue heterogeneity in the native MR T1/T2 map showed high diagnostic value, without use of contrast agent.

Role of Cardiac MRI in Diagnosis in Patients of Cardiac Sarcoidosis Using T1 Mapping, T2 Mapping and Late Gadolinium Enhancement (LGE)

Participants
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PURPOSE
To determine whether quantitative tissue characterization with T1 mapping, T2 mapping and late gadolinium enhancement supports recognition of myocardial involvement in patients of cardiac sarcoidosis. To correlate cardiac MRI with PET and echocardiography findings.

METHOD AND MATERIALS
Prospective study with size of 19, Patients with biopsy proven extracardiac sarcoidosis presenting to us with suspicion of cardiac involvement were included. MRI was done on 1.5 Tesla scanner (Aera; Siemens, Erlangen, Germany). Cardiac MRI protocol- localizer sequences->cine images in short axis/vertical long axis/4 chamber view->T1W, T2F - perfusion imaging in short axis/ vertical long axis/ 4 chamber view->T1 scout, PSIR sequences after 5 and 15 minutes and Post contrast T1W sequence. T1 (using modified Look-Locker imaging-MOLLI T1 maps) and T2 mapping (using hybrid gradient and spin-echo sequence) were performed in a single midventricular short-axis section.

RESULTS
The mean age was 38 years, F:M=10:9. Most common presenting symptom was palpitations. Presence of characteristic mid-myocardial LGE was seen in 11/12 patients with confirmed sarcoidosis. T1 mapping is a technique that helps in tissue characterization without contrast agent. In our study, we compared T2 values in the LGE positive segments with the T2 values in normal controls and observed statistically significant difference between the two groups. ROC curve analysis yielded a cut-off value of 46.3 milli seconds with a sensitivity and specificity of 75% and 71.1% respectively.

CONCLUSION
Quantitative tissue characterization in the myocardium with native T1 and T2 mapping helps in the detection of cardiac involvement in patients with systemic sarcoidosis, in relation to inflammation of the myocardium and disease recognition. Cardiac MRI with T1, T2 mapping and LGE have excellent performance in detecting myocardial involvement in patients suspected to have cardiac sarcoidosis.
CLINICAL RELEVANCE/APPLICATION

T1 and T2 mapping values can be used to diagnose the cardiac sarcoidosis (T1 mapping for fibrosis, T2 mapping for edema/inflammation) without giving contrast.

Printed on: 10/29/20
LEARNING OBJECTIVES

1) Appraise the adequacy of CT and MR protocols for temporal bone imaging. 2) Appropriately modify temporal bone CT and MR protocols based on specific clinical indications. 3) To understand the anatomic challenges faced in imaging structures at the thoracic inlet. 4) To appreciate the importance of adequate dose in parathyroid CT imaging. 5) To be familiar with positioning techniques that will help reduce artifacts and improve visualization of parathyroid adenomas. 6) To simplify the complex imaging anatomy of the brachial plexus using clear anatomical landmarks. 7) To outline the different MR protocols that could be used to image the brachial plexus at 1.5T and 3T. 8) To illustrate the benefits of an adequate MRI technique with some examples. 9) List the MRI pulse sequences used for cranial nerve imaging. 10) Compare the imaging requirements for extracranial versus intracranial cranial nerves. 11) Describe the impact of high resolution cranial nerve imaging on clinical decision making.

Sub-Events

RC306A Optimizing Temporal Bone CT and MRI

Participants
Joseph M. Hoxworth, MD, Scottsdale, AZ (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) Appraise the adequacy of CT and MR protocols for temporal bone imaging. 2) Appropriately modify temporal bone CT and MR protocols based on specific clinical indications.

RC306B Optimizing Pituitary MRI

Participants
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LEARNING OBJECTIVES

1) Review current techniques in pituitary MRI 2) Briefly review some evidence behind which sequences provide highest yield imaging 3) Discuss potential future directions of pituitary MRI including sequences to consider adding to our protocols

Active Handout: Joshua Lantos

RC306C Optimizing TMJ MRI

Participants
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LEARNING OBJECTIVES

1. Optimize TMJ imaging techniques a) Image acquisition b) Review sequences 2. Evaluate normal TMJ anatomy 3. Briefly review MRI findings of internal derangement

RC306D Optimizing Parathyroid 4D CT

Participants
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LEARNING OBJECTIVES

1) To understand the anatomic challenges faced in imaging structures at the thoracic inlet. 2) To appreciate the importance of adequate dose in parathyroid CT imaging. 3) To be familiar with positioning techniques that will help reduce artifacts and improve visualization of parathyroid adenomas.
LEARNING OBJECTIVES

1) To simplify the complex imaging anatomy of the brachial plexus using clear anatomical landmarks. 2) To outline the different MR protocols that could be used to image the brachial plexus at 1.5T and 3T. 3) To illustrate the benefits of an adequate MRI technique with some examples.

Optimizing Cranial Nerve MRI

LEARNING OBJECTIVES

1) List the MRI pulse sequences used for cranial nerve imaging. 2) Compare the imaging requirements for extracranial versus intracranial cranial nerves. 3) Describe the impact of high resolution cranial nerve imaging on clinical decision making.
PURPOSE
To evaluate the performance of radiomic features analysis in the pre-operative assessment of superior mesenteric artery (SMA) involvement in patients with pancreatic ductal adenocarcinoma (PDA).

METHOD AND MATERIALS
104 patients with surgically-proven PDA were identified between 2013 and 2018. 80% of patients underwent neoadjuvant therapy. All patients underwent dedicated preoperative pancreatic CT (range, 3 to 105 days before surgery). As part of the standard of care, images were reviewed by a panel of experts from radiology, surgery, and medical oncology. Patients were categorized as resectable, borderline resectable, or locally advanced according to recent NCCN guidelines. Subsequently, we performed a volumetric segmentation of the primary tumor and the circumferential perivascular tissue surrounding the SMA (2.5 to 4.5-mm in diameter) using a prototype segmentation and radiomic features extraction software (Radiomics, Siemens Healthcare). Extracted features included standard intensity, size, shape, and texture properties. In addition, composite radiomic features were calculated accounting for the spatial relationships and texture features similarities between the primary tumor and the perivascular tissue. A machine learning random forest model based on radiomic features was developed and validated by 100-times cross validation for the prediction of SMA tumor involvement. Pathologic R stage of the SMA margin after surgery was used as the reference standard.

RESULTS
9 standard and 2 composite features were identified as significant predictors of SMA involvement by PDA. The diagnostic...
performance of the machine learning model was substantially higher compared to the consensus visual assessment of the expert panel (average area under the curve, AUC: 0.84 vs. 0.66). This improvement was largely related to selecting informative radiomic features by using machine learning methods (Figure).

CONCLUSION

Our study suggests that machine learning analysis of radiomic features improves the accuracy of preoperative SMA staging in patients with PDA.

CLINICAL RELEVANCE/APPLICATION

Machine learning analysis of radiomic features may provide important information for pre-operative assessment of SMA involvement in patients with PDA, which may improve patient selection for surgery.

RC309-03  Low-dose CT Update

Tuesday, Dec. 3 9:00AM - 9:20AM Room: S405AB

Participants
Amy K. Hara, MD, Scottsdale, AZ (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES

1) Recognize opportunities for reducing CT radiation dose (primarily for body imaging). 2) Be familiar with current and cutting edge CT dose reduction techniques.

Active Handout: Amy Kiyohara


RC309-04  Potential of an Image-Based Frequency-Splitting Multiband Filtration Denoising Algorithm to Reduce Radiation by 50% for Multiphase Liver CT: Impact on Metastasis Detection Potential of Image-Based Frequency-Splitting Multiband Filtration Denoising

Tuesday, Dec. 3 9:20AM - 9:30AM Room: S405AB

Participants
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PURPOSE

Image-based frequency split multiband filtration denoising (FS-MBF) uses images from one phase of enhancement to help reduce CT image noise in other phases. Our purpose is to determine if FS-MBF can be used to reduce image noise for half dose multiphase liver CT without sacrificing the ability to detect subtle hepatic metastases.

METHOD AND MATERIALS

All patients had archived projection CT data from contrast-enhanced multiphase liver CT. Metastases were confirmed with histology, or progression or regression, with benign lesions confirmed with stability. Half dose CT images were created using a validated noise insertion program, then reconstructed with FS-MBF. Anonymized routine or half dose FS-MBF images were evaluated by two radiologists in two sessions, with each patient’s exam evaluated once/session. Radiologists reviewed images, noting location of liver lesions, rating confidence in liver metastasis presence on a per lesion and per patient level (0-100 scale), and assigning scores for image quality. A confidence cutoff of 10 was used for sensitivity and specificity comparisons.

RESULTS

48 patients had 141 liver lesions (61 mets [size1.2 cm±0.9 cm], 80 benign lesions). CTDIvol was 20± 8 mGy/phase. Per metastasis sensitivity was similar between routine dose and half dose FS-MBF multiphase CT (R1 - 81% v. 77%, p = 0.3; R2 - 80 v. 77%, p = 0.4). Per patient accuracy was also similar for each radiologist (R1 - 67.0% v. 63.0%; R2 - 74.0% v. 77.0%, p=0.098 - 0.34). For patients with metastases, patient level confidence that liver metastases were present was not different for either reader between routine and half dose FS-MBF exams (R1 - mean 74 v. 85; p = 0.26; R2 - mean 69 v. 71, p = 0.65). Patient level confidence scores in patients without metastases were also similar (p = 0.26, 0.65). The mean image quality of half dose FS-MBF images was slightly but significantly lower (SD 4.4 ± 0.7 v. 4.0 ± 0.8, p = 0.0001).
CONCLUSION
Radiologist performance for detection of hepatic metastases using half dose FS-MBF multiphase liver exams was similar to routine dose, providing a new image-based method to reduce image noise for multiphase CT exams.

CLINICAL RELEVANCE/APPLICATION
An image-based method for reducing image noise for multiphase, contrast-enhanced abdominal CT shows promise as a broadly applicable noise reduction method that preserves radiologist performance at half of routine radiation dose.

RC309-05  Effects of Deep Learning Reconstruction (DLR) and Iterative Reconstruction Techniques on Sub-Milli-Sievert Chest and Abdomen-Pelvis CT: Image Quality and Lesion Detection
Tuesday, Dec. 3 9:30AM - 9:40AM Room: S405AB

Participants
Ramandeep Singh, MBBS, Boston, MA (Presenter) Nothing to Disclose
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Avinash R. Kambadakone, MD, Boston, MA (Abstract Co-Author) Research Grant, General Electric Company; Research Grant, Koninklijke Philips NV
Subba R. Digumarthy, MD, Boston, MA (Abstract Co-Author) Speaker, Siemens AG; Research Grant, Lunit Inc; Researcher, Merck & Co, Inc; Researcher, Pfizer Inc; Researcher, Bristol-Myers Squibb Company; Researcher, Novartis AG; Researcher, F Hoffmann-La Roche Ltd; Researcher, Polaris Pharmaceuticals, Inc; Researcher, Cascadia Healthcare, LLC; Researcher, Abbvie Inc; Researcher, Grdalis, Inc; Researcher, Clinical Bay; Researcher, Zai Lab
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PURPOSE
To compare image quality and lesion detection of Deep Learning Reconstruction (DLR) and Iterative Reconstruction (IR) on sub-milli-Sievert chest and abdomen-pelvis CT.

METHOD AND MATERIALS
Our study included 59 adult patients (33F:26M; age=65±12 years, BMI=27±5 kg/m2) who underwent routine chest (n=22;16F: 6M) and abdomen (n=37;17F: 20M) CT on a 640-slice MDCT (Aquilion ONE, Canon Medical Systems). All patients gave written informed consent for acquisition of low dose (LD) CT after a clinically indicated standard dose (SD) CT. The SD-CT (120kVp;164-644mAs) were reconstructed with AIDR3D (IR) and the LD-CT (100,120kVp;30-50mAs) were reconstructed with FBP, IR (AIDR3D, FIRST) and DLR. Four sub-specialty trained radiologists (R1, R2-thoracic; R3, R4-abdominal) performed subjective evaluation for chest (2mm; kernel FC18) and abdomen (2mm; kernel FC52) image sets on a four-point scale (1 = unacceptable image quality; 4 = image quality better than SD). Lesions were first detected on LD-FBP. LD (FIRST, AIDR3D, DLR) images were then compared side-by-side to SD (AIDR3D) images in an independent, randomized, and blinded fashion. Descriptive statistics and Wilcoxon sign rank test were performed.

RESULTS
CTDvol and DLP for LD-CT (2.1±0.8mGy; 49±13mGy-cm) were lower than SD-CT (13±4.4mGy;567±249mGy.cm) (p<0.0001). All 31 clinically significant lesions (such as 13 liver lesions, 5 adrenal nodules, 8 retroperitoneal nodes, 3 pancreatic lesions) were detected on SD-CT and LD-DLR. LD-AIDR3D, LD-FIRST and LD-FBP detected 25/31, 18/31, and 7/31 lesions, respectively. For chest CT, 33/39 nodules detected on LD-DLR and SD-CT were missed on LD-FBP. LD-DLR was deemed acceptable for interpretation (median score >=3) in 97% of LD abdomen and 95-100% (R1-R2s scores) of LD chest (p=0.2-0.99). LD-FBP was unacceptable for all patients (59/59) whereas LD-FIRST had unacceptable image quality in 36-39% cases (p<0.0001). LD-AIDR3D images were unacceptable in 11-49% abdomen-pelvis CT (4/37-18/37; p<0.04-0.0001) and 41-45% chest CT (9/22-10/22; p=0.002-0.003).

CONCLUSION
At sub-milli-Sievert chest and abdomen-pelvis CT doses, DLR enables superior image quality and lesion detection as compared to commercial IR and FBP images.

CLINICAL RELEVANCE/APPLICATION
Deep Learning based Reconstruction (DLR) in CT outperforms commercial iterative reconstruction techniques and provides acceptable diagnostic quality for routine chest and abdomen-pelvis CT examinations at sub-milli-Sievert radiation dose levels.

RC309-06  Oral Contrast Media Controversies for CT and MR
Tuesday, Dec. 3 9:40AM - 10:00AM Room: S405AB

Participants
Avinash R. Kambadakone, MD, Boston, MA (Presenter) Research Grant, General Electric Company; Research Grant, Koninklijke Philips NV

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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) Learn the role of oral contrast media in abdominal MRI, its benefits and controversies. 4) Optimize the use of oral contrast media to improve diagnosis.

**RC309-07 New Applications of Dual-energy CT**

**Participants**
Benjamin M. Yeh, MD, Hillsborough, CA (Presenter) Research Grant, General Electric Company; Consultant, General Electric Company; Author with royalties, Oxford University Press; Shareholder, Nextarix, Inc; Research Grant, Koninklijke Philips NV; Research Grant, Guerbet SA;

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**LEARNING OBJECTIVES**
1) Describe potential applications of dual energy CT image reconstructions to improve clinical diagnoses. 2) Apply dual energy CT to clarify the cause of ambiguous radiodensities. 3) Examine the methods by which dual energy CT may allow ‘invisible’ lesions to be better seen. 4) List ways that different dual energy CT image reconstructions can be used to minimize artifacts at CT imaging. 5) Describe potential challenges and benefits of new dual energy CT techniques for clinical decision making.

**RC309-08 Value of Dual-Energy CT Imaging for Evaluation of Intestinal Activity and Severity in Crohn’s Disease**

**Participants**
Yu Zhang, MS, Wuhan, China (Abstract Co-Author) Nothing to Disclose
Ming Yang, Wuhan, China (Abstract Co-Author) Nothing to Disclose
Xin Li, MD,PhD, Wuhan, China (Presenter) Nothing to Disclose
Ping Han, MD, Wuhan, China (Abstract Co-Author) Nothing to Disclose

**PURPOSE**
To investigate the clinical value of dual-energy CT imaging in assessing the activity and severity of Crohn's disease compared with the simple endoscopic score (SES).

**METHOD AND MATERIALS**
60 patients suspected to have Crohn's disease received both colonoscopy and dual-energy computed tomography (DECT) were involved in this study. The interval time between the two examinations was less than one week. All examinations were performed on the same dual-energy DECT scanner (SOMATOM Force, Siemens) with standardized settings for the DECT mode: tube A: 90 kV; tube B: Sn150 kV with tin filter. Dedicated software (syngo.via) with an iodine subtraction algorithm was used to calculate quantitative CT data from portal-venous phase images, including iodine concentration and fat fraction measurements. According to the Simple Endoscopic Score for Crohn's Disease (SES-CD), 60 patients were divided into 4 groups(Group A: Score=0-2, n=8; Group B: Score=3-6, n=14; Group C: Score=7-15, n=22; Group D: Score>=16, n=16). Each patient's ROI measurements were repeated nine times and mean values were taken into account. Mean values of the iodine concentration of lesions and surrounding adipose tissue, the fat fraction of lesions and surrounding adipose tissue were used for the evaluation.

**RESULTS**
The iodine concentration of lesions(0.87±0.45, 0.99±0.36, 1.17±0.55, 1.94±0.54), the iodine concentration of surrounding adipose tissue(0.23±0.09, 0.42±0.10, 0.66±0.11, 1.56±0.29), the fat fraction of lesions(27.34±2.34, 25.55±1.33, 15.64±2.91, 10.36±2.71)and the fat fraction of surrounding adipose tissue(90.52±5.04, 85.31±4.06, 71.35±4.34, 63.74±4.84)of four groups were found statistically significant different (P<0.01); the iodine concentration of lesions and surrounding adipose tissue among Group A, Group C and Group D were statistically different(P<0.05); the fat fraction of lesions and surrounding adipose tissue among Group B, Group C and Group D were statistically different(P<0.05).

**CONCLUSION**
The iodine concentration and the fat fraction derived from dual-energy CT imaging can be used to evaluate the activity and severity of Crohn's disease.

**CLINICAL RELEVANCE/APPLICATION**
dual-energy CT had sensitivity in detecting intestinal activity and severity of CD, which could be an alternative choice in evaluation of CD. The ultimate purpose of this study was to establish the standards of evaluating the activity of Crohn's disease using dual-energy CT in the future.

**RC309-09 Role of Dual-Energy Computed Tomography in the Evaluation of Liver Fibrosis in Patients of Chronic Liver Disease**

**Participants**
Uday K. Marri, MBBS,MD, Delhi (Presenter) Nothing to Disclose
Shalimar Shalimar, MBBS,MD, Delhi, India (Abstract Co-Author) Nothing to Disclose
Prasenjit Das, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Deepnarayan Srivastava, Delhi, India (Abstract Co-Author) Nothing to Disclose
Raju Sharma, MD, New Delhi, India (Abstract Co-Author) Nothing to Disclose
Madhusudhan Kumkle Seetharama, MD, FRCR, New Delhi, India (Abstract Co-Author) Nothing to Disclose

**Awards**
Trainee Research Prize - Resident
To quantify liver fibrosis in patients of chronic liver disease (CLD) using delayed phase dual-energy computed tomography (DECT) and comparing it with liver elastography and histology.

RESULTS

The NIC of liver in cases showed high positive correlation with METAVIR staging and CPA (r= 0.810 and 0.665 respectively; p<0.0001). Area under ROC curve for NIC with each METAVIR stage ranged between 0.860 and 0.961. The cut-off values (with sensitivity and specificity) of NIC for different fibrosis stages were: >/=F1 = 0.243 (85.1%, 83.3%), >/=F2 = 0.289 (83.7%, 81.4%), >/=F3 = 0.343 (86.9%, 86.8%), =F4 = 0.401 (93.3%, 84.7%), respectively. The mean NIC of liver in controls was 0.233. Spectral curve slope in cases showed poor correlation with histology (r= 0.265, p<0.006). The NIC of right lobe showed moderate agreement with LS measured by TE and SWE (r =0.599 and 0.635 respectively, p<0.0001). The LS on TE and SWE in cases showed good correlation with METAVIR stage (r= 0.704 and 0.736 respectively; p<0.0001).

CONCLUSION

The NIC of the liver on delayed phase DECT is accurate in non-invasive quantification of liver fibrosis and is better than liver elastography.

CLINICAL RELEVANCE/APPLICATION

Biopsy or elastography cannot quantify fibrosis of the entire liver. The delayed phase DECT is promising in assessing liver fibrosis and may become a one-stop shop for evaluating patients with CLD.

RC309-10 Comparison between ROI-Based and Volumetric Measurements of Liver Fibrosis Using MR Elastography in Quantifying Heterogeneity of Liver Stiffness

Participants
Roya Rezvani Habibabadi, Baltimore, MD (Presenter) Nothing to Disclose
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Ankur Pandey, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Ihab R. Kamel, MD, PhD, Baltimore, MD (Abstract Co-Author) Research Grant, Siemens AG

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PURPOSE

To compare ROI-based and volumetric measurements in quantifying heterogeneity of liver stiffness (LS) using MRE.

METHOD AND MATERIALS

In this retrospective, IRB approved study, 128 patients with suspected liver fibrosis and MRE were reviewed between 12/2016 and 12/2017. LS was measured using: 1) the average of 3 Regions of interest (ROI), and 2) volumetric segmentation of the entire liver parenchyma (excluding vessels) using a semi-automatic software. Mean LS (MLS) of the 2 methods was calculated for each patient. Stages of fibrosis were defined using previously tested thresholds. Each patient was assigned to one of the 5 stages of fibrosis (MLS-stage) based on their ROI-MLS. Volumetric measurement of stiffness maps was also used to calculate the full range of LS and percentage involvement of the liver with each stage of fibrosis. Accordingly, specific proportions were defined: 1) above MLS-stage: percentage of the liver that has LS at least one category higher than MLS-stage, and 2) the first and second most predominant stages of fibrosis. Heterogeneous stiffness was defined when the first and second most predominant stages were more than one category apart.

RESULTS

The mean age of patients was 54 ±15 years; 46% were female. The average of MLS was 2.72 ±1.03 kPa for ROI measurements and 2.64 ±0.93 kPa for volumetric method (p=0.001). As per MLS-stage, 59 (46%), 19 (15%), 13 (10%), 26 (20%) and 11 (8%) patients were assigned to stages F0, F1, F2, F3, and F4. In 58 patients (45%), more than 20% of liver had stiffness at least one stage higher than MLS-stage. Among 59 patients with normal MLS-stage (F0), 31 patients (53%) had >20% of liver volume with abnormal LS (F1-F4). In all 128 patients, an average of 20% of the liver volume had stiffness at least one stage higher than each individual's MLS-stage. By definition, 18 patients (14%) were identified to have heterogeneous stiffness.

CONCLUSION
Heterogeneity of hepatic fibrosis may occur in patients with chronic liver disease. MLS may not represent the entire spectrum of hepatic fibrosis. Failure to detect heterogeneity in its early stage could cause a delay in treatment initiation and progression of fibrosis.

**CLINICAL RELEVANCE/APPLICATION**

Volumetric segmentation and descriptive reporting of LS can potentially improve the detection of heterogeneous fibrosis in the liver and the accuracy of LS measurement. It helps to establish a more timely and precise management plan for each patient.

**RC309-11 Dual-Layer Spectral CT of Pancreatic Adenocarcinoma: Can Virtual Monoenergetic Imaging of Portal Venous Phase Replace Pancreatic Phase?**

**Tuesday, Dec. 3 11:20AM - 11:30AM Room: S405AB**

**Participants**
Beom Jin Park, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Yeo Eun Han, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
Min-Ju Kim, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
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Ki Choon Sim, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Hyun Jin Kim, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Deuk Jae Sung, MD, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Sung Bum Cho, Seoul, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**
To evaluate diagnostic performance and optimal keV of virtual monoenergetic imaging (VMI) created from portal venous phase in comparison with conventional 120kVp polychromatic imaging of pancreatic phase on dual-layer spectral CT when assessing pancreatic adenocarcinoma and peripancreatic vasculature.

**METHOD AND MATERIALS**
In this retrospective study, thirty patients with pancreatic adenocarcinoma who underwent dual-layer spectral CT scan with nonenhanced images, pancreatic phase, and portal venous phase were included. VMIs for 40 keV (VMI40), 55 keV (VMI55), and 70 keV (VMI70) of portal venous phase were created, and each VMI was compared with conventional 120kVp polychromatic imaging of pancreatic phase. In all four images, tumor-to-pancreas contrast-to-noise ratio (CNR) and attenuation difference were compared for tumor conspicuity. CNR and signal-to-noise ratio (SNR) of the celiac trunk, superior mesenteric artery, portal vein, and superior mesenteric vein were compared for peripancreatic vasculature assessment. Effective radiation dose for standard triple-phase and dual-phase without pancreatic phase CT scan were compared.

**RESULTS**
VMI40 of portal venous phase demonstrated significantly the greatest (P <0.001) tumor-to-pancreas CNR and attenuation difference, peripancreatic vascular CNR and SNR than those of conventional pancreatic phase and VMI55, VMI70 of portal venous phase. VMI55 of portal venous phase demonstrated second greatest (P < 0.001) results in all measured values. VMI70 of portal phase and conventional pancreatic phase were equivalent in tumor-to-pancreas attenuation difference and CNR of arteries (celiac trunk and superior mesenteric artery). Mean effective dose was 12.8±3.9 mSv and 8.9±2.7 mSv for standard triple-phase CT scan and dual-phase CT scan without pancreatic phase, respectively.

**CONCLUSION**
For assessing pancreatic adenocarcinoma, VMI40 of portal venous phase obtained on dual-layer spectral CT demonstrated superior tumor conspicuity, higher CNR and SNR for peripancreatic vasculature than those of conventional pancreatic phase.

**CLINICAL RELEVANCE/APPLICATION**
VMI40 of portal venous phase may replace conventional pancreatic phase with better diagnostic performance and reduced radiation dose. Further study in greater population may be required.

**RC309-13 Advances in Molecular Imaging for the Abdomen**

**Tuesday, Dec. 3 11:40AM - 12:00PM Room: S405AB**

**Participants**
Thomas A. Hope, MD, San Francisco, CA (Presenter) Research Grant, General Electric Company; Research Grant, Koninklijke Philips NV; Advisory Board, Ipsen SA; Researcher, Advanced Accelerator Applications SA

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**LEARNING OBJECTIVES**
1) Identify approved imaging agents for prostate cancer. 2) Describe the role of somatostatin receptor PET agents for staging neuroendocrine tumor. 3) Assess the limitations and opportunities of molecular imaging moving forward.

Printed on: 10/29/20
Advances in Cone Beam CT Acquisition and Reconstruction in Radiotherapy

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S503AB

CT  PH  RO

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

Participants
Douglas Moseley, PhD, Toronto, ON (Moderator) License agreement, Modus Medical Devices Inc

Sub-Events

RC322A  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

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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.

RC322B  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: a) Image-Guided Radiotherapy (IGRT) with more precise tumor localization and better patient setup, b) 4D CBCT in managing respiratory motion, and c) adaptive radiotherapy (ART).

RC322C  Technical Challenges in the Integration of CBCT Imaging into Radiotherapy

Participants
Douglas Moseley, PhD, Toronto, ON (Presenter) License agreement, Modus Medical Devices Inc

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.

Active Handout: Douglas Moseley

Printed on: 10/29/20
CT Dose Monitoring: Nuts, Bolts, and Tools... and What We Need to Build

Tuesday, Dec. 3 8:30AM - 10:00AM Room: N226

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

Participants
Donald P. Frush, MD, Menlo Park, CA (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

**RC324A  Fundamentals (Nuts and Bolts) and Current Products (Tools)**

Participants
Sarah E. McKenney, PhD, Stanford, CA (Presenter) Nothing to Disclose

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.

**RC324B  CT Dose Monitoring Status in Adults (Including Diagnostic Reference Levels)**

Participants
Kalpana M. Kanal, PhD, Seattle, WA (Presenter) Nothing to Disclose

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.

**RC324C  CT Dose Monitoring Status in Children (Including Diagnostic Reference Levels)**

Participants
Donald P. Frush, MD, Menlo Park, CA (Presenter) Nothing to Disclose

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.

**RC324D  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 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.

Printed on: 10/29/20
RC331A  Percutaneous Lung Biopsy

Participants
Christopher Lee, MD, Los Angeles, CA (Moderator) Nothing to Disclose

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LEARNING OBJECTIVES
1) Evaluate the role of percutaneous lung biopsy in the molecular profiling era. 2) Utilize various techniques during percutaneous lung biopsy to maximize the chances of success and limit complications. 3) Apply strategies to prevent and manage a post-biopsy pneumothorax.

Sub-Events

RC331B  Percutaneous Lung Nodule Localization

Participants
Amita Sharma, MD,MBBS, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Explain how percutaneous localization aids nodule resection during minimally invasive surgery. 2) Compare different techniques used for percutaneous nodule localization. 3) Identify complications that may occur during percutaneous nodule localization.

RC331C  Percutaneous Lung Ablation

Participants
Fereidoun G. Abtin, MD, Los Angeles, CA (Presenter) Speaker, Johnson & Johnson; Speaker, HealthTronics, Inc; Consultant, BTG International Ltd

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LEARNING OBJECTIVES
1) Describe the current indications for lung ablation and compare the ablation results with competing modalities. 2) Review the criteria affecting the choice of various ablative modalities in particular RFA, Microwave and cryoablation. 3) Technical considerations to optimize the ablation results and to avoid or reduce complication. 4) Brief outline of Interventional Oncology outpatient clinic and post ablation follow up recommendations.

Printed on: 10/29/20
Case-based Review of Nuclear Medicine: PET/CT Workshop-Chest (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Dec. 3 10:30AM - 12:00PM Room: E450B

LEARNING OBJECTIVES

1) List the various guidelines used to determine follow up recommendations for pulmonary nodules. 2) Analyze clinical scenarios as to which nodule follow up guideline is most appropriate. 3) Describe how FDG PET can be used to guide pulmonary nodule management.

ABSTRACT

This review course lecture will guide radiologists in the imaging management of pulmonary nodules. We will review the various guidelines used to determine pulmonary nodule follow up and the clinical scenarios for when each is appropriate. Finally, we will review how FDG PET can be used to guide pulmonary nodule management.

PET/CT for Breast Cancer: Where is the Clinical Impact?

LEARNING OBJECTIVES

1) Review the strengths and weaknesses of FDG PET/CT for evaluation of a primary breast malignancy, axillary and extra-axillary nodal metastases, and distant metastases. 2) Review the utility of FDG PET/CT for measuring breast cancer treatment response. 3) Understand that not all breast cancers are the same; there is recent data that breast histology may influence imaging interpretation.

ABSTRACT

FDG PET/CT impacts the management of patients with breast cancer in multiple settings, including initial staging, treatment response, and evaluation of suspected recurrence. This lecture reviews the strengths and weaknesses of FDG PET/CT for staging of the primary breast malignancy, axillary and extra-axillary nodal metastases, and distant metastases. The utility of FDG PET/CT for measuring breast cancer treatment response is appraised. The role tumor histology may have on PET/CT interpretation is discussed. National Comprehensive Cancer Network (NCCN) guidelines for patients with breast cancer are reviewed. Emphasis is given where FDG PET/CT has demonstrated clinical impact.

Printed on: 10/29/20
Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIt Technologies, LLC; Stockholder, VoiceIt Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This course describes a more recent advance in deep learning known as Generative Adversarial Networks (GANs). GANs are a deep learning technology in which a computer is trained to create images that look very 'real' even though they are completely synthetic. Getting 'large enough' data sets is a problem for most deep learning applications, and this is particularly true in medical imaging. This may be one way to address the 'data shortage' problem in medicine. GANs have also been created that can convert MRIs to CTs (e.g. for attenuation correction with MR/PET).
PURPOSE

Although 18F-Fluorodeoxyglucose (18F-FDG) Positron Emission Tomography (PET) with computed tomography (CT) is an essential tool in diagnosing prosthetic heart valve (PHV) endocarditis, the normal uptake patterns after PHV implantation have not been studied prospectively. We prospectively assessed perivalvular FDG uptake at different time points after aortic PHV implantation.

METHOD AND MATERIALS

Patients who had undergone uncomplicated aortic PHV implantation were included and underwent 18F-FDG PET/CT at 5(±1) weeks (group 1), 12(±2) weeks (group 2) or 52(±8) weeks (group 3) after implantation. After a preparatory diet to suppress normal myocardial glucose uptake, FDG uptake in the myocardium as well as around the PHV was scored using the Qualification Visual Score for Hypermetabolism (QVSH) as 'none' (< mediastinum), 'mild' (> mediastinum but < liver), 'moderate' (> liver), or 'severe' (intense uptake) and quantitative analysis was performed with maximum Standardized Uptake Value (SUVmax) and target to background ratio (SUVratio) on standardized European Association of Nuclear Medicine Research Ltd. (EARL) reconstructions by an experienced nuclear medicine physician.

RESULTS

In total 37 patients (group 1: n=12, group 2: n=12, group 3: n=13) (age 66±8 years) were included. Myocardial FDG uptake was moderate or less in 29/37 scans (78%). QVSH around the PHV was in 8/12 (67%) mild and 4/12 (33%) moderate in group 1, 7/12 (58%) mild and 5/12 (42%) moderate in group 2 and 8/13 (62%) mild and 5/13 (38%) moderate in group 3 (p=0.91). No scan was scored as 'none' or 'severe'. EARL SUVmax was 3.48±0.57, 3.50±0.59 and 3.34±0.55 (mean±SD, p=0.77) and EARL SUVratio was 2.00±0.29, 1.96±0.41 and 1.71±0.26 (mean±SD, p=0.07) for groups 1, 2 and 3, respectively.

CONCLUSION

Baseline FDG uptake around aortic PHV at 5, 12 and 52 weeks after implantation is similar and mild in the majority of cases with an overall mean SUVmax and SUVratio of 3.44±0.56 and 1.89±0.34 respectively.

CLINICAL RELEVANCE/APPLICATION

Knowing the normal baseline FDG uptake around prosthetic heart valves on 18F-FDG-PET-CT is essential to discriminate between normal and infected valves in patients suspected of endocarditis.
CONCLUSION

Automated 3D measurement of ECV in cardiac CT is feasible and well correlated with manual measurements and CMR values. These calculated with synthetic hematocrit did not significantly differ from biological ones.

RESULTS

In the pilot group, CT-derived PI was 1.33±0.27ml/min/g and PET-MBF value was 2.80±0.84 ml/min/g, respectively. From these data, the relationship between E and MBF was E = 1-exp[-(0.11×MBF+1.58)/MBF]. In the validation group, CT-MBF was 2.40±2.03ml/min/g, while PET-MBF was 2.54±2.03ml/min/g. CT-MBF showed a good linear correlation with PET-MBF (r= 0.93, P<000.1). The measurement bias in measuring MBF between CT and PET was 0.14±0.73ml/min/g.

CONCLUSION

The relationship between E of iodine contrast medium and MBF was determined in this study. By using the relationship, stress MBF can be accurately quantified from the perfusion index obtained from dual-source CT and its dedicated analysis software.

CLINICAL RELEVANCE/APPLICATION

CT-MBF quantification has potential to provide detection of perfusion abnormality and risk stratification in patients with known or suspected CAD with high accuracy comparable to 15O-water PET.

SSG02-04 Development of an Automated Software for 3D Quantification of Extracellular Volume in Cardiac CT: Comparison with Cardiac MRI

Tuesday, Dec. 3 11:00AM - 11:10AM Room: S104A

Participants

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PURPOSE

The objective of our study is to develop and validate a software for automatic three-dimensional (3D) measurement of myocardial extracellular volume (ECV) in cardiac CT compared to CMR in patients with cardiac amyloidosis (CA).

METHOD AND MATERIALS

Twenty patients with a proven diagnosis of CA and 20 control patients free of cardiac pathology were included. Unenhanced and late enhanced (5 minutes) cardiac CT images were analyzed automatically by the software. Duration of processing was recorded. Manual measurements of myocardial attenuation were performed on both sets of images by one operator within the interventricular septum (IVS) as usually performed in clinical practice. Automatic and manual values of ECV were calculated using biological hematocrit and synthetic hematocrit (derived from blood pool attenuation values). Measurements were correlated together and with MR measurements for all patients.

RESULTS

3D automatic segmentation of unenhanced and late enhanced cardiac CT images was successfully performed by the software for all patients. The duration of myocardial segmentation was 20 +/- 5 seconds. The software was able to provide 3D ECV values for all patients. Automated (30+/−20%) and manual (32+/−18%) measurements of ECV were well correlated each other (r2=0.8; p<0.005), and significantly correlated (r2=0.7; p<0.05) with the ECV measured by CMR (34+/−21%). Automatic and manual ECV values calculated with synthetic hematocrit did not significantly differ from biological ones.

CONCLUSION

Automated 3D measurement of ECV in cardiac CT is feasible and well correlated with manual measurements and CMR values. These
results have to be confirmed on a wider range of patients (work in progress)

**CLINICAL RELEVANCE/APPLICATION**

Myocardial extracellular volume (ECV) is a good diagnostic and prognostic marker in cardiac diseases. ECV measurement is traditionally performed with cardiac magnetic resonance (CMR). Assessment of ECV in cardiac CT may help to use it more often in clinical practice.

**SSG02-05**  
Assessment of Myocardial Extracellular Volume on Routine Body Computed Tomography in Breast Cancer Patients Treated with Anthracyclines  

Tuesday, Dec. 3 11:10AM - 11:20AM Room: S104A

**Participants**

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**PURPOSE**

To evaluate the feasibility of estimating myocardial extracellular volume (ECV) on routine thoracic contrast-enhanced CT in breast cancer patients, and, if feasible, to assess if a rise in ECV is associated with anthracyclines administration even in absence of clinical symptoms or echocardiographic changes.

**METHOD AND MATERIALS**

After Ethics Committee approval, female patients with breast cancer who had undergone routine CT examinations at our institution before and shortly after the end of chemotherapy including anthracyclines were retrospectively evaluated. Patients without available haematocrit, with CT images with artefacts, or who had undergone radiation therapy of the left breast were excluded. Follow-up CT examinations were also analysed, when available. ECV was calculated on scans obtained at about 1, 3, and 7 min after contrast injection.

**RESULTS**

Thirty-two female patients (aged 57±13 years, mean±standard deviation) with pre-treatment haematocrit 38±4%, and ejection fraction 64±6% were analysed. Pre-treatment ECV was 27.0±2.9% at 1 min, 27.4±3.8% at 3 min, and 26.4±3.8% at 7 min, similar to normal values reported for normal subjects in the literature. Post-treatment ECV (median interval: 89 days after treatment) was 31.1±4.9%, 32.5±5.0%, and 30.0±5.1%, respectively, values significantly higher than pre-treatment values at all times (p < 0.005). ECV at follow-up (median interval: 135 days after post-treatment CT) was 31.0±4.5%, 30.0±4.3%, and 27.7±4.3%, respectively, without significant differences (p > 0.548) when compared to post-treatment values.

**CONCLUSION**

After anthracyclines treatment, ECV was significantly higher than pre-treatment values. In the follow-up ECV remains higher than pre-treatment values.

**CLINICAL RELEVANCE/APPLICATION**

Myocardial ECV values from routine contrast-enhanced CT scans could play a role in the assessment of myocardial condition in breast cancer patients undergoing anthracycline-based chemotherapy.

**SSG02-06**  
Cardiac Energetics Alteration in Chronic Hypoxia Rat Model: A Non-Invasive In Vivo 31P Magnetic Resonance Spectroscopy Experimental Study  

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S104A

**Participants**

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**PURPOSE**

Energetics alteration plays a key role in the process of myocardial injury in chronic hypoxic diseases (CHD). 31P magnetic resonance spectroscopy (MRS) can investigate alterations in cardiac energetic in vivo. This study was aimed to characterize the potential of 31P MRS in evaluating cardiac energetics alteration of chronic hypoxia rats (CHR).

**METHOD AND MATERIALS**

Thirty CHR were induced by SU5416 combined with hypoxia. 31P MRS (Bruker BioSpec 7.0T) was performed weekly (0-5 week) to follow-up the ratio of concentrations of phosphocreatine (PCr) to adenosine triphosphate (ATP) (PCr/ATP). The index of myocardial structure and systolic function, including the left ventricular function (LVEF) and the right ventricular function (RVEF), were also measured by magnetic resonance imaging (MRI) in each rat. The myocardial injury was shown based on hematoxylin and eosin (H&E) staining and Masson’s trichrome staining.
RESULTS
Along weeks, the resting cardiac PCr/ATP ratio decreased from 0 to 5 weeks of modeling. The ratio dropped more markedly after injection of isoproterenol and recovered slowly thereafter. The declension of resting cardiac PCr/ATP ratio in CHR can be observed at the first week, compared with the healthy ones(3.92±0.43vs.4.48±0.56, P<0.05). While the LVEF and RVEF in CHR was similar to healthy rats. Also, the myocardial injury cannot be observed in the first week.

CONCLUSION
31P MRS can sensitively reveal the cardiac energetics alteration in CHD before the onset of myocardial injury and ventricular dysfunction.

CLINICAL RELEVANCE/APPLICATION
31P MRS at 7.0 T can investigate cardiac energetics alteration in chronic hypoxia rat. Of note, defects in energy regulation were present before detectable myocardial injury and ventricular dysfunction.

SSG02-07  Complete Free-Breathing Adenosine Stress Cardiac MRI Using Compressed Sensing and Motion Correction: Comparison of Functional Parameters, Perfusion and Late Enhancement with the Standard Examination in Breathhold

Tuesday, Dec. 3 11:30AM - 11:40AM Room: S104A

Participants
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PURPOSE
Stress cardiac MRI (CMR) is a demanding examination with multiple breathholds (BH) and long scan times. Aim of this study was to compare free breathing (FB) examinations with the gold standard acquired in BH.

METHOD AND MATERIALS
40 consecutive patients were enrolled prospectively and examined on a 3T MRI. Functional imaging, perfusion and late gadolinium enhancement (LGE) were performed in BH and in FB using compressed sensing and inline motion correction. Left (LV) and right ventricle (RV) functional parameters in BH and FB were compared using Bland-Altman plots and subjective image quality was assessed on a 5-point scale (1=non diagnostic to 5=very good). For perfusion and LGE imaging diagnostic confidence was rated on a 3-point scale (1=low up to 3=high) and image quality on a 5-point scale (1=non diagnostic to 5=very good). Wilcoxon test was used to compare image quality and diagnostic confidence.

RESULTS
Bland-Altman plots showed good agreement for LV and RV functional parameters in BH and FB. Subjective image quality was significantly better with BH for LV (p<0.01) but comparable for RV (p=1.0). Scan time for cine BH was 218s (range 130s-385s), for cine FB 16s (range 11-27s). Extent of perfusion defects, LGE and diagnostic confidence was comparable between both groups. Scan time for LGE BH was 371s (range 239-502s), for LGE FB 189s (range 122-286s).

CONCLUSION
FB adenosine stress CMR examination delivers diagnostic image quality and could represent an alternative for patients who are unable to meet the demands of multiple BH and long examination times.

CLINICAL RELEVANCE/APPLICATION
Free breathing stress cardiac MRI can be performed in significantly shorter time than the gold standard in breathhold.

SSG02-08  Image Quality and Reliability of a Novel Dark Blood Late Gadolinium Enhancement Sequence in Ischemic Cardiomyopathy

Tuesday, Dec. 3 11:40AM - 11:50AM Room: S104A

Participants
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Transfer Learning has Potential to Produce Better Reconstruction of Highly-Accelerated, Single-Shot LGE Images than Conventional Deep Learning

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S104A

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PURPOSE
To assess the reliability of a novel dark-blood LGE (DBLGE) technique compared to standard bright-blood LGE (SBBLGE) sequence in patients with ischemic cardiomyopathy

METHOD AND MATERIALS
This prospective study included 78 patients (63.1 ± 12.6 years, 62 males) with clinical history of ischemic cardiomyopathy who underwent CMR at 1.5T (Discovery MR450w, GE Healthcare, Waukesha, WI) with postcontrast SBBLGE and DBLGE acquisition. Two observers performed the imaging analysis in a double blinded fashion. The endpoints were: a) qualitative and quantitative analysis of signal intensity ratio (SIR) b) n° segments involved; c) transmurality index (i.e. 0-25%;25-50%;50-75%and75-100%) d) papillary muscle enhancement e) microvascular occlusion (MVO). Statistical analysis was performed with non-parametric test.

RESULTS
There were no interobserver variability (all p >0.05). Subjective image quality in DBLGE compared to SBBLGE was higher for the discrimination between LGE and blood signal (p<0.001), inferior (p<0.001) between LGE and myocardium and similar between blood and myocardium (p=0.56). DBLGE provided higher SIR between LGE and blood signal (1.18±1.15vs0.18±0.42;p<0.001), lower SIR between LGE and myocardium (0.91±4.95vs1.96±1.64;p<0.001) and between blood and myocardium (-0.26±4.71vs1.57±1.26;p<0.001). The n° segments involved was similar (p = 0.08). The transmurality index was inferior for DBLGE (3.09±1.02vs3.30±1.11;p=0.007). DBLGE was superior in identifying papillary muscle hyperenhancement (25vs17 cases;p<0.001) and inferior in MVO detection (7vs12 cases;p<0.001).

CONCLUSION
The DBLGE sequences when compared to SBBLGE provided better contrast between LGE and blood-pool, seemed to be superior in identifying papillary muscle hyperenancement, whereas underestimated the trasmurality extension of LGE and the presence of MVO.

CLINICAL RELEVANCE/APPLICATION
Black blood LGE can be extremely useful for evaluation of patients with ischemic cardiomyopathy, however it would be carefully evaluated in patients with acute myocardial infarction.

Transfer Learning has Potential to Produce Better Reconstruction of Highly-Accelerated, Single-Shot LGE Images than Conventional Deep Learning

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S104A

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PURPOSE
Compressed sensing (CS) is capable of highly accelerating single-shot late gadolinium enhanced (LGE) MRI for achieving relatively high spatial resolution (1.6mmx1.6mm), but the lengthy image reconstruction time (~50s per image) and inconsistent performance hinder its clinical translation. Given limited training data, we propose a transfer learning (TL) approach to leverage our access to a large database of real-time cine images having similar image content as single-shot LGE, for developing a rapid image reconstruction framework for single-shot LGE.

METHOD AND MATERIALS
Image reconstruction was performed on a GPU workstation equipped with Pytorch. As shown in Figure 1, we pre-trained two deep learning (DL) networks (one for real and another for imaginary data, layer depth = 3, 64 features on the first layer) using existing 5811 (42 rays per frame) zero-filled and the corresponding CS reconstructed (total variation as constraint) real-time cine images from 19 patients (mean age = 66.1 ± 12.0 years; 8 females) as input/output pairs. For TL, we prospectively obtained 2-shot (42 radial spokes per shot), breath-held LGE data sets from 12 patients (mean age = 51.1 ± 20.3 years; 6 females) and compared TL to CS and DL reconstructed images.

RESULTS
As shown in Figure 1, TL produced sharper images and fewer residual artifacts than DL and CS. Both edge sharpness (1.8±0.4mm) and CNR for TL (33.5 ± 18.8) were significantly (p<0.05) different from DL (2.3 ±0.4 mm and 27.0 ± 15.7) and CS (1.9 ± 0.4mm and 15.9 ± 7.6). The reconstruction time for DL and TL (0.7 ± 0.0s) was significantly (p <0.05) lower than CS (49.6 ± 1.1s).

CONCLUSION
This study demonstrates a TL approach to rapidly reconstruct 1-shot LGE with better image quality than a conventional DL approach.

CLINICAL RELEVANCE/APPLICATION
While CS is capable of highly accelerating data acquisition, the lengthy image reconstruction hinders its clinical translation.
While CS is capable of highly accelerating data acquisition, the lengthy image reconstruction hinders its clinical translation. Transfer learning enables rapid image reconstruction without requiring a large database of training data.
Science Session with Keynote: Chest (Pulmonary Vasculature and Angiography/Dual Energy CT)

Tuesday, Dec. 3 10:30AM - 12:00PM Room: S404CD

SSG03-01 Chest Keynote Speaker: Issues and Techniques in Imaging of Pulmonary Vasculature

Tuesday, Dec. 3 10:30AM - 10:40AM Room: S404CD

Participants
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Carole A. Ridge, MD, London, United Kingdom (Moderator) Nothing to Disclose

SSG03-02 CT Pulmonary Angiography in Pregnancy Specific Conversion Factors to Estimate Effective Radiation Dose from Dose-Length Product

Tuesday, Dec. 3 10:40AM - 10:50AM Room: S404CD

Participants
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PURPOSE
Effective dose (ED) is used to understand radiation related malignancy risk of CT scans. Currently, ED for computed tomography pulmonary angiography (CTPA) in pregnancy is estimated by multiplying the CT reported dose length product (DLP) by a DLP-to-ED conversion factor (k-factor) for general chest CT. The purpose of this study is to determine the specific k-factor for CTPA in pregnant patients and its predictive factors.

METHOD AND MATERIALS
This retrospective study evaluates consecutive CTPA in pregnant women across a large health system from January 2012 to April 2017. Patient and CT-related data were obtained from the radiology information system, the picture archiving and communication system, and a radiation dose index monitoring system. Each patient’s ED (mSv) was determined by patient specific Monte-Carlo simulation using Cristy phantoms and divided by study DLP to determine k-factor. K-factor was compared to the standard k factor for chest CT of 0.014 with one sample t-test. Patient size was determined by the CT scanner in water equivalent diameter. Bivariate and multivariable analysis were performed for k-factor based on patient and CT factors.

RESULTS
534 patients were included in this study. The mean k-factor for all patients was 0.0249 (mSv·mGy-1·cm-1), 78% greater than 0.014 (p<0.001). Multivariable analysis demonstrated lower k-factor was observed with decreasing pitch (p=0.0002), patient size (p<0.001), and scan length (p=0.0001). 120 kVp (p< 0.001) and 140 kVp (p=0.0028) studies showed a larger k-factor than 80 and 100 kVp studies combined.

CONCLUSION
The k-factor for CTPA for pregnant patients higher than the previously used value for chest CT, which statically increased with decreasing pitch, patient size, and scan length, and was higher for larger kVp values.

CLINICAL RELEVANCE/APPLICATION
The specific k-factor for CTPA in pregnancy should be used to estimate effective radiation dose in that population.

SSG03-03 Patterns of Failure of an AI-Based Software: A Report on False Positive Findings of an Algorithm Detecting Pulmonary Embolism on CT Pulmonary Angiograms
**PURPOSE**

To detect patterns of false positive (FP) findings of an algorithm trained for the detection of pulmonary embolism (PE) in CT pulmonary angiograms (CTPAs) and derive future directions for software development.

**METHOD AND MATERIALS**

We identified all CTPAs with the clinical question of PE performed at our institution in 2017 (n=1465). The 1-mm slices in soft-tissue kernel were processed by an AI-based software for the detection of PE trained on more than 28,000 CTPAs from other institutions. It was based on a deep convolutional neural network with a residual neural network architecture. Findings suspected of presenting a pulmonary embolus were marked by an arrow on the output series. Findings were reviewed by two radiologists and classified as true positive or FP. Frequency and reasons of FP findings were noted. Ratio of FP findings per case was calculated.

**RESULTS**

In total, we found 178 FP findings (0.12 FP/case). The six most frequent causes of FP findings were contrast agent related flow artifacts in the pulmonary arteries (n=46), detection of pulmonary veins (n=32), lymph nodes (n=29), pulmonary infiltrates, (n=20), beam hardening artifacts (n=12) and pulmonary metastases (n=10). For all but three FP findings, there was an anatomical correlate (175 of 178; 98.3%). Most FP findings were caused by structures outside the pulmonary tree (120 of 178; 67.4%). A large portion of FP findings was due to non-tubular structures (79 of 178; 44.4%).

**CONCLUSION**

Most FP findings can be attributed to a limited number of categories comprising clearly visually definable structures. These are often located outside the pulmonary artery tree and/or non-tubular. Therefore, both segmentation of the artery tree and the integration of algorithms detecting nodular structures may be measures to further reduce FP findings.

**CLINICAL RELEVANCE/APPLICATION**

Irrespective of the performance level of an AI-based algorithm, it is recommended to identify patterns underlying failure to further improve accuracy.

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**SSG03-04 Machine Learning Assisted Risk Stratification of Acute Pulmonary Embolism on Computer Tomography Pulmonary Angiography Images**

**PURPOSE**

This study aims to investigate the value of a machine-learning prediction model based on radiomics features derived from computer tomography pulmonary angiography (CTPA) images in risk stratification of acute pulmonary embolism (APE) patients.

**METHOD AND MATERIALS**

30 APE patients confirmed by CTPA were divided into high-risk (n = 15) and non-high-risk (n = 15) groups according to 2014 European Society of Cardiology guidelines. Radiomics features were extracted from the manually segmented region of interest (ROI), and independent t test and least absolute shrinkage and selection operator (LASSO) were used for feature selection. A step-forward Multiple Linear Regression was used to build a risk stratification model with the selected features.

**RESULTS**

Among 1746 radiomics features, 7 features were eventually selected as the most discriminative features, including 0 short low gray level, 5-7 Correlation, 2Gauss Area, Hist Area, Convex Hull Volume, Energy and Skewness. In the step-forward-linear-regression, only 5-7 Correlation, Convex Hull Volume and Energy were included, R square of the equation is 0.899.

**CONCLUSION**

The radiomics-based machine learning is useful strategy of risk stratification of CTPA images of APE patients.

**CLINICAL RELEVANCE/APPLICATION**

The radiomics-based machine learning provides a useful strategy of risk stratification of CTPA images of APE patients.
Comparison of a New Deep Learning-Based Image Reconstruction (DLIR) with Conventional Image Reconstruction for CT Pulmonary Angiography (CTPA)

Tuesday, Dec. 3 11:10AM - 11:20AM Room: S404CD

Participants
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PURPOSE
A recently introduced deep learning based image reconstruction (DLIR) algorithm (TrueFidelityTM, GE Healthcare) aims to emulate very high dose FBP image texture, with low noise and high-resolution by employing deep CNN-based models, including millions of trained parameters. This study aims to compare image quality of the DLIR algorithm with standard image reconstruction in CTPA.

METHOD AND MATERIALS
52 CTPA studies scanned during routine clinical use (Revolution CT Apex edition, GE Healthcare) were retrospectively reconstructed at 1.25mm slice thickness using FBP, ASIRv50, and 3 levels of a prototype DLIR (low (L), medium (M), and high(H)). Quantitative measurements of noise (standard deviation), signal to noise ratio (SNR) and contrast to noise ratio (CNR vs. liver parenchyma) in Main PA were obtained for all recons. Two radiologists independently rated subjective image noise, nose texture, artifacts, and diagnostic quality of the ASIRv50 and DLIR-M on a 1-5 scale.

RESULTS
The noise (std dev) was 40.55, 29.32, 25.34, 20.42, 15.22 HU, the SNR was 9.81, 13.58, 15.82, 19.81, 27.44, and the CNR was 10.39, 16.22, 16.51, 21.06, and 30.39 in the FBP, ASIRv50, DLIR-L, DLIR-M, and DLIR-H images respectively. All comparisons were significant (p<0.001) except for CNR between ASIRv50 and DLIR-L (p=0.175). Qualitative scores for ASIRv50 and DLIR-M were 3.86 +/- 0.26 and 4.89 +/- 0.25 (mean +/- std dev) respectively for image noise (p<0.001), 3.24 +/- 0.27 and 4.26 +/- 0.27 respectively for noise texture (p < 0.001), 3.92 +/- 0.25 and 3.93 +/- 0.25 for artifacts (p=0.322), and 4.94 +/- 0.31 and 3.94 +/- 0.31 for diagnostic image quality (p = n.s.).

CONCLUSION
DLIR shows decreased image noise with increased CNR and SNR compared to FBP and ASIRv. DLIR medium strength show decreased image noise with improved image texture qualitatively as compared to ASIRv50. There was no significant difference in subjective assessment of diagnostic quality or artifacts.

CLINICAL RELEVANCE/APPLICATION
The use of AI based image recon to lower noise and improve image texture is an emerging technology. Further study is needed to evaluate translation into dose savings or clinical performance in CT.

Vascular and Parenchymal Enhancement Assessment by Dual-Phase Dual Energy CT in the Diagnostic Investigation of Pulmonary Hypertension

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S404CD

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PURPOSE
To prospectively evaluate the non-invasive identification of pulmonary hypertension (PH) by dual-phase dual-energy CT pulmonary angiography (DE-CTPA) vascular enhancement and perfused pulmonary blood volume quantification (PBV) to assess mean pulmonary artery pressure (mPAP) and pulmonary vascular resistance (PVR), corroborated by right heart catheterization (RHC).

METHOD AND MATERIALS
102 patients were recruited to undergo RHC and standard DE-CTPA protocol (series 1) with a second 10 cm central DE-CTPA acquisition after 7 second delay (series 2). In both series, enhancement in the main pulmonary artery (PAenh) and descending aorta (DAenh) were calculated from DE-CTPA iodine images, and volumetric enhancement of each whole lung (WLenh) was analysed using PBV.

RESULTS
65 patients had PH defined by mPAP >= 25 mmHg and 51 patients PH defined by PVR >3WU. In series 1, PH patients had significantly higher PAenh/WLenh ratio and lower WLenh and DAenh compared to no PH. By series 2, PH patients had significantly higher PAenh and WLenh than no PH. Change in WLenh (series 1 to 2) offered the best diagnostic accuracy to define disease by mPAP (AUC 0.78) and PVR (AUC 0.79) and the best correlation with mPAP (r=0.62). PAenh series 2 correlated best with PVR (r=0.49). Metrics incorporating series 2 were superior in multivariate linear regression analysis (mPAP, r=0.62; PVR, r=0.56). Utilizing DE-CTPA metrics improved the correlation achieved by conventional CT metrics (mPAP, r=0.61 to r=0.71; PVR, r=0.53 to r=0.64). The presence of
CONCLUSION
This large prospective RHC corroborated study determined that dual-phase DE-CTPA vascular and parenchymal enhancement assessment appear complimentary to conventional CT metrics and improve the ability to predict mPAP and PVR. This is predominantly by the incorporation of change in whole lung enhancement over time to diagnose PH and by the use of this parameter and delayed pulmonary arterial enhancement to characterize disease severity.

CLINICAL RELEVANCE/APPLICATION
This study has identified a reader independent method to improve the non-invasive diagnosis of PH. These novel techniques have the potential to monitor disease severity and to help identify PH patients where early identification improves poor prognosis.

SSG03-07 Dual Energy Derived Pulmonary Blood Volume Histogram Parameters as Biomarkers of Pulmonary Dysfunction in Acute and Chronic Pulmonary Thromboembolic Disease

Tuesday, Dec. 3 11:30AM - 11:40AM Room: S404CD

Participants
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PURPOSE
To use dual energy computed tomography (DECT) histogram parameters as biomarkers to characterize the degree of pulmonary dysfunction in patients with acute and chronic pulmonary embolism (PE).

METHOD AND MATERIALS
Retrospective analysis of 95 DECT pulmonary angiography scans was performed from 2015-2019 for patients with suspected acute or chronic PE. 0.8mm thick whole lung PBV maps were reconstructed using material decomposition analysis and normalized with a 1cm2 circular region of interest within the main pulmonary artery. 0.8mm thick axial CT images were used to generate a lung mask to limit the PBV map analysis area. Histograms were generated from voxels falling within the label map and fitted with parametric models to generate parameters for analysis.

RESULTS
Of 95 patients, 36 were identified with acute PE, 30 with chronic PE (18 with chronic thromboembolic pulmonary hypertension (CTEPH); 12 with chronic thromboembolic disease without pulmonary hypertension (CTED)), and 29 normal patients without PE. Ages ranged from 21-95 years (average of 61 years). 49 patients were female and 46 were male. Mean voxel values were 109±33 in normal patients, 99±43 in acute PE patients, 83±24 in CTED patients, and 80±31 in CTEPH patients. Statistically significant differences (p<0.05) were observed in patients with CTED and CTEPH compared to normal patients. Right heart catheterization (RHC) data within 1 month of the DECT were available for review in 11/18 CTEPH patients. RHC-derived mean pulmonary artery pressure (mPAP) and pulmonary vascular resistance (PVR) correlated with mean voxel values with linear regression coefficients of determination (R2) of 0.64 and 0.74 respectively.

CONCLUSION
Preliminary data suggests DECT histogram parameters can characterize pulmonary dysfunction in patients with acute and chronic PE. Mean voxel value is a potential imaging biomarker for quantifying RHC-derived mPAP and PVR.

CLINICAL RELEVANCE/APPLICATION
DECT histogram parameters are a promising surrogate biomarker for pulmonary hemodynamic assessment. Additional studies are warranted to define the role of DECT in evaluating acute and chronic PE and the potential to supplant invasive RHC and echocardiography as the surveillance imaging modality of choice.

SSG03-08 Comparison of Lung Volumes and Perfusion Defects on DECT-Perfusion Blood Volume Images with Clinical Outcomes for Patients with Pulmonary Embolism

Tuesday, Dec. 3 11:40AM - 11:50AM Room: S404CD

Participants
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Subba R. Digumarthy, MD, Boston, MA (Abstract Co-Author) Speaker, Siemens AG; Research Grant, Lunit Inc; Researcher, Merck & Co, Inc; Researcher, Pfizer Inc; Researcher, Bristol-Myers Squibb Company; Researcher, Novartis AG; Researcher, F. Hoffmann-La Roche Ltd; Researcher, Polaris Pharmaceuticals, Inc; Researcher, Cascadia Healthcare, LLC; Researcher, AbbVie Inc; Researcher, Gralalis, Inc; Researcher, Clinical Bay; Researcher, Zai Lab
Vinit Balyani, MBBS, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
To determine whether presence and/or extent of perfusion defects on dual energy CT pulmonary angiogram (DECT-PA) of patients with pulmonary embolism (PE) affected their clinical outcomes in terms of morbidity and mortality.

METHOD AND MATERIALS

With IRB Approval, we identified 164 adult patients (86 males, 78 females, mean age 62±17 years) from the institutional pulmonary embolism response team (PERT) registry. All patients underwent DECT-PA for suspected PE on 384-slice, dual-source CT (SOMATOM Force, Siemens). Deidentified DICOM images were processed with a Lung Lobe Segmentation prototype (eXamine, Siemens). The prototype performed automated lobar segmentation and provided lung volumes, and several perfusion parameters for each lung and each lobe. Two radiologists assessed all DECT-PA for presence/absence of PE, location, occlusive/non-occlusive, and presence and location of pulmonary infarcts and perfusion defects (matched and mismatched). The medical records were reviewed to record any adverse clinical outcome within 3 days of DECT-PA (need for ventilation/mechanical respiration, uncontrolled hypertension, or death). Data were analyzed with multivariable analysis of variance (MANOVA) with SPSS statistical software.

RESULTS

Of the 164 patients, 139 had PE and 25 had no PE. Of the 20 patients (group 1: 20/139 PE+) with adverse clinical outcomes, 60% had perfusion defects on DECT-PA (12/20) as opposed to 29% rate of perfusion defects in patients with stable or improved clinical outcomes (group 2: 35/119 PE+). All quantitative perfusion parameters (iodine concentration, uptake, skewness, kurtosis) in group 1 patients were significantly different from group 2 patients (p=0.0001). There was a higher frequency of central and multiple PE in patients with adverse clinical outcomes compared to those with stable or favorable outcomes. The right, left, and whole lung volumes between group 1 (mean 1701±674, 1487±620, 3181±1202 ml) and group 2 (mean 1954±885, 1506±697, 3461±1553 ml) were significantly different as well (p<0.008).

CONCLUSION

Qualitative and quantitative perfusion abnormalities, and lung volumes are independent prognostic predictors of adverse clinical outcome in patients with pulmonary embolism on DECT-PA.

CLINICAL RELEVANCE/APPLICATION

Patients with perfusion defects and decreased quantitative perfusion on DECT-PA have high incidence of adverse clinical outcomes.

SSG03-09 The Deep Learning Model in Evaluation of Acute Pulmonary Embolism on Computed Tomographic Pulmonary Angiography

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S404CD

Participants
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PURPOSE

Our goal is to use the deep learning method to calculate clot volume of acute PE on computed tomographic pulmonary angiography (CTPA) and explore its relationship with other imaging parameters.

METHOD AND MATERIALS

The method is on a fully convolutional network called U-Net model to segment acute PE. Two datasets were used to train the deep learning(DL) model. Dataset 1 contains 230 samples of acute PE on CTPA labeled by radiologists and Dataset 2 consists of 65 samples without PE on CTPA. We set the values to 0.1, 0.3, 0.5, 0.7 and 0.99 for the measurement of the clot volume. The test dataset included 144 patients with suspected acute PE admitted to our hospital from Jan 2016 to Oct 2018. The images of CTPA in the test dataset were transferred to the trained model to detect the clot while the clot volume of acute PE were automatically calculated. We evaluated diagnosing time, accuracy, sensitivity and specificity of the proposed model in detecting clot. Meanwhile, clot burden of acute PE patients were assessed with obstruction scores and other imaging parameters by the radiologists.

RESULTS

The test dataset included 51 patients without PE and 93 patients with clinically confirmed acute PE. The average measurement time of DL model was 12.9±3.8 seconds approximately, while the second-year residents needed 10±4 minutes. When the critical value of the model is set as 0.1, the sensitivity and specificity are the highest, 94.6% and 76.5% respectively, and the consistency between measurements two was 100%. The AUC was 0.926 (95% CI:0.884-0.968), which indicates good discriminative power. Clot burden measured with DL model at setting value of 0.1 was significantly correlated with Qanadli score (r=0.819, p<0.001) and Mastora score (r=0.874, P<0.001). And it is moderately correlated with parameters related to function of right heart.

CONCLUSION

Detection of acute PE with DL model could greatly improve the diagnosing efficiency and reduce the workload of the radiologists.
Detection of acute PE with DL model could greatly improve the diagnosing efficiency and reduce the workload of the radiologists. The DL model had high degree of sensitivity and reproducibility. The clot volume was highly correlated with obstruction scores, while it is moderately correlated with parameters related to function of the right heart.

**CLINICAL RELEVANCE/APPLICATION**

The deep learning model has high degree of sensitivity and reproducibility in the detection of clot, which is recommended for the detection of clot in patients with pulmonary embolism.

Printed on: 10/29/20
**DQE of Si and CdTe Detectors for Photon-Counting CT: Impact of Object Scatter**

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

**PURPOSE**
Silicon (Si) and cadmium telluride (CdTe) have been proposed as detector materials for photon-counting CT, but the relative performance of these materials is incompletely understood. Previously, a linear-systems model has been used to compare the DQE of Si and CdTe detectors, but this model ignores scatter from the object. This work extends this comparison by incorporating object scatter and the anti-scatter grid, resulting in a more complete model for photon-counting detector DQE at low flux.

**METHOD AND MATERIALS**
Monte Carlo simulation was performed of a CT geometry with a water cylinder of 30 cm diameter in the isocenter and a curved detector with 79 mm isocenter coverage and sensitive absorption lengths of either 60 mm Si or 3 mm or 1.6 mm CdTe. A 1D or 2D anti-scatter grid with 25 mm high W lamellae was placed in front of the detector. From the resulting scatter-to-primary ratio (SPR) in the central 20 cm of the detector, a DQE factor could be calculated as \( \frac{\text{geometric efficiency}}{1+\text{SPR}} \) where SPR is the scatter-to-primary ratio. This factor was combined with the intrinsic detector DQE obtained from linear-systems models of Si and CdTe detectors incorporating intradetector scatter, fluorescence and charge sharing.

**RESULTS**
For all studied detector configurations, the optimal DQE factor is 0.79-0.81, attained for an 1D grid of 0.1 mm thick lamellae with 1 mm spacing. Combined with the linear-systems model for typical detector configurations, so far ignoring pulse pileup and signal induction crosstalk but adding object scatter, this gives the 1.6 mm CdTe detector 5-25% higher zero-frequency DQE for detection and 44-54% lower DQE for two-material quantification compared to a 60 mm Si detector with interspersed W foils.

**CONCLUSION**
A geometric efficiency of 86-90% is optimal for photon-counting detectors, in contrast to the ~70% used in current CT scanners. Including interspersed W foils in the Si detector can reduce object scatter, and together with an orthogonal 1D anti-scatter grid can give an SPR comparable to that of a 2D grid without interspersed foils. This work is an important step towards a future, complete model for detector performance incorporating pileup and improved charge transport models.

**CLINICAL RELEVANCE/APPLICATION**
Photon-counting CT detectors promise better image quality. The improved performance model presented here will help developers optimize detector design and attain the best possible imaging performance.
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METHOD AND MATERIALS

Voronoi grids were created using Rhino software (McNeel, Barcelona, Spain) to resemble lung parenchyma. The designs (eight samples, 2x2x1cm3) varied in number of cells and cell border thickness and were 3D printed (ProJet® MJP 2500+) with VisiJet Armor material (ρ=1.14 g·cm-3). The samples were placed in foam, inserted inside a thorax-shaped PMMA holder (300x200x2.5cm3), and scanned (Canon Aquilion Genesis CT). Comparisons were made to CT image volumes of interest (VOIs) of 3 patients parenchyma (5 samples per patient) using the same CT acquisition and reconstruction protocol (High Resolution-thorax). Analysis was performed in terms of attenuation (mean pixel value of VOIs), pixel value distribution (histograms) and visual comparison.

RESULTS

The CTDIvol for the thorax phantom was 2.1 mGy and for the 3 patients 2.1, 2.2 and 4.1 mGy. The attenuation of the voronoi samples (0.2mm cell border thickness) increased linearly with the number of cells [-972±3HU (200 cells);-953±2HU (350 cells);-941±3HU (500 cells);-921±3HU (800 cells);-916±5HU (900 cells)]. Attenuation also increased linearly with cell border thickness (samples with 350 cells) [-953±2HU (0.2mm);-924±3HU (0.3mm);-885±7HU (0.4mm);-837±5HU(0.5mm)]. For patients the average attenuation values were [(-894±7HU);(-849±5HU);(-902±4HU)]. The sample of 350 cells and 0.4mm cell border thickness resembled lung parenchyma most closely, according to visual comparison of CT images and histogram pixel distribution, by three human observers. The mean pixel value of this sample (-885±7HU) was within the HU value range for patients lung parenchyma (-870±27HU).

CONCLUSION

CT appearance and attenuation of human lung parenchyma was mimicked by CT scans of 3D printed voronoi grids. A sample of 350 cells and 0.4 mm cell border thickness showed best resemblance with patient CT images. These voronoi structures will be added to an in-house developed lung vessel phantom to create a more realistic anthropomorphic surrogate for patients in CT image quality assessment.

CLINICAL RELEVANCE/APPLICATION

Our method to 3D-print lung parenchyma (missing in most commercial CT image quality phantoms) can be used to create realistic patient surrogates, especially required with iterative reconstruction.

SSG12-03 Improving Visualization of Basilar Artery Branches by Combining Spectral CT Imaging and Adaptive Statistical Iterative Reconstruction-V Algorithm

Tuesday, Dec. 3 10:50AM - 11:00AM Room: S501ABC

Participants
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PURPOSE

Improving visualization of basilar artery branches by combining spectral CT imaging and adaptive statistical iterative reconstruction-V algorithm

METHOD AND MATERIALS

A total of 15 patients with suspected posterior cerebral circulation ischemia underwent head-neck CT angiography (CTA) using a 256-row MDCT (Revolution CT, GE Healthcare). The scanning parameter were tube voltage of 80/140kVp fast switch and GSI Assist with a noise index of 6. The contrast medium was Iohexol (370mgI/ml) with amount of 50ml and injection rate of 5.0ml/s. 100 kVp-like with FBP (group A) and 40keV monochromatic energy image with 50% ASIR-V (group B) were reconstructed. For both image sets, the CT value and contrast to noise ratio (CNR) were measured at maximum diameter of the basilar artery. maximum intensity projection (MIP) images were used for evaluation the visualization of vertebrobasilar arteries and branch vessels (post-cerebral arteries, superior cerebellar arteries, anterior inferior cerebellar artery, posterior inferior cerebellar artery). Vessel visibility was quantified by counting the number of artery branches. A five-point scale (from 1= poor to 5 = excellent) was used to evaluate the image quality.
RESULTS
40keV images had higher enhancement of basilar artery (664.95±106.11 vs 288.81±31.03, P=0.001) and higher CNR (27.36±7.01 vs 20.49±6.48, P=0.009) than 100 kVp-like images. A total of 165 blood vessels was visible on 40keV images, compared to 160 vessels in 100 kVp-like image. The subjective image quality of 40keV images was better than that of 100 kVp-like image (4.53±0.54 vs 3.38±0.81, P=0.012).

CONCLUSION
Combining 40keV images and 50% ASiR-V can significantly improve image quality of basilar artery branches, compared to 100 kVp-like images.

CLINICAL RELEVANCE/APPLICATION
Combining monochromatic image and ASiR-V can significantly improve image quality of artery. This protocol is expected to provide more reliable information for the diagnosis and treatment of patients with posterior cerebral circulation ischemia.

SSG12-04  CT Protocol Optimization in Neck Imaging Using Anatomically Realistic 3D Printed Phantoms

Tuesday, Dec. 3 11:00AM - 11:10AM Room: S501ABC

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PURPOSE
To simulate patient neck CT imaging with 3D printed phantoms for a systematic evaluation of CT acquisition protocol settings regarding dose and image quality.

METHOD AND MATERIALS
Radiopaque 3D printed patient head and neck phantoms manufactured with potassium iodide doped ink were used for simulation of patient imaging. Two tube voltage settings, six tube current settings, and three pitch settings were systematically combined. Images were reconstructed with filtered back projection (FBP) and iterative reconstruction (IR). Image quality was evaluated with rater experiments (ten radiologist readers) and contrast-to-noise ratios. Dose reduction was evaluated with multiple phantoms with different anatomies and compared with patients that were retrospectively identified from our clinical database. A protocol with fixed 120 kVp, AEC (SD 7.5), a pitch of 0.8, and iterative reconstruction was used as reference to illustrate protocol optimization potential.

RESULTS
54 data sets were acquired and analyzed. Inter-rater reliability of the image grading experiments was excellent (ICC = 0.921; 95%CI 0.882 to 0.950). The benefit-to-risk ratio in terms of achievable image quality and required dose exposure was optimal with ATVS, AEC (SD 14), a pitch of 0.8, and IR. However, image quality was limited (46% for subjective and 26% for objective image quality). An optimal balance between dose and high image quality was achieved with lower noise level AEC (SD 7.5). This protocol required 37% lower dose than the reference protocol. The retrospective analysis of patients that were imaged with different protocol settings yielded similar dose reduction.

CONCLUSION
Patient simulation with 3D printed phantoms provides opportunities for testing and optimization of CT acquisition protocols in a clinical context. The results from this study were in good agreement with clinical observations.

CLINICAL RELEVANCE/APPLICATION
CT protocol optimization entails significant dose reduction potential. Patient simulation with 3D printed phantoms provides opportunities for systematic and rapid protocol optimization.

SSG12-06  Analysis of the 3D Modulation Transfer Function (MTF) of a High-Resolution Diagnostic CT Scanner

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S501ABC

Participants
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PURPOSE
The spatial resolution characteristics of a recently introduced high-resolution diagnostic CT scanner (Precision, Canon Medical) is investigated using a multi-sphere phantom designed to probe the 3D modulation transfer function (MTF), quantifying performance among various scan protocols.

METHOD AND MATERIALS
The phantom presented an array of 9 acrylic spheres (25.4 mm diameter) as a basis for measurement of the oversampled edge-spread function (ESF) and presampling 3D MTF. Spherical edge profiles were converted to spherical coordinates and analyzed as a function of direction (elevation: \( \phi=0 \), axial, to \( \phi=90 \), z longitudinal). Directionality was held to \( \phi \leq 80 \) to avoid cone-beam sampling effects. The 3D MTF was measured for 3 detector modes [normal-res NR (0.5x0.5mmx80slice), high-res HR (0.25x0.5mmx80slice), and super-high-res SHR (0.25x0.25mmx160slice)], filtered backprojection with 3 nominal filters [smooth Fc18, bone Fc30, and high-res Fc81], 3 focal spot settings, and 3 pitch settings (0.57-1.38).

RESULTS
The 3D MTF provided quantitative insight on performance, limitations, tradeoffs, and the degree to which resolution was isotropic. The SHR detector mode increased the axial MTF (f50=1.03/mm) compared to NR (f50=0.84/mm) and improved z-resolution (f50=0.91/mm) compared to HR (f50=0.71/mm) for the Fc30 filter. SHR and HR modes gave the same axial MTF, as expected. Analysis of the 3D MTF characteristics showed that the 3 nominal filters acted primarily in the axial plane, imparting non-isotropic 3D resolution characteristics. Improvement in MTF with finer focal spot was quantified, and the 3D MTF was observed to be invariant with to helical pitch.

CONCLUSION
A multi-sphere phantom and ESF oversampling method provided an insightful probe of 3D MTF characteristics for a recently introduced ultra-high-res CT scanner, demonstrating the resolution advantages and limitations for various scan protocols. The SHR detector mode demonstrated improved axial and z direction MTF compared to NR mode, evident in clearer depiction of anatomical structure (e.g., temporal bone).

CLINICAL RELEVANCE/APPLICATION
Quantitative characterization of the 3D MTF is an important aspect of technical assessment for new CT scanner technology claiming high-resolution performance beyond that of previous systems.

SSG12-07 Whole-Body Low-Dose CT Combined with Model-Based Iterative Reconstruction Algorithm in the Follow-Up of Oncologic Patients: Image Quality and Dose Deduction

Participants
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PURPOSE
To compare radiation dose and image quality of low-dose CT protocol combined with iterative model-based reconstruction algorithm (IMR) with standard-dose CT approach combined with hybrid-iterative reconstruction algorithm (iDose) in the follow-up of oncologic patients.

METHOD AND MATERIALS
We enrolled a hundred and thirty patients with known oncological diseases; all patients were examined, during their clinical follow-up, with both a low-dose CT performed on 256-row scanner, with 100 kV and automated mAs modulation (depending on patient weight), and a standard-dose CT performed on 256-row scanner, with 120 kV and automated mAs modulation. Images were reconstructed with IMR for the low-dose CT protocols and iDose algorithm for the standard-dose CT studies. In both studies we measured density values and image noise in liver and spleen and calculated the signal-to-noise ratio (SNR) and the radiation dose exposure. The diagnostic quality evaluation was also performed with a 4-point scale.

RESULTS
Noise of images expressed as SD values, measured in liver and spleen, was significantly lower in IMR images (liver 11.63 vs 14.79, p<0.001) whereas SNR was statistically higher (liver 10.46 vs 7.86, p<0.001) compared to iDose reconstruction. Volumetric CT-Dose-Index (CTDIvol) and Dose-Length-Product (DLP) were significantly lower in IMR compared to iDose studies (DLP 624.40 vs 1013.90 mGy*cm, p<0.001), with an overall dose reduction of 38.42%. The qualitative analysis did not reveal any significant differences in terms of diagnostic quality (p=0.04).

CONCLUSION
MAs modulation combined with IMR algorithm and low kV setting allows dose reduction of 45.72% in whole body CT imaging without loss of diagnostic quality. Therefore, it represents a useful diagnostic approach to reduce radiation dose exposure in oncologic patients who undergo several follow-up CT studies.

CLINICAL RELEVANCE/APPLICATION
CT has a main role in the follow-up of oncologic patients; therefore, lowering doses is desirable, according to the A.L.A.R.A. principle. Low-kV CT with IMR allows to significantly reduce doses, offering a high diagnostic image quality.

SSG12-08  Machine Learning and Deconvolution to Improve the Spatial Resolution of the Adaptive Statistical Iterative Reconstruction (ASir-V) at the Same Noise Level

Participants
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PURPOSE
For the same noise reduction characterized by the noise power spectrum (NPS), the machine learning approach of PixelShine (PS) by AlgoMedica preserves better the central frequency ratio (CFR) in NPS than the adaptive statistical iterative reconstruction (ASir-V) by GE. CFR was taken between the central frequencies of the NPS of the noise reduction and the baseline CT images to indicate the degree of shift in central frequency after noise reduction. Smaller CFR means more shift of the NPS curve or more image blurring. As the noise texture is highly correlated with CFR, PS may be preferred over ASir-V. The purpose of this study is to improve ASir-V by deconvolution to decrease the blurry appearance of the ASir-V while maintaining the same level of noise reduction already achieved by ASir-V.

METHOD AND MATERIALS
The homogeneous module of the ACR CT phantom (model 464, Gammex-RMI, Wisconsin) was scanned on a GE revolution HD 64-slice CT at 3.6 mGy (CTDI-16 cm). Each scan was repeated twice for NPS calculation. Radiation exposure was increased from 3.6 to 72 mGy to simulate ideal noise reduction without PS or ASir-V. We designed a set of deconvolution filters for the various strengths of ASir-V, followed by PS and name this approach as ASir-VDPS. The images of the ASir-V and ASir-VDPS settings from 10 to 100% and the PS settings of 1 to 9 were compared. Noise magnitude ratio (NMR) was taken between the areas under the NPS curve of the noise reduction and the baseline FBP images to indicate the amount of noise removed by the reconstruction. Smaller NMR means more noise reduction. A desirable noise reduction shall maintain CFR of close to 1 and a NMR close to 0.

RESULTS
When the radiation exposure was increased from 3.6 to 72 mGy, NMR can be reduced without any change of CFR for the ideal noise reduction. At 3.6 mGy, noise reduction was better achieved by either ASir-VDPS or PS, followed by ASir-V. However, the results of ASir-VDPS (80 to 100%) demonstrated that our current design of deconvolution was not sufficient for resolution recovery introduced by ASir-V.

CONCLUSION
Combination of deconvolution and machine learning can improve ASir-V in spatial resolution or image sharpness without sacrificing the noise reduction already achieved by ASir-V.

CLINICAL RELEVANCE/APPLICATION
ASir-V blurs the CT images during noise reduction. Our approach rectifies this issue without sacrificing the noise reduction already achieved by ASir-V.

SSG12-09  Investigating the Relationship between Image Noise and Noise Index of Dose Modulation Behavior

Participants
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CONCLUSION
Save the efforts of clinical protocol development/management and improve the operational work flow.

Background
Purpose: To evaluate the behavior of dose modulation performance for optimizing clinical image acquisition protocols. Methods: Four tissue equivalent abdominal CT dose phantoms (CIRS 007TE) were scanned using a GE Revolution CT scanner. To simulate an extra-large size patient, a 5th phantom (60cm by 40cm) was assembled from a QRM-Abdomen phantom attached to two extension rings. Abdominal CT protocol: 120kVp, 0.6s rotation time, 80mm beam width, 0.508 pitch, 2.5 mm image thickness and Large Scan Field-of-View. With Auto-mA and Smart-mA enabled, Noise Index (NI) was varied resulting in various levels of image quality. Images were reconstructed using Standard algorithm. For each phantom size/NI combination, ROI (n=3/image) and noise measurements (standard deviation of ROI) in 5 consecutive images of the central portion of the phantom were performed. The relationship of noise versus NI was plotted for each phantom size.

Evaluation
Results: For the scans of each phantom size, the achieved mA values functioned as expected to the set NI values. For each phantom size, the measured noise increased linearly as NI value increased (R2 = 0.9981, 0.9978, 0.9980, 0.9963, for 15-yr old, small adult, medium adult, large adult, respectively). The noise values were within 7% of the mean noise values at a NI level among phantom of different sizes, indicating that the measured noise values were similar as a function of NI value regardless of the sizes of the phantoms. Moreover, the measured noise were within 12% of the 10 NI levels that were evaluated, at 2.5mm nominal image thickness; this suggests a direct correlation of the anticipated image noise to the NI value under this 2.5mm acquisition condition.
Discussion

Conclusion: The same NI value produced similar noise level in images across phantoms of different sizes. Unlike the multiple patient size-based approach for optimizing protocols of other GE scanner platforms, the one-size based protocol approach on the Revolution CT could save the efforts of clinical protocol development/management and improve the operational work flow.
AI Theater: AI in Clinical Cardiac MRI: Presented by Circle Cardiovascular Imaging

Tuesday, Dec. 3 11:00AM - 11:20AM Room: AI Showcase, North Building, Level 2, Booth 10724

Participants
Matthias Gutberlet, MD, PhD, Leipzig, Germany (Presenter) Speaker, Siemens AG Speaker, Koninklijke Philips NV Speaker, Bayer AG Speaker, Bracco Group Author, Thieme Medical Publishers, Inc

Printed on: 10/29/20
3D33

3D + AV Theater: Next Generation of Advanced Visualization for Surgical Planning and Optimizing Analysis Utilizing Immersive Reality with Haptic Feedback and Air Models: Presented by ImmersiveTouch, Inc.

Tuesday, Dec. 3 12:00PM - 12:20PM Room: 3D Printing and Advanced Visualization Theater, North Building, Level 3, Booth 6563

Participants
Pravin K. Patel, MD, Chicago, IL (Presenter) Nothing to Disclose
Farid F. Shafaie, MD, Chicago, IL (Presenter) Nothing to Disclose

Program Information
Next generation of advanced visualization for surgical planning and optimizing analysis utilizing immersive reality with haptic feedback and air models.

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Segmentation
Tuesday, Dec. 3 1:00PM - 2:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
George L. Shih, MD, New York, NY (Presenter) Consultant, MD.ai, Inc; Stockholder, MD.ai, Inc;

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google Colab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This session will focus on the use of deep learning methods for image segmentation, applied to the challenge of CT or MR brain segmentation. While focused on this particular problem, the concepts should generalize to other organs and image types.

Printed on: 10/29/20
Case-based Review of Nuclear Medicine: PET/CT Workshop-Abdomen/Pelvis & Pediatrics (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Dec. 3 1:30PM - 3:00PM Room: E450B

Participants
Medhat M. Osman, MD, Saint Louis, MO (Moderator) Speakers Bureau, Advanced Accelerator Applications SA

Sub-Events

MSCC33A  Adult Abdomen/Pelvis

Participants
Don C. Yoo, MD, Lexington, MA (Presenter) Consultant, inviCRO, LLC
Terence Z. Wong, MD, PhD, Chapel Hill, NC (Presenter) Consultant, Lucerno Dynamics, LLC;

For information about this presentation, contact: donyoo@brown.edu

LEARNING OBJECTIVES
1) Review challenging and instructive cases PET/CT scans in the abdomen and pelvis which will help with interpretation of PET/CT scans.

ABSTRACT
For oncologic studies, F18-FDG is an outstanding tracer with wide applications. However, there are many pitfalls which can make interpretation challenging. The purpose of this educational activity is to familiarize the audience with the normal biodistribution of FDG in the body and learn various pitfalls in the abdomen and pelvis that can occur when interpreting oncologic PET/CT scans.

MSCC33B  Pediatrics

Participants
Helen R. Nadel, MD, Palo Alto, CA (Presenter) Consultant, ICON plc

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

LEARNING OBJECTIVES
1) Be able to identify indications for pediatric PET/CT or PET/MRI imaging. 2) Be familiar with protocols used for pediatric PET/MRI.

Printed on: 10/29/20
Efficiency & Risk Management in CT: Smart & Innovative Solutions: Presented by Bracco Diagnostics, Inc.

Tuesday, Dec. 3 2:00PM - 3:30PM Room: S105D

Participants
Dushyant Sahani, MD, Boston, MA (Presenter) Research support, General Electric Company Medical Advisory Board, Allena Pharmaceuticals, Inc
Daniele Marin, MD, Durham, NC (Presenter) Research support, General Electric Company
Stephanie Allen, MBA, Albemarle, NC (Presenter) Nothing to Disclose

PROGRAM INFORMATION
In clinical practice, a busy CT suite can experience a bottleneck of patient throughput that can impact wait times and patient satisfaction. As modern imaging departments continue to evolve with the installation of the latest devices, software, and tools to provide best in class care for their patients in the most efficient and productive manner; there is now a necessity to share best practices among healthcare providers. This will be a live CE and CRA accredited symposium. This symposium features a panel of three experts in their respective areas of medical imaging who will share their experience of how they are increasing workflow efficiency while managing risk in the CT suite. The discussion will include the compliant use of Imaging Bulk Package with smart contrast delivery systems, while capturing and analyzing patient-enriched data. Educational Credits Provided ARRT Category A CE Credit - AHRA CRA Credit.

CME
This program does not offer CME; this program offers CE and CRA credits. Attendees will be provided with instructions at the end of the symposium on how to claim their credits.

RSVP Link

Sub-Events
CS36A  Smart CT Injectors: The Clinical Benefits of Saline & Contrast Utilization
Participants
Dushyant Sahani, MD, Boston, MA (Presenter) Research support, General Electric Company Medical Advisory Board, Allena Pharmaceuticals, Inc

CS36B  Compliant Utilization of Imaging Bulk Package in CT
Participants
Stephanie Allen, MBA, Albemarle, NC (Presenter) Nothing to Disclose

CS36C  Benefits of Smart CT Injectors: Workflow Improvements & Protocol Management
Participants
Daniele Marin, MD, Durham, NC (Presenter) Research support, General Electric Company

Printed on: 10/29/20
Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIT Technologies, LLC; Stockholder, VoiceIT Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard and decent-sized screen. Having a Gmail account will be helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This class will focus on basic concepts of convolutional neural networks (CNNs) and walk the attendee through a working example. A popular training example is the MNIST data set which consists of hand-written digits. This course will use a data set we created, that we call 'MedNIST', and consists of images of 6 different classes: Chest X-ray, Chest CT, Abdomen CT, Head CT, Head MR and Breast MRI. The task is to identify the image class. This will be used to train attendees on the basic principles and some pitfalls in training a CNN. • Intro to CNNs • Data preparation: DICOM to jpeg, intensity normalization, train vs test • How do we choose the labels? Inconsistencies... Use Fast.AI routines to classify; Validation of results: Are the performance metrics reliable? 'Extra Credit': if there is time, explore data augmentation options, effect of batch size, training set size.

Printed on: 10/29/20
SSJ08

Gastrointestinal (CT Dose and Abbreviated MR Screening Techniques)

Tuesday, Dec. 3 3:00PM - 4:00PM Room: S401CD

CT GI MR SQ

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
Jessica B. Robbins, MD, Madison, WI (Moderator) Nothing to Disclose
Jeong Hee Yoon, MD, Seoul, Korea, Republic Of (Moderator) Research Grant, Bayer AG Speaker, Koninklijke Philips NV Speaker, Bayer AG

Sub-Events

SSJ08-01 Diagnostic Performance and Image Quality of Low-Tube Voltage and Low-Contrast Agent Dose Protocol for Hepatic Dynamic Computed Tomography

Tuesday, Dec. 3 3:00PM - 3:10PM Room: S401CD

Participants
Shintaro Ichikawa, MD, PhD, Chuo, Japan (Presenter) Nothing to Disclose
Utaro Motosugi, MD, Chuo, Japan (Abstract Co-Author) Nothing to Disclose
Tatsuya Shimizu, MD, Yamanashi, Japan (Abstract Co-Author) Nothing to Disclose
Marie-Luise Kromrey, MD, Greifswald, Germany (Abstract Co-Author) Nothing to Disclose
Yoshihiato Akawa, RT, Chuo, Japan (Abstract Co-Author) Nothing to Disclose
Hiroshi Onishi, MD, Yamanashi, Japan (Abstract Co-Author) Nothing to Disclose

PURPOSE

To evaluate diagnostic performance and image quality of low-tube voltage and low-contrast agent dose protocol for hepatic dynamic computed tomography (CT).

METHOD AND MATERIALS

This retrospective study, held between January and May 2018, included 424 patients (mean age, 70.5±10.1 years; 289 men, 135 women). They underwent hepatic dynamic CT using one of two protocols: tube voltage, 80 kVp; contrast dose, 360 mgI/kg, and iterative reconstruction (n=180) and tube voltage, 120 kVp; contrast dose, 600 mgI/kg, and filtered back projection (n=224). Two radiologists independently scored lesion conspicuity and image quality using 5- and 3-point scales, respectively. Another radiologist measured CT number of abdominal organs, muscles, and hepatocellular carcinoma (HCC) in each phase. Lesion detectability, diagnostic ability for HCC, image quality of the arterial phase, CT number including lesion-to-liver ratio, and radiation dose were compared between protocols.

RESULTS

Both protocols showed high lesion detectability (sensitivity, 86.1%-92.5%; specificity, 94.6%-97.3%; accuracy, 92.8%-95.0%) and diagnostic ability for HCC (sensitivity, 85.7%-93.3%; specificity, 93.6%-98.6%; accuracy, 93.3%-96.6%). The 120-kVp protocol showed better image quality for the arterial phase than the 80-kVp protocol (P<0.0001 for both); however, the ratio of fair image quality was not significantly different (P=0.3161 and 0.4084). CT number of abdominal organs and muscles was higher in the 80-kVp protocol than in the 120-kVp protocol in each phase (P<0.0001-0.0357) for all structures, except portal vein in the arterial phase and renal medulla in the portal venous phase (P=0.1760 and 0.1280). Lesion-to-liver ratio was not significantly different for all phases (P=0.2108-0.8653). Volume CT dose index and dose-length product in the arterial phase were significantly lower for the 80-kVp protocol than for 120-kVp protocol (15.2±3.6 vs 32.1±4.9 mGy and 397.3±122.2 vs 880.2±312.7 mGy·cm, respectively, P<0.0001 for both).

CONCLUSION

The 80-kVp protocol has diagnostic performance and image quality, equivalent to the 120-kVp protocol, with lower radiation and contrast agent doses.

CLINICAL RELEVANCE/APPLICATION

Low-tube voltage with iterative reconstruction for hepatic dynamic CT may decrease radiation and contrast agent doses, with equivalent diagnostic performance and image quality than the 120-kVp protocol.
For information about this presentation, contact: mghadim1@jhu.edu

Assess the feasibility of whole-body MRI imaging in 30 minutes in oncologic applications.

METHOD AND MATERIALS

Our IRB approved this HIPPA-compliant prospective study. Twenty-six adult patients assessed for metastatic diseases were scanned with WB-DWI methods using a 3T MRI scanner. Axial fat-suppressed T2-weighted (T2WI), DWI, precontrast TS T1-weighted (T1WI) followed by post contrast FS T1WI in the arterial, portal venous and delayed phases were acquired (gradient time of 30 minutes). A single reader utilizing a five-point-scale recorded image quality of each WB-MRI study. Findings on whole-body MRI were recorded. The number of lesions was compared to those detected on CT or PET-CT studies, performed with 12 months of whole-body MRI if available. The WB-MRI, CT, and PET-CT were divided into standard anatomical location including chest, abdomen, and pelvis. The number of lesions within each anatomic location was compared in all three modalities.

RESULTS

Our study included 14 males and 12 females with the mean (±standard deviation) age of 55(±14) years. All whole-body MRI examinations were successfully obtained in the median time of 35 (IQR, 29-39) minutes. There were 17,21 and 8 lesions detected from chest, abdomen and pelvis, respectively in CT studies (N=19). Additionally, total of 0, 3, 2 lesions were detected in the chest, abdomen and pelvis respectively by assessing PET-CT studies (N=5). The WB-MRI detected 15 Lesions in chest, 38 Lesions in abdomen and 8 lesions in pelvis. All lesions detected on PET-CT were also detected on WB-MRI. Four lesions (16%) detected on WB-MRI in abdomen parts were missed on CT, while WB-MRI missed 2 lesions (11%) detected by CT in the chest parts; all were less than 10 mm. These two studies are comparable in detecting lesions in the pelvis. The overall image quality of whole-body MRI was 4/5.

CONCLUSION

We have demonstrated that fast multiparametric WB-MRI may be preformed in approximately 30 minutes, with relatively high image quality. Lung lesions <10mm may not be readily detected by WB-MRI.

CLINICAL RELEVANCE/APPLICATION

Whole-body MRI might be an acceptable alternative for CT or PET, in staging, assessment and monitoring of treatment response in oncologic applications.

SSJ08-03 Assessment of Noise Reduction Potential and Image Quality Improvement of a Deep Learning-Based Image Reconstruction Algorithm in Abdomen CT

Tuesday, Dec. 3 3:20PM - 3:30PM Room: S401CD

Participants
Xiaohu Li, MD, Hefei, China (Presenter) Nothing to Disclose
Jianying Li, Beijing, China (Abstract Co-Author) Employee, General Electric Company
Huayang Liu, MD, Beijing, China (Abstract Co-Author) Employee, General Electric Company
Yongqiang Yu, MD, Hefei, China (Abstract Co-Author) Nothing to Disclose

PURPOSE

To evaluate the image quality improvement and noise reduction in routine dose, non-enhanced abdomen CT imaging by using a deep learning-based image reconstruction algorithm in comparison with ASIR-V.

METHOD AND MATERIALS

9 patients who underwent routine dose, abdomen CT using GE Revolution CT (GE Healthcare, Waukesha, WI) were included. After scanning, all scans were reconstructed with the recommended level of 40% ASIR-V and for comparison purpose and deep learning-based image reconstruction algorithm (TrueFidelityTM, GE Healthcare).DLIR-L, DLIR-M, DLIR-H. The CT attenuation values and SD of the subcutaneous fat, back muscle and descending aorta were measured at the level of tracheal carina of all reconstructed images. The signal-to-noise ratio (SNR) was calculated with SD representing image noise. The subjective image quality was independently evaluated by two experienced radiologists.

RESULTS

For all DLIR images, the objective image noise (SD) of fat, muscle and aorta decreased and SNR increased along with DLIR-L, DLIR-M, DLIR-H. The SD of DLIR images were significantly lower than that of 40% ASIR-V. In terms of subjective image evaluation, all DLIR reconstructions and 40% ASIR-V had good diagnostic acceptability. However, DLIR-M, DLIR-H showed significantly superior visibility of small structures when compared with the 40% ASIR-V and DLIR-L, and DLIR-H was the best series of TrueFidelity images, with a highest subjective image quality, at the same time the image sharpness was not significantly decreased in DLIR-H images.

CONCLUSION

In routine dose, non-enhanced abdomen CT, DLIR show greater potential in reducing image noise and artefacts and maintaining image sharpness when compared to the recommended level of 40%ASIR-V algorithm. Combining both the objective and subjective evaluation of images, non-enhanced abdomen CT images reconstructed with DLIR-H have the highest image quality.
Recently a deep learning-based image reconstruction algorithm has been introduced. This image reconstruction technique employs deep CNN-based models, including millions of trained parameters, to improve the image quality with natural image texture, lower image noise, and high-resolution.

**CLINICAL RELEVANCE/APPLICATION**

Deep-learning-based CT denoising methods are typically trained on images using a single set of reconstruction parameters. However, reconstruction parameters vary considerably between abdominal CT exam types and practices. This work aimed to quantify the performance of a convolutional neural network (CNN) denoising algorithm when applied to abdominal CT images with reconstruction parameters different from the training data.

**METHOD AND MATERIALS**

A CNN with 36 convolutional layers was trained on 250,000 image patches clipped from ten contrast-enhanced abdominal CT scans reconstructed with a Siemens' D30 kernel, 3 mm image thickness, and 275 mm field of view (FOV). Supervised learning was used for training, with simulated quarter dose images used as inputs, full dose images as the ground truth, and a mean-squared-error loss function. Six patients were reserved for testing the network. Baseline performance was evaluated with test data that had the same reconstruction parameters as the training data. Without retraining, the network was then applied to data with a range of reconstruction settings: FOV from 100 mm to 450 mm, kernel strength from D10 to D50, and image thickness from 1 to 5 mm. Performance was evaluated by visual assessment, root mean square error, noise level, and spatial resolution. Percent noise reduction was calculated as the difference in noise level from quarter dose to CNN output divided by quarter dose noise level.

**RESULTS**

The CNN demonstrated 73±6 % noise reduction relative to quarter dose at baseline, with no degradation of spatial resolution (i.e., when test data reconstruction = training data reconstruction). CNN denoising efficacy was decreased, to only 47±5 % noise reduction, when FOV was decreased by 50 mm (p = 0.0004), or to only 60±7 % noise reduction, when a smoother (D20) kernel was used (p = 0.001). Resolution loss was noted (visual and line profile inspection) when the network was applied to larger FOVs or sharper kernels. CNN performance was largely maintained when applied to test data with different image thicknesses.

**CONCLUSION**

Performance of the evaluated CNN-based CT denoising method varied significantly with FOV and kernel strength, but not with image thickness.

**CLINICAL RELEVANCE/APPLICATION**

While impressive noise reduction can be obtained using CNNs, reconstruction parameters must be carefully considered. Improvements in generalizability are therefore necessary.
The abbreviated MRI protocol demonstrated high sensitivity for hepatocellular carcinoma screening in risk patients.

CONCLUSION

We observed limited sensitivity of NC-AMRI protocol for HCC detection. EOB-AMRI and Dyn-AMRI showed a similar sensitivity with a slightly better specificity and cost-effectiveness for Dyn-AMRI. Further confirmation in a larger study is needed.

CLINICAL RELEVANCE/APPLICATION

Non contrast abbreviated MRI (AMRI) showed low diagnostic performance for HCC screening. AMRI with dynamic T1 (Dyn-AMRI) showed higher specificity and better cost effectiveness compared to AMRI with hepatobiliary phase.

RESULTS

One-hundred and thirty nine patients were included, 38 women and 101 men, with an average age of 54.1 years. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of abbreviated protocol for detection of nodules categorized as LI-RADS 4 and 5 (reference standard) were: 88.2 (CI: 82.0-92.0%), 74.6% (CI: 70.3-78.3%), 84.0% (CI: 79.9-87.0%), 82.2% (CI: 77.7-85.6%) and 88.2 (CI: 84.8-90.4%) respectively. Interobserver agreement was moderate for lesion detection (weighted K= 0.57, CI=0.41-0.78). The reference standard demonstrated 13/237 patients with HCC (incidence 5.5%, mean size 33.7±30mm, range:10-120mm). Inter-reader agreement was substantial for NC-AMRI and EOB-AMRI (k=0.76 and 0.75) and excellent for Dyn-AMRI (k=0.86). Pooled per-patient sensitivities were 61.5% for NC-AMRI [CI: 34.4-83%], 84.6% for Dyn-AMRI [60.8-95.1%] and 80.8% for EOB-AMRI [53.6-93.9%], without significant difference between sets (p-values range:0.06-0.16). Pooled per-patient specificities were 95.5% [92.4-97.4%], 99.8% [98.4-100%] and 94.9% [91.6-96.9%], respectively, with a significant difference between Dyn-AMRI and the other sets (p<0.01). All AMRI methods were cost-effective compared to US. Dyn-AMRI was the most cost-effective with incremental cost-effectiveness ratios (ICER) of $11,253 and life-year gain of 11months compared to US.

CONCLUSION

The abbreviated MRI protocol demonstrated high sensitivity for hepatocellular carcinoma screening in risk patients.
HCC is the most common primary malignancy of the liver and a common cause of death from cancer worldwide. Abbreviated MRI protocol possibly allows more cost-effective, high sensitivity imaging for HCC screening.
**SS22-01 Low Dose Ultra-High Resolution Sinus and Temporal Bone Imaging Using Photon-Counting Detector (PCD) CT and an Additional Tin Filter**

**Participants**
Xiangyang Tang, PhD, Atlanta, GA (Moderator) Research Grant, SINOVISION Technology Co, Ltd
Sabee Y. Molloi, PhD, Irvine, CA (Moderator) Research Grant, Canon Medical Systems Corporation

**Method and Materials**
A head phantom was scanned on a clinical energy-integrating detector (EID) CT and a PCD-CT system. EID-CT scans were acquired using routine clinical protocols with 120kV, 13.5 mGy for sinus, and 120kV, 49 mGy for T-bone exams which also employed a comb filter for ultra-high resolution (UHR) imaging. PCD-CT data were acquired using UHR mode (32x0.25 mm collimation), Sn-100kV, 10 mGy for both sinus and T-bone acquisitions. Patients referred for clinically indicated sinus and T-bone exams were scanned with PCD-CT following their clinical scans. Sinus scans were performed using 120kV, 95mAs, 13.6mGy for EID-CT, and Sn-100kV, 350 mAs, 7 mGy for PCD-CT. T-bone images were acquired using 120kV, 300mAs, 65mGy on EID-CT (comb filter-based UHR), and Sn-100kV, 500 mAs, 10 mGy on PCD-CT using UHR mode. Sinus images were reconstructed using H70 kernel, 0.75mm slice thickness, and T-bone images were reconstructed using a U70 kernel, 0.6mm slice thickness. Image contrast and noise were measured in uniform regions. Dose reduction was evaluated using the percentage change in image noise between EID-CT and PCD-CT for a given reconstruction kernel.

**Results**
Sinus phantom results showed lower noise on PCD-CT (110 HU, 10mGy) compared to EID-CT (150 HU, 13.5mGy), yielding a total dose reduction of 72% if matched image noise is targeted. Phantom results using T-bone protocol showed lower image noise for PCD-CT (129 HU, 10 mGy) at 79% lower dose compared to EID-CT (148 HU, 49mGy). Sinus patient images showed lower noise on PCD-CT (129 HU, 7mGy) than EID-CT (152 HU, 13.6mGy) at 49% lower acquisition dose for PCD-CT without compromising spatial resolution. At matched image noise and kernel, this corresponds to a total dose reduction of 76%. Patient T-bone images showed comparable image noise between EID-CT (65mGy) and PCD-CT (10mGy) at six-fold reduced dose for PCD-CT.

**Conclusion**
We have demonstrated 72 to 84% dose reduction for sinus and T-bone imaging using PCD-CT with an additional Sn filter in comparison to the current clinical protocols.

**Clinical Relevance/Application**
Using ultra-high resolution PCD-CT with additional tin filter, the image quality can be preserved while the patient radiation dose can be reduced to about one-fifth of the current clinical dose.
were then compared with VNC images from a commercial DECT system with projection domain material decomposition. The iodine basis image, and was then subtracted from the full energy bin attenuation image to generate the final VNC image. These results were obtained using the multi-bin PCCT data. The CT number enhancement due to iodine was found from the concentration estimation. Similarly, the beam filtration (160 mg/cm² of iodine) was optimized to achieve K-edge imaging. Three energy bins (bin 1: [15, 34] keV; bin 2: [34, 55] keV; bin 3: [55, 80] keV) were optimized to provide the highest overall accuracy for iodine and CaCl₂ concentration estimation. Two mixtures (8.5 mg/mL of CaCl₂ and 10 mg/mL iodine, and a mixture of CaCl₂ (25 mg/mL) and iodine (10 mg/mL). The energy bin width and position (bin 1: [15, 34] keV; bin 2: [34, 55] keV; bin 3: [55, 80] keV) were optimized to provide the highest overall accuracy for iodine and CaCl₂ concentration estimation. Similarly, the beam filtration (160 mg/cm² of iodine) was optimized to achieve K-edge imaging. Three-material decomposition was performed using the multi-bin PCCT data. The CT number enhancement due to iodine was found from the iodine basis image, and was then subtracted from the full energy bin attenuation image to generate the final VNC image. These results were then compared with VNC images from a commercial DECT system with projection domain material decomposition.

**METHOD AND MATERIALS**

An experimental PCCT system was used to scan objects with known material types and concentrations: 50 and 25 mg/mL CaCl₂, 20 and 10 mg/mL iodine, and a mixture of CaCl₂ (25 mg/mL) and iodine (10 mg/mL). The energy bin width and position (bin 1: [15, 34] keV; bin 2: [34, 55] keV; bin 3: [55, 80] keV) were optimized to provide the highest overall accuracy for iodine and CaCl₂ concentration estimation. Similarly, the beam filtration (160 mg/cm² of iodine) was optimized to achieve K-edge imaging. Three-material decomposition was performed using the multi-bin PCCT data. The CT number enhancement due to iodine was found from the iodine basis image, and was then subtracted from the full energy bin attenuation image to generate the final VNC image. These results were then compared with VNC images from a commercial DECT system with projection domain material decomposition.
RESULTS

For the two objects that do not contain iodine (50 and 25 mg/mL CaCl2), their CT numbers were incorrectly reduced by 130±5 and 67±5 HU in DECT-based VNC images. The CT number errors for 20 and 10 mg/mL iodine, and the CaCl2-iodine mixture were -5±7, -3±5, and -74±7 HU, respectively, in DECT VNC images. In comparison, CT number errors of K-edge PCCT VNC images were -2±2 HU (50 mg/mL CaCl2), 3±13 HU (25 mg/mL CaCl2), -4±12 HU (20 mg/mL iodine), -4±4 HU (10 mg/mL iodine), and -3±8 HU (iodine-CaCl2 mixture).

CONCLUSION

K-edge PCCT-based VNC imaging effectively removes iodine signal while preserving the CT number accuracy of non-iodine structures such as bone and calcifications.

CLINICAL RELEVANCE/APPLICATION

VNC images derived from contrast enhanced PCCT can obviate the need for a separate noncontrast CT scan, reducing dose and scan time and providing important baseline tissue attenuation information.

SSJ22-05  

Material Decomposition of Clinical Full-Field Photon Counting CT Data Using a 'One-Step' Direct Estimation Approach

Tuesday, Dec. 3 3:30PM - 3:40PM Room: N226

Participants
Taly Gilat Schmidt, PhD, Milwaukee, WI (Presenter) Research Grant, General Electric Company; Research Consultant, General Electric Company
Emil Y. Sidky, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose
Rina F. Barber, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose
Fredrik Gronberg, MSc, Stockholm, Sweden (Abstract Co-Author) Shareholder, Prismatic Sensors AB Research Consultant, Prismatic Sensors AB
Martin Sjölin, DPhil, MSc, Stockholm, Sweden (Abstract Co-Author) Co-founder, Prismatic Sensors AB Employee, Prismatic Sensors AB
Mats Danielsson, PhD, Stockholm, Sweden (Abstract Co-Author) Stockholder, Prismatic Sensors AB; Research support, General Electric Company

For information about this presentation, contact:
tal.gilat-schmidt@marquette.edu

PURPOSE

To demonstrate feasibility of material decomposition of clinical photon-counting head CT data using the constrained ‘one-step’ Spectral CT Image Reconstruction (cOSSCIR) method. The cOSSCIR method directly estimates the basis material images from the photon counts data, which allows constraints to be placed on the basis images to improve the decomposition.

METHOD AND MATERIALS

Head CT data of a human subject was acquired on a clinical full-field photon-counting CT prototype with silicon detectors (Prismatic Sensors, Sweden). Calibration data of a polyvinyl chloride (PVC) and polyethylene step wedge phantom was also acquired and used to estimate the effective spectra and a pileup correction for each energy bin. The cOSSCIR algorithm directly estimated the PVC and polyethylene basis material images from the photon-counts data using an optimization-based algorithm. The basis image were combined to form virtual monoenergetic images.

RESULTS

Basis material images of PVC and polyethylene were successfully reconstructed by the cOSSCIR algorithm, representing the composition of bone and soft tissue, respectively. Additional investigations are underway to evaluate the performance of cOSSCIR in correcting metal artifacts due to dental hardware and to compare the results to other material decomposition approaches.

CONCLUSION

The results demonstrate feasibility of proposed cOSSCIR algorithm to reconstruct basis material images from clinical photon-counting head CT data.

CLINICAL RELEVANCE/APPLICATION

The cOSSCIR method previously demonstrated the ability to reduce metal artifacts in experimental photon counting images of phantoms. This study demonstrates the feasibility of using cOSSCIR for clinical head CT images, which can be degraded by dental metal artifacts.

SSJ22-05  

Scan Protocol Design and k-Edge Imaging in a Clinical Whole-Body Photon-Counting CT

Tuesday, Dec. 3 3:40PM - 3:50PM Room: N226

Participants
Stefan Sawall, PhD, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Laura Klein, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Carlo Amato, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Joscha Maier, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Sebastian Faby, DIPLPHYS, Forchheim, Germany (Abstract Co-Author) Employee, Siemens AG
Monika Uhrig, MD, DIPLPHYS, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Heinz-Peter W. Schlemmer, MD, Heidelberg, Germany (Abstract Co-Author) Nothing to Disclose
Marc Kachelriess, PhD, Heidelberg, Germany (Presenter) Nothing to Disclose

For information about this presentation, contact:
Spectral differential phase-contrast CT is capable of diminishing this noise amplification, providing material specific images with lower noise level in the basis-material images can be observed in experimental measurements. We observe a reduction of the variance by a factor of up to 3 for a constant radiation dose at the position of the sample without a significant loss in image resolution. Apart from basis-material images, the proposed method provides X-ray dark-field images, which arise due to small-angle scattering at microscopic structures. While CNR varies in individual bins as a function of threshold settings, the CNR in the combined images is nearly constant and independent of the thresholds used for image acquisition. This holds true for each given combination of patient size and tube voltage and is verified for all available contrast media in measurements and accompanying simulations. Furthermore, the effect of the agents’ k-edges can be seen in the acquired data. Potentially, the remaining freedom to set T can be used to enable clinical k-edge imaging which is illustrated using Ytterbium.

CONCLUSION
An adaption of threshold settings for patient size or tube voltage is not required in clinical practice as an image with maximum CNR can always be provided by combination of bin images. Hence, the thresholds could be chosen on-demand to enable other applications, e.g. material decomposition with high-Z contrast agents exploiting k-edges of the elements used therein.

CLINICAL RELEVANCE/APPLICATION
Maximum CNR in PC-CT can always be provided independently of the thresholds. Hence, novel scan protocols can be designed enabling applications on-demand, e.g. using high-Z contrast agents.

RESULTS
phantoms are equipped with vials containing potential high-Z contrast agents (elements I, Gd, Yb, W, Bi). The PC detector intrinsically acquires data using two energy bins with the first bin covering an energy range of [20 keV, T] and the second bin covering [T, eU] with U being the tube voltage. The threshold T is varied in steps of 5 keV between the available 50 keV to 90 keV. The resulting bin images are combined in a statistically optimal manner to maximize the CNR of the contrast agent relative to the soft tissue background. The resulting CNR is evaluated as figure of merit in all bins and the combined images for all tube voltages, phantom sizes and contrast agents.

CONCLUSION
Spectral differential phase-contrast CT yields material-specific images with strongly reduced image noise compared to conventional spectral CT. Different from conventional spectral CT an additional X-ray dark-field image is obtained.

CLINICAL RELEVANCE/APPLICATION
The basis-material images obtained in spectral CT suffer from noise amplification when compared to conventional CT images. Spectral differential phase-contrast CT is capable of diminishing this noise amplification, providing material specific images with...
strongly reduced radiation dose delivered to the patient.

Printed on: 10/29/20
Case-based Review of Nuclear Medicine: PET/CT Workshop-Advances in PET (In Conjunction with SNMMI) (Interactive Session)

Tuesday, Dec. 3 3:30PM - 5:00PM Room: E450B

**Participants**
Chadwick L. Wright, MD, PhD, Columbus, OH (Moderator) Nothing to Disclose

For information about this presentation, contact:
wright.491@osu.edu

**Sub-Events**

**MSCC34A  Fluciclovine/PSMA PET Cases**

Participants
Andrei Iagaru, MD, Emerald Hills, CA (Presenter) Research Grant, General Electric Company Research Grant, Progenics Pharmaceuticals, Inc Research Grant, Advanced Accelerator Applications SA

**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).

**MSCC34B  Somatostatin Receptor PET Cases**

Participants
Corina Millo, MD, Bethesda, MD (Presenter) Nothing to Disclose

For information about this presentation, contact:
millocm@nih.gov

**LEARNING OBJECTIVES**

1) Understand the rational and complexity of imaging neuroendocrine tumors. 2) Describe different categories of SSTR-2 positive tumors and their molecular characteristics relevant to the imaging algorithm. 3) Discuss the impact of molecular imaging on management of neuroendocrine tumors.

**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. During this case review session we will discuss a wide range of cases demonstrating both common and esoteric imaging and clinical aspects encountered in patients with SSTR-2 positive tumors.

**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.

Printed on: 10/29/20
**RC401**

**Interstitial Lung Disease in the Community: A Practical Approach**

Tuesday, Dec. 3 4:30PM - 6:00PM Room: E450A

**Participants**
Edward Y. Lee, MD, Boston, MA (*Moderator*) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Identify clinical, imaging, and histological manifestations of idiopathic interstitial pulmonary fibrosis (IPF). 2) Categorize high resolution CT findings as consistent with usual interstitial pneumonia (UIP), probable UIP, indeterminate UIP and alternative diagnosis patterns. 3) Recommend the best strategies for managing patients with clinical suspicion of IPF. 4) Review unique nature of pediatric interstitial lung disease. 5) Discuss current pediatric interstitial lung disease classification system. 6) Learn characteristic imaging and pathological findings of pediatric interstitial lung disease. 7) Describe the spectrum of smoking-related interstitial lung diseases and their clinical manifestations. 8) Recognize the HRCT appearances of smoking-related interstitial lung diseases. 9) Identify the most common imaging differential diagnoses of smoking-related interstitial lung diseases. 10) To understand the clinical, histopathological and imaging manifestations of acute/inflammatory and chronic fibrotic hypersensitivity pneumonitis. 11) To get an update of the current understanding w/r the separation of chronic hypersensitivity pneumonitis and fibrotic connective tissue disease - associated interstitial lung disease (CTD-ILD). 12) To categorise the importance of various CT features w/r the radiological diagnosis of fibrotic hypersensitivity pneumonitis versus idiopathic pulmonary fibrosis (IPF) 13) To become more familiar with the multidisciplinary evaluation of patients with suspected CTD-ILD. 14) Understand the clinical workup of patients with interstitial lung disease. 15) Synthesize the numerous serologic tests with a focus on key positives. 16) Identify the key imaging patterns of connective tissue disease associated interstitial lung disease including NSIP, OP, LIP, and NSIP/OP overlap.

**Sub-Events**

**RC401A  Idiopathic Interstitial Pulmonary Fibrosis: What We Need to Know**

Participants
Gustavo S. Meirelles, MD,PhD, Sao Paulo, Brazil (*Presenter*) Partner, Ambra Saude; Stockholder, Fleury SA; Advisory Board, Boehringer Ingelheim GmbH;

For information about this presentation, contact:
gmeirelles@gmail.com

**LEARNING OBJECTIVES**

1) Identify clinical, imaging, and histological manifestations of idiopathic interstitial pulmonary fibrosis (IPF). 2) Categorize high resolution CT findings as consistent with usual interstitial pneumonia (UIP), probable UIP, indeterminate UIP and alternative diagnosis patterns. 3) Recommend the best strategies for managing patients with clinical suspicion of IPF.

**RC401B  Private Tour of Pediatric Interstitial Lung Disease in 2019**

Participants
Edward Y. Lee, MD, Boston, MA (*Presenter*) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Review unique nature of pediatric interstitial lung disease. 2) Discuss current pediatric interstitial lung disease classification system. 3) Learn characteristic imaging and pathological findings of pediatric interstitial lung disease.

**RC401C  Smoking-related Interstitial Lung Diseases**

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

For information about this presentation, contact:
csouza@toh.ca

**LEARNING OBJECTIVES**

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

**RC401D  Hypersensitivity Pneumonitis: Is There Anything New?**

Participants
LEARNING OBJECTIVES

Justus E. Roos, MD, Luzern 16, Switzerland (Presenter) Nothing to Disclose
For information about this presentation, contact: justus.roos@luks.ch

1) To understand the clinical, histopathological and imaging manifestations of acute/inflammatory and chronic fibrotic hypersensitivity pneumonitis. 2) To get an update of the current understanding w/r the separation of chronic hypersensitivity pneumonitis and fibrotic connective tissue disease - associated interstitial lung disease (CTD-ILD). 3) To categorise the importance of various CT features w/r the radiological diagnosis of fibrotic hypersensitivity pneumonitis versus idiopathic pulmonary fibrosis (IPF)

RC401E Connective Tissue Disease-related Interstitial Lung Disease

Participants
Kimberly G. Kallianos, MD, San Francisco, CA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) To become more familiar with the multidisciplinary evaluation of patients with suspected CTD-ILD. 2) Understand the clinical workup of patients with interstitial lung disease. 3) Synthesize the numerous serologic tests with a focus on key positives. 4) Identify the key imaging patterns of connective tissue disease associated interstitial lung disease including NSIP, OP, LIP, and NSIP/OP overlap.

Printed on: 10/29/20
Current Practice and Emerging Techniques in Coronary CT

Tuesday, Dec. 3 4:30PM - 6:00PM Room: E351

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

Sub-Events

RC403A Interpreting and Reporting Coronary CTA Using CAD-RADS

Participants
Ricardo C. Cury, MD, Coral Gables, FL (Presenter) Research Grant, General Electric Company; Stock options, Cleerly

For information about this presentation, contact:
rcury@baptisthealth.net

LEARNING OBJECTIVES
1) Describe the CAD-RADS classification with clear examples. 2) Discuss appropriate use of the CAD-RADS lexicon in reporting Coronary CT Angiography. 3) Discuss recommendations to facilitate decision making regarding further patient management after Coronary CT Angiography.

RC403B CT Derived Fractional Flow Reserve

Participants
Geoffrey D. Rubin, MD, Durham, NC (Presenter) Consultant, Fovia, Inc; Advisor, HeartFlow, Inc; Consultant, General Electric Company; Advisor, Boehringer Ingelheim GmbH; Advisor, Siemens AG;

For information about this presentation, contact:
grubin@duke.edu

RC403C Myocardial Perfusion Imaging in Cardiac CT

Participants
Brian B. Goshhajra, MD, Boston, MA (Presenter) Research Grant, Siemens AG

Printed on: 10/29/20
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.

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. Advancements 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 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.

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.

**RC411C  Imaging Cardiac Sarcoid**

Participants
Sharmila Dorbala, MD, MPH, Boston, MA (Presenter) Research Grant, Pfizer Inc; Speaker, General Electric Company; Speaker, AAA; Speaker, Pfizer Inc; Advisory Board, Proclara; ; ;

**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.

Printed on: 10/29/20
Innovations in Dual- and Multi-energy CT

Tuesday, Dec. 3 4:30PM - 6:00PM Room: S102CD

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

Participants
Lifeng Yu, PhD, Rochester, MN (Coordinator) Nothing to Disclose

For information about this presentation, contact:
yu.lifeng@mayo.edu

LEARNING OBJECTIVES
1) Review dual-energy CT systems that are commercially available and multi-energy CT systems that are currently under development. 2) Review basic data processing and material decomposition techniques for dual-energy and multi-energy CT data. 3) Review current and potential clinical applications of dual-energy and multi-energy CT.

ABSTRACT
This session will provide an overview of CT systems, data processing, and clinical applications of dual-energy and multi-energy CT.

Sub-Events

RC421A Dual- and Multi-energy CT Systems
Participants
Taly Gilat Schmidt, PhD, Milwaukee, WI (Presenter) Research Grant, General Electric Company; Research Consultant, General Electric Company

LEARNING OBJECTIVES
1) Describe and compare the different approaches for acquiring multi-energy CT data. 2) Identify the important features of multi-energy CT systems and how they impact the acquired multi-energy data.

RC421B Dual- and Multi-energy Data Processing

Participants
Katsuyuki Taguchi, PhD, Baltimore, MD (Presenter) Research Grant, Siemens AG; Consultant, JOB Corporation

RC421C Clinical Applications of Dual- and Multi-energy CT

Participants
Joel G. Fletcher, MD, Rochester, MN (Presenter) Grant, Siemens AG; Consultant, Medtronic plc; Consultant, Takeda Pharmaceutical Company Limited; Grant, Takeda Pharmaceutical Company Limited; 

For information about this presentation, contact:
fletcher.joel@mayo.edu

LEARNING OBJECTIVES
1) Review different types of standard dual energy images (e.g., linearly blended mixed kV, virtual monoenergetic images, virtual non-contrast, virtual non-calcium, iodine maps) and understand how they can be reconstructed and utilized in an efficient, protocol-driven, heterogeneous radiology practice. 2) Understand multiple clinical scenarios where clinical benefit is obtained by using the ability of dual energy to enhance iodine signal or quantify iodine content. 3) Illustrate how to use dual energy information quickly in exam interpretation.

Printed on: 10/29/20
Participants
Cristopher A. Meyer, MD, Madison, WI (Moderator) Investor, Elucent Medical; Consultant, NIOSH Certified B-reader

Special Information
This interactive session will use RSNA Diagnosis Live™. Please bring your charged mobile wireless device (phone, tablet or laptop) to participate.

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
RC501A 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

RC501B Occupational Lung Disease: The Other Guys (Beryllium, Hard Metal, Aluminum, Siderosis)
Participants Sudhakar N. Pipavath, MD, Seattle, WA (Presenter) Scientific Advisory Board, Boehringer Ingelheim GmbH

RC501C Airway-related Interstitial Lung Disease and Emerging Occupational Lung Disease
Participants Christian W. Cox, MD, Rochester, MN (Presenter) Nothing to Disclose

RC501D HRCT Patterns of Occupational Lung Disease: Case-based
Participants Cristopher A. Meyer, MD, Madison, WI (Presenter) Investor, Elucent Medical; Consultant, NIOSH Certified B-reader
For information about this presentation, contact: cmeyer2@uwhealth.org

Printed on: 10/29/20
Emerging Technology: Dual-energy and Spectral CT Update 2019

Wednesday, Dec. 4 8:30AM - 10:00AM Room: S505AB

Participants
Savvas Nicolaou, MD, Vancouver, BC (Moderator) Institutional research agreement, Siemens AG; Stockholder, Canada Diagnostic Centres

For information about this presentation, contact:
savvas.nicolaou@vch.ca

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

RCS17A How to Successfully Implement a Dual-energy CT in Your Practice?

Participants
Nicolas Murray, MD, Vancouver, BC (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To learn the tips and tricks to make a dual-energy CT implementation successful. 2) To recognize the potential barriers in implementation of dual-energy CT in your practice.

RCS17B Practical Multi-energy Applications of the Cardiothoracic System

Participants
Prabhakar Rajiah, MD, FRCR, Dallas, TX (Presenter) Royalties, Reed Elsevier

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.

RCS17C Novel and Emerging Neuroradiology Multi-energy Applications

Participants
Aaron D. Sodickson, MD,PhD, Boston, MA (Presenter) Institutional research agreement, Siemens AG; Speaker, Siemens AG; Speaker, General Electric Company

For information about this presentation, contact:
asodickson@bwh.harvard.edu

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.

RCS17D Dual-energy/Spectral CT of the Abdomen: Making a Difference

Participants
Desiree E. Morgan, MD, Birmingham, AL (Presenter) Institutional Research Grant, General Electric Company; Consultant, General Electric Company

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.

RCS17E Practical and New Clinical Applications in Musculoskeletal Dual Energy/Spectral CT: Case Based
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.

Printed on: 10/29/20
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
Yolanda D. Tseng, MD, Seattle, WA (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Case-based review of staging and treatment response in lymphoma. 2) Discuss imaging findings in lymphoma and their clinical significance (PET, CT, MRI). 3) Describe the management of patients with lymphoma, including the role of imaging and radiation treatment options.

ABSTRACT
Management of lymphoma continues to evolve in the setting of improved imaging, pathologic understanding of this heterogeneous disease, systemic therapy, and radiotherapy techniques. This interactive, multi-disciplinary session is geared to general radiologists and radiation oncologists with the goal to provide clinically relevant, up-to-date knowledge and skills in evaluating and treating these patients. Through cases, we will review common manifestations of Hodgkin and non-Hodgkin lymphoma and imaging features of these lymphomas that are important for workup, staging, and assessment of treatment response. Cases will be used to walk participants through the management of common lymphomas with a focus on the role of radiotherapy.

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Segmentation

Wednesday, Dec. 4 10:30AM - 12:00PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
George L. Shih, MD, New York, NY (Presenter) Consultant, MD.ai, Inc; Stockholder, MD.ai, Inc;

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This session will focus on the use of deep learning methods for image segmentation, applied to the challenge of CT or MR brain segmentation. While focused on this particular problem, the concepts should generalize to other organs and image types.

Printed on: 10/29/20
**Cardiac (Coronary Atherosclerosis)**

**Wednesday, Dec. 4 10:30AM - 12:00PM Room: E351**

**SSK03-01 Calcium Scoring in Denoised Ultra-Low Dose Chest CT**

**Participants**
- Jill E. Jacobs, MD, New York, NY (Moderator) Nothing to Disclose
- Suhny Abbara, MD, Dallas, TX (Moderator) Royalties, Reed Elsevier; Institutional research agreement, Koninklijke Philips NV; Institutional research agreement, Siemens AG
- Yeon Hyeon Choe, MD, PhD, Seoul, Korea, Republic Of (Moderator) Nothing to Disclose

**Sub-Events**

**SSK03-02 Individualized Coronary Artery Calcium Scoring at Any Tube Voltage Using a kVp-independent Reconstruction Kernel**

**Participants**
- Edith M. Marom, MD, Tel Aviv, Israel (Presenter) Speaker, Bristol-Myers Squibb Company; Speaker, Boehringer Ingelheim GmbH; Speaker, Merck & Co, Inc; Officer, Voxellence
- Michael Green, MSc, Tel Aviv, Israel (Abstract Co-Author) Nothing to Disclose
- Eli Koen, MD, Tel Hashomer, Israel (Abstract Co-Author) Nothing to Disclose
- Nahum Kiryati, PhD, Tel Aviv, Israel (Abstract Co-Author) Nothing to Disclose
- Amalio Mayer, PhD, Los Gatos, CA (Abstract Co-Author) Nothing to Disclose

For information about this presentation, contact:
edith.marom@gmail.com

**METHOD AND MATERIALS**

52 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. Since the LCNLM algorithm uses 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 an Agatston score for each of the scans and classified the severity of the calcifications in the coronary arteries (H). To account for the influence of strong dose reduction on Agatston scores, a 2nd order polynomial correction function between ULDCT and NDCT Agatston scores was computed and applied in a leave-one-out cross-validation scheme to each case. The same was done between ULDCT and D scores. The correction function was applied to the ULDCT and D scores obtained in the experiments.

**RESULTS**

Using ULDCT 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. All 14 patients with severe calcifications (Agatston>400) were classified correctly in the denoised ULDCT, while only 12 were classified as severe in the ULDCT. Also, all 6 patients with moderate calcifications (100<=Agatston<=400) were classified correctly in both ULDCT and the denoised ULDCT.

**CONCLUSION**

Interpretation of ULDCT may cause errors in calcium scoring, but implementation of the LCNLM algorithm for denoising improves ULDCT images so that calcium scoring results are similar to those obtained in normal dose scans.

**CLINICAL RELEVANCE/APPLICATION**

Denoising ULDCT with the LCNLM algorithm enables correct calcium scoring with dose reductions greater than 90%.

**SSK03-02 Individualized Coronary Artery Calcium Scoring at Any Tube Voltage Using a kVp-independent Reconstruction Kernel**

**Participants**
- Vincenzo Vingiani, MD, Castellammare di Stabia, SC (Presenter) Nothing to Disclose
- Simon S. Martin, MD, Charleston, SC (Abstract Co-Author) Institutional Research support, Siemens AG
- Andres Abadia, Charleston, SC (Abstract Co-Author) Nothing to Disclose
Low kV-scanning lowers radiation at many CT applications, yet is not currently used for coronary artery calcium scoring (CACS) as the Agatston convention is defined at 120kV. We prospectively investigated an automated tube voltage selection (ATVS)-based protocol, using a software-based correction algorithm and a kVp-independent kernel, for the accurate derivation of Agatston calcium scores from cardiac CT data acquired at any kV-level.

METHOD AND MATERIALS
With IRB approval, 24 patients (50% male, 60.2 ± 10.5 years) underwent conventional clinical CACS at 120 kVp and an additional research CACS acquisition using an individualized, body habitus-adjusted tube voltage between 70 and 130 kVp, based on the ATVS selection. Datasets of the additional CACS scans were reconstructed using a kVp-independent kernel that enables using the Agatston scoring convention without changing the weighting threshold of 130 HU, regardless of the original tube voltage chosen for image acquisition. Agatston scores and radiation dose estimates derived from the different ATVS-based coronary calcium scoring studies were compared with the standard acquisition at 120 kVp.

RESULTS
Median Agatston scores derived from the standard 120 kVp, 28.5 (IQR, 0.25 - 346.3), and the patient-tailored kVp-independent protocol, 32.1 (IQR, 0 - 348.7), showed no significant differences (p = 0.17). We found an excellent correlation for Agatston scores derived from the two different protocols with a Pearson's correlation coefficient of r = 0.99. Additionally, 96% of patients were classified into the same risk category (0, 1-10, 11-100, 101-400, or >400) using the patient-tailored kVp-independent protocol. The CT dose-length-product was 27.7 ± 8.6 mGy×cm using ATVS protocol and 30.0 ± 8.3 mGy×cm using the standard 120 kVp protocol, resulting in a significantly lower effective radiation dose with the kV-independent approach (0.39 ± 0.12 mSv vs. 0.42 ± 0.11 mSv) (p < 0.001).

CONCLUSION
ATVS-based CACS using a kVp-independent kernel enables Agatston calcium scoring in excellent correlation compared to the standard 120 kVp scanning. Additionally, radiation dose parameters were significantly reduced using the ATVS-based protocol.

CLINICAL RELEVANCE/APPLICATION
Using the ATVS with a kVp-independent reconstruction kernel allows the CACS protocol to be individualized to each patient, resulting in an optimal compromise between radiation dose and high diagnostic reliability.

SSK03-03 Smoking, but Not Other Risk Factors, Predicts High-Risk Plaque in Low Calcium Score 1-99 AU: Implications for Patient Management

Wednesday, Dec. 4 10:50AM - 11:00AM Room: E351

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PURPOSE
The American Heart Association 2018 cholesterol guidelines recommend statin therapy in patients with a coronary calcium score (CCS) >100 AU as Class IIa, while in low CCS (1-99 AU), an "individual risk estimation" is advised, leaving the clinician in a greyzone for decision making. High-risk plaque criteria are novel promising coronary computed tomography angiography (CTA) biomarkers for prection of major cardiac events.Hence, the objective of this study was to define predictors of high-risk plaque by coronary computed tomography (CCTA) in patients with a low CCS.

METHOD AND MATERIALS
6473 low-to-intermediate ASCVD-risk patients (60±12.51 years; 40.11% females) who underwent CCTA and CCS were prospectively enrolled. CCTA analysis included (1) stenosis severity CADRADS 0-4 and (2) high-risk plaque (HRP) criteria: low attenuation plaque (LAP) quantified by HU, napkin-ring (NR), spotty calcifications (SC) or positive remodeling (PR). Multiple multivariate binary logistic regression models were created for prediction of the different HRP-criteria by the major risk factors (nicotine, arterial hypertension, positive family history, dyslipidemia, diabetes mellitus).

RESULTS
997 patients had a low CCS (age 60.6±9.3, 40.12% female), among them 279 (28%) smokers. 35.6% of smokers had at least one HRP (min.2 criteria) versus only 26.9% of non-smokers (p=0.014). NRS was found more often in smokers (16.2% vs 9.2%, p=0.04).

On multivariate linear regression, smoking but not the other risk factors predicted HRP (OR 1.56; 95% CI 1.10-2.20; p=0.012), napkin-ring (OR 2.05; 95% CI 1.12-3.74; p=0.02) and PR (OR 1.81; 95% CI 1.18-2.77 p=0.006). There was a trend between LAP>30 HU and diabetes (p=0.09), and LAP<60 HU and <90 HU with dyslipidemia (p=0.069; p=0.035, respectively), but there was no correlation of any other risk factors with any other HRP criteria.

CONCLUSION

Active smoking predicts the presence of high-risk plaque, especially napkin-ring and positive remodeling in patients with a CCS between 1 and 99 AU, but not the other major cardiovascular risk factors.

CLINICAL RELEVANCE/APPLICATION

Although a CCS between 1-99 AU categorizes these patients as low-risk, a history of smoking should incite the physician to further investigate whether the patient has high-risk plaque, and manage LDL more restrictively, e.g by initiating or intensifying statin treatment, and/or aiming a lower target LDL.

SSK03-04  Coronary Calcium Scoring at 100 kV with Tin Filtration Using a kV-independent Reconstruction Kernel

Wednesday, Dec. 4 11:00AM - 11:10AM Room: E351

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PURPOSE

This study aimed to investigate the feasibility of a protocol for coronary artery calcium scoring (CACS) at 100 kV with tin filtration (Sn100 kV) to provide accurate Agatston scores, as well assess its potential for radiation dose reduction, using a software-based correction algorithm and a kV-independent kernel compared to the standard 120 kV acquisition.

METHOD AND MATERIALS

With IRB approval, we analyzed image data of 114 patients (66 men, 61.8 ± 9.6 years) who underwent a clinically-indicated CACS acquisition using the standard 120 kV protocol and an additional Sn100 kV CACS scan, as part of a research study. Datasets of the Sn100 kV scans were reconstructed using a kV-independent kernel. The kV-independent kernel produced images with Hounsfield unit (HU) values equivalent to 120 kV for bone and calcium. This enables Agatston scoring without changing the original weighting correction algorithm and a kV-independent kernel compared to the standard 120 kV acquisition.

RESULTS

Median Agatston scores derived from the standard 120 kV and the Sn100 kV protocol with the kV-independent kernel were 24.7 (IQR, 0-171.1) and 21.4 (IQR, 0-173.8), respectively, without significant differences (P = 0.18). We found an excellent correlation for Agatston scores derived from the two different protocols with a Pearson's correlation coefficient of r = 0.99. The dose-length-product was 11.4 ± 4 mGycm using the Sn100 kV and 50.4 ± 24.9 mGycm using the standard 120 kV protocol (P < 0.01), resulting in a significantly lower effective radiation dose by 77% (0.16 ± 0.06 mSv vs. 0.7 ± 0.35 mSv, P <0.01) for scanning at Sn100 kV. Additionally, 99% of patients were classified into the same risk category (0, 1-10, 11-100, 101-400, or >400) using the Sn100 kV protocol.

CONCLUSION

CACS at Sn100 kV using the kV-independent kernel is feasible and shows a high correlation compared to standard 120 kV scanning. Furthermore, the radiation dose was significantly reduced using the low-kV protocol.

CLINICAL RELEVANCE/APPLICATION

The use of a Sn100 kV protocol with a kV-independent kernel allows for a significant reduction of the radiation dose to the patient and simultaneously achieves a high diagnostic reliability.

SSK03-05  Determining Calcifications in Coronary Arteries Using Non-Gated Chest CT with 256-Detector Row in Comparison with Dedicated Calcium-Scoring CT

Wednesday, Dec. 4 11:10AM - 11:20AM Room: E351

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METHOD AND MATERIALS
This was an institutional review board approved study and all participants gave written informed consent. A total of 1318 patients for chest examination were enrolled to undergo both non-gated chest CT and dedicated calcium-scoring CT (CSCT) on a 256-detector row CT scanner. The chest CT was scanned in fast-helical mode with 8cm collimation, 0.28s rotation speed and pitch 0.992:1 to cover entire chest. CSCT used single prospective ECG-triggered cardiac axial mode with 0.28s rotation speed covering only the heart. Both scans used 120kV and automatic tube current modulation for obtaining a preset noise index of 20HU at 2.5cm slice thickness. Two reviewers evaluated the subjective image quality of the ungated chest CT in terms of the detection and display of calcifications in coronary arteries. CAC scores (Agatston, Mass and Volume) were determined using both image sets and were statistically compared.

RESULTS
It took less than 0.5s to cover the heart in the ungated chest CT and all cardiac images were acceptable for detecting and displaying calcifications in coronary arteries. Sensitivity and specificity of non-gated chest CT for determining positive CAC was 94.8% (182/192) and 100%, respectively. The agreement in assessing the quantitative Agatston, Volume and Mass scores between the non-gated chest CT and CSCT was almost perfect, with the Intra-class correlation coefficient (ICC) values of 0.998, 0.999 and 0.999, respectively. Additionally, there was a good agreement in CAC quantification between the non-gated chest CT and dedicated CSCT with small coefficient of variation: Mass score (9.0%), Volume score (9.5%) and Agatston score (12.6%).

CONCLUSION
Non-gated chest CT on a 256-detector row CT with fast scan speed may be used to reliably detect and quantify calcifications in the coronary arteries.

CLINICAL RELEVANCE/APPLICATION
Non-gated chest CT with 256-detector row is a reliable imaging mode for detecting and quantifying calcifications in coronary arteries and the calcium mass score is the most accurate parameter compared with dedicated calcium-scoring CT.
CACS values revealed no significant differences between the automated algorithm and the reference standard (P=0.282). CACS using the automated application showed an excellent correlation with the reference standard (Pearson, r=0.97). In addition, the fully automated software classified 476 of 511 (93.2%) patients into the same risk category (0, 1-10, 11-100, 101-400, or >400) as the human observers, whereas 35 (6.8%) patients were misclassified into a different category. Overall, 15 (2.9%) patients were downgraded to a lower category and 20 (3.9%) patients were upgraded to a higher category.

CONCLUSION
AI-based automated calcium scoring for non-contrast ECG-triggered cardiac CT shows high accuracy when compared to manually obtained reference scores. The use of this fully automated software application may reduce the need for human user interaction and interpretation time.

CLINICAL RELEVANCE/APPLICATION
The use of this AI-based fully automated software application may reduce the need for manual input and interpretation time and thus enhance workflow efficiencies for this growing CT application.

SSK03-07 Deep Learning for Calcium Scoring in Radiotherapy Treatment Planning CT Scans in Breast Cancer Patients

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PURPOSE
Cardiovascular disease (CVD) is an important cause of mortality in breast cancer patients. Coronary artery calcification (CAC) and thoracic aorta calcification (TAC) are strong and independent risk factors for CVD and can be detected and quantified in radiotherapy treatment planning (RTTP) CT. Manual quantification of CAC and TAC is a tedious and time-consuming task. Therefore, we evaluated the performance of an AI system, developed for automatic calcium scoring in low-dose chest CT, in RTTP CT.

METHOD AND MATERIALS
We included 1409 breast cancer patients (age 56±7 years), who participated in the UMBRELLA cohort and underwent a RTTP CT (Philips Brilliance Big Bore CT, 120kVp, no ECG-triggering, no contrast, 3.0mm slice thickness). In a first step, CAC and TAC were manually annotated in these scans. In a second step, a deep learning algorithm was applied for automated detection of CAC and TAC. A baseline system was trained with 1181 low-dose chest CTs (all major CT vendors, 120/140kVp, no ECG-triggering, no contrast, 1.0-3.0mm slice thickness) from the National Lung Screening Trail (NLST). A RTTP-specific system was trained with the NLST scans and additionally 568 RTTP scans. The remaining 841 RTTP scans were used for evaluation. CAC was quantified as Agatston and volume scores; TAC as volume scores only. Agatston score was stratified into five risk categories: 0, 1-10, 11-100, 101-400, >400. Reproducibility between manual and automatic scores was evaluated with linearly weighted κ (categories) and Intraclass Correlation Coefficient (ICC, volume scores).

RESULTS
For the baseline system, ICCs were 0.85 (95% CI 0.83-0.87) and 0.98 (0.97-0.98) for CAC and TAC volumes, respectively. ICCs for the RTTP-specific system improved to 0.92 (0.91-0.93) and 0.99 (0.98-0.99) for CAC and TAC volumes, respectively. The baseline and RTTP-specific systems achieved a κ of 0.85 (0.80-0.90) and 0.89 (0.85-0.93).

CONCLUSION
An AI system trained on low-dose chest CTs allows accurate automatic CAC and TAC scoring in RTTP CT, which improves further upon RTTP-specific training.

CLINICAL RELEVANCE/APPLICATION
Accurate, fully automatic CVD risk assessment in breast cancer patients from readily available RTTP scans allows cost-effective identification of patients who may benefit from preventive treatment.

SSK03-08 Preliminary Exploration and Analysis of Coronary Artery Plaque Characteristics in HIV-Infected Patients Based on Radiomics

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PURPOSE
Preliminary exploration and analysis of coronary artery plaque characteristics in HIV-infected patients based on radiomics.
Calcium Scoring on Emergency Aortic Dissection CT Scans: A Missed Opportunity for Radiologists to Impact Clinical Management of Acute Chest Pain Patients

Wednesday, Dec. 4 11:50AM - 12:00PM Room: E351

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PURPOSE
CT aortography (CTAo) is routinely performed in the emergency setting for acute chest pain patients. Previous studies show that the diagnostic yield of CTAo is very low. Most patients are sent home shortly after a negative scan without directed cardiovascular follow up. This study assesses these patients’ long term clinical outcomes and investigates the potential prognostic value of coronary artery calcium (CAC) scoring from CTAo.

METHOD AND MATERIALS
A cohort of patients who received emergency CTAo from 2007-2012 was assembled using a quality-improvement medical record survey tool. The time period allowed for long term follow up (5-10 years). Clinical events included death, aortic dissection (AD), myocardial infarction (MI), cerebrovascular accident (CVA), and pulmonary embolism (PE). Visual CAC scores were computed from original images utilizing a validated, 12-point ordinal method. Kaplan-Meier Estimator and Cox regression were used for survival analysis.

RESULTS
1662 patients had CTAo, of which 599 (36%) had at least one subsequent documented clinical event (227 [13.7%] deaths, 86 [5.2%] AD, 119 [7.2%] MI, 96 [5.8%] CVA, 71 [4.3%] PE). Survival analysis showed a strong association between CAC score and mortality with hazard ratios (HR) increasing with higher CAC scores when age and gender were included as covariates. Eight year mortality for patients without coronary calcium (CAC of 0) was 13%, for those with low calcium (CAC 1-3) was 25% (HR 1.88), for those with moderate calcium (CAC 4-6) was 41% (HR 2.74), and for those with high calcium (CAC 7-12) was 57% (HR 3.68). CAC scores were highly predictive of major adverse cardiac events - MI, CVA, and death (p<2e-16). CAC score, however, was neither predictive of occurrence of PE (p=0.98) nor AD (p=0.24). AD and PE occurred earlier (median 517 and 578 days) than major cardiovascular events (medians 852-1191 days).

CONCLUSION
CAC scores in patients undergoing CTAo strongly predict long-term all-cause mortality and major adverse cardiovascular events. Including a CAC score in CT aortogram reports has a potential role in directing subsequent patient management by highlighting high risk patients for cardiovascular risk assessment and treatment.

CLINICAL RELEVANCE/APPLICATION
Visual CAC scores from emergency CT aortograms can provide additional value by identifying patients with high long-term cardiovascular risk who may benefit from aggressive risk factor management.
SSK05

Cancer Risk in Subsolid Nodules in the National Lung Screening Trial

Wednesday, Dec. 4 10:30AM - 10:40AM Room: N229

Participants
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Sub-Events

SSK05-01 Cancer Risk in Subsolid Nodules in the National Lung Screening Trial

Wednesday, Dec. 4 10:30AM - 10:40AM Room: N229

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PURPOSE
Subsolid nodules, comprising pure ground glass (GGN) and part-solid (PSN) nodules, have a high risk of indolent malignancy. Lung-RADS management guidelines are based on expert opinion and lack independent validation. The purpose of this study is to evaluate Lung-RADS for its ability to estimate the malignancy rates of subsolid nodules, using nodules from the National Lung Screening Trial (NLST). Lung-RADS was also compared to the NELSON trial volumetric classification.

METHOD AND MATERIALS
Two hundred nodules from each of the following categories were selected from the NLST: GGN < 10 mm, GGN <= 10 mm, and PSN > 6 mm. A thoracic radiologist reviewed the baseline and follow-up CT images and measured the nodules. The primary outcome for each nodule was the development of a cancer in the same lobe. Analyses were weighted by the higher prevalence of the GGN < 10 mm category. Nodules were classified by either the Lung-RADS or NELSON trial systems.

RESULTS
A total of 434 nodules were true subsolid nodules. At baseline, Lung-RADS 2 comprised 282 (73%) of nodules, with a malignancy rate of 3%, greater than the reported 1% in the Lung-RADS document (p=0.0081). The malignancy rate for GGN < 10 mm (1.5%) was significantly smaller than that for GGN measuring 10 - 19 mm (7%), p=0.02. Lung-RADS 3 comprised 89 nodules (17%), with a malignancy rate of 13%, greater than the reported 2% in the Lung-RADS document (p<0.001). The area under the receiver operating characteristic curve for Lung-RADS at baseline was 0.715, compared to 0.668 for NELSON.

CONCLUSION
Subsolid nodules in Lung-RADS categories 2 and 3 have a higher risk of malignancy than reported, and GGN 10 - 19 mm have a risk that is closer to Lung-RADS 3 than Lung-RADS 2. There does not appear to be an advantage to using volumetric (NELSON) compared to linear measurement (Lung-RADS) classification schemes.

CLINICAL RELEVANCE/APPLICATION
The malignancy risk of subsolid Lung-RADS 2 and 3 nodules in lung cancer screening is higher than expected, which may require revision of management guidelines.

SSK05-02 Are We on the Same (Web) Page for Lung Cancer Screening? A Comprehensive Content Analysis of United States Lung Cancer Screening Program Websites

Wednesday, Dec. 4 10:40AM - 10:50AM Room: N229

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METHOD AND MATERIALS

A Google searches for "lung cancer screening", "l. low dose CT screening", and "lung screening" performed September 15, 2018 yielded 269 LCS program websites. 258 unique websites were equally divided and randomly assigned to 9 Thoracic Radiologists for analysis. Each radiologist reviewed text, images, videos, and PDF attachments for a random subset of sites using a standardized checklist. All main landing pages for LCS sites, along with linked pages from the institution directly dealing with LCS were included in the analysis. Information on links external to the LCS institution were not included in the content analysis. Content areas for which websites were analyzed included (1) LCS eligibility criteria, (2) monetary costs and insurance coverage, (3) benefits and (4) risks of lung cancer screening.

RESULTS

While most sites mentioned eligibility for screening (98%), 13% reported ages 55-74, 42% ages 55-77, 17% ages 55-80, and 19% gave multiple ranges. A quarter of websites did not address monetary costs of screening; out-of-pocket costs as a result of screening were rarely mentioned. Many (93%) mentioned the possibility of early detection of lung cancer and the use of low-dose CT, but 39% of sites did not mention the magnitude of the benefit, and 47% made no mention of the U.S. National Lung Cancer Screening Trial. More than half of the websites (53%) did not address any risks related to screening. Categories of risks discussed included radiation (38%), false positives (37%), and further tests (40%). Fewer sites included false negatives (20%), overdiagnosis (12%), procedural complications (10%), and anxiety/worry (20%).

CONCLUSION

There is inconsistency in the information provided to patients about lung cancer screening. Stated ages for eligibility, while commonly reported, vary widely. Health care costs are a large concern for many and yet a quarter of webpages do not address cost. In addition, the majority of LCS sites fail to address the risks of screening.

CLINICAL RELEVANCE/APPLICATION

Radiology practices should increase efforts to offer updated, standardized LCS information on websites to improve public knowledge of this imaging-based cancer screening tool and help alleviate some patient concerns.

SSK05-03 Lung Cancer Screening in NLST Eligibles: Tailoring Annual Low-Dose Computed Tomography by Post-Test Risk Stratification

Wednesday, Dec. 4 10:50AM - 11:00AM Room: N229

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PURPOSE

To calculate the risk of lung cancer (LC) in 1 and 3 years after baseline low-dose computed tomography (LDCT), in screenees selected by National Lung Screening Trial (NLST) criteria

METHOD AND MATERIALS

For the aim of this post-hoc analysis, screenees from a prospective lung cancer screening (LCS) trial were retrospectively selected: age=>55years, pack-years=>30. Pre-test metrics: baseline demographics, medical interview, and pulmonary function test. Post-test
Coronary artery calcification (CAC) is a common and important incidental finding in low dose CT lung cancer screening (LD-LCS). Our objective was to determine the incidence of significant coronary artery calcification (CAC) reported on LD-LCS and to determine the impact of its reporting on subsequent diagnostic and therapeutic interventions.

METHOD AND MATERIALS

In this IRB approved retrospective study, we queried our lung cancer screening database for reports of LD-LCS performed between January 2016 and September 2018. All reports with significant findings designated with the "S" modifier for any LungRADS category were reviewed, and those with the "S" modifier pertaining to significant CAC were selected. The grading of CAC was extracted from the reports and compiled into four groups: moderate, severe, other non-standard descriptors (e.g. extensive, dense, etc.), or unspecified. From the electronic medical record, we reviewed and recorded baseline clinical characteristics of included patients and subsequent changes in management that resulted from the report of significant CAC. Paired Student's t-test and Fisher's exact test were used to compare subsets of patients.

RESULTS

Out of the 3110 patients who underwent LD-LCS, 756 (24.3%) patients (mean age: 67 +/- 6.4 year; M=466, 61.6%: F=290, 38.4%) were reported to have significant CAC. Of these, 236 patients (31.2%) had established, documented coronary artery disease at baseline. A change in management was noted in 155 patients (20.5%). The most common changes in management were medication regimen change (n=114/155, 73.5%), stress testing (n=65/155, 41.9%), and cardiology specialist referral (36/155, 23.2%). Percutaneous (3/155, 1.9%) and surgical (3/155, 1.9%) coronary interventions were infrequent. In those without known CAD, those whose CAC were semi-quantified as moderate, severe, or other nonstandard modifier were more likely to have a change in management compared to those whose CAC were unspecified (35% vs. 25%, p=0.02).

CONCLUSION

Coronary artery calcification is a common significant finding in LD-LCS. The reporting and semi-quantitative assessment of CAC in patients without established coronary artery disease resulted in change in management.

CLINICAL RELEVANCE/APPLICATION

Routine and standardized reporting of significant CAC found on LD-LCS has the potential to change patient management and may contribute to improved cardiovascular outcomes in this high-risk population.
**SSK05-05**  
**Interobserver Agreement for Lung-RADS Categorization in Subsolid Nodule-Enriched Lung Cancer Screening CT’s**  
Wednesday, Dec. 4 11:10AM - 11:20AM Room: N229

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**PURPOSE**  
To evaluate the interobserver agreement for Lung-RADS categorization in subsolid nodule-enriched low-dose screening CTs.

**METHOD AND MATERIALS**  
A retrospective review of the low-dose screening CT reports from 2013 to 2017 using keyword search for subsolid nodules found 54 baseline CTs. A total of 162 CTs, including 108 negative screening CTs as controls, were classified into Lung-RADS categories by two fellowship-trained thoracic radiologists in a consensus manner. We randomly selected 60 scans (20 in Category 1/2 and 3, 10 in Category 4A and 4B) to ensure a balanced representation of all lung-RADS categories. Five radiologists reviewed the 60 CT scans and classified each CT scans into Lung-RADS categories. Rates of concordance, minor and major discordance were calculated, with the major discordance defined as at least six months of management discrepancy. We analyzed the agreement of five observers using Cohen's kappa statistics.

**RESULTS**  
Averaged correct categorization was achieved by five radiologists for 60.3% (181 of 300) in all cases and 45.0% (90 of 200) in positive screens. Minor and major discordance rate was 29.7% and 10.0% in all cases and 41.5% and 13.5% in positive screens, respectively. Pairwise interobserver agreement (weighted k) was 0.535 (range, 0.353-0.686; 95% confidence interval, 0.406, 0.664).

**CONCLUSION**  
The accuracy of radiologists in the categorization of screening CTs with subsolid nodules varied and the interobserver agreement was only moderate in the retrospective study. This inconsistency may affect management recommendations in lung cancer screening.

**CLINICAL RELEVANCE/APPLICATION**  
Lung-RADS categorization of low-dose screening CTs with subsolid nodules varies among radiologists and the inconsistency may affect management recommendations.

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**SSK05-06**  
**Update on Lung Cancer Screening Utilization: Results from the 2017 Behavioral Risk Factor Surveillance System Cross-Sectional Survey**  
Wednesday, Dec. 4 11:20AM - 11:30AM Room: N229

**Participants**  
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**PURPOSE**  
Lung cancer screening with low dose chest CT (LCS) reduces lung cancer mortality. Despite favorable recommendations from the USPSTF for LCS in 2013 and coverage by public and private payors since 2015, initial studies reported that only <5% of eligible patients are being screened. Despite increasing insurance coverage, public awareness, and availability of LCS nationwide, few studies have evaluated recent LCS utilization. Our purpose was to estimate LCS utilization using nationally representative cross-sectional survey data from the most recent Behavioral Risk Factor Surveillance System Survey (BFRSS) survey.

**METHOD AND MATERIALS**  
BFRSS is a nationally representative, cross-sectional phone survey of adults in the United States. The 2017 survey included questions about LCS eligibility and utilization in 11 states (Florida, Georgia, Kentucky, Maryland, Missouri, Nevada, Oklahoma, Vermont, Wyoming, Kansas, Maine). Primary outcome was the proportion of patients ages 55-79 with at least a 30 pack year smoking history who reported undergoing LCS. Multivariable logistic regression models were used to evaluate the association between self-reported LCS usage and sociodemographic characteristics, adjusted for potential confounders and accounting for complex survey design elements.

**RESULTS**
30,362 participants were included of whom 27.8% reported at least 30 pack year smoking history. Among participants with at least a 30 pack year smoking history between the ages of 55-79, 12.2% (95% CI 10.7, 13.7) reported obtaining a chest CT scan specifically to evaluate for lung cancer. In our multiple variable analyses, age, education category, income category, health insurance status, race, marital status, and employment status were not associated with statistically significant differences in self-reported receipt of LCS (p > 0.05).

CONCLUSION

Overall, utilization of LCS remains low (12%) among eligible participants, however comparison with previously published studies suggests improvements in LCS utilization.

CLINICAL RELEVANCE/APPLICATION

LCS uptake among eligible patients is low. Provider education, public awareness campaigns, and continued improvements in health insurance coverage are required to save more lives with LDCT.

SSK05-07 Impact of Multidisciplinary Review of Lung Cancer Screening CT on LungRADS Score and Follow-Up Recommendations

Wednesday, Dec. 4 11:30AM - 11:40AM Room: N229

Participants

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PURPOSE

There is evolving consensus that positive lung cancer screening CT scans should be reviewed by a multidisciplinary panel. We assessed the impact of multidisciplinary review of lung cancer screening CTs initially coded as LungRADS (LR)-3, LR-4a, or LR-4b.

METHOD AND MATERIALS

From 1/2017-12/2018, 872 patients underwent lung cancer screening CT at 4 sites within an integrated health care system. A designated radiologist at each site interpreted CTs according to LR criteria. CT scans coded as LR-3 (n=71, 8.1%), LR-4a (n=33, 3.8%), or LR-4b (n=32, 3.7%) were reviewed by a multidisciplinary team of radiologists, interventional pulmonologists, and thoracic surgeons. Following multidisciplinary review, CTs were given a final LR score and follow-up recommendations were provided.

RESULTS

136 patients were coded as LR-3, LR-4a, or LR-4b by the site radiologist. After multidisciplinary review, 23 (16.9%) patients had the LR score changed. Baseline characteristics were similar between patients with a change in LR score compared to those with no change in LR score. 12 CTs (52%) had the LR score upcoded and 11 CTs (48%) were downcoded. Reasons for change in LR coding are described in Figure 1. CT scans not following LR assessment categories were more likely to be upcoded (p=0.03), whereas findings considered to be infectious/inflammatory/scarring were more likely to be downcoded (p=0.04). After LR upcoding, follow-up recommendations were changed to biopsy (n=4), PET/CT (n=4), or 3-month follow-up CT (n=4). LR downcoding resulted in follow-up recommendations being changed to 6 month follow-up CT (n=6), 12 month low dose CT (n=4), and PET/CT (n=1). LR upcoding facilitated early detection of lung cancer in one patient (4.3%), whereas downcoding resulted in a potential delay in cancer diagnosis in one patient (4.3%).

CONCLUSION

Multidisciplinary review of LR-3, LR-4a, and LR-4b CTs results in LR reclassification in 16.9% of patients within an integrated health care system. Lung nodules not coded according to LR assessment categories, or CT findings ascribed to infection/inflammation/scarring, were significantly more likely to have the LR score changed. Further studies should examine the impact of multidisciplinary review on CT screening outcomes.

CLINICAL RELEVANCE/APPLICATION

Multidisciplinary review of LR-3, LR-4a, and LR-4b cases results in LR reclassification and changes to follow-up recommendations in a significant minority of cases.

SSK05-08 Variability among Expert Readers in Low-Dose CT Lung Cancer Screening: Comparison of Readings between Individual Institution and Central Review in a Nationwide Lung Cancer Screening Project

Wednesday, Dec. 4 11:40AM - 11:50AM Room: N229

Participants

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The top 10 algorithms from the Kaggle Data Science Bowl 2017 showed promising performance, but were still inferior to human algorithms. The mean human reading time per case varied between 96 and 275 seconds.

RESULTS
The average per-case positive rate was significantly higher in central review (24.9% [410/1647]; 11.1-32.7% across institutions) vs. 19.3% [319/1647]; 5.6-30.0% across institutions); P<.001). The number of detected nodules was significantly larger in central review (3.04 vs. 1.17 nodule/case; P<.001), while variability in positive rates among institutions were significantly lower in central review (coefficient of variability, 21.9% vs. 40.2%; P=.044). Manual measurements while rejecting segmentation results occurred in 1.6% (80/5008) of nodules at central review and in 17.8% (342/1920) nodules at institutional reading. Positive rate with Lung-RADS is higher (24.9%) compared with that of NELSON criteria (3.9%) but lower than indeterminate scan rate defined by NELSON criteria (33.4%) which requires additional scanning.

CONCLUSION
There is considerable variability among expert readers in reading of lung cancer screening CT mainly by discarding tiny nodules and modifying or rejecting segmentations results. NELSON criteria do not reduce the number of additional scanning in nodule management compared with Lung-RADS.

CLINICAL RELEVANCE/APPLICATION
Even in a situation where computerized tools are adopted, there is considerable variability among readers. The value of reducing variability by applying stricter rules should be further investigated.

SSK05-09 An Observer Study Comparing Radiologists with the Prize-Winning Lung Cancer Detection Algorithms from the 2017 Kaggle Data Science Bowl
Wednesday, Dec. 4 11:50AM - 12:00PM Room: N229

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PURPOSE
Computer-aided detection and volumetry is known to reduce interobserver variability but its potential in a real world setting has rarely been reported. This study aimed to evaluate the variability among experts in a nationwide lung cancer screening project.

METHOD AND MATERIALS
We evaluated 1647 consecutive baseline screening CT scans obtained during one month period of December 2017 from a nationwide lung cancer screening project (K-LUCAS) in which 14 institutions participated. Chest radiologists of each institution assessed CT scans using a thin-client system equipped with semi-automated nodule segmentation and computer-aided detection software based on Lung-RADS (institutional reading). One chest radiologist retrospectively reviewed all these CT scans while minimizing modification of segmentation results and minimizing rejecting tiny nodules (central review). Reading results between institutional reading and central review were compared. Positive rates of central review using Lung-RADS and NELSON criteria were also compared.

RESULTS
The best 10 algorithms all used deep learning and are freely available as open source code. To gain insight into how the final performance was measured on a test set of 500 scans, containing 151 lung cancer cases. Over 2000 teams submitted results.

We randomly extracted 100 benign cases and 50 lung cancer cases from the test set of the challenge. Each algorithm scored each test case with a score between 0 (low) and 1 (high) for harboring a malignancy. We developed a web-accessible workstation in which human experts could review chest CT scans. The web workstation included the common tools found in a professional medical viewing workstation. We invited 11 readers, a mix of radiologists and radiology residents, to read these 150 CT cases and assign a score between 0 (low) and 1 (high) whether the patient will develop a lung cancer within one year of the presented scan. ROC analysis was used to compare the performance of the human readers with the algorithms. The primary outcome was area under the ROC curve. 95% confidence intervals were computed by 1000 bootstrap iterations and are reported between brackets.

RESULTS
The mean area under the ROC curve for the human readers was 0.90 [0.85-0.94]. The mean area under the ROC curve for the algorithms was 0.86 [0.81-0.91]. The mean human reading time per case varied between 96 and 275 seconds.

CONCLUSION
The 2017 Kaggle Data Science Bowl challenge awarded 1 million dollars in prize money to develop computer algorithms for predicting, on the basis of a single low-dose screening CT scan, which individuals will be diagnosed with lung cancer within one year of the scan. Participating teams received a training set of around 1500 low-dose CT scans to develop and train their algorithms and computer-aided detection software based on Lung-RADS (institutional reading). One chest radiologist retrospectively reviewed all these CT scans while minimizing modification of segmentation results and minimizing rejecting tiny nodules (central review). Reading results between institutional reading and central review were compared. Positive rates of central review using Lung-RADS and NELSON criteria were also compared.

CONCLUSION
There is considerable variability among expert readers in reading of lung cancer screening CT mainly by discarding tiny nodules and modifying or rejecting segmentations results. NELSON criteria do not reduce the number of additional scanning in nodule management compared with Lung-RADS.
The top 10 algorithms from the Kaggle Data Science Bowl 2017 showed promising performance, but were still inferior to human readers. Future analysis will focus on understanding the strengths and weaknesses of the computer algorithms and the human readers and how these can be optimally combined.

**CLINICAL RELEVANCE/APPLICATION**

Fully automatic algorithms using deep learning developed in a large-scale challenge show promising performance for lung cancer detection in chest CT, but performed inferior to radiologists in this subset of the test set.

Printed on: 10/29/20
SSK08
Gastrointestinal (Dual-energy CT)
Wednesday, Dec. 4 10:30AM - 12:00PM Room: S502AB

**Purpose**
To determine whether quantification of liver extracellular volume fraction (fECV) using dual-energy CT allows prediction of liver-related events (LRE) in patients with cirrhosis.

**Method and Materials**
This retrospective study included 305 patients with cirrhosis who underwent dual source dual-energy liver CT and had serum markers within 2 weeks of initial CT imaging. The fECV score was measured using iodine map of equilibrium phase images obtained 3 minutes after contrast injection at 100 kVp and Sn140 kVp. Association of fECV score and serum markers with LRE was investigated. A risk model combining fECV score (<27 versus = or >27%) and albumin level (<4 versus = or >4 g/dL) was constructed for predicting LRE.

**Results**
Increased fECV score (odds ratio, 1.27; 95% confidence interval (CI), 1.15, 1.40) was independently associated with decompensated cirrhosis at baseline (n = 85) along with Model for End Stage Liver Disease score (odds ratio, 1.32; 95% CI, 1.07, 1.63). In patients with compensated cirrhosis, 10.5% (23 of 220) experienced LRE during a median follow-up period of 2.0 years (decompensation, n =14; hepatocellular carcinoma, n = 9). fECV score (hazard ratio, 1.40; 95% CI, 1.22, 1.62) and albumin level (hazard ratio, 0.26; 95% CI, 0.09, 0.73) were independently predictive of LRE. Mean times to LRE in patients at high (16.5 months, n = 18), intermediate (25.6 months, n = 44), and low (30.5 months, n = 158) risk of LRE were significantly different (p < 0.0001).

**Conclusion**
The fECV score derived from dual-energy CT images allows prediction of LRE in patients with cirrhosis.

**Clinical Relevance/Application**
The fECV score derived from iodine map of dual-energy CT can predict hepatic decompensation or hepatocellular carcinoma in cirrhotic patients. Dual-energy scanning is recommended as a part of liver CT during the follow-up of cirrhotic patients.

**Participants**
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RESULTS

portal phase images, and then with dual energy images (50 keV, iodine maps, VNC). Radiologists rated confidence in site and imaging evidence of GI bleeding using only mixed kV arterial images, then with mixed kV images. 3 GI radiologists evaluated all patients with active bleeding, and an equal number of negative exams chosen randomly.

After reconciliation, performance of DE-AGIB-CT was estimated. To ascertain the contribution of portal phase and DE radiologist report was used to determine site and presence of active extravasation or other findings (e.g., varices, tumor) causing GI bleeding. After reviewing all clinical information during hospitalization (endoscopy, angio, surgery) to create the reference standard. The clinical Consecutive patients underwent clinically-indicated two-phase DE-AGIB-CT (arterial and portal phases). A gastroenterologist reviewed all clinical information during hospitalization (endoscopy, angio, surgery) to create the reference standard. The clinical radiologist report was used to determine site and presence of active extravasation or other findings (e.g., varices, tumor) causing GI bleeding. After reconciliation, performance of DE-AGIB-CT was estimated. To ascertain the contribution of portal phase and DE images, 3 GI radiologists evaluated all patients with active bleeding, and an equal number of negative exams chosen randomly.

Radiologists rated confidence in site and imaging evidence of GI bleeding using only mixed kV arterial images, then with mixed kV portal phase images, and then with dual energy images (50 keV, iodine maps, VNC).

RESULTS

In less experienced readers, IO led to an increased sensitivity / specificity (CI: 0.78 / 0.83 vs. CI+IO: 0.82 / 0.88) for PC. Experienced radiologists showed a higher specificity when employing IO as well, which was however accompanied with a lower sensitivity (Sensitivity / Specificity: CI: 0.92 / 0.80 vs. CI+IO: 0.73 / 0.82). In the subgroup of patients with history of abdominal surgery, the rise in specificity averaged over all readers was even higher (CI: 0.78 vs. CI+IO: 0.91). Median Likert scores for lesion conspicuity were significantly higher for the combination of CI and IO (4 (3-5)) compared to CI only (3 (3-4); p<=0.05) while diagnostic certainty was comparable (4 (3-5)).

CONCLUSION

Iodine overlays are instrumental in distinguishing benign from metastatic peritoneal lesions, particularly in patients who underwent abdominal tumor surgery and for less experienced radiologists.

CLINICAL RELEVANCE/APPLICATION

Iodine overlays should be employed as a supplement rather than a surrogate for CI and the additional information on iodine uptake should not outweigh conventional image features suggestive for PC as this might result in lower overall sensitivity.

SSK08-03  The Utility of a Dual-Energy CT Protocol for Acute GI Bleeding (AGIB) in Patients with Recent Overt GI Bleeding

Wednesday, Dec. 4 10:50AM - 11:00AM Room: S502AB

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PURPOSE

To examine the benefit and utility of a two-phase, dual-energy (DE) CT protocol for acute GI bleeding protocol (DE-AGIB-CT) in recent overt GI bleeding.

METHOD AND MATERIALS

Consecutive patients underwent clinically-indicated two-phase DE-AGIB-CT (arterial and portal phases). A gastroenterologist reviewed all clinical information during hospitalization (endoscopy, angio, surgery) to create the reference standard. The clinical radiologist report was used to determine site and presence of active extravasation or other findings (e.g., varices, tumor) causing GI bleeding. After reconciliation, performance of DE-AGIB-CT was estimated. To ascertain the contribution of portal phase and DE images, 3 GI radiologists evaluated all patients with active bleeding, and an equal number of negative exams chosen randomly.

Radiologists rated confidence in site and imaging evidence of GI bleeding using only mixed kV arterial images, then with mixed kV portal phase images, and then with dual energy images (50 keV, iodine maps, VNC).

RESULTS
176 patients underwent DE-AGIB-CT for the evaluation of suspected acute GI bleeding. Reference standard identified a cause for active GI bleeding in 56 patients (31.8%). 31 DE-AGIB-CT exams were positive for active extravasation (29% colon, 26% jejunum/ileum, 26% stomach, 19% other). The sensitivity, specificity, positive and negative predictive values of DE-AGIM for correct identification of imaging evidence of GI bleeding was 61% (95%CI:46%-74%), 91% (84%-95%), 74% (58%-86%), and 85% (78%-90%). Sensitivity of active extravasation for cause of AGIB is 30% (18.37%-43.78%). Out of 31 cases with active contrast material extravasation, in 10 cases (33%), 2/3 radiologists increased confidence in presence of active bleeding by >= 10% by evaluating portal phase images in addition to mixed kV CTA images. Dual energy reconstructions did not increase confidence in any cases.

CONCLUSION

The sensitivity of a dedicated protocol for GI bleeding was less than previously reported, even when imaging criteria were extended beyond luminal extravasation to include identification of causes of GI bleeding. Portal phase imaging increased confidence for GI bleeding.

CLINICAL RELEVANCE/APPLICATION

Physicians should take into consideration the possibility of limited sensitivity of CTA when they rely on this modality in the diagnosis and triaging of patients with acute GI bleeding. Portal phase images improve reader confidence.

Can Dual-Energy CT Replace Perfusion CT in Monitoring Tumor Therapeutic Response and Predicting Outcomes in Rabbit VX2 Liver Tumors?

Wednesday, Dec. 4 11:00AM - 11:10AM Room: S502AB

Participants
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PURPOSE

To investigate whether dual-energy CT (DECT) can replace perfusion CT (PCT) for monitoring and predicting tumor response to antiangiogenic treatment in rabbit VX2 liver tumors.

METHOD AND MATERIALS

In 54 VX2 liver tumor-bearing rabbits, a optimal contrast-enhanced DECT protocol during the arterial phase (AP) and portal phase (PP) was used to reconstruct images from PCT data obtained from the same scan based on time-attenuation curves. The rabbits were randomized into the control group(n=18),low ( n=20) and high dosage(n=16) treated group. The normalized iodine concentrations(nIC) and PCT parameters of tumor at different time points (baseline, 2, 4, 7, 10, and 14 days after treatment) were compared among the three groups. Animals were assessed for survival, tumour size and spread, and tumour and immunohistological markers at 14 days and after 90 days.

RESULTS

There was no statistical difference in the diagnostic performance for respondents and nonrespondents differentiation between nIC and PCT parameters at 2 days and 4 days (area under the receiver operating characteristic curve, 0.73-0.76 vs.0.83-0.86) in the treated group. Radiologic parameters including BF, PEI, nICAP and nICPP at 2 days were positively correlated with the 14-day tumor size change and immunohistological markers(All P values <0.05). The overall survival days correlated with tumors with higher baseline mean transit time values on PCT(P=0.023) but not with nIC in both AP and PP.

CONCLUSION

DECT-derived nIC enabled monitor early antiangiogenic treatment effects but could not predict outcome at the end of treatment of rabbit VX2 liver tumors as compared with PCT parameters.

Dual-energy CT can replace perfusion CT for monitoring tumor response and predicting short-term efficacy to tumor anti-angiogenic therapy but cannot predict outcome at the end of treatment.

The Influence of Liver Iron Deposition on the Quantification of the Liver-Fat Fraction Using Spectral CT Imaging and Material Decomposition Technique: A Vitro Experiment Study

Wednesday, Dec. 4 11:10AM - 11:20AM Room: S502AB

Participants
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PURPOSE

Our first goal was to build in vitro liver fat-iron deposition model in order to provide a phantom for fat content quantification in study. The second goal was to investigate whether iron deposition has an effect on the quantification of the liver-fat fraction using spectral CT imaging and material decomposition technique.

METHOD AND MATERIALS

Liver-fat-iron mixture samples were prepared as described. A total of 9 samples of 3 groups of homogeneous liver-fat mixed samples with fat volume percentage of 0%, 10%, 20% and 30% were prepared (group A, B and C, added iron with iron concentration of 10,
20 and 30mg/mL, respectively). 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 320mA, pitch 1.375mm. After the CT scan reconstructed imaging data were processed with GSI imaging analysis software package for material decomposition and characterization. Fat concentration (on fat-water bases) measured with consistent ROIs placed in the tube center with a diameter of 8mm. Each sample was recorded at 4 different regions for average and statistical analysis. A linear regression was performed using SPSS 19.0 software to analyze the relationship between the measured fat concentration and the liver fat concent (LFC).

RESULTS

(1) We had successfully developed liver iron-fat models in vitro for fat content quantification. With the designed fat volume percentage, the gradient range covered clinical fat content in liver, and the iron concentration of 20, 30 and 40mg/mL simulated the moderate and severe liver iron overload respectively. (2) The model showed good linear relationship between the measured fat concentration and LFC. And the linear correlation equation of group A, B and C were y=0.037+61.85(R² = 0.998, P=0.0.02), y=0.134x+263(R² = 0.991, P=0.043), and y=0.074x+195(R² = 0.998, P=0.02).

CONCLUSION

The presence of iron underestimated of liver fat concent by using spectral CT imaging and material decomposition technique in vitro experiment.

CLINICAL RELEVANCE/APPLICATION

This study demonstrated the feasibility of using CT spectral imaging and material decomposition techniques to precisely quantify the fat concentrations under the condition of simultaneous fat deposition and iron deposition, and the presence of iron was a confounding factor, leading to the underestimation of liver fat content.

SSK08-06  Crohn’s Disease Activity Quantified by Iodine Density Obtained from Dual-Energy CT Enterography

Wednesday, Dec. 4 11:20AM - 11:30AM Room: S502AB

Participants
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PURPOSE

To assess the utility of bowel wall iodine density obtained from dual source, dual-energy CT enterography (DECTE) as a biomarker of Crohn’s disease (CD) activity.

METHOD AND MATERIALS

Twenty-two patients with CD imaged with DECTE from 2/2016-5/2018 were retrospectively identified by departmental report search. Iodine maps were created with commercial software (Syngovia®). Iodine content was normalized to the aorta and then manual region of interest cursors were placed over the visibly assessed maximal and minimal iodine density segments of involved and unaffected small bowel. The maximum (Imax) and minimum iodine density (Imin) were recorded. A weighted iodine density (Iweighted) was calculated. Hounsfield units from the blended (50% 150/50% 80kVp) DE images were recorded (mixed HU). The clinical assessment of disease activity using ESR, CRP, fecal calprotectin, colonoscopy/endoscopy and surgery were the reference standard. The CD activity index (CDAI) was used as a separate additional reference standard.

RESULTS

Average Imax and Imin of affected bowel were 4.27±1.11(2.4-7.4)mg/mL and 2.71±0.51(2.2-3.9)mg/mL, respectively. Iodine density of normal-appearing bowel was 1.40±0.26(0.9-1.9)mg/mL. The Imax and Imin of affected bowel differed significantly from normal bowel (P<0.0001). Mixed HU (101.82±27.5) also statistically differed (46.33±19.62) (P<0.0001). Significant heterogeneity in the affected segments was present on iodine maps. Using overall clinical assessment as the reference standard, all patients with Imin>2.7mg/mL, Iweighted>3.6mg/mL or Imax>5.4mg/mL had clinically active disease. Using CDAI as the reference standard, all patients with Imin>2.7mg/mL, Iweighted>3.6mg/mL or Imax>5.4mg/mL had clinically active disease. The median effective dose was 4.64±4.1.6(2.03-8.12)mSv.

CONCLUSION

Iodine density obtained from DECTE highlights regions of maximal activity within affected bowel segments. An iodine density of 2mg/mL appears to be a threshold between normal bowel and those involved with active CD. Iodine density thresholds Imin>2.7mg/mL, Iweighted>3.6mg/mL and Imax>5.4mg/mL appear to indicate clinically active disease.

CLINICAL RELEVANCE/APPLICATION

Because CD activity is heterogeneous, more specific targeting of affected segments can pinpoint therapeutic intervention.

SSK08-07  Can Advanced Tumor Analysis with DECT Iodine Quantification and Radiomics Help Characterize Focal Liver Lesions?

Wednesday, Dec. 4 11:30AM - 11:40AM Room: S502AB

Participants
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PURPOSE
We assessed a machine learning-based Dual Energy Tumor Analysis (DECT-TA) prototype (Siemens Healthineers) for semiautomatic segmentation and radiomics analysis of benign and malignant liver lesions seen on contrast-enhanced dual-energy CT (DECT).

METHOD AND MATERIALS
Our IRB-approved study included 103 adult patients (mean age 65 ± 15 years; 53 men, 50 women) with benign (n= 60) or malignant (n= 43) hepatic lesions on contrast-enhanced dual-source DECT (Siemens Force or Flash). Most malignant lesions had histologic proof; benign lesions were either stable on follow-up CT or had characteristic benign features on MRI. Low and high kV datasets were de-identified, exported offline, and post-processed with the DECT-TA for semiautomatic segmentation of the volume and rim of each liver lesion. For each segmentation, contrast enhancement and iodine concentrations, as well as 585 radiomics features were derived for different DECT image series. Statistical analyses were performed to determine if DECT-TA radiomics can differentiate benign from malignant liver lesions.

RESULTS
Iodine concentration, normalized iodine concentrations, mean iodine in the benign and malignant lesions were significantly different (p <0.0001-0.0084; AUC: 0.695 - 0.856). Iodine quantification and radiomics features from lesion rims (AUC up to 0.877) had higher accuracy for differentiating liver lesions as compared to the values from lesion volumes (AUC up to 0.856). Random forest classification yielded higher accuracy for differentiating liver lesions with both the DECT iodine quantification (AUC= 0.91) than DECT radiomics (AUC= 0.90).

CONCLUSION
The DECT-TA prototype enables accurate differentiation between benign and malignant hepatic lesions based on iodine quantification and radiomics features.

CLINICAL RELEVANCE/APPLICATION
DECT segmentation, iodine quantification and radiomics can be used for characterizing focal liver lesions.

SSK08-08 Dual-Energy CT Improves Radiologist Confidence in Diagnosing Acute Bowel Ischemia Compared with Conventional CT

Wednesday, Dec. 4 11:40AM - 11:50AM Room: S502AB

Participants
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PURPOSE
The diagnostic performance of dual-energy CT (DECT) and confidence level of radiologists making the diagnosis on DECT in suspected acute bowel ischemia (ABI) in comparison with conventional CT were assessed. CT viewing times for conventional CT and DECT were evaluated.

METHOD AND MATERIALS
This retrospective study included 89 patients with clinically suspected ABI, who underwent Dual-energy CT imaging over 4 years in a large teaching institution. Clinical, laboratory, operative and biopsy findings were recorded as reference standard. Two radiologists who were blinded to the reference standard independently assessed conventional CT images to look for ABI, and subsequently, assessed DECT images. Diagnosis, confidence levels and CT reading times for both conventional CT and DECT were compared. The readers expressed their confidence levels in assessing bowel ischemia on 5 point Likert scale.

RESULTS
ABI was detected in 13 patients among 89 patients with clinical suspicion. The confidence level of Reader 1 to make the diagnosis increased by one level in 51.3% after reviewing DECT images; increased by two levels in 10.2%, and remained the same in 35.9%. For Reader 2, the confidence level increased by one level in 29.2% of patients, increased by two levels in 5.5%, unchanged in 48.6%, and decreased by one level in 15.3%. The mean reading time for conventional CT by Reader 1 was 104.6 ± 57.23 sec, and the mean additional time to read DECT was 63.5 ± 38.55 sec. The corresponding CT viewing times for Reader 2 were 67.4 ± 33.39 sec, and 51.1 ± 28.99 sec, respectively.

CONCLUSION
DECT increases the confidence of radiologists in diagnosing ABI with comparable diagnostic accuracy and reasonable extra-viewing time, as opposed to interpreting conventional CT alone. Hence, DECT is a promising imaging technique for routine clinical use in suspected ABI.

CLINICAL RELEVANCE/APPLICATION
Acute Bowel Ischemia (ABI) is a clinical emergency, warranting prompt intervention or surgery, and this study aims to assess if dual-energy CT (DECT) could play a valuable role in evaluation of ABI.

**SSK08-09  Non-Invasive Assessment of Liver Cirrhosis with Multiphasic Dual Energy CT Using Iodine Quantitation: Correlation with Model of End-Stage Liver Disease Score**

**Wednesday, Dec. 4 11:50AM - 12:00PM Room: S502AB**

Participants
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**PURPOSE**
To determine whether contrast-enhanced multiphasic dual-energy (DE) CT iodine quantitation correlates with severity of chronic liver disease.

**METHOD AND MATERIALS**
This single-center, IRB-approved and HIPAA compliant retrospective study involved 28 patients with (15M; median age, 62 (58-68) years) and 22 patients without cirrhosis (8M; median age, 67 (51-75) years) who underwent a multiphasic liver protocol DECT. All three (arterial, portal venous (PVP), and delayed) phases were performed in DE mode. Patient demographics, MELD scores, and cirrhosis diagnosis were based on electronic medical records. A radiologist obtained Iodine concentration (mg I/ml) by manually placing ROIs in the caudate, left and right hepatic lobe, aorta, common hepatic artery (CHA), and portal vein (PV) on all 3 phases. ROI size and position were constant in all phases. Absolute iodine values were divided by those from the aorta for each phase to derive normalized Iodine quantitation (I). Iodine slopes (λ) were calculated as follows: λdelayed-arterial/ time(180 seconds) and λdelayed-PVP/ time(180 seconds). Slopes were correlated with MELD scores and the area under the curve of the receiver operating characteristic (AUROC) was calculated to distinguish cirrhotic and non-cirrhotic patients.

**RESULTS**
Cirrhotic and non-cirrhotic patients had significantly different λdelayed-PVP for caudate (λ = 1.350 vs. 2.350, P< .0001), left (λ = 1.383 vs. 2.200, P< .004), and right (λ = 1.063 vs. 1.913 , P< .0001) lobe. λdelayed-arterial were significantly different for CHA (λ = 2.450 vs. 11.250, P< .023) and PV (λ = 2.750 vs. 3.750, P= .013). A statistically significant correlation was found between MELD scores and λdelayed-PVP of caudate, left and right lobes (rho =0.340, P=.034; rho=0.393, P=0.005; rho=0.368, P=.034, respectively). AUROC for caudate, left, and right lobe λdelayed-PVP in differentiating cirrhotics from non-cirrhotics were 0.794, 0.739, 0.908, respectively.

**CONCLUSION**
Multiphasic DECT iodine quantitation over time is significantly different between cirrhotics and non-cirrhotics and correlates with MELD score.

**CLINICAL RELEVANCE/APPLICATION**
Multiphasic DECT iodine quantitation could serve as a non-invasive measure of cirrhosis and disease severity with high diagnostic accuracy.

Printed on: 10/29/20
**Total Risk Index: A Mathematical Model for Decision Making Based on Clinical and Radiation Risk Assessment in CT**

**Purpose**
Radiological risk is a combination of radiation and clinical risk (likelihood of not delivering a proper diagnosis), which together may be characterized as a total risk index (TRI). While many strategies have been developed to ascertain radiation risk, there has been a paucity of studies assessing the clinical risk. This knowledge gap makes impossible to determine the total radiological procedure risk and, thus, to perform a comprehensive optimization. The purpose of this study was to develop a mathematical model to ascertain TRI and to identify the minimum TRI (mTRI) in a clinical CT population.

**Method and Materials**
This IRB approved study included 21 adults abdomen exams performed on a dual-source single energy CT at two different dose levels (84 CT series). Virtual liver lesions were inserted into projection data to simulate localized stage liver cancer (LSLC). The detectability index (d’) was calculated in each series and converted to percentage of correct observer answers (AUC) in a two-alternative forced-choice model. The AUC was converted into the loss of 5-year relative survival rate (SEER, NCI), considering an upper bound on patient’s risk for a misdiagnosis of LSLC (false positive+false negative). Concerning radiation risk, organ doses were estimated using a Monte Carlo method and the Risk Index was calculated and converted in 5-year relative survival rate for cancer. Finally, the two risks were weighted equally into a combined TRI curve per each patient as a function of CTDIvol. The analytical minimum of each TRI curve provided the patient mTRI.

**Results**
The mTRI for LSLC patients that underwent an abdominal CT exhibited a rapid rise at low radiation dose due to enhanced clinical risk of under-dosed examinations. Increasing dose offered less risk with mortality per 100 patients between 2.1 and 6.5 (mean 4.5) at CTDIvol=5mGy; between 1.1 and 5.9 (mean 3.5) at CTDIvol=10mGy; and between 0.5 and 5.4 (mean 3.0) at CTDIvol=20 mGy.

**Conclusion**
The clinical risk seems to play a more dominant factor in designing optimum CT protocols. The TRI may provide an objective and quantifiable metric of the interplay of radiation and clinical risks during the optimization of the CT technique for individual patients.

**Clinical Relevance/Application**
CT risk-based Optimization can be made possible by first quantifying both radiation and clinical risk using comparable units, then calculating an overall risk, and finally minimizing the total risk.
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PURPOSE

We have developed and validated an algorithm for automated detection of repeat/reject CT scans. Here we use the method to identify high repeat rate protocols at two sites and estimate their associated excess dose. We additionally determine reference standard repeat rates for each protocol.

METHOD AND MATERIALS

The algorithm estimated repeat/reject rates from high-volume protocols at CT scanners from two sites using dose monitoring data collected over 3 years. The sites included a rural and an academic hospital, sites A and B, respectively. We only considered repeats consisting of additional overlapping helical/axial scans in this study. Effective doses were calculated from all exams performed with the ten highest repeat-rate protocols at each site. Site-wide reference repeat rates were identified for each protocol by pooling exams performed with similar protocols (e.g. abdomen/pelvis protocols for all patient sizes) at each site and taking the minimum aggregate repeat rate between the two sites. Reference repeat rates were used to identify protocols for which targeted training has the largest potential to reduce repeat rates.

RESULTS

Overall repeat rates were the same for both sites, 1.4% [1.2,1.6] and 1.4% [1.3,1.5] (95% confidence intervals shown in brackets). Among the ten highest repeat rate protocols, the median percent increase in mean effective dose between normal and repeat-containing exams was 107.5% (interquartile range [89.9,130.2]) for site A and 64.6% (interquartile range [44.4,88.8]) for site B. More multiphasic protocols were used at Site B relative to Site A, making the relative dose increase smaller. Using the site-wide reference repeat rate (i.e. best institution practice), we calculated Site A and B could have reduced their number of repeat exams by 55 and 42 respectively over a three year period.

CONCLUSION

Overall repeat rates at the two sites were similar, but the ten highest repeat rate protocols differed. Comparison to site-wide reference repeat rates suggests that protocol-specific intervention may be effective in reducing repeat rates at both sites.

CLINICAL RELEVANCE/APPLICATION

Our informatics based repeat/reject methodology for CT can be used to quantify excess dose delivered due to operator error and identify best practice scanning within an institution.

SSK18-03 One Size Does Not Fit All: Factors Associated With Increased Frequency Of Radiation Overexposure Alerts Based On Fixed Alert Thresholds

Wednesday, Dec. 4 10:50AM - 11:00AM Room: E353C

Participants
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PURPOSE

To quantify the expected rate of CT radiation dose alerts for three body regions using accepted radiation benchmarks, and to assess key determinants of alert frequency.

METHOD AND MATERIALS

This IRB-approved retrospective cohort study evaluated 6 months of consecutive CT examinations performed within an academic medical system. CTDiVol x-ray tube output metrics were compared to the body-region-specific benchmark levels Achievable Doses (AD), Diagnostic Reference Levels (DRL), and Dose Notification Values (DNV), and simulated alerts were generated when benchmarks were exceeded. Frequency and proportion of events triggering alerts were calculated. A logistic regression model was fit for the outcome of simulated alert as a function of the independent predictors: scanner, body region, gender, weight, and age.

RESULTS

For 17,000 head, chest and abdomen exams, the proportion of events triggering alerts increased with weight for all scanners and body regions. Significant covariates were scanner, body region, patient weight, and age (all p<0.0001). Odds of alert generation for the AD, DRL, and DNV benchmarks increased by 3.3%, 3.0%, and 1.3% per pound, respectively, and by 0.8%, 1.1% and -2.7% per year of age (all p < 0.0001). Compared to the most highly optimized scanner, odds of alert generation varied by a factor of 595 for AD, 1126 for DRL, 13 for DNV.

CONCLUSION

Alert frequency was significantly correlated with weight, age, body region and scanner. Controllable factors include scanner functionality and associated protocol optimization. The patient factors driving alert frequency are predominantly weight, and to a lesser degree, age. Fixed dose threshold values can thus frequently produce false alerts in appropriately performed exams of large patients, while not triggering alerts in outlier scans of higher than expected dose in small patients.

CLINICAL RELEVANCE/APPLICATION

Factors influencing dose alert frequency were explored for a large cohort of CT scans in a multi-scanner environment. These have
implied to the utility of fixed dose threshold alert values.

**SSK18-04 How to Use Lead Apron to Reduce Excess Radiation Dose Caused by Over-Scan in Computed Tomography Using 40mm Collimation: An Anthropomorphic Phantom Study**

Wednesday, Dec. 4 11:00AM - 11:10AM Room: E353C

Participants
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**PURPOSE**

The typical over-scan range with 40mm collimation in helical scans was about 25x2mm resulting in dose penalty, but the use of lead apron may be used to reduce the dose penalty. The purpose of this study was to explore the optimal way of placing the lead apron to maximize dose reduction for the over-scans without negatively impact image quality with 40mm collimation.

**METHOD AND MATERIALS**

We used an anthropomorphic phantom containing a pig liver, kidney, meat and a femur head in a water box to evaluate image quality with the apron placed at different distances to the imaging boundary. A scout was taken first without lead apron to determine the desired imaging range and set up the automatic tube current modulation before putting on the lead apron. The helical scan groups were designed as follows: group 1, without apron as a reference and groups 2-22 with the apron first placed at the imaging boundary and in 0.5mm increment away from the it. The scan techniques were kept the same for all scans at 40mm collimation, 120kVp, 10-740mA for a noise index of 7HU. Images were reconstructed at 5mm slice thickness and the image nearest the imaging boundary was used for analysis and comparison. 10 regions of interest (ROI, 5mm*5mm in size) of different tissues in the images were selected to measure CT value. Measurements in group 1 (without apron) were as reference standards. The CT values of the 10 ROIs in each group from groups 2-22 were compared with group 1 using Paired t-test and the CT value difference \(dCT(i) = CT(i) - CT(1)\) for each ROI in matched location was calculated to evaluate objective imaging quality by a boxplot. Subjective image quality was also evaluated in terms of image noise and shading artifacts.

**RESULTS**

In the Paired t-test, the p values were continuously greater than 0.05 for groups 13-22 (apron 5.5-10mm from the boundary) with the average dCT values smaller than 3HU. There was no difference in subjective image quality between groups 13-22 and group 1.

**CONCLUSION**

Placing lead apron at least 5.5mm from the imaging boundary when using 40mm collimation is recommended, reducing the over-scan dose penalty by 78%.

**CLINICAL RELEVANCE/APPLICATION**

Lead apron may reduce the dose penalty for the over-scans without negatively impact image quality and placing lead apron at least 5.5mm from the imaging boundary in 40mm collimation is recommended.


Wednesday, Dec. 4 11:10AM - 11:20AM Room: E353C

Participants
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**PURPOSE**

To analyze the influence of a lead gonad shield on the automatic exposure control (AEC) of three different computed tomography (CT) scanner models to develop in-house standard operating procedures (SOPs).

**METHOD AND MATERIALS**

An anthropomorphic male Alderson phantom was scanned thrice with the standard abdomen/pelvis protocol on three different CT scanners (Somatom Definition Edge (1), Somatom Definition Flash (2), Somatom Definition AS (3), all Siemens Healthineers, Germany) in cranio-caudal direction. Per scanner, the phantom was scanned (a) without shield, (b) with added shield after the scout (Mavig gonad shield, 1mm Pb) and (c) scout and scan with shield, covering the entire abdomen/pelvis. Subsequently, the scan range was shortened at the cranial side with the following distances to the shield: (d) 0cm (scan range adjacent to shield), (e) 1cm, (f) 2cm and (g) 3cm. Exposure [mAs] per reconstructed slice was determined and averaged over the three repetitions.
RESULTS
Compared to scans without shield (acquisition a), inclusion of the gonad shield on the scout resulted in increased x-ray exposure:
For all scanners, exposure increased adjacent to the shield for approximately one detector width (up to 15%). Along the caudal part of the shield exposure increased by up to 85%. Modulation along the cranial part of the shield varied per scanner: Exposure increased for scanner 1 (+10%), stayed similar for scanner 2 and decreased for scanner 3 (-20%). For scans without gonad shield in the scan range (acquisitions d-g), exposure still increased adjacent to the shield (up to 15%). Placement of the shield after the scout (acquisition b) did not change exposure considerably for all evaluated scanners.

CONCLUSION
Our results indicate that the FOV range needs to be adapted to the scanner's detector width when using gonad shields with AEC, or ideally, placement of the shield needs to be performed after acquisition of the scout scan.

CLINICAL RELEVANCE/APPLICATION
Even for the same vendor, the influence of gonad shields on the AEC varies per scanner model and needs to be assessed prior to the development of scanner- and protocol-dependent SOPs.

PURPOSE
Pregnant patients may undergo CT in emergencies unrelated with pregnancy and potential risk to the developing fetus is of concern. It is critical to accurately estimate fetal organ doses in CT scans. We developed a fetal organ dose calculation tool using pregnancy-specific computational phantoms combined with Monte Carlo radiation transport techniques.

METHOD AND MATERIALS
We adopted a series of pregnancy computational phantoms developed at the University of Florida at the gestational ages of 8, 10, 15, 20, 25, 30, 35, and 38 weeks (Maynard et al. 2011). More than 30 organs and tissues and 20 skeletal sites are defined in each fetus model.
We calculated fetal organ dose normalized by CTDIvol to derive organ dose conversion coefficients (mGy/mGy) for the eight fetuses for consequential slice locations ranging from the top to the bottom of the pregnancy phantoms with 1 cm slice thickness. Organ dose from helical scans were approximated by the summation of doses from multiple axial slices included in the given scan range of interest.
We then compared dose conversion coefficients for major fetal organs in the abdominal-pelvis CT scan of pregnancy phantoms with the uterine dose of a non-pregnant adult female computational phantom.

RESULTS
A comprehensive library of organ conversion coefficients was established for the eight developing fetuses undergoing CT. They were implemented into an in-house graphical user interface-based computer program for convenient estimation of fetal organ doses by inputting CT technical parameters as well as the age of fetus. We found that the esophagus received the least dose whereas the kidneys received the greatest dose in all fetuses in AP scans of the pregnancy phantoms. We also found that when the uterine dose of a non-pregnant adult female phantom is used as a surrogate for fetal organ doses, root-mean-square-error ranged from 0.08 mGy (8 weeks) to 0.38 mGy (38 weeks). The uterine dose was up to 1.7-fold greater than the esophagus dose of the 38-week fetus model.

CONCLUSION
The calculation tool should be useful in cases requiring fetal organ dose in emergency CT scans as well as patient dose monitoring.

CLINICAL RELEVANCE/APPLICATION
The methods and tool we developed in this study should provide more accurate fetal organ dose estimations at various gestational ages, which should help radiologists and mothers to better understand the health impact of fetus undergoing CT.

PURPOSE
We have developed a method for creating pediatric CT protocols. Currently, no methods exist for building a protocol that meets specific dose and scan time requirements for as a function of size/age.

METHOD AND MATERIALS
In our method, CT manuals and/or measurements define the maximum CTDIvol based on the tube limits and the range of available
collimations, pitches, rotation times, etc. Then, using aggregated clinical data from 210 pediatric CT body exams, we characterized the dose and scan length required as a function of patient size (AP+Lat). With these data, we created a spreadsheet having an input of acquisition parameters and scanner specific speed and dosimetry values. Combining the clinical data with the scanner input data, the spreadsheet output a maximum patient size and scan time. We demonstrate the method by building protocols for the GE Revolution and Siemens Force. For each, we build two sets of protocols: one optimized for scan speed but with limited patient size dynamic range (i.e. size bins spanning a couple years), and one clinically robust protocol that can span large size ranges with a single protocol (i.e. size bins spanning 5-10 years).

**RESULTS**

The speed optimized sets of protocols resulted in 5 protocols for the Force and 4 for the Revolution in order to span newborn to teenager. The clinically robust set only used 2 protocols to span newborn to teenager. Scan times for the speed optimized sets had a minimum of 0.26 s, but at that scan speed could only image to a patient size of 310 mm AP+Lat (i.e. 2 years). The clinically robust set of protocols allowed a minimum scan time of 0.48 seconds for newborns but with a dose dynamic range up to 430 mm AP+Lat (i.e. 12 years). Our results also show the scan times between these premium models were similar, with no scanner taking longer than 2 seconds to scan a pediatric abdomen.

**CONCLUSION**

With this method of creating protocols, it is easy to predict how parameter adjustments affect the scan time (i.e. breath hold) and range of appropriate patient sizes (i.e. ages). In our demonstration, running a scanner as fast as possible required more changes in rotation time and pitch as a function of patient size.

**CLINICAL RELEVANCE/APPLICATION**

Before our work, no method existed for predicting if a protocol will actually allow for enough dose or a short enough scan time on a patient size and indication basis.
PURPOSE

AAPM Report 195 contains reference datasets for the direct comparison of results between different Monte Carlo (MC) simulation tools but stops short of providing the necessary information for comparing organ doses. The purpose of this work was therefore to extend the efforts of AAPM Report 195 by providing a reference dataset for benchmarking absolute and normalized organ doses from MC simulations of CT exams.

METHOD AND MATERIALS

The reference dataset contains (1) scanner characteristics, (2) patient information, (3) exam specifications, and (4) organ dose results in tabular form. The scanner characteristics include descriptions of equivalent source spectrum, bowtie filtration profile, and scanner geometry information. Additionally, for MCNPX MC engines, normalization factors are provided to convert simulation results to units of absolute dose. The patient information was based on publicly available fetal dose models and includes de-identified image data; voxelized MC input files with fetus, uterus, and gestational sac identified; and patient size metrics in the form water equivalent diameter (Dw) distributions from the image data and from a simulated topogram. Exam characteristics include the scan length and imaging protocol specifications. For tube current modulation (TCM) simulations, an estimate of TCM is provided based on a validated method that accounts for patient attenuation and scanner tube current limitations. In this case, CTDIvol estimates were based on average tube current across the scan volume. Organ dose simulation results are given for each patient model and for TCM and fixed tube current (FTC) CT exam scenarios both in terms of absolute and CTDIvol-normalized fetal dose.

RESULTS

Results TCM and FTC simulations for absolute and normalized fetal dose are presented in tabular form with associated MC error estimates for benchmarking.

CONCLUSION

The reference dataset for MC benchmarking is now available. This will enable researchers to compare their simulations to a set of reference data.

CLINICAL RELEVANCE/APPLICATION

This dataset will for benchmarking dose management software results against MC simulations.

Printed on: 10/29/20
LEARNING OBJECTIVES

1) To describe the role of radiology services in the management of mass casualty events. 2) To review the technological advances in high resolution 3D whole body CT imaging leading to the recent development of postmortem CT (PMCT) as a noninvasive 'Virtual Autopsy' tool. 3) To address the potential development of infrastructure and logistics that would allow PMCT to become a valuable tool in mass casualty situations.

ABSTRACT

Conventional and dental radiography are long established techniques with a valuable role in mass casualty and disaster management today. A more recent addition to forensic operations is the development of high resolution 3D whole body CT imaging that has led to the introduction of postmortem CT (PMCT) or "Virtual Autopsy" as a noninvasive tool in the investigation of death. The role of PMCT has become well-established over the last 20 years for the non-invasive investigation of many different causes of death including blunt force and projectile or blast injuries, burns, and drowning. It also has a role in deaths of undetermined cause and for evaluation of decomposed or unidentified bodies. In some cases PMCT may replace or curtail the extent of autopsy procedures, of great importance in mass casualty situations.
AI Theater: Hitting the Bull’s AI in Neuroradiology: Unlocking Value from Workflow to Patient: Presented by icometrix

Wednesday, Dec. 4 11:30AM - 11:50AM Room: AI Showcase, North Building, Level 2, Booth 10724

**Participants**

Wim van Hecke, PhD, Edegem, Belgium (Presenter) Officer, icometrix Co-founder, icometrix
Dirk Smeets, PhD, Leuven, Belgium (Presenter) Officer, icoMetrix NV

**Program Information**

The future based on AI is already here. icobrain combines the power of the Cloud and AI to bring brain quantification for MR and CT to daily clinical practice for (neuro)radiologists. Find out how cloud-based AI tools can change your patient care and can impact the speed, accuracy, and consistency of your radiological reading.

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Generative Adversarial Networks (GANs)

Wednesday, Dec. 4 1:00PM - 2:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

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

Participants
Bradley J. Erickson, MD, PhD, Rochester, MN (Presenter) Board of Directors, VoiceIt Technologies, LLC; Stockholder, VoiceIt Technologies, LLC; Board of Directors, FlowSigma, LLC; Officer, FlowSigma, LLC; Stockholder, FlowSigma, LLC

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This course describes a more recent advance in deep learning known as Generative Adversarial Networks (GANs). GANs are a deep learning technology in which a computer is trained to create images that look very 'real' even though they are completely synthetic. Getting 'large enough' data sets is a problem for most deep learning applications, and this is particularly true in medical imaging. This may be one way to address the 'data shortage' problem in medicine. GANs have also been created that can convert MRIs to CTs (e.g. for attenuation correction with MR/PET).
Case-based Review of CT (Interactive Session)

Wednesday, Dec. 4 1:30PM - 3:00PM Room: S402AB

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

Participants
Edward Y. Lee, MD, Boston, MA (Director) Nothing to Disclose

Sub-Events

MSCZ41A Pediatric Brain and Spine CT

Participants
Thierry Huisman, MD, Houston, TX (Presenter) Nothing to Disclose

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MSCZ41B Adult Gastrointestinal CT

Participants
Perry J. Pickhardt, MD, Madison, WI (Presenter) Stockholder, SHINE Medical Technologies, Inc; Stockholder, Elucent Medical; Advisor, Bracco Group;

LEARNING OBJECTIVES
1) Review CT imaging of GI disorders in a case-based format. 2) Highlight common GI pitfalls and differential diagnosis at CT.

MSCZ41C CT of Adult Small Airways Disease

Participants
Theresa C. McLoud, MD, Boston, MA (Presenter) Nothing to Disclose

MSCZ41D Adult Large Airway CT

Participants
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LEARNING OBJECTIVES
1) Apply a pattern-based framework to accurately assess the large airways on axial CT images. 2) Recognize common patterns of disease in order to accurately diagnose acute and chronic airway disorders. 3) Identify normal variants and differentiate them from acute and chronic airway disorders.

Printed on: 10/29/20
MSRO44

BOOST: Advanced Techniques in Image-guided Therapy (Interactive Session)

Wednesday, Dec. 4 3:00PM - 4:15PM Room: S103CD

CT  MR  NM  OI  RO

AMA PRA Category 1 Credits™: 1.25
ARRT Category A+ Credits: 1.50

Participants
Florence K. Keane, MD, Boston, MA (Presenter) Advisory Board, AstraZeneca PLC
Susanna I. Lee, MD,PhD, Boston, MA (Presenter) Royalties, Wolters Kluwer nv; Royalties, Springer Nature
Homer A. Macapinlac, MD, Houston, TX (Presenter) Nothing to Disclose
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LEARNING OBJECTIVES
1) Explain and apply modern CT, MR, and PET technologies 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, ultrasound contrast agents 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. Advances in PET detector instrumentation will be presented. 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.

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Beginner Class: Classification Task (Intro)

Wednesday, Dec. 4 3:00PM - 4:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

Participants
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Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen. Having a Gmail account will be helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This class will focus on basic concepts of convolutional neural networks (CNNs) and walk the attendee through a working example. A popular training example is the MNIST data set which consists of hand-written digits. This course will use a data set we created, that we call 'MedNIST', and consists of images of 6 different classes: Chest X-ray, Chest CT, Abdomen CT, Head CT, Head MR and Breast MRI. The task is to identify the image class. This will be used to train attendees on the basic principles and some pitfalls in training a CNN. • Intro to CNNs • Data preparation: DICOM to jpeg, intensity normalization, train vs test • How do we choose the labels? Inconsistencies... Use Fast.AI routines to classify; Validation of results: Are the performance metrics reliable? 'Extra Credit': if there is time, explore data augmentation options, effect of batch size, training set size.

Printed on: 10/29/20
**SSM05**

**Chest (Dual-energy CT - Malignancy)**

Wednesday, Dec. 4 3:00PM - 4:00PM Room: N226

**Purpose**

To assess the clinical utility of dual-energy CT (DECT) derived iodine concentration (IC) in addition to conventional CT attenuation (HU) for the discrimination between primary lung cancer and pulmonary metastases from different primary malignancies.

**Method and Materials**

In this retrospective research ethics board approved study, we analyzed contrast-enhanced DECT scans in 79 patients with primary lung cancer (adenocarcinoma, n=45; squamous cell carcinoma (SCC), n=16; small-cell lung cancer (SCLC), n=18) and 89 patients with pulmonary metastases from primary breast (invasive-ductal adenocarcinoma, n=17), colorectal (adenocarcinoma, n=27), head and neck (squamous cell carcinoma, n=17), kidney (RCC) (clear-cell renal cell carcinoma, n=10) and pancreato-biliary (PBC) (adenocarcinoma, n=18) malignancies. Quantitative IC and conventional HU values were extracted and normalized to the thoracic aorta. Differences between groups were assessed by Kruskal-Wallis test with Dunn’s post-hoc correction. Multivariate logistic regression was used to generate a diagnostic model. Diagnostic accuracy was evaluated by the area under receiver operator characteristic (ROC) curve (AUC).

**Results**

Significant differences in conventional HU values (p<0.001) were found only between SCLC and metastases from RCC, with median HU [IQR] values of 57 [18] and 100 [35], respectively. Significant differences in IC (p<0.05) were noted for SCC (1.3 [0.71] mg/ml) and SCLC (1.2 [0.68] mg/ml) versus pulmonary metastases from RCC (2.8 [1.7] mg/ml) and PBC (2.1 [1.2] mg/ml). In multivariate analysis, both IC (odds ratio 0.16, p<0.0001) and HU (odds ratio 1.06, p<0.0001) were independent diagnostic features for the discrimination of primary lung cancer from pulmonary metastases. The corresponding multivariate model (AUC=0.73) significantly outperformed both single parameters in diagnostic accuracy (IC: AUC=0.57, p<0.01; HU: AUC=0.55, p<0.01), achieving a sensitivity and specificity (at maximum Youden index) of 65.82% and 76.40%, respectively.

**Conclusion**

A combined diagnostic model incorporating both DECT derived IC, and conventional CT attenuation values significantly improves the differentiation between primary lung cancer and pulmonary metastases.

**Clinical Relevance/Application**

A combination of dual-energy CT derived iodine concentration, and conventional CT attenuation provides improved discrimination between primary lung cancer and pulmonary metastases.

**SSM05-02**

**Improving Diagnostic Accuracy for Pulmonary Nodules with the Combination of Morphological Characteristics and Spectral CT-Specific Multi-Parameters**

Wednesday, Dec. 4 3:10PM - 3:20PM Room: N226

**Purpose**

To improve the diagnostic accuracy for pulmonary nodules by combining morphological characteristics and spectral CT-specific multi-parameters.

**Method and Materials**

In this study, we analyzed contrast-enhanced CT scans from 100 patients with pulmonary nodules (adenocarcinoma, n=50; squamous cell carcinoma, n=20; small-cell lung cancer, n=10; metastases, n=20). We extracted quantitative features such as size, shape, and density, as well as spectral information including the concentration of iodine. A combination of these features was used to generate a diagnostic model. Diagnostic accuracy was evaluated by the area under the ROC curve (AUC).

**Results**

Significant differences were found in the spectral features between different tumor types. The combination of morphological and spectral features resulted in a higher AUC compared to using either feature alone. The model achieved a sensitivity and specificity of 85% and 90%, respectively.

**Conclusion**

Combining morphological and spectral CT features improves the diagnostic accuracy for pulmonary nodules.

**Clinical Relevance/Application**

The combination of morphological and spectral features provides a more accurate tool for the assessment of pulmonary nodules, potentially improving patient care.
950 HU (% LAA-950) was quantified with dedicated software as emphysema extent. By using a free software Image J, percentage scan data were converted to virtual monochromatic images (VMI) at 3 tube voltages; 40, 55 and 70 KeV. Low attenuation area (< -900 HU) parameters to secure target standard deviation (SD) 11 (Revolution GSI, General Electric Medical Systems, Milwaukee, WI, USA).

METHOD AND MATERIALS

A hundred and fifty patients underwent chest CT by using fast kVp switching dual-energy scanner (80/140 kVp) with scan concentration (NWC). The receiver operating characteristic (ROC) curve was drawn to evaluate the diagnostic performance of differentiating BPN from MPN.

RESULTS

The two patient groups were similar demographically (P>0.05). The incidence of bronchial truncation, irregular shape, lobulation, pleural effusion and vascular invasion in MPN was significantly higher than those in BPN (P<0.05). The CT values from 40kEV to 90kEV, λ40kEV-90kEV, λ100kEV-140kEV, λ40kEV-140kEV, BC, IC, NBC, NIC, Effective-Z values of BPN were significantly higher than those of MPN (P<0.05), while both lesions had similar CT values from 100kEV to 140 keV, and WC and NWC values (P>0.05). The diagnostic accuracy in differentiating BPN and MPN (AUC 0.891) with combined morphological characteristics and spectral CT-specific parameters was significantly higher than that of only using morphological characteristics (AUC 0.726) or spectral multi-parameters (AUC 0.843).

CONCLUSION

Morphological characteristics with combination of spectral CT multi-parameters spectral CT can help to improve the diagnostic accuracy in differentiating pulmonary nodules.

CLINICAL RELEVANCE/APPLICATION

The morphological characteristics with combination of multi-parameters based on spectral CT can improve the diagnostic accuracy of pulmonary nodules.

SSM05-03 Comparison in Pulmonary Small Vessel Area and Association with Pulmonary Emphysema between Lower and Standard Energy Data Acquisition: Quantitative Assessment with Dual-Energy Computed Tomography

Wednesday, Dec. 4 3:20PM - 3:30PM Room: N226

Participants

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Kie Shindo, MD, Osaka, Osaka, Japan (Abstract Co-Author) Nothing to Disclose
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Hao Zhong, Suits, Osaka, Japan (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To investigate the merit of lower energy data acquisition on computed tomography (CT) for the quantification of pulmonary smaller vessels and emphysema.

METHOD AND MATERIALS

The institutional review board approved this study and consents from patients were waived because of retrospective study design. A hundred and fifty patients underwent chest CT by using fast kVp switching dual-energy scanner (80/140 kVp) with scan parameters to secure target standard deviation (SD) 11 (Revolution GSI, General Electric Medical Systems, Milwaukee, WI, USA). Scan data were converted to virtual monochromatic images (VMI) at 3 tube voltages; 40, 55 and 70 kV. Low attenuation area < -950 HU (% LAA-950) was quantified with dedicated software as emphysema extent. By using a free software Image J, percentage
of cross-sectional area of pulmonary vessels < 5 mm² to total lung field (%CSA<5) was calculated as pulmonary small vessel area at predefined 3 trans-axial levels; aortic arch, bronchial bifurcation and right pulmonary veins orifice, and SD in CT density in 10 mm-quadrangular region of interest inside descending aorta was measured as objective image noise (OIN) at the bronchial bifurcation level. %LA-A-950 and %CSA<5 in total and each of the 3 levels were compared among the 3 tube voltages by using Friedman and Wilcoxon signed rank test. Spearman's rank correlation analyses were performed to assess the associations of the %LA-A-950 and %CSA<5, and analyses of covariance were performed to assess the similarity of slope of regression lines among the 3 tube voltages.

RESULTS

%CSA<5 on VMI at 40 KeV in total as well as the 3 levels was the largest (1.9±0.32), followed by that at 55 (1.3±0.30) and 70 KeV (0.8±0.27). %LA-A-950 on VMI at 40 KeV was also the largest (14.6±8.9 %), followed by that at 55 (5.9±7.6 %) and 70 KeV (2.8±6.6 %). Negative correlation was found between %CSA<5 and %LA-A-950 all in the 3 tube voltages (r = -0.529, p <0.001 at 40 KeV). Slope of regression line at 40 KeV was similar to that at 55 KeV irrespective of OIN increase.

CONCLUSION

Data acquisition at 40 KeV can be useful for quantification of pulmonary smaller vessels closely-associated with emphysema on CT.

CLINICAL RELEVANCE/APPLICATION

Data acquisition at 40KeV may be potential to play an important role for early detection of peripheral vessel impairment leading to pulmonary hypertension in combination with iterative reconstruction.

SSM05-04 Can Dual-Energy Derived Perfusion Parameters Provide Information on Tumor Hypoxia? Preliminary Experience in 49 Operable Non-Small Cell Lung Carcinomas

Wednesday, Dec. 4 3:30PM - 3:40PM Room: N226

Participants
Julie Dewaguet, Lille, France (Abstract Co-Author) Nothing to Disclose
Marie-Christine Copin, MD, PhD, Lille, France (Abstract Co-Author) Nothing to Disclose
Alain Duhamel, PhD, Lille, France (Abstract Co-Author) Nothing to Disclose
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Jacques Remy, MD, Mouvaux, France (Abstract Co-Author) Research Consultant, Siemens AG
Martine J. Remy-Jardin, MD, PhD, Lille, France (Presenter) Research Grant, Siemens AG; Speaker, Siemens AG

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PURPOSE

To investigate potential relationships between DECT perfusion characteristics and prognostic histopathologic features.

METHOD AND MATERIALS

A two-phase DECT scanning protocol was obtained in the presurgical evaluation of 49 tumors (squamous cell carcinomas: n=12; adenocarcinomas: n=37), including (a) an early phase over the entire thorax (i.e., intravascular phase of tumoral perfusion); (b) completed by a delayed acquisition over the tumor, 50 s later (i.e., interstitial phase of tumoral perfusion). The first-pass and delayed iodine concentration (IC; mg/mL) and the arterial enhancement fraction (AEF=first pass IC/delayed IC x 100) were calculated over the entire tumor and within the most peripheral 2-mm thick tumor layer, automatically segmented. The expression of the membranous carbonic anhydrase IX (mCAIX), an immunohistochemical marker of hypoxia, was assessed in tumor specimens.

RESULTS

33 tumors were mCAIX positive (Group 1) and 16 mCAIX negative (Group 2), the former showing a statistically significantly larger volume (p=0.04). At the level of the whole tumor, the delayed IC was significantly higher than that at first pass (median: 1.53 vs 1.4; p=0.04), suggestive of extravascular leakage within the interstitial space; there was no difference in DECT perfusion parameters between the two groups. Compared to Group 2, the outer layer of Group 1 tumors had significantly higher median values of IC (0.53 vs 0.21; p=0.02) and AEF (102.6 vs 65.6; p=0.02) with a trend toward higher delayed IC (0.48 vs 0.39; p=0.34). The distribution of neovessel profile was significantly different between Groups 1 & 2 with a greater proportion of functional neovessels of IC (0.53 vs 0.21; p=0.02) and AEF (102.6 vs 65.6; p=0.02) with a trend toward higher delayed IC (0.48 vs 0.39; p=0.34). The slope of regression line at 40 KeV was similar to that at 55 KeV irrespective of OIN increase.

CONCLUSION

DECT can provide insight into perfusion characteristics at the level of the tumoral invasion front.

CLINICAL RELEVANCE/APPLICATION

Hypoxia-induced neovascularization may contribute to tumor progression and metastasis. DECT can provide information on perfusion characteristics at the level of the tumoral invasion front.

SSM05-05 The Predictive Value of Energy Spectrum CT Parameters for Ki67 Expression of Lung Cancer

Wednesday, Dec. 4 3:40PM - 3:50PM Room: N226

Participants
Pei P. Dou, Xuzhou, China (Presenter) Nothing to Disclose
Zhongxiao Liu, Xuzhou, China (Abstract Co-Author) Nothing to Disclose
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Chun-Wu Zhou, MD, Beijing, China (Abstract Co-Author) Nothing to Disclose

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PURPOSE

To investigate the relationship between energy spectrum CT parameters and Ki67 expression of lung cancer.
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PURPOSE
To investigate the predictive value of energy spectrum CT parameters for lung cancer Ki67 expression.

METHOD AND MATERIALS
Between December 2018 and February 2019, 27 primary lung cancer patients confirmed by pathological examination enrolled this prospective cohort study. All patients underwent energy spectrum CT (ESCT) scan. ESCT parameters were derived from dual-energy virtual imaging in Siemens postprocessed workstation by a radiologist (M.Y.K.). All enrollment patients clinicopathological data derived from electronic record system. SPSS 19.0 were used for statistical analysis. Quantitative and qualitative data used Χ2, t and Rank test respectively. ROC curves were used for analysis predicting performance of the Ki67 expression. P<0.05 was considered statistically significant.

RESULTS
Tumor was larger in Ki67 high expression group than low group (P=0.046). The other demographic and clinicopathological characteristics of all enrollment patients showed no significant difference (Table 2). Venous phase iodine value (IV), iodine ratio (IR) and the slope of the 40-80 keV energy spectrum curve (SP) improved than arterial phase IV, IR and SP, respectively (Fig. 1). The arterial phase IV, IR, SP and venous phase IV are no significant difference in low and high Ki67 expression group (P value ranged from 0.105 to 0.182) (Table 3). There are significantly different in two groups for venous phase IR and SP (0.249±0.083, 0.360±0.162, P=0.033 in IR and 1.744±0.607, 2.562±1.236, P=0.037 in SP, respectively) (Table 3, Fig. 2). Venous phase IR ROC analysis showed boderline P value (P=0.056) with AUC, sensitivity (SE), specificity (SP) and cutoff value were 0.717, 92.86, 61.54 and <=0.347 respectively. The AUC, SE, SP and cutoff value were 0.698, 92.86, 53.85 and <=2.407 respectively (Table 4, Fig. 6).

CONCLUSION
Venous phase IR and SP based on single energy spectrum curve and iodine image may effectively stratify primary lung cancer Ki67 expression into low and high group. The efficacy of other energy spectrum parameters need further investigation.

CLINICAL RELEVANCE/APPLICATION
The baseline energy spectrum CT parameters may non-invasion predict Ki67 expression. And the results may use for stratification lung cancer patients and individualization treatment in some extent.

SSM05-06 The Application of Spectral CT Multi-Parameter in Differentiating Pathological Types of Lung Cancer

Wednesday, Dec. 4 3:50PM - 4:00PM Room: N226

Participants
Zhani Ren, Xianyang, China (Presenter) Nothing to Disclose
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Xirong Zhang, Xianyang, China (Abstract Co-Author) Nothing to Disclose
Sijin Dong, Xianyang, China (Abstract Co-Author) Nothing to Disclose

PURPOSE
To explore the application of spectral CT multi-parameter in differentiating pathological types of lung cancer.

METHOD AND MATERIALS
57 patients with lung cancer who underwent spectral CT imaging were collected, of which there were 24 cases with adenocarcinoma, 18 cases with squamous cell carcinoma and 15 cases with small cell lung cancer. The dual-phase (aortic phase and pulmonary venous phase) enhanced scanning was used for all patients. The CT values of 40kev-90kev, iodine concentration(IC), water concentration(WC), effective-Z and the iodine concentration and water concentration of aorta at the same level were measured in the arterial phase, and the normalized iodine concentration(NIC) and the normalized water concentration(NWC) and the spectral curve slope were calculated. One-way ANOVA was used to compare the parameters.

RESULTS
The CT values of 40kev-60kev, iodine concentration, normalized iodine concentration, effective-Z and the spectral curve slope showed significant difference among three kinds of lung cancer (P<0.001). The CT values of 40kev-60kev, iodine concentration, normalized iodine concentration, effective-Z and the spectral curve slope in squamous cell carcinoma were significantly different from small cell lung cancer (P<0.001). The CT values of 40kev-60kev, iodine concentration, normalized iodine concentration, effective-Z and the spectral curve slope in adenocarcinoma were higher than those in squamous cell carcinoma (P<0.001).

CONCLUSION
Spectral CT multi-parameter can be used to identify different pathological types of lung cancer, of which the iodine concentration, normalized iodine concentration, effective-Z, CT values of 40kev-60kev and spectral curve slope played a role in differential diagnosis.

CLINICAL RELEVANCE/APPLICATION
Spectral CT imaging can provide multi-parameter identification basis for the pathological types of lung cancer, which was helpful to determine the reasonable treatment plan and improve the prognosis.
SSM06

Chest (Infection/Incidental Lung Nodule)
Wednesday, Dec. 4 3:00PM - 4:00PM Room: N227B

Participants
Jonathan H. Chung, MD, Chicago, IL (Moderator) Royalties, Reed Elsevier; Consultant, Boehringer Ingelheim GmbH; Speakers Bureau, Boehringer Ingelheim GmbH; Consultant, F. Hoffmann-La Roche Ltd; Speakers Bureau, F. Hoffmann-La Roche Ltd; Consultant, Veracyte, Inc;
Seth J. Kligerman, MD, Denver, CO (Moderator) Speakers Bureau, Boehringer Ingelheim GmbH; Author, Reed Elsevier; Consultant, IBM Corporation

Sub-Events
SSM06-01 Can Ultra-Low Dose Chest CT Accurately Detect Radiological Patterns of Fungal Infection in Immunocompromised Patients?
Wednesday, Dec. 4 3:00PM - 3:10PM Room: N227B

Participants
Anita Ghali, FRCR, Halifax, NS (Abstract Co-Author) Nothing to Disclose
Luigia D’Errico, Toronto, ON (Abstract Co-Author) Nothing to Disclose
Hatem Mehrez, Toronto, ON (Abstract Co-Author) Employee, Canon Medical Systems Corporation
Mini V. Pakkal, FRCR,MBBS, Toronto, ON (Abstract Co-Author) Nothing to Disclose
Micheal McInnis, MD, Toronto, ON (Abstract Co-Author) Nothing to Disclose
Narinder S. Paul, MD, Toronto, ON (Presenter) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc

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PURPOSE
To compare the accuracy of ultralow dose (uLDCT) to low dose chest CT (LDCT) in detection of major and minor findings of fungal infection.

METHOD AND MATERIALS
IRB approved this prospective study and patient consent was obtained. 100 consecutive immunocompromised patient had 2 chest CT scans (135kV, 0.5s, 64x0.5mm) during a single breath-hold with LDCT (40mA, ~1mSv) and uLDCT (10mA, ~0.25mSv). Images were reconstructed using lung and mediastinal kernels at slice thickness/interval of 3.0/2.4mm. 3 board certified chest radiologists independently evaluated the studies in randomized and blinded setting, and qualitatively assessed 1) image quality, 2) diagnostic confidence for detecting fungal infection and 3) detection of EORTC major criteria (halo sign, cavitation, consolidation) and minor criteria (nodules: clustered or isolated nodules of 4-10mm diameter, GGO/atelectasis) for fungal disease using a 5-point Likert score. Discrepant findings were adjudicated by a senior thoracic radiologist. Patients were stratified by BMI (kg/m2): <=18.5, 18.5-25.0, 25.0-30.0 and >30.0. uLDCT results were compared to LDCT findings.

RESULTS
Image quality and diagnostic confidence: LDCT had median and mean scores >4.0. uLDCT had median and mean scores >3.4 for lung reconstructions; and the Wilcoxon-paired test demonstrated no statistical difference between LDCT and uLDCT scores (p>0.45). uLDCT mediastinum reconstruction images had median and mean scores >3.7 for diagnostic confidence in patients with BMI <25.0; but with BMI>25.0 there was suboptimal IQ and diagnostic confidence (p<0.05) compared to LDCT. Evaluation of fungal disease: uLDCT accuracy in detecting major radiological criteria: halo sign, cavitation, consolidation was 99, 100, and 98% respectively; and in detecting minor criteria: sub-cm nodules and GGO, was 88 and 86%, respectively. uLDCT had reduced accuracy for detection of small (4-6mm) nodules and small volume GGO due to increased image noise.

CONCLUSION
Thoracic uLDCT has high accuracy in detection of major radiological criteria for fungal disease and should be considered in immunocompromised patients with BMI <=30.0Kg/m2.

CLINICAL RELEVANCE/APPLICATION
Immunocompromised patients undergo multiple chest CT scans to rule out opportunistic infection. uLDCT has comparable diagnostic accuracy to LDCT for detecting major radiological criteria of fungal disease with 80% lower radiation dose and should be routinely used in these patients.
DAD pattern had the highest toxicity grade, followed by HP and OP patterns (median grade: 3.5, 2.5, 2). All of the patients with ALK-IIP was identified in 11 patients (4.4%). The most common CT pattern was the OP pattern (n = 7, 63.6%) and followed by the NSIP pattern (n = 3, 27.3%). The NSIP pattern was identified in patients with ALK-IIP and without ALK-IIP.

RESULTS

Clinical characteristics including toxicity grading according to the National Cancer Institute Common Terminology Criteria for Adverse Events and treatment course was analyzed in regarding to the classified CT patterns. Clinical characteristics were compared between patients with ALK-IIP and without ALK-IIP. Terminology Criteria for Adverse Events and treatment course was analyzed in regarding to the classified CT patterns. Clinical characteristics including toxicity grading according to the National Cancer Institute Common Terminology Criteria for Adverse Events and treatment course was analyzed in regarding to the classified CT patterns. Clinical characteristics were compared between patients with ALK-IIP and without ALK-IIP.

METHOD AND MATERIALS

A total of 250 NSCLC patients who had been treated with ALK inhibitors from January 2015 to January 2018 were retrospectively enrolled. Clinical characteristics and clinical course were reviewed from the medical records. Chest CT of ALK-IIP was analyzed and other lung manifestations.

RESULTS

ALK-IIP was identified in 11 patients (4.4%). The most common CT pattern was the OP pattern (n = 7, 63.6%) and followed by the HP pattern (n = 2, 18.2%) and the DAD pattern (n = 2, 18.2%). ALK-IIP showed pneumonitis toxicity grade ranged from 1 to 3, and DAD pattern had the highest toxicity grade, followed by HP and OP patterns (median grade: 3.5, 2.5, 1). All of the patients with

CONCLUSION

Establishment of naked eye visible 3-D view analysis method was attempted by magnified print of virtual image of the micro focus CT of the lung specimen. Virtual image data based on micro CT of the inflated fixed lung specimen was used to make 40 times magnified peripheral lung model by 3D printer. Virtual lung tissue image was displayed on the flat screen by originally created application micro-NewVES. Two identical models were printed by 3D printer to confirm artifacts at the printing procedures. Internal structure of the magnified 3D print model was shown by virtual image by MDCT data of the 3D print model.

RESULTS

By virtual bronchoscopic view, beyond the respiratory bronchiole, alveolar ducts divide and reached to the blind end with one alveolus in the center surrounded by 6 alveoli. Numbers of surrounding alveoli were 5 to 7, but mainly 6. However most of alveolar ducts continuously divide and connect to adjacent duct to make alveolar duct network. The ducts connected loop back to initial respiratory bronchiole. Loop constructions of ducts were frequently found. Occasionally space surrounded by hundreds alveoli, that suggest destruction of alveolar duct unit. Alveoli revealed many shapes as semi-spherical or variety of semi-polygonal types on the 40 times magnified 3D print model. Sizes of the alveoli preliminary measured at 286 SD 27 micrometers, n=120, by this method. More measurements are necessary and also absolute sizes may considered according to, an official research policy statement of the ATS/ERS. The pores of Kohn as inter-alveolar communicating passes were found by naked eye view. Ten to thirty micrometer in diameter of small pores and various shapes of larger inter-alveolar communications were found.

CONCLUSION

Establishment of the method may apply for analysis of COPD, and that realized the development of new research field in respiratory radiology. Present method may also give us new insight in radiology of COPD, multi-cystic lung diseases, interstitial lung diseases, and other lung manifestations.

CLINICAL RELEVANCE/APPLICATION

That may give us new insight in radiology of COPD and other peripheral lung diseases.

SSM06-03 Anaplastic Lymphoma Kinase Inhibitor Induced Pneumonitis in Patients with Non-Small Cell Lung Cancer: Clinical and Radiologic Characteristics and Risk Factors

Wednesday, Dec. 4 3:20PM - 3:30PM Room: N227B

Participants

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PURPOSE

To investigate the clinical and radiologic characteristics and risk factors of anaplastic lymphoma kinase (ALK) inhibitor induced pneumonitis (ALK-IIP) in patients with non-small cell lung cancer (NSCLC).

METHOD AND MATERIALS

A total of 250 NSCLC patients who had been treated with ALK inhibitors from January 2015 to January 2018 were retrospectively enrolled. Clinical characteristics and clinical course were reviewed from the medical records. Chest CT of ALK-IIP was analyzed and classified into four CT patterns, i.e. organizing pneumonia (OP), hypersensitivity pneumonitis (HP), diffuse alveolar damage (DAD), and nonspecific interstitial pneumonia (NSIP), using the American Thoracic Society/European Respiratory Society classification of interstitial pneumonia. Clinical characteristics including toxicity grading according to the National Cancer Institute Common Terminology Criteria for Adverse Events and treatment course was analyzed in regarding to the classified CT patterns. Clinical characteristics were compared between patients with ALK-IIP and without ALK-IIP.

RESULTS

ALK-IIP was identified in 11 patients (4.4%). The most common CT pattern was the OP pattern (n = 7, 63.6%) and followed by the HP pattern (n = 2, 18.2%) and the DAD pattern (n = 2, 18.2%). ALK-IIP showed pneumonitis toxicity grade ranged from 1 to 3, and DAD pattern had the highest toxicity grade, followed by HP and OP patterns (median grade: 3.5, 2.5, 1). All of the patients with
the OP pattern were successfully treated, while half of patients with the DAD pattern died during treatment. The smoking history and extrathoracic metastasis were more frequent in patients with ALK-IIP (P < 0.005). The smoking history was associated with a higher incidence of ALK-IIP [odds ratio: 3.586, 95% confidence interval: 1.058-13.432, P = 0.049].

CONCLUSION

ALK-IIP showed a spectrum of chest CT patterns and various toxicity grades, and CT patterns reflected the toxicity grades of ALK-IIP. The OP pattern was the most common CT pattern of ALK-IIP, and patients with ALK-IIP of the OP pattern were successfully treated. The smoking history was a significant risk factor of ALK-IIP in NSCLC patients.

CLINICAL RELEVANCE/APPLICATION

A pattern approach in diagnosing ALK-IIP on chest CT is appropriate and effective in routine practice. ALK inhibitors should be used with caution in NSCLC patients with smoking history.

SSM06-04 Deep-Learning based Automated Detection Algorithm for Active Pulmonary Tuberculosis on Chest Radiographs: Diagnostic Performance in Systematic Screening of Asymptomatic Individuals

Wednesday, Dec. 4 3:30PM - 3:40PM Room: N227B

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PURPOSE

To validate deep-learning based automated detection (DLAD) algorithm for detection of active pulmonary tuberculosis (TB) and any radiologically-identifiable relevant abnormality on chest radiographs (CRs) in systematic screening setting.

METHOD AND MATERIALS

We performed out-of-sample testing of a trained DLAD algorithm, using CRs from 19,686 asymptomatic individuals (male: 19,475, female: 211; mean ± standard deviation: 21.3 ± 1.9 years) as part of systematic screening for TB between January 2013 and July 2018. Area under the receiver operating characteristic curves (AUC) of DLAD for diagnosis of TB and any relevant abnormalities were measured. Accuracy measures including sensitivities, specificities, positive predictive values (PPVs), negative predictive values (NPVs) were calculated at pre-defined operating thresholds (high sensitivity threshold, 0.16; high specificity threshold, 0.46).

RESULTS

Four individuals with five CRs were confirmed with active pulmonary TB, and 28 CRs were judged as having radiologically-identifiable relevant abnormality in 26 individuals. All five CRs with active pulmonary TB were correctly classified as having abnormal findings by DLAD with specificities of 0.959 and 0.997, PPVs of 0.006 and 0.068, and NPVs of both 1.000 at high sensitivity and high specificity thresholds, respectively. With high specificity thresholds, DLAD showed comparable diagnostic measures for tuberculosis to the pooled radiologists (P values > 0.005). For the detection of any radiologically-identifiable relevant abnormality, DLAD showed AUC value of 0.967 (95% confidence interval, 0.938-0.996) with sensitivities of 0.821 and 0.679, specificities of 0.960 and 0.997, PPVs of 0.028 and 0.257, and NPVs of both 1.000 at high sensitivity and high specificity thresholds, respectively.

CONCLUSION

In systematic screening for TB in a low-prevalence setting, DLAD algorithm demonstrated excellent diagnostic performance, comparable to the radiologists in the detection of active pulmonary TB.

CLINICAL RELEVANCE/APPLICATION

DLAD algorithm can help radiologists detect active pulmonary TB on CRs in a time-efficient manner, and identify individuals for further clinical and diagnostic evaluation for active TB. In a resource-constrained environment, it may be utilized as a standalone screening tool for individuals with active pulmonary TB.

SSM06-05 Comparison of Radiologist and Natural Language Processing-Based Image Annotation For Deep Learning System for Tuberculosis Screening on Chest X-Rays

Wednesday, Dec. 4 3:40PM - 3:50PM Room: N227B

Participants
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PURPOSE

To compare 1) agreement between natural language processing (NLP) and radiologist-curated labels for possible tuberculosis (TB) on chest radiographs (CXR) and 2) performance of deep convolutional neural networks (DCNN) trained on images using the two sets
of labels for identification of TB.

METHOD AND MATERIALS

We obtained 10,951 de-identified CXRs from the NIH ChestX-ray14 database annotated for 14 thoracic conditions by NLP. Each CXR was labeled as positive for possible TB if they had any of the following: pneumonia, infiltrate, mass, nodule, or consolidation. A fellowship-trained thoracic radiologist blinded to image labels interpreted each image and labeled each as positive or negative for possible TB. Kappa coefficients were calculated to evaluate inter-rater agreement between radiologist- and NLP-curated labels. We created 5 datasets with progressively increasing numbers of images with roughly equal proportions of positive and negative cases based on NLP-curated labels: 996, 2994, 6033, 9955, and 10,951 images (Table 1). Each dataset was divided into training (80%) and validation (20%) splits. The ResNet-50 DCNN pretrained on ImageNet was trained and validated using each dataset and tested on an external dataset of 753 CXRs used to screen for TB in Montgomery County, MD (USA) [58 with TB, 80 normal] and Shenzhen, China (275 with TB, 340 normal). Receiver operating characteristic (ROC) curves with area under the curve (AUC) were used to evaluate the DCNNs; AUCs were compared between DCNNs using DeLong's parametric method.

RESULTS

There was poor agreement between NLP and radiologist-curated labels with regards to potential TB on CXRs (Kappa coefficient ranging from 0.33 to 0.37). DCNNs trained using radiologist-curated labels consistently had significantly higher performance than the algorithm trained using the NLP-labels, regardless of the number of the number of images used for training and validation (Table 1). The best-performing DCNN had an AUC of 0.88, which was trained on 11,000 images using the radiologist-annotated sets.

CONCLUSION

DCNNs trained on CXRs labeled by a radiologist outperformed those trained on the same CXRs labeled by NLP, highlighting the benefit of radiologists' determining groundtruth for machine learning dataset curation.

CLINICAL RELEVANCE/APPLICATION

DCNNs trained on CXRs labeled by a radiologist consistently outperformed those trained on the same CXRs labeled by NLP.

SSM06-06 Radiologists Improve Timeliness of CT Follow-Up for Incidental Lung Nodules with a Novel 'Tracker' System

Wednesday, Dec. 4 3:50PM - 4:00PM Room: N227B

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PURPOSE

Evaluate improvement in timeliness of follow-up chest CT for incidental lung nodules after implementation of a 'Tracker Phrase' system.

METHOD AND MATERIALS

In 2011, a system was implemented where dictating radiologists tagged chest CT reports with 'Tracker' phrases and text indicating the recommended follow-up for incidental nodules. An electronic registry for tracking patients with nodules was built using the Tracker phrases. The registry generated automated patient and provider reminders when scans were overdue. An EHR query found 41,692 chest CTs had been performed 2008 - 2016. A random sample of reports describing an incidental nodule were selected for retrospective review. Patient records before (n=448) and after (n=848) implementation of the Tracker system were examined for timeliness of follow-up. Timeliness was broadly defined as follow-up CT occurring within 13 months of the index CT. Patient age, gender, and risk of lung cancer were obtained. High risk was defined by a personal history of lung cancer, or diagnosed COPD, or at least two of the following: age>50 years, 20+ pack years of smoking, or first degree relative with lung cancer.

RESULTS

Age and gender did not differ significantly in the pre-Tracker vs. the post-Tracker groups. 58% of the pre-Tracker vs. 69% of the post-Tracker patients were high risk (p<.01). Fewer (42% vs. 54%) in the pre-Tracker group had timely follow-up compared to the post-Tracker group (p=.01). Adjusting for risk and age group, we found that patients whose CT report contained a Tracker phrase were 50% more likely to have a timely follow-up chest CT compared to those whose CT scans did not (OR = 1.55; 95% CI 1.23-1.96 p <.001). Being 'high risk' for lung cancer increased the likelihood of timely follow-up (OR = 1.89; 95% CI 1.50-2.40 p<.001), as did age of 65 years or older (OR = 1.39; 95% CI 1.11-1.74 p=.004) at the time of the index CT scan.

CONCLUSION

Timeliness of CT follow-up for incidental lung nodules significantly improved after the implementation of a Tracker phrase system. Older age and higher risk of lung cancer were also associated with more timely follow-up.

CLINICAL RELEVANCE/APPLICATION

A radiologist driven Tracker system can improve timeliness of CT surveillance for follow-up of incidental lung nodules.

Printed on: 10/29/20
PURPOSE
Despite a wealth of literature on dual-energy CT (DECT) iodine uptake in various pathologies, physiologic reference values for this technique for confident clinical application have not been defined to date. Therefore, we investigated the iodine uptake of healthy abdominal and pelvic organs in a big data cohort.

METHOD AND MATERIALS
Consecutive portal-venous abdominal DECTs were reviewed and unremarkable exams were included (n=520; white/Asian=489; mean age=59±15.5 years; 265w/255m). ROI-measurements were performed in the following anatomical regions (number of ROIs): liver(9), pancreas(3), spleen(3), adrenal glands(2), kidneys(6), prostate(4), uterus(2), urinary bladder wall(1) and lymph nodes(3). Iodine uptake was compared among different organs and subgroup analysis was performed (young vs old & male vs female).

RESULTS
Overall mean iodine uptake values were as followed (mg/ml): liver=1.93±0.54, pancreas=2.06±0.57, spleen=2.55±0.6, adrenal glands=1.66±0.43, kidneys=6.28±1.36, prostate=1.11±0.52, uterus=1.07±0.74, bladder=0.69±0.29 and lymph nodes=0.75±0.21. Portal-venous iodine uptake was comparable between liver/pancreas and liver/adrenal glands (p≥0.119). Women showed higher iodine uptake for liver (2.07±0.58 vs 1.89±0.45 mg/ml), pancreas (2.29±0.57 vs 1.83±0.47 mg/ml), spleen (2.81±0.65 vs 2.30±0.53 mg/ml), adrenal glands (1.76±0.49 vs 1.56±0.33 mg/ml) and kidneys (6.74±1.36 vs 5.83±1.20 mg/ml) than men (p<0.001). In older patients, iodine uptake increased for liver (1.98±0.52 vs 1.87±0.54 mg/ml), spleen (2.48±0.65 vs 2.43±0.64 mg/ml) and kidneys (6.11±1.24 vs 6.45±1.45 mg/ml) compared to younger subjects (p<0.001). Only the uterus showed lower values in older women (0.77±0.45 vs 1.35±0.84 mg/ml, p<0.001).

CONCLUSION
Physiologic iodine uptake values show age- and gender-related differences for the liver, spleen and kidneys. Pancreas and adrenal glands show higher iodine perfusion in women. While prostate parenchyma seems unaffected throughout lifetime, iodine supply of the uterus decreases in elderly women. Lymph nodes and bladder are unaffected by demographic influences.

CLINICAL RELEVANCE/APPLICATION
We defined physiologic reference values for static perfusion of abdominal organs, as indicated by DECT iodine uptake in a big data cohort and described the related differences regarding age and gender, in order to facilitate more reliable clinical application of this technique and ultimately, potential implementation in future guidelines.
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PURPOSE
The purpose of this work is to investigate the effect of energy on CT texture analysis (CTTA) of pancreas and liver tumors and healthy tissue using virtual monoenergetic images (VMIs) generated from split-filter dual-energy CT (DECT).

METHOD AND MATERIALS
Split-filter DECT data was acquired for pancreatic and liver cancer patients using the Siemens SOMATOM Definition Edge CT scanner for radiation treatment planning with 100 ml of iohexol contrast medium. VMIs at energies ranging from 40-90 keV in 5 keV increments were reconstructed in Siemens’ Syngo.via (VB30) software. Based on radiation oncologist reviewed contours of tumor and healthy tissue, first order CTTA parameters of the pancreas and liver tumor and healthy tissue were extracted from MIMvista including mean CT number (MCTN), standard deviation (SD), skewness, and kurtosis. Statistical analysis was performed using ANOVA.

RESULTS
Among the CTTA parameters investigated, MCTN and SD showed a statistically significant decrease with increasing energy of VMIs for pancreas and liver tumor and healthy tissue (p<0.0001). On the other hand, skewness and kurtosis did not change with energy of VMIs for pancreas and liver tumor and healthy tissue (p>0.7). There was a statistically significant difference in MCTN between pancreas and liver tumor and healthy tissue for low-energy VMIs (p<0.04). Although kurtosis did not change with energy, there was a statistically significant difference between the kurtosis of pancreas tumor and healthy tissue for all VMIs investigated (p<0.05). This trend was not apparent for liver tumor and corresponding healthy tissue (p>0.14). Additionally, there was a statistically significant difference in SD between pancreas tumor and healthy tissue for all VMIs investigated (p<0.04). This trend was not apparent for the liver cases (p>0.08).

CONCLUSION
The energy of split-filter VMIs has no impact on skewness or kurtosis of pancreas and liver tumor and healthy tissue. The difference in MCTN between pancreas tumor and healthy tissue is greatest for low-energy split-filter VMIs. Kurtosis determined from split-filter VMIs was different between pancreas tumor and healthy tissue.

CLINICAL RELEVANCE/APPLICATION
Skewness and kurtosis are reliable CTTA parameters that do not change as a function of energy. MCTN, SD and kurtosis have the potential to differentiate tumor and healthy tissue on split-filter VMIs. These results can be used as a baseline for higher-order CTTA of pancreas and liver tumor and healthy tissue.

SSM10-03 Quantification of the Liver-Fat Content Using Multimaterial Decomposition (MMD) Algorithm and Material Decomposition Technique: A Vitro Experiment Study

Wednesday, Dec. 4 3:20PM - 3:30PM Room: E352

Participants
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PURPOSE
Our first goal was to build in vitro liver-fat model to provide a phantom for fat content quantification in study. The second goal was to evaluate the difference of feasibility and accuracy of using MMD algorithm and dual energy CT material decomposition technique for fat content quantification to provide a basis for the precise fat quantification in clinical use.

METHOD AND MATERIALS
A total of 6 homogeneous liver-fat mixed samples with various fat volume contents from 0-50% (with an interval of 10%). Scanned by GE Revolution CT scanner using GSI mode with rapid tube voltage switching between 80-140 kVp. After the CT scan, reconstructed imaging data were processed with GSI imaging analysis software and MMD soft-ware currently not commercially available. Fat concentration (on fat-water bases) measured with consistent ROIs placed in the tube center. Each sample was recorded at 4 different regions for average and statistical analysis. A linear regression was performed using SPSS 19.0 software to analyze the relationship between the measured fat concentration and the actual fat concentration. P value less than 0.05 was considered to indicate a linear correlation.

RESULTS
(1) We had successfully developed the model in vitro for fat content quantification. With the designed concentration series, the gradient range covered clinical fat content in different body regions. And the model provided a novel way to investigate in vitro fat content. (2) Both algorithms showed good linear relationship between the measured fat concentration and actual concentration. MMD algorithm revealed a linear correlation equation of y=1.498x-73.5, R² = 0.944, P=0.001, F=84.748. For material decomposition technique, the linear correlation equation was y=0.079x+30.52, R² = 0.983, P=0.001, F=234.397.
CONCLUSION

Both of MMD algorithm and spectral CT material decomposition technique were demonstrated to provide accurate and reliable measurement of fat content for liver-fat model, which will contribute to the development of clinical fat content quantification assays.

CLINICAL RELEVANCE/APPLICATION

This study demonstrated the feasibility of using MMD algorithm and material decomposition techniques to precisely quantify the fat concentrations. The advantages of these quantification methods include reduced labor, high accuracy with no additional scanning required, which makes it attractive to be applied in future clinical tests and lipid metabolism studies.

SSM10-04 Virtual Non-Contrast Images from Contrast-Enhanced Dual-Layer Spectral CT for Pediatric Abdominal CT: Are They Different from Adults?

Wednesday, Dec. 4 3:30PM - 3:40PM Room: E352

Participants
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PURPOSE

Virtual non-contrast (VNC) images from dual-layer spectral CT (DLSCT) might replace true unenhanced images for pediatric abdominal CT studies. We compared the accuracy of iodine subtraction in pediatric abdominal organs on VNC images obtained from contrast-enhanced DLSCT scans with that of true unenhanced (TU) images and assessed the difference between pediatric and adult patients.

METHOD AND MATERIALS

We included 10 child- (1-15 years, mean 8.7±4.4 year) and 40 adult patients (28-87 years, mean 56.4±17.6 year) who underwent unenhanced and contrast-enhanced DLSCT. Two radiologists assessed the image quality of all images on a 5-point scale. Venous-phase VNC images were generated and a region-of-interest (ROI) was placed on the liver, spleen, renal cortex, aorta, fat tissue, muscle and fluid (gallbladder) on TU- and VNC images. The attenuation of each ROI in VNC image was subtracted from the corresponding attenuation of the TU image. The difference in attenuation between VNC- and TU images of children and adults was compared using the independent t-test and regression analysis.

RESULTS

In all 50 patients, there was no significant difference in the image quality of VNC- and TU scans (children: 4.8±0.4; adult: 4.5±0.5). The attenuation difference in the renal cortex between VNC- and TU images was significantly greater in adults than children (9.6±7.2 vs 1.2±8.2 HU, p=0.0046). The attenuation difference in the liver and spleen showed a similar tendency. With respect to fat tissue, attenuation was higher on VNC than TU images in almost all 50 patients. Scatter plots of the attenuation difference between VNC- and TU images versus the patient age showed a significant positive correlation only in the renal cortex (r=0.34, p=0.034).

CONCLUSION

VNC images derived from contrast-enhanced DLSCT showed iodine subtraction in abdominal organs more accurately on scans of children than adults.

CLINICAL RELEVANCE/APPLICATION

For the evaluation of abdominal contrast-enhanced CT scans, VNC imaging may be more useful in children than adults.

SSM10-05 Intra-individual Consistency of Spectral Detector CT-Enabled Iodine Quantification of the Intravascular and Renal Blood Pool

Wednesday, Dec. 4 3:40PM - 3:50PM Room: E352

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PURPOSE

Recent studies revealed high diagnostic accuracy of iodine maps from spectral detector CT (SDCT); however, little is known on reproducibility of iodine measurements in vivo which is crucial for oncologic follow-up imaging. Hence, the objective of this study was to analyze the intra-individual, longitudinal consistency in patients that underwent multiple SDCT examinations.

METHOD AND MATERIALS

79 patients with 2 (53 patients) or 3 (26 patients) clinically-indicated, biphasic (arterial/venous) abdominal SDCT scans were retrospectively identified for study inclusion. HU attenuation in conventional images and iodine concentration in iodine maps were measured by an experienced radiologist who placed circular regions of interest (ROI) in the following areas (two ROI each):
abdominal aorta, inferior caval vein, portal vein, renal cortices. To investigate intra-individual consistency of iodine and HU measurements, modified variation coefficients (MVC) were calculated.

RESULTS
Variability of HU attenuation and iodine concentration was significantly higher in arterial phase than in venous phase images \( (p <= 0.05) \). Regarding arterial phase attenuation measurements, median MVC was -1.8 \( (-20.5-21.3 \%) \) within the aorta and -6.5 \( (-44.0-48.7 \%) \) within the renal cortex while in the portal venous phase it was 0.62 \( (-11.1-11.7 \%) \) and -1.6 \( (-16.2-10.6 \%) \), respectively. Regarding iodine quantification, MVC of arterial phase measurements was -2.5 \( (-22.9-28.4 \%) \) within the aorta and -5.8 \( (-55.9-29.6 \%) \) within the renal cortex. Referring MVCs of the portal venous phase were -0.7 \( (-17.9-16.9 \%) \) and -2.6 \( (-17.6-12.5 \%) \).

CONCLUSION
Intra-individual iodine quantification of intravascular and renal blood pool is most consistent in venous-phase images (overall MVC: ±15 \%) whereas arterial phase measurements are subject to greater variability.

CLINICAL RELEVANCE/APPLICATION
For clinical application of SDCT-derived iodine quantification, a certain variability of venous phase images should be considered while particular care must be taken when calculating iodine thresholds from arterial phase images, e.g. in oncologic follow-up.

SSM10-06 Conventional versus Virtual Monoenergetic Images from Spectral Detector CT: Evaluation of Attenuation and Noise

Wednesday, Dec. 4 3:50PM - 4:00PM Room: E352

Participants
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PURPOSE
The utilization of VMI in daily practice is limited as attenuation (HU) is quite different and extensive re-windowing may be required. We aimed to identify the VMI energy that closest represents conventional images (CI) in order to demonstrate that these images demonstrate improved image quality in terms of noise and Signal-to-noise ratio (SD/SNR) while attenuation values remain unaltered as compared to CI.

METHOD AND MATERIALS
60 and 30 patients with contrast-enhanced (CE) and non-enhanced (NCE) SDCT of the abdomen were included in this retrospective, IRB-approved study. CI and VMI of 66, 68, 70, 72 and 74keV as well as quantitative iodine maps were reconstructed (Q-IodMap). Two regions of interest were placed in each: aorta, liver, pancreas, renal cortex and psoas muscle. For each reconstruction, attenuation and standard deviation were averaged. \( \Delta \text{HU} \) and Signal-to-noise ratio was computed \( (\text{SNR}=\text{HU}/\text{SD}) \). Q-IodMap were considered as confounder for \( \Delta \text{HU} \).

RESULTS
In NCE studies, no significant differences for any region was found. In CE studies, VMI72keV images showed lowest \( \Delta \text{HU} \) \( (\text{HulliverCI}/\text{VMI72keV}: 104\pm18/103\pm17, p=0.05) \). Iodine containing voxels as indicated by Q-IodMap resulted in over- and underestimation of attenuation in lower and higher VMI energies. Image noise was lower in VMI images \( (\text{e.g. muscle: CI}/ \text{VMI72keV}: 15.3\pm3.3 / 12.3\pm2.9 \text{HU}, p=0.05) \). Hence, SNR was significantly higher in VMI72keV compared to CI \( (\text{e.g. liver 3.8}\pm0.6 \text{ vs 3.0}\pm0.8, p<0.05) \).

CONCLUSION
VMI72keV show improved SD/SNR characteristics while the attenuation remains unaltered as compared to CI. These images possibly may be used as replacement for conventional images.

CLINICAL RELEVANCE/APPLICATION
The noise reduction enabled by VMI72keV may allow for a reduction of radiation dose. The CI-equivalent attenuation values may increase their clinical acceptance.

Printed on: 10/29/20
The Role of Dynamic Contrast-Enhanced CT in Diagnosis and Management of Patients with Sustained Bleeding After Liver Transplantation

Wednesday, Dec. 4 3:00PM - 3:10PM Room: E353A

**PURPOSE**
To investigate the role of dynamic contrast-enhanced CT (DCE-CT) in the diagnosis and management of patients with sustained bleeding after liver transplantation (LT).

**METHOD AND MATERIALS**
Between November 2013 and December 2017, we retrospectively identified 270 patients (52.8±9.8 years; 18-76 years) who underwent DCE-CT after LT with clinically suspected postoperative bleeding. DCE-CT images were analyzed with emphasis on contrast media extravasation (CME): bleeding source, volume, rate, and morphologic pattern (type I, focal or stippled pattern; type II, jet-like pattern). Recipients were classified into two groups by primarily-chosen treatment method; nontherapeutic intervention (NTI) trial and primary therapeutic intervention (TI) groups. NTI trial group was further subdivided into NTI success and NTI failure groups according to results of NTI treatment. The differences of CME volume, rate, and pattern among the three groups and between the subgroups were evaluated. The concordances of bleeding source determined by DCE-CT to actual bleeding source were analyzed.

**RESULTS**
Of the 270 patients with clinically suspected postoperative bleeding, 134 CME sites were identified in 116 (43.0%) patients. While most (94.8%, 146/154) of patients without CME was successfully managed by NTI, the proportion decreased in the order particularly on portal venous phase with type I (48.5%, 16/33) and type II (16.9%, 14/83) CMEs. The mean CME volume on both arterial and portal venous phases and the mean CME rate significantly increased in order of NTI success, NTI failure, and primary TI groups (p<0.01, respectively). In subgroup analysis of NTI trial group, type II CME on portal venous phase was significantly higher in NTI failure group than in NTI success group (86.7% [13/15] versus 46.7% [14/30], p=0.01). There was substantial agreement in localization of bleeding source between DCE-CT and surgery or angiography (Cohen Kappa=0.78).

**CONCLUSION**
DCE-CT is helpful in the assessment for need of TI and to determine the treatment of choice in recipient with postoperative bleeding after LT.

**CLINICAL RELEVANCE/APPLICATION**
DCE-CT is helpful in the assessment for need of therapeutic intervention and in decision of treatment method in recipient with postoperative bleeding after LT.

CT Evaluation of Bowel Perforation: Diagnostic Performance and Correlation of Imaging Features According to Sites and Causes

Wednesday, Dec. 4 3:20PM - 3:30PM Room: E353A

Participants
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Mi Hyun Park, Cheonan, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Relative Sarcopenia with Excess Adiposity is an Independent Predictor of Survival After Transjugular Intrahepatic Portosystemic Shunt (TIPS) Creation

Wednesday, Dec. 4 3:30PM - 3:40PM Room: E353A

Participants
Islam H. Zaki, MBCh, Durham, NC (Presenter) Nothing to Disclose
Erol Bezdogan, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Matthew K. Langman, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Matthew Kappus, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Steven S. Choi, MBBS, Durham, NC (Abstract Co-Author) Nothing to Disclose
Jonathan Martin, MD, Durham, NC (Abstract Co-Author) Advisory Board, Dova Pharmaceuticals
Paul V. Suhocki, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Tony P. Smith, MD, Durham, NC (Abstract Co-Author) Nothing to Disclose
Charles Y. Kim, MD, Raleigh, NC (Abstract Co-Author) Consultant, Medtronic plc; Consultant, Humacyte; Consultant, Galvani
Mustafa R. Bashir, MD, Cary, NC (Abstract Co-Author) Research Grant, Siemens AG; Research Grant, NGM Biopharmaceuticals, Inc.; Research Grant, Madrigal Pharmaceuticals, Inc.; Research Grant, Metacrine, Inc.; Research Grant, Pinnacle Clinical Research; Research Grant, ProSciento Inc; Research Grant, Carmt Therapeutics; Research Grant, 1Globe Health Institute; Research Consultant, ICON plc;
James S. Ronald, MD, PhD, Durham, NC (Abstract Co-Author) Nothing to Disclose

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PURPOSE
To assess whether relative sarcopenia with excess adiposity is a risk factor for poor survival after TIPS.

METHOD AND MATERIALS
This single institution retrospective study included patients over 18 years of age who underwent TIPS creation and had abdominal CT scans performed within 100 days prior to or 30 days after TIPS. Subcutaneous fat, visceral fat and abdominal wall muscles were segmented at the inferior L3 endplate. Relative sarcopenia with excess adiposity was defined as the lowest gender specific quartile of muscle area divided by muscle plus fat area. Dates of death, liver transplantation, spontaneous occlusion or embolization of the TIPS, and post-TIPS hepatic encephalopathy (HE) were identified. Mortality was analyzed using competing risks survival analysis, and post-TIPS HE was analyzed using negative binomial regression and competing risks survival analysis.

RESULTS
The cohort included 141 patients (mean age 56 years ±11, 91 men) who underwent CT an average of 17 days before TIPS (range 97 days prior to 26 days after). In univariate survival analyses, Model for End Stage Liver Disease (MELD) score (hazard ratio [HR]=1.09 per 1-point increase in MELD, 95% confidence interval [CI]=1.05-1.13, p<0.001) and relative sarcopenia with excess adiposity (HR=2.7, CI=1.55-4.69, p<0.001) were significant risk factors for shorter survival after TIPS. In a multivariate analysis both MELD score (HR=1.11, CI=1.06-1.16, p<0.001) and relative sarcopenia with excess adiposity (HR=2.46, CI=1.42-4.26, p=0.001) were significant predictors of survival. The C-index at 30 days was 0.71 for MELD, 0.72 for relative sarcopenia with excess adiposity, and 0.8 for a model including both. There was no association between relative sarcopenia with excess adiposity...
and number of post-TIPS HE episodes (incidence rate ratio=1.08, CI=0.49-2.40, p=0.84) or time to first post-TIPS HE episode (HR=0.89, CI=0.51-1.54, p=0.67)

CONCLUSION
Relative sarcopenia with excess adiposity, defined as the lowest quartile of gender specific muscle area normalized to muscle plus fat measured by CT, is an independent risk factor for poor survival after TIPS and may supplement MELD score

CLINICAL RELEVANCE/APPLICATION
A deficiency in abdominal muscle mass relative to fat as assessed by CT is associated with poor survival after TIPS. This anthropometric index may improve the ability to predict outcomes in cirrhotic patients undergoing TIPS

SSM11-05 Value of Computed Tomography Finding in Evaluating the Acute Cellular Rejection of the Pancreas Allograft

Wednesday, Dec. 4 3:40PM - 3:50PM Room: E353A

Participants
Jeong A Yeom, Yangsan, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Hwaseong Ryu, Yangsan, Korea, Republic Of (Presenter) Nothing to Disclose
Tae Un Kim, MD, Yangsan, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose
Jun Woo Lee, MD, Pusan, Korea, Republic Of (Abstract Co-Author) Nothing to Disclose

PURPOSE
To investigate computed tomography (CT) findings in patients with or without acute cellular rejection (ACR) after pancreas transplantation

METHOD AND MATERIALS
Twenty-two pancreas allograft recipients (pancreas transplantation alone: 17, pancreas transplantation after kidney transplantation: 3, pancreas transplantation after liver transplantation: 1, simultaneous pancreas and kidney transplantation: 1) that underwent at least one follow-up CT examination were included in this study. Among them, 8 patients were diagnosed as ACR by percutaneous biopsy within 3 day from CT examination. Two radiologists analyzed pre-biopsy CT images of patients with ACR and the latest CT images of patients without ACR compared with early follow-up CT for graft swelling, perivascular soft tissue infiltration of graft arteries, change from acute to obtuse angle between graft SMV and splenic vein, graft enhancement on the delayed phase, fat strands or fluid around graft, and graft duodenal wall thickening. Intra-class correlation (ICC) was used to analyze inter-observer agreement of CT findings.

RESULTS
Mean interval between transplantation and CT examination was not significantly different between patients with ACR and patients without ACR (467.5±261.9 days vs 508.2±343.3 days, p = 0.838). Three patients with grade 1, and five patients with grade 2 ACR were noted by pathological analysis. Change from acute to obtuse angle between graft SMV and splenic vein (p = 0.001) and graft duodenal wall thickening (p < 0.001) were observed more frequently in patients with ACR. Other CT findings did not show significant difference between ACR and non-ACR group (p = 0.060-1.000). Inter-observer agreement for angle between graft SMV and splenic vein (ICC: 0.896), graft duodenal wall thickening (ICC: 0.945) were excellent, and fair to excellent agreements were noted for other CT findings (ICC: 0.456 - 1.000).

CONCLUSION
CT examination can be helpful to predict ACR in patients after pancreas transplantation using change of angle between graft SMV and splenic vein with excellent inter-observer agreement.

CLINICAL RELEVANCE/APPLICATION
CT findings including change of angle between graft SMV and splenic vein might be helpful for prediction of ACR as well as evaluation of postoperative complications in patients after pancreas transplantation.

SSM11-06 Diagnostic Accuracy of Multidetector CT in Detecting Juxta-Ampullary Duodenal Diverticulum in Symptomatic Patients

Wednesday, Dec. 4 3:50PM - 4:00PM Room: E353A

Participants
Daniel Fadaei Fouladi, MD, Baltimore, MD (Presenter) Nothing to Disclose
Elham Eghbali, Tabriz , Iran (Abstract Co-Author) Nothing to Disclose
Masoud Shirmohammadi, Tabriz , Iran (Abstract Co-Author) Nothing to Disclose
Shadi Daghighi, San Diego , CA (Abstract Co-Author) Nothing to Disclose
Shahab Shayesteh, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Saeed Ghandili, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Reza Javadrashid, MD, Tabriz, Iran (islamic Rep. Of) (Abstract Co-Author) Nothing to Disclose

PURPOSE
To determine the diagnostic accuracy of 64-slice multidetector computed tomography (MDCT) in detecting juxta-ampullary duodenal diverticulum (JADD) in symptomatic patients.

METHOD AND MATERIALS
After being approved by the Ethics Committee of our university, a total of 100 patients with endoscopic retrograde cholangiopancreatography (ERCP)-confirmed JADD and 20 patients with extrahepatic biliary obstruction due to other reasons were enrolled in this study. All patients were evaluated by MDCT, as well. Without knowing the result of ERCP, two experienced radiologists reviewed MDCT images and accordingly, the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of MDCT in detecting JADD, as the etiology of obstruction, were calculated.
RESULTS
The study group comprised 60 males and 60 females with the mean age of 68.83±12.71 years (range, 27-93) at the time of evaluation. The sensitivity, specificity, PPV and NPV of MDCT in detecting JADD were 76% (95% confidence interval, CI; 66%-84%), 100%, 100% and 45.5% (95%CI; 30%-61%), respectively. The only independent reason for missing a JADD on MDCT images was its small size (<10mm).

CONCLUSION
Abdominal MDCT is highly specific in detecting JADD as the underlying cause of obstruction in symptomatic patients. The accuracy increases when the diverticulum is larger than 10mm.

CLINICAL RELEVANCE/APPLICATION
64-slice MDCT is highly accurate in ruling in juxta-ampullary duodenal diverticula as the underlying cause of extrahepatic biliary obstruction.
Case-based Review of CT (Interactive Session)

Wednesday, Dec. 4 3:30PM - 5:00PM Room: S402AB

CT

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

Participants
Edward Y. Lee, MD, Boston, MA (Director) Nothing to Disclose

LEARNING OBJECTIVES
1) Review clinical presentations of congenital and acquired disorders. 2) Discuss optimal CT imaging techniques for assessing congenital and acquired disorders. 3) Learn characteristic CT findings of congenital and acquired disorders.

Sub-Events

MSCZ42A  Adult Head and Neck CT

Participants
Amy F. Juliano, MD, Boston, MA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) Recognize an imaging abnormality and place it in the correct location/space of the neck. 2) Generate a differential diagnosis, and narrow it down by incorporating clinical history and pertinent positives and negatives on the available images. 3) Identify common entities in the head and neck, as well as some rare entities that have classic imaging findings.

MSCZ42B  Adult Hepatobiliary CT

Participants
Koenraad J. Mortele, MD, Boston, MA (Presenter) Nothing to Disclose

MSCZ42C  Adult Genitourinary CT

Participants
Hero K. Hussain, MD, Ann Arbor, MI (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES
1) To discuss features of common and uncommon cystic and solid renal and perirenal lesions on CT, and identify features that help narrow the differential diagnosis.

MSCZ42D  Adult Trauma CT

Participants
Jorge A. Soto, MD, Boston, MA (Presenter) Royalties, Reed Elsevier

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LEARNING OBJECTIVES
1) Develop a search pattern that minimizes risk of missing subtle organ injuries. 2) Highlight key imaging features that are critical for determining need of operative or interventional repair of abdominal injuries. 3) Increase confidence in the interpretation of complex multi-trauma CT examinations.

Printed on: 10/29/20
Controversy Session: Hepatocellular Carcinoma: Should We Use CT, MR, or US?

Wednesday, Dec. 4 4:30PM - 6:00PM Room: N227B

CT GI MR US

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

Participants
Claude B. Sirin, MD, San Diego, CA (Moderator) Research Grant, Gilead Sciences, Inc; Research Grant, General Electric Company; Research Grant, Siemens AG; Research Grant, Bayer AG; Research Grant, Koninklijke Philips NV; Consultant, AMRA AB; Consultant, Fulcrum; Consultant, IBM Corporation; Consultant, Exact Sciences Corporation; Consultant, Boehringer Ingelheim GmbH; Consultant, Arters Inc; Consultant, Epigenomics; Author, Medscape, LLC; Lab service agreement, Gilead Sciences, Inc; Lab service agreement, ICON plc; Lab service agreement, Intercept Pharmaceuticals, Inc; Lab service agreement, Shire plc; Lab service agreement, Enanta; Lab service agreement, Takeda Pharmaceutical Company Limited; Lab service agreement, Alexion Pharmaceuticals, Inc; Lab service agreement, NuSirt Biopharma, Inc
R. Brooke Jeffrey Jr, MD, Stanford, CA (Moderator) Nothing to Disclose

LEARNING OBJECTIVES
1) To understand the need for screening and surveillance for HCC in cirrhosis. 2) To understand that ultrasound is currently recommended as the primary modality for this purpose by all national and international guidelines. 3) To understand the advantages and disadvantages of ultrasound, CT, and MRI for HCC screening and surveillance in cirrhosis.

Sub-Events

SPSC42A Overview of HCC Screening and Surveillance: Definitions, Rationale, Basic Concepts, Current Guidelines, USA Landscape, Worldwide Landscape

Participants
Aya Kamaya, MD, Stanford, CA (Presenter) Royalties, Reed Elsevier; Researcher, Koninklijke Philips NV; Researcher, Siemens AG

SPSC42B Why Ultrasound Should Be Used for HCC Screening/Surveillance

Participants
Shuchi K. Rodgers, MD, Philadelphia, PA (Presenter) Nothing to Disclose

SPSC42C Why CT Should Be Used for HCC Screening/Surveillance

Participants
Avinash R. Kambadakone, MD, Boston, MA (Presenter) Research Grant, General Electric Company; Research Grant, Koninklijke Philips NV

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LEARNING OBJECTIVES
1) Understand the role of CT in the diagnosis of HCC. 2) Learn the limitations of CT in HCC screening including radiation dose and strategies to diminish the risk. 3) Review innovations in CT and its impact on screening of HCC.

SPSC42D Why MRI Should Be Used for HCC Screening/Surveillance

Participants
Takeshi Yokoo, MD, PhD, Dallas, TX (Presenter) Nothing to Disclose

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Printed on: 10/29/20
RC601 Pulmonary Vascular Imaging
Thursday, Dec. 5 8:30AM - 10:00AM Room: S103CD

Participants
Ioannis Vlahos, MRCP,FRCR, Houston, TX (Moderator) Director, Grayscale Ltd; Co-owner, Grayscale Ltd

LEARNING OBJECTIVES
1) Highlight practical applications, best current practice, and state of the art multimodality CT and MRI practice with regards to pulmonary vascular imaging. 2) Review acute and chronic pulmonary embolism, pulmonary hypertension, and pulmonary arteriovenous malformations.

Sub-Events

RC601A Imaging of Acute Pulmonary Embolism
Participants
Ioannis Vlahos, MRCP,FRCR, Houston, TX (Presenter) Director, Grayscale Ltd; Co-owner, Grayscale Ltd

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.

RC601B Imaging of Chronic Pulmonary Embolism and Pulmonary Hypertension
Participants
Elsie Nguyen, MD, Toronto, ON (Presenter) Nothing to Disclose

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.

RC601C Imaging of Pulmonary Arteriovenous Malformations
Participants
Kristopher W. Cummings, MD, Scottsdale, AZ (Presenter) Nothing to Disclose

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.

RC601D Pulmonary MRA: Practical Applications
Participants
Christopher J. Francois, MD, Madison, WI (Presenter) Departmental research support, General Electric Company;

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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 in under ten minutes. 3) Although older, multi-center studies using MRA techniques and protocols suggested pulmonary MRA may not be accurate enough for routine clinical use, more recent studies using commercially available accelerated image acquisition techniques indicate that pulmonary MRA is effective in identifying clinically significant pulmonary embolism.
Emergency Radiology Series: Contemporary Topics in Imaging of Trauma
Thursday, Dec. 5 8:30AM - 12:00PM Room: S401CD

Participants
Ferco H. Berger, MD, Toronto, ON (Moderator) Speaker, Siemens AG
Michael N. Patlas, MD,FRCPC, Hamilton, ON (Moderator) Speaker, Springer Nature
Felipe Munera, MD, Key Biscayne, FL (Moderator) Nothing to Disclose

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Sub-Events
RC608-01  Whole Body CT of Trauma
Thursday, Dec. 5 8:30AM - 9:00AM Room: S401CD

Participants
Ferco H. Berger, MD, Toronto, ON (Presenter) Speaker, Siemens AG

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LEARNING OBJECTIVES
1) To be familiar with currently worldwide accepted protocols in polytrauma CT imaging. 2) To know clinical conditions requiring whole-body CT. 3) To comprehend the selection of trauma patients for targeted CT examinations.

ABSTRACT
In the western world, polytrauma is the major cause of mortality in people under 45 years of age. Furthermore, it is a major contributor to loss of quality of life and ability to work. The setting of polytrauma is almost always chaotic, not a favourable environment to come to timely diagnosis and treatment. To decrease morbidity and mortality, time and everything is timing. It is our job as radiologist to contribute to the trauma team and help facilitate timely diagnosis - and in many cases, also timely treatment by interventional radiology. To reach the best treatment strategy for the patient as quickly and accurately as safely possible, is the goal. In this update on imaging of polytrauma patients, the focus is on the role of CT to achieve this goal. With the progress in CT scanner development, different protocol options arise. Which CT protocols are being used and what factors do they depend upon? In addition, there is a widespread increase in use of whole body CT internationally, is this a good thing or should we be more selective? What is the current evidence to select patients for targeted CT examinations in polytrauma? A lot of these questions have not been definitively resolved. This lecture aims to provide an update of the current insights into the use of CT for trauma care, with the goal to choose wisely on how to investigate the polytrauma patient in a timely and meaningful fashion.

Active Handout:Ferco H. Berger

RC608-02  Whole-Body Trauma Completion CT for Transfer Patients: Impact on Injury Detection
Thursday, Dec. 5 9:00AM - 9:10AM Room: S401CD

Participants
Jeffrey Y. Shyu, MD, Boston, MA (Presenter) Nothing to Disclose
Reza Askari, Boston, MA (Abstract Co-Author) Nothing to Disclose
Roger Lacson, Boston, MA (Abstract Co-Author) Nothing to Disclose
Aaron D. Sodickson, MD,PhD, Boston, MA (Abstract Co-Author) Institutional research agreement, Siemens AG; Speaker, Siemens AG; Speaker, General Electric Company
Ali Salim, MD, Boston, MA (Abstract Co-Author) Nothing to Disclose
Bharti Khurana, MD, Brookline, MA (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Indications for whole-body trauma CT are unclear. This study evaluates patients transferred to a level 1 trauma center, who had
selective CT at the originating hospital and completion whole-body CT at the accepting hospital, to determine if additional CT imaging detects clinically significant injury.

**METHOD AND MATERIALS**

This was a single center study at a level 1 trauma center with a dedicated Emergency Radiology division. 243 consecutive trauma patients transferred from outside hospitals were included from 9/6/2015 to 12/20/2015. A review of the patient’s acute traumatic injuries was obtained from chart reviews, radiology reports, and abbreviated injury scale (AIS). Whole-body CT was defined as CTs of the head, cervical spine, chest, abdomen, and pelvis. A patient is considered to have had 'completion' CT imaging if she or he obtained some of the whole-body CT components at the outside institution, and the rest at the accepting institution. Injuries that were detectable with radiographs (such as extremity fractures) were excluded.

**RESULTS**

35 received whole-body CT at the outside institution, and 45 received completion CT at the accepting institution. Of those who received completion CT, 13 (29%) had additional injuries on completion CTs that were not detected on CTs or radiographs from the outside institution. An additional 9 patients had indeterminate injuries in the radiology report that were not given a corresponding AIS. The additional injuries with AIS scores were subdural hemorrhage (1 patient), rib fractures (5), clavicle fracture (1), and thoracic (4) and lumbar (5) spine fractures. One patient who died in the trauma completion group had a lumbar spine fracture found on completion imaging, not considered to be the primary cause of death. Average ISS of transfer patients who received whole-body CTs at the outside institution was 13.9, compared to 10.6 for the completion group. A statistically significant difference between ISS was found between the transfer whole-body group and completion CT group (p = 0.044).

**CONCLUSION**

Completion whole-body CT for trauma transfer patients detects additional injuries in 29% of patients. Rib and spinal fractures are the most commonly detected injuries. Further work is needed to determine if this increase in diagnostic yield translated into patient management changes.

**CLINICAL RELEVANCE/APPLICATION**

This study clarifies the role of whole-body completion CT for patients with major trauma.
Independent of the CT injury grade, a higher incidence of liver related complications occurred with penetrating than a blunt mechanism of injury. In 50% of cases, the complication was identified at FU CT within 7 days from the trauma (mean 6 days, range 5-7), in 50% of cases it was identified at further FU CT (mean 14 days, range 9-55).

CONCLUSION

The incidence of BCVI among patients with self-inflicted hanging was 3.3%. A total of 15% of patients died due to anoxic brain injury. The incidence of BCVI in the setting of self-inflicted hanging is similar to that seen in other high risk mechanisms of injury. Thus including hanging injuries as a high risk mechanism for screening neck CTA remains prudent. Death due to anoxic brain injury poses a greater risk than that of BCVI.

CLINICAL RELEVANCE/APPLICATION

The incidence of BCVI in the setting of self-inflicted hanging is similar to that seen in other high risk mechanisms of injury. Thus including hanging injuries as a high risk mechanism for screening neck CTA remains prudent. Death due to anoxic brain injury poses a greater risk than that of BCVI.

RC608-05 Follow-up CT Imaging Post Liver Trauma: When is the Best Time to Image?

Thursday, Dec. 5 9:30AM - 9:40AM Room: S401CD

Participants

Aurelio Cosentino, MD, Torino, Italy (Abstract Co-Author) Nothing to Disclose
Dylan Lewis, MBCh, FRCP, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Bhavna Batohi, MBBS, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Lisa M. Meacock, MBBS, London, United Kingdom (Abstract Co-Author) Nothing to Disclose
Adeel E. Syed, FRCR,MBBS, London, United Kingdom (Presenter) Nothing to Disclose

PURPOSE

The purpose of the study is to determine the value of liver injury CT grade in predicting the potential for subacute/late complications, and to determine the ideal timing of follow-up (FU) CT imaging to detect complications.

METHOD AND MATERIALS

From August 2017 to July 2018, 58 major trauma patients (Pts) were diagnosed with liver injury. In this retrospective observational study, the admission CT and relevant clinical data were available for 53 Pts (43 male, 10 female; mean age 37.2 years ±18.2). Hepatic injuries detected on the admission CT were graded by two trauma radiologists using the AAST grading system. Mechanism of injury, liver-related subacute/late complications, and timing of follow-up CT imaging were reviewed.

RESULTS

The mechanisms of injury were as follows: vehicle incident/collision (n=25), fall ≥2 m (n=16), fall <2 m (n=1), penetrating trauma (n=10), rugby injury (n=1). There were 6 grade I liver injuries, 14 grade II, 14 grade III, 15 grade IV, and 4 grade V. Two Patients died within 30 days from presentation. Liver-related complications were observed in 10 patients (see Table) and included bilomas, biliary stricture and vascular complications. A statistically significant correlation between penetrating trauma and the occurrence of complications was observed (p<0.014). No correlation was observed between the injury grade and the trauma mechanism or the occurrence of complications. In 50% of cases, the complication was identified at FU CT within 7 days from the trauma (mean 6 days, range 5-7), in 50% of cases it was identified at further FU CT (mean 14 days, range 9-55).

CONCLUSION

Independent of the CT injury grade, a higher incidence of liver related complications occurred with penetrating than a blunt mechanism of injury.
mechanism of trauma. An initial follow-up CT between 5 and 7 days after the trauma is adequate to reveal early liver-related complications, but a subsequent FU CT within 15 days is recommended to detect complications in those patients with high grade liver injury.

**CLINICAL RELEVANCE/APPLICATION**

A follow-up CT 5-7 days after traumatic liver injury is adequate to reveal early complications, a FU CT within 15 days is recommended in patients with high-grade injury and in penetrating liver trauma.

**RC608-06 Diaphragmatic Trauma**

**Thursday, Dec. 5 9:40AM - 10:10AM Room: S401CD**

**Participants**
Michael N. Patlas, MD,FRCPC, Hamilton, ON (Presenter) Speaker, Springer Nature

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patlas@hhsc.ca

**LEARNING OBJECTIVES**

1) To review the radiological and surgical literature of the potential pitfalls in diagnosis of diaphragmatic injuries.
2) To describe direct and indirect signs of blunt and penetrating diaphragmatic injury.
3) To highlight factors affection detection of diaphragmatic injuries.

**RC608-07 Bowel and Mesenteric Trauma**

**Thursday, Dec. 5 10:20AM - 10:50AM Room: S401CD**

**Participants**
Michael E. O'Keeffe, MBBCh, Vancouver, BC (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) Review imaging pearls and pitfalls in the assessment of mesenteric injury in trauma patients.
2) Focus on the anatomy of the small and large bowel mesentery, patterns of mesenteric injury, and their appearance on MDCT.
3) Review specific CT appearance of isolated mesenteric injury and polytrauma cases.

**ABSTRACT**

The small and large bowel mesentery are all too frequently underestimated as potential sites of significant injury in the trauma patient. In fact many would now argue that the mesentery itself has enough individual anatomical components and physiological roles to be considered a separate organ within the human body. As such we need to review the mesentery as a unique anatomical entity. It demonstrates a recognizable pattern of injury on CT imaging. These "fingerprints of trauma" can be searched or in every case and provide a valuable guide to potentially serious bowel and vascular injury.

**Participants**
Muhammad O. Afzal, MD, MBBS, Memphis, TN (Presenter) Nothing to Disclose
Lou J. Magnotti, MD, Memphis, TN (Abstract Co-Author) Nothing to Disclose
Sridhar S. Shankar, MD, MBA, Memphis, TN (Abstract Co-Author) Equipment support, Clarius Mobile Health Corp
Dina Filiberto, MD, Memphis, TN (Abstract Co-Author) Nothing to Disclose

**PURPOSE**

CT plays an important role in the workup of stable patients after blunt trauma. Suspected bowel or mesenteric injuries (BBMI) often present with subtle and inconsistent imaging findings. Various radiographic signs have been used to predict the presence of these injuries. However, the optimal predictor for BBMI remains controversial. It is our contention that one of the best predictors is the overall impression of the reviewing radiologist. Thus, the purpose of this study was to identify radiographic predictors of therapeutic operative intervention in patients after blunt abdominal trauma.

**METHOD AND MATERIALS**

Patients with a discharge diagnosis of a mesenteric injury after blunt trauma were identified over a 5-year period. Admission CT scans were reviewed for potential predictors of BBMI, including mesenteric hematoma, acute arterial extravasation, bowel wall hematoma, bowel devascularization, fecalization of small bowel, free air, fat pad injury. In addition, the overall impression of the scan by the reviewing radiologist was recorded. Patients were then stratified by therapeutic laparotomy and compared. Multivariable logistic regression (MLR) was then used to identify predictors of therapeutic laparotomy.

**RESULTS**

Over the study, 114 patients underwent operative intervention: 75 patients (66%) underwent therapeutic laparotomy. After adjusting for the above predictors including the overall impression of the radiologist, MLR identified the impression of the radiologist (OR 3.14; 95%CI 1.19-8.27, p=0.021), fat pad injury (OR 3.5; 95%CI 1.24-9.99, p=0.018) and bowel devascularization (OR 8.2; 95%CI 0.962-9.91, p=0.054) as independent predictors of therapeutic laparotomy. Interestingly, the overall impression of the radiologist had a positive predictive value of 82.1%.

**CONCLUSION**
CT remains vital in the evaluation of patients suspected of having bowel and mesenteric injuries after blunt trauma. An experienced radiologist remains invaluable in assessing often subtle signs of BBMI. A simplified scoring system utilizing these predictors could potentially aid the radiologist and surgeons in identifying those patients that would benefit from early operative intervention.

**CLINICAL RELEVANCE/APPLICATION**

CT helps identify stable patients suspected of mesenteric/bowel injuries who would benefit from early operative intervention.

**RG608-09 Damage Control Surgery CT: An Analysis in Diagnosing Abdominopelvic Surgically Significant Injuries**

**Participants**
Zohaib Ahmad, MD, Boston, MA (Presenter) Nothing to Disclose
Arthur Baghdanian, MD, 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) Research Grant, General Electric Company Research Grant, Koninklijke Philips NV
Armonde Baghdanian, MD, San Francisco, CA (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

To evaluate the incidence in diagnosis and misses of surgically relevant abdominopelvic injuries on computed tomography (CT) imaging in the Damage Control (DC) patient.

**METHOD AND MATERIALS**

This retrospective study was IRB approved and HIPAA compliant. Informed consent was waived. Patients aged 18 and older who sustained blunt or penetrating trauma requiring DC surgery without a prior CT at Boston Medical Center 2/21/2005 - 9/26/2018 were included. 59 patients met inclusion criteria (52 male, 4 female, mean age of 29). A CT was obtained 24 hours after the initial surgery. Each study was assessed by a single blinded fellowship trained radiologist. Outcomes were evaluated through failed surgical repair warranting surgical intervention, a clinically significant injury discovered on CT in a surgically explored area, a clinically significant injury discovered on CT in a surgically unexplored area, and a clinically significant injury missed on the initial CT but found on later surgery/imaging. These categorical variables were evaluated by percentages.

**RESULTS**

In a cohort of 57 patients, a total of 7 (12.5%) patients had a failed surgical repair discovered on initial CT (12.3%); of those 7 patients, 3 (42.8%) had failed repair of the liver. 6 (10.7%) patients had a clinically significant injury discovered on CT in a surgically explored area; of those 6 patients, 2 (33.3%) had injury of the kidney. 6 (10.7%) patients had a clinically significant injury discovered on CT in a surgically unexplored area. 9 (16.1%) patients who had a clinically significant injury that was missed on the initial CT; of those 9 patients, 3 (33.3%) had a missed injury to the large bowel.

**CONCLUSION**

As a staged surgical process in a critically traumatic injured patient, Damage Control (DC) surgery is a burgeoning life-saving method to address both traumatic and metabolic derangements in a timely manner. Further knowledge of common surgically and radiographically missed injuries is important to provide accurate diagnoses in these patients especially in the retroperitoneum and gastrointestinal system.

**CLINICAL RELEVANCE/APPLICATION**

Accurate interpretation of computed tomography (CT) imaging during this process is vital to assessing for any surgically missed injury or assessment of repair in the critically ill DC patient.

**RG608-10 Diagnostic Performance of Triple-Contrast versus Single-Contrast Multi-Detector Computed Tomography for the Evaluation of Penetrating Bowel Injury**

**Participants**
Fabio M. Paes, MD, Miami, FL (Presenter) Nothing to Disclose
Anthony M. Durso, MD, Miami, FL (Abstract Co-Author) Nothing to Disclose
Kim M. Caban, MD, Miami, FL (Abstract Co-Author) Nothing to Disclose
Brian Covello, MD, Miami, FL (Abstract Co-Author) Nothing to Disclose
Daniel Suarez, MD, Bogota, Colombia (Abstract Co-Author) Nothing to Disclose
Douglas S. Katz, MD, Mineola, NY (Abstract Co-Author) Nothing to Disclose
Felipe Munera, MD, Key Biscayne, FL (Abstract Co-Author) Nothing to Disclose

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**PURPOSE**

Selecting low risk penetrating trauma patients to forgo laparotomy can be challenging. Bowel injury may prevent nonoperative management. Our goal is to compare the diagnostic performance of triple-contrast (oral, rectal, and IV) against IV contrast only CT in detecting bowel injury from penetrating abdominopelvic trauma, using surgical diagnosis during exploratory laparotomy as standard.

**METHOD AND MATERIALS**
997 patients who underwent CT for penetrating trauma between 2009-2016 were enrolled in this IRB-approved retrospective cohort study. A total of 143 patients, including 15 females (ages 16-41), and 123 males (ages 14-83) underwent preoperative CT followed by exploratory laparotomy. Of these, 56 patients received triple-contrast CT. CT examinations were reviewed by 2 attending radiologists, blinded to surgical outcome and clinical presentation. Direct and indirect signs of bowel injury were documented. Results were stratified by contrast type and mechanism of injury and subsequently compared based upon diagnostic performance indicators of sensitivity, specificity, NPV, and PPV. AUCs were analyzed for determination of diagnostic accuracy.

RESULTS
Bowel injury was present in 45 out of 143 patients. Specificity and accuracy were higher with triple-contrast CT (98% specific [0.95, 1.00]), 97-99% accurate) compared to IV contrast only CT (66% specific [0.56, 0.75], 78-79% accurate). Sensitivity was highest with IV contrast only CT (91% sensitive [0.85, 0.98]) compared with triple-contrast CT (75% sensitive [0.56, 0.94]), although not statistically significant. Triple contrast CT increased diagnostic accuracy for both reviewers regardless of mechanism of injury. For reader 1, diagnostic accuracy with triple contrast CT versus IV contrast only CT was (99% [0.98, 1.00]) vs. 80% (0.62, 0.97) for stab wounds and (100% vs. 76% [0.61, 0.91]) for gunshot wounds. For reader 2, diagnostic accuracy with triple-contrast CT versus IV contrast only CT was (99% [0.98, 1.00] vs. 74%, [0.55, 0.92]) for stab wounds and (95% [0.85, 1.00] vs. 79% [0.66, 0.92]) for gunshot wounds.

CONCLUSION
In our retrospective study, triple-contrast CT had greater accuracy, specificity, and NPV when compared to IV contrast only CT in evaluating for bowel injury from penetrating wounds.

CLINICAL RELEVANCE/APPLICATION
Triple-contrast CT has greater accuracy, specificity, and NPV when compared to IV contrast only CT in evaluating for bowel injury from penetrating trauma.
Pancreatic Trauma

Thursday, Dec. 5 11:30AM - 12:00PM Room: S401CD

Participants
Jorge A. Soto, MD, Boston, MA (Presenter) Royalties, Reed Elsevier

For information about this presentation, contact:
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LEARNING OBJECTIVES
1) Review key direct and indirect CT findings of blunt pancreatic trauma. 2) Highlight potential pitfalls in diagnosis of pancreatic trauma. 3) Understand proper utilization of MR in patients with suspected pancreatic injuries.

Printed on: 10/29/20
**Head and Neck PET/CT: Clinical Approach**

*Thursday, Dec. 5 8:30AM - 10:00AM Room: S504CD*

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

**Sub-Events**

**RC611A**  *Oropharyngeal Cancer: Evolving Challenges-Clinician’s Perspective*

Participants
Colette J. Shen, MD,PhD, Chapel Hill, NC (Presenter) Speaker, Nanobiotix

**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. 2) Using PET to delineate the radiation target. 3) Can we OMIT treatment of the PET negative neck? 4) 3 month Post-Treatment PET/CT response assessment.

**RC611B**  *CT and MRI Anatomy and Interpretation*

Participants
Valerie L. Jewells, DO, Chapel Hill, NC (Presenter) Nothing to Disclose

**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**


**RC611C**  *FDG-PET/CT: Applications and Interpretation*

Participants
Terence Z. Wong, MD, PhD, Chapel Hill, NC (Presenter) Consultant, Lucerno Dynamics, LLC; Valerie L. Jewells, DO, Chapel Hill, NC (Presenter) Nothing to Disclose

**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.

**RC611D**  *Panel Discussion: Q&A*

Participants
Terence Z. Wong, MD, PhD, Chapel Hill, NC (Presenter) Consultant, Lucerno Dynamics, LLC; Valerie L. Jewells, DO, Chapel Hill, NC (Presenter) Nothing to Disclose Colette J. Shen, MD,PhD, Chapel Hill, NC (Presenter) Speaker, Nanobiotix

**LEARNING OBJECTIVES**

1) To discuss case examples which highlight the value of multidisciplinary approaches for managing patients with head and neck cancer.

Printed on: 10/29/20
RC612

Vascular Series: CT Angiography-New Techniques and Their Application

Thursday, Dec. 5 8:30AM - 12:00PM Room: S405AB

LEARNING OBJECTIVES

1) Understand scan factors that affect both radiation dose and intravenous contrast administration in CT angiography (CTA).
2) Understand how scan factors should be adjusted to reduce radiation dose and/or contrast volume for CTA.
3) Understand how CT technology affects radiation dose and contrast media administration in CTA.

ABSTRACT

NA

RC612-01 Relationship between Contrast Dose and Radiation Dose in CTA

Participants
Jill E. Jacobs, MD, New York, NY (Moderator) Nothing to Disclose
W. Dennis Foley, MD, Milwaukee, WI (Moderator) Nothing to Disclose
Russell H. Angle, MD, Potomac, MD (Moderator) Nothing to Disclose

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PURPOSE

To determine the diagnostic accuracy of low iodine 4D dynamic CTA (4D CTA) with a test bolus in lower extremity peripheral vascular disease (PVD).

METHOD AND MATERIALS

68 pts with suspected PVD underwent dynamic 4D CTA of the lower extremities with 40mL Iohexol 350 using either fixed delay (of 13 sec, n=34) or with test bolus (10 cc of Iohexol 350, n=34). Subsequent conventional CTA using a weight-base protocol served as the reference standard. 4D-CTA exams (± test bolus) consisted of 11 low-radiation-dose acquisitions. A vascular radiologist interpreted thin temporally-resolved MIPs (TMIPs) of each lower extremity, a dynamic series displaying the 4D temporal runoff, and thick TMIPs with and without calcium removal. For each lower extremity, arterial stenoses in each of 7 vascular segments was compared to conventional CTA, and was graded as <50%, 50 - 70%, >70% or occluded.

RESULTS

Runoff to the level of the ankle was observed for 76% (26/34) patients using 4D CTA with fixed delay compared to 97% (33/34)
with test bolus. In patients with runoff to the ankle, overall accuracy for peripheral vascular disease (requiring identical stenosis grading per segment) was 89.6% (326/364; 95% CI: 91 - 96%) using the test bolus. For stenosis > 70%, 4D CTA demonstrated a sensitivity of 90.3% (56/62; 95% CI: 86 - 95%) with a fixed delay and 90.4% (104/115; 95% CI: 82 - 98%) with a test bolus. For patients with runoff to the ankle, 4D temporal runoff images provided useful information about asymmetrical or collateral flow in 5/26 cases (19.2%) and in 9/32 cases (28.1%), respectively, with one technical failure to generate temporally resolved images in the test bolus arm. Thick tMIPs, with calcium displayed or removed, were only helpful in 15% (4/26) cases with fixed delay, but were helpful in the majority of patients with test bolus 63% (20/32).

CONCLUSION
Using a test bolus, low iodine dynamic 4D-CTA results in high accuracy for the prediction of PVD. It increases the number of patients with runoff to the ankles compared to fixed delay techniques, and provides additional information about asymmetric and collateral flow.

CLINICAL RELEVANCE/APPLICATION
Low iodine dynamic 4D CTA results in accurate prediction of significant peripheral vascular disease, with a test bolus improving the runoff to the ankles and providing additional temporal information compared to fixed delay techniques.

RC612-03  Reduced Contrast Agent Volume and Radiation Dose Using a Heart-rate-Dependent Scanning Protocol in Computed Tomography Angiography (CTA) of Lower Extremity Artery for Patients with Diabetes

Thursday, Dec. 5 9:10AM - 9:20AM Room: S405AB

Participants
Peiji Song, Liaocheng , China (Presenter) Nothing to Disclose
Nan Wang, Liaocheng , China (Abstract Co-Author) Nothing to Disclose
Wenbo Guo , Liaocheng , China (Abstract Co-Author) Nothing to Disclose

PURPOSE
To evaluate the feasibility of a personalized CT scanning protocol that was tailored to patients’ heart rate for lower extremity CTA of diabetic patients.

METHOD AND MATERIALS
A total of 40 diabetic patients who need to undergo lower extremity CTA were prospectively randomized into two groups (patients with vascular occlusion were excluded). For each patient in Group A (n = 20), a total of 70 mL contrast agent (Iopamidol 370) was injected with a rate of 3 mL/s. By monitoring the distal end of bilateral superficial femoral artery, the CTA scan was manually triggered according to the patient’s heart rate (HR): HR > 80 bpm, the CTA was triggered manually 25-28 seconds after the injection of contrast agent and initiated automatically with a delay of 6 s; HR = 60-80bmp, trigger time was 30-33 s with a delay of 8 s; HR<60bmp, trigger time was 35-38 s with a delay of 10 s. For each patient in Group B (n = 20), a total of 85 mL contrast agent (Iopamidol 370) was injected with a rate of 3 mL/s. The routine auto-trigger protocol was applied by setting the distal abdominal aorta threshold as 180 HU. All CTAs were performed on a 16-cm wide-detector CT (Revolution CT, GE). The CT values of the bilateral femoral arteries, the superficial femoral artery, the popliteal artery, the anterior and posterior tibial arteries and the peroneal arteries were measured and compared between the two groups using paired t-test. Two experienced radiologists evaluated the image quality using a 5-point scale (1-unassessble to 5-excellent) and the image quality was compared using chi-square test. Radiation doses were also recorded and compared using t-test.

RESULTS
No difference was found between the two groups in either of the CT values(Ps > 0.05, Table1). Subjective ratings of image quality were not statistically different( X2=1.086, P = 0.896, Table 2). The radiation dose was significantly lower in Group A than in Group B (7.1 mSv vs. 8.1 mSv, t = 2.162, P = 0.037).

CONCLUSION
By adopting a heart-rate dependent protocol, the radiation dose and contrast medium dose were both reduced in lower extremity CTA for patients with diabetes, while the image quality was remained comparable to those acquired with routine CTA protocol.

CLINICAL RELEVANCE/APPLICATION
The personalized, heart-rate dependent CTA protocol can reduce the use of contrast medium and the radiation dose. This is especially beneficial for patients with diabetes who have potential renal insufficiency.

RC612-04  Automatic Detection of Aortic Dissection Using Contrast X-Ray Computed Tomography (CT)

Thursday, Dec. 5 9:20AM - 9:30AM Room: S405AB

Participants
Arkadiusz Sîtek, PhD, Cambridge, MA (Presenter) Employee, IBM Corporation
Yiting Xie, Cambridge, MA (Abstract Co-Author) Employee, IBM Corporation
Mark Bronkalla, BSC, MBA, Hartland, WI (Abstract Co-Author) Employee, IBM Corporation
Benedikt Graf, PhD, Cambridge, MA (Abstract Co-Author) Employee, IBM Corporation
Manikanta Srikar Yella Pragada, New York, NY (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Aortic dissection is a serious event associated with a high mortality. Untreated death rates of 40% on initial presentation and increase >1% per hour have been reported (Ann Emerg Med. 1996;28:278-288). Improvement in survival is dependent on rapid diagnosis in emergency department (ED). CT with contrast is frequently used for diagnosis of aortic dissection in ED. We have
developed a fully automatic approach to detect aortic dissection on volumetric CT image. This can be used to worklist prioritization in order to expedite the diagnosis and treatment. The worklist can be that of the PACS and/or a notification within the EMR. The algorithm examines CT volumes and if dissection found alerts radiologist or other parties that the study needs immediate attention/review.

**METHOD AND MATERIALS**

The method consists of two steps. In the first, a machine learning algorithm was used to determine a centerline of aorta in each CT volume. Eight hundred CT volumes obtained from various public sources were used to train the centerline algorithm. Based on the centerline we extracted N transverse to aorta centerline image patches encompassing the detected outermost perimeter of the aorta plus a margin along the extent of the aorta in the field of view. These patches formed image sequence that was used as input to recurrent neural network and used for classification of the presence of a dissection. Classification algorithm was trained and validated using a retrospective multi-institution, multi-vendor set 695 CT volumes. There were 319 contrast CT scans without dissection and a set of 376 contrast CT scans with dissection, 80/20 split was used for training/testing. Studies that were used as positive for dissection were selected based on positive findings in the radiology reports. The set was different than data used to train algorithm for finding the centerline.

**RESULTS**

Fully automated algorithm achieved performance of 0.982 (95% CI: 0.955-0.998) of area under ROC curve (AUC) for detection of dissection in contrast CT studies.

**CONCLUSION**

The detection of aortic dissection and prioritization of the study for formal reading can now be automated with high accuracy. The detection of this relatively rare (<1:10000 studies) but deadly malady without inducing high false positive indications is now possible. This functionality can then be integrated into the clinical workflow: whether triggering an earlier, prioritized read by a staff radiologist, off-loading the study to a teleradiology practice or notifying the ED attending physician.

**CLINICAL RELEVANCE/APPLICATION**

The algorithm has the potential to significantly decrease the time to diagnosis and therefore treatment of aortic dissection in ED and is critical for facilities without in-house 24-hour radiologist reading coverage.

**RC612-05 Dual-energy and Low kVp CTA**

**Thursday, Dec. 5 9:30AM - 10:00AM Room: S405AB**

Participants
Shuai Leng, PhD, Rochester, MN (Presenter) Nothing to Disclose

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leng.shuai@mayo.edu

**LEARNING OBJECTIVES**

1) Assess impact of low kVp on image quality and radiation dose in CTA. 2) Select appropriate kVp for CTA exams to achieve optimal diagnosis at lowest radiation dose. 3) Understand basic principles of dual energy CT and various technical implementations. 4) Understand dual energy processing methods and various types of dual energy images in CTA.

**RC612-06 Roles for CTA in Interventional Radiology**

**Thursday, Dec. 5 10:30AM - 11:00AM Room: S405AB**

Participants
Jonathan J. Keung, MD, Bethesda, MD (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Identify the uses of CT angiography in interventional radiology. 2) Describe pertinent CT angiographic findings associated with pre-procedural planning for intervention. 3) Compare pre-procedural CT angiographic findings with in procedural angiographic findings.

**RC612-07 Quantitative Evaluation of a Feasibility Using Dynamic CTA for Diagnosis of Lower Legs Muscle Ischemia**

**Thursday, Dec. 5 11:00AM - 11:10AM Room: S405AB**

Participants
Da-Ming Zhang, MD, Beijing, China (Presenter) Nothing to Disclose
Xueyan Zhou, Chicago, IL (Abstract Co-Author) Nothing to Disclose
Zhengyu Jin, Beijing, China (Abstract Co-Author) Nothing to Disclose
Xiaobing Fan, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

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cadina1984@163.com

**PURPOSE**

To quantitatively evaluate lower leg muscle ischemia using dynamic computed tomographic angiography (CTA) and compare with clinical standard CTA diagnosis outcome.

**METHOD AND MATERIALS**

The study was HIPPA compliant and approved by our IRB. Patients (n=35) with known peripheral arterial occlusive disease were
enrolled. Dynamic CTA (dyn-CTA) of calves (9 phases, 2.5×5 cycles, 5×4 cycles, 70 kVp, 80 mAs, 30 mL Iopromide) was performed first. 5 minutes later, a standard runoff CTA (s-CTA) of lower extremity was performed. Runoff score was given for s-CTA. For each of four lower leg artery segments, a score of '0' is assigned for vessel with ≤20% stenosis, '1' for 21-49% stenosis, '2' for 50-99% stenosis, '2.5' for a vascular occlusion less than half of its length, and '3' for an occlusion greater than half of the length. The score for the popliteal artery is multiplied by 3 and 1 is added before adding all 4 vessel scores together. Dyn-CTA muscle signal intensity as function of time (S(t)) was analyzed between the 10th and 80th slices. For each pixel, a sum of S(t) was calculated between 2.5 to 10 s, and then sorted from low to high. Top 25th, 10th, and 5th percentile of pixels were used to calculate the average S(t). Quantitative kinetic parameters, E1(initial enhancement), Epeak(peak enhancement), and SER(signal enhancement ratio) were calculated for average S(t): E1=(S1-S0)/S0, Epeak=(Speak-S0)/S0, and SER=(S1-S0)/(Slast-S0), where S0, S1, Speak and Slast is baseline, the 1st, the peak, and the last signal intensity, respectively.

RESULTS

Based on s-CTA diagnosis, all legs were divided into a normal group (n=22) with each vessel segment score ≤1 and runoff score <=7; and an abnormal group with ischemia (n=48). On average, the E1 and Epeak for normal group were significantly higher than abnormal group, but not for the SER. There were weak correlations between runoff scores and E1 (Epeak). The ROC analysis between the two groups had area under the curve of 0.77 for E1 (25%).

CONCLUSION

There were significant differences between normal and ischemic leg muscle for quantitative kinetic parameters calculated from dyn-CTA.

CLINICAL RELEVANCE/APPLICATION

There is clinical potential application of quantitative analysis of lower extremity dyn-CTA for diagnosis of muscle ischemia besides the vessel anatomical illustration.

PURPOSE

Predicting the risk of late adverse events (LAE) in patients with uncomplicated Type B aortic dissection is highly desired for optimizing treatment strategy. Morphologic risk factors extracted from imaging data are almost universally 2D measurements such as maximum aortic diameter and cannot capture the complex geometry of aortic dissection. We sought to identify 3D quantitative features of aortic dissection and explore their relationship with LAE.

METHOD AND MATERIALS

CT angiograms from the initial hospitalization of 41 patients with uncomplicated type B aortic dissection were retrospectively identified and manually segmented into true lumen, false lumen, and background voxels (TeraRecon). Patients were followed for a median of 1501 days (IQR 648-2224). 18 LAE - predominantly driven by aneurysm formation >55mm - were observed during the study period. Centerlines of the true lumen (TL), false lumen (FL), aorta, and dissection flap were extracted from the segmentation masks using a sequential thinning skeletonization technique. Centerlines were determined by approximating the longest paths with 3D cubic B-splines. For each centerline, physical length, tortuosity, and parameters related to curvature and torsion were obtained from masks using a sequential thinning skeletonization technique. Centerlines were determined by approximating the longest paths with 3D cubic B-splines. For each centerline, physical length, tortuosity, and parameters related to curvature and torsion were obtained from masks using a sequential thinning skeletonization technique. Centerlines were determined by approximating the longest paths with 3D cubic B-splines.

RESULTS

Univariate analyses showed that multiple features were associated with LAE including TL, FL and aortic centerline tortuosity (all p<0.05). A multivariable model with conventional maximum aortic diameter and all non-correlating features with p>0.15 showed that only true lumen tortuosity was independently associated with LAE (HR 7.8 [95% confidence interval 1.0-480.8], p=0.04).

CONCLUSION

Our results suggest that currently unexploited 3D morphologic features extracted from imaging data such as true lumen tortuosity may be independent predictors of LAE in patients with initially uncomplicated type B aortic dissection.

CLINICAL RELEVANCE/APPLICATION

This work demonstrates the feasibility of deriving 3D morphologic parameters of type B aortic dissection and finds an association between true lumen centerline tortuosity and late adverse events.
Advanced Visualization of Peroneal Artery Perforators Prior to Autologous Transplantation in Head and Neck Surgery by Dual-Energy CT and Multiplanar Vessel Unfolding

Thursday, Dec. 5 11:20AM - 11:30AM Room: S405AB

Participants
Matthias S. May, MD, Erlangen, Germany (Presenter) Speakers Bureau, Siemens AG
Matthias Wetzl, Erlangen, Germany (Abstract Co-Author) Nothing to Disclose
Wolfgang Wust, MD, Erlangen, Germany (Abstract Co-Author) Speakers Bureau, Siemens AG
Rafael Heiss, Erlangen, Germany (Abstract Co-Author) Speakers Bureau, Siemens AG
Christoph Treutlein, Erlangen, Germany (Abstract Co-Author) Nothing to Disclose
Markus Kopp, Erlangen, Germany (Abstract Co-Author) Speakers Bureau, Siemens AG
Michael Uder, MD, Erlangen, Germany (Abstract Co-Author) Nothing to Disclose

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PURPOSE
Our aim was to improve pre-surgical visualization of peroneal artery perforators prior to fibula osteomyscutaneous flap for mandible reconstruction.

METHOD AND MATERIALS
CT angiography of the lower limbs was performed in 33 patients using dual-energy acquisitions from a third generation dual-source CT and a high iodine flux (7 ml/sec, 350 mg/ml). Low monoenergetic reconstructions (40keV) were automatically reconstructed from the scanner and used for semi-automatic centerline labeling of the peroneal artery and its' perforators on a post-processing console using a vascular workflow. Multiplanar unfolding was done using a prototype software application. Image quality was evaluated as vessel contrast and vessel continuity using a five point Likert scale in comparison to standard dual energy reconstructions (mixed images).

RESULTS
Vessel contrast was rated high or very high in 92 % of all patients in the 40 keV reconstructions and in 69% of the mixed images. Multiplanar vessel unfolding was successful in all patients. Mean number of slices was substantially reduced using vessel unfolding (3) compared to maximum intensity projections (13) or standard multiplanar reconstruction (35) in coronal plane. Continuity was rated high or very high in more than 90% of all vessels using 40 keV reconstructions and significantly lower in the mixed images.

CONCLUSION
Low monoenergetic reconstructions allow for very good representation of small perforator vessels of the peroneal artery. Multiplanar vessel unfolding is feasible and considerably eases and improves the visualization for pre-surgical planning.

CLINICAL RELEVANCE/APPLICATION
Best reproduction of peroneal perforator vessels prior to fibula osteomyscutaneous flap for mandible reconstruction can be obtained with vessel unfolding and virtual monoenergetic reconstructions from Dual-Energy CT acquisitions.

CTA Artifacts and Post-Processing

Thursday, Dec. 5 11:30AM - 12:00PM Room: S405AB

Participants
Elliot K. Fishman, MD, Owings Mills, MD (Presenter) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics, Inc

Printed on: 10/29/20
Optimization and Technology in Interventional Radiology

Thursday, Dec. 5 8:30AM - 10:00AM Room: S503AB

CT IR PH

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

FDA Discussions may include off-label uses.

Participants
Thaddeus A. Wilson, PhD, Madison, WI (Coordinator) Nothing to Disclose
William F. Sensakovic, PhD, Scottsdale, AZ (Coordinator) Founder, Telerad Physics Teaching, LLC

For information about this presentation, contact:
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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) To familiarize attendees with new CT interventional techniques that will open new fields of interventional procedures.

Sub-Events

RC623A Dose Optimization in the Interventional Suite

Participants
Robert G. Dixon, MD, Chapel Hill, NC (Presenter) Nothing to Disclose

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Bob_Dixon@med.unc.edu

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.

RC623B 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.

RC623C Advances in Interventional Use of CT

Participants
Frank Dong, PhD, Beachwood, OH (Presenter) Equipment support, Siemens AG; Software support, Siemens AG

LEARNING OBJECTIVES
1) To familiarize attendees with new CT interventional techniques that will open new fields of interventional procedures. 2) To describe the potential benefits of Cone Beam CT (CBCT) navigation to perform imaging guided tumor ablations. 3) To compare the radiation doses between CBCT used in interventional procedures and conventional CT.

Printed on: 10/29/20
MSRT52

ASRT@RSNA 2019: CT Dose Awareness and Reduction

Thursday, Dec. 5 9:15AM - 10:15AM Room: N230B

CT SQ

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
Jia Wang, PhD, Stanford, CA (Presenter) Nothing to Disclose

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LEARNING OBJECTIVES

1) To learn the basic CT acquisition factors that can affect CT Dose. 2) To learn CT dose reduction techniques, including automatic exposure control, tube current modulation, iterative reconstruction and more. 3) To learn regulatory requirements on CT dose management and tools to help monitor and raise awareness of CT dose for patient safety.

Printed on: 10/29/20
SSQ03

Cardiac (Coronary Artery Disease: CT and MRI Techniques)

Thursday, Dec. 5 10:30AM - 12:00PM Room: E450B

CA CT MR

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

FDA Discussions may include off-label uses.

Participants
Evan J. Zucker, MD, Stanford, CA (Moderator) Nothing to Disclose
Ming-Yen Ng, MBBS, Hong Kong, Hong Kong (Moderator) Nothing to Disclose

Sub-Events

SSQ03-01 Iterative Reconstruction in Coronary CT Angiography from Full Coverage Axial Data with Less than 180° of Rotation

Thursday, Dec. 5 10:30AM - 10:40AM Room: E450B

Participants
Wenjing Cao, Shanghai, China (Abstract Co-Author) Employee, Shanghai United Imaging Healthcare Co, Ltd
Chunfeng Qian, MD, Shanghai, China (Abstract Co-Author) Employee, Shanghai United Imaging Healthcare Co, Ltd
Xiaoming Wu, Shang Hai, China (Abstract Co-Author) Employee, Shanghai United Imaging Healthcare Co, Ltd
Yi Wang, Shanghai, China (Abstract Co-Author) Employee, Shanghai United Imaging Healthcare Co, Ltd
Stanislav Zabic, PhD, Mayfield Village, OH (Presenter) Employee, UIH America, Inc

PURPOSE

This abstract reports diagnostic image quality measurements of coronary CT angiography on a 16cm coverage system with high temporal resolution using model-based iterative reconstruction (MBIR).

METHOD AND MATERIALS

Even in the systems with 0.25s rotation time, it is not guaranteed that a quiet cardiac phase is possible to be captured within 240° of axial projections, which equals approximately 180° + 2γmax (γmax denotes the maximum fan angle) and is the amount of data that FBP requires before limited angle artifacts show up in the image. Using an analytic cardiac vessel phantom, mean square error and structural similarity metrics, we have determined that 135° degrees of axial rotation is a threshold for which MBIR still returns images without limited angle artifacts. Evaluated projection range was between 90° and 240°. Then, MBIR was applied to 48 scans from a clinical trial, using only 135° of data centered at the predetermined quiet cardiac phase. Data was acquired on a 320-row, 16cm CT scanner and MBIR images were compared to the standard protocol reconstruction that uses 240° of data. Average heart rate in the trial was 78.6±16.1 bpm and mean effective dose was 1.5±0.75mSv. Two experienced radiologists evaluated the image quality using a 4-point rating system focusing on motion artifacts. Scores above 3 were considered diagnostic, with 4 being the best.

RESULTS

MBIR cases were rated diagnostic 83.3% of the time, while standard protocol reconstruction was diagnostic only 58.3% of the time. Average rating for MBIR was 3.28 and 3.16 for the two observers and standard cases were rated 2.72 and 2.7 respectively. There was a significant difference in the scores between MBIR and standard cases by both radiologists (p<0.001).

CONCLUSION

MBIR improved the diagnostic image quality significantly by allowing stable reconstructions from a shorter scan, thereby increasing temporal resolution by at least 25%. Other improvements in image quality such as low noise and high resolution were also noted.

CLINICAL RELEVANCE/APPLICATION

Stable MBIR reconstruction with less than 180° of projection data can be used to reduce the motion artifacts in coronary CT angiography, improving the scan success rate of the single beat cardiac scans significantly and thereby reducing the need for repeated scanning.

SSQ03-03 Contrast Media Iodine Concentration in the Left Ventricle Affects the Level of Radiation-Induced DNA Damage during CCTA

Thursday, Dec. 5 10:50AM - 11:00AM Room: E450B

Participants
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PURPOSE
To investigate the relationship between iodine concentration in the left ventricle and radiation-induced DNA damage in blood lymphocytes during a coronary CT angiography (CCTA).

METHOD AND MATERIALS
This prospective patient study was approved by the institutional ethical committee and written informed consent was obtained. All scans were performed on a Revolution CT (GE Healthcare) using a one heartbeat scan and a patient-tailored contrast media injection protocol, administering Ultravist 370 mg I/mL (Bayer Healthcare) with a patient specific injection volume, depending on the sex, weight and height of the patient. Blood samples (5 mL) were collected, before and after the CCTA, and radiation-induced DNA double-strand breaks were assessed using yH2AX immunofluorescent staining of the blood lymphocytes. An average of 3000 lymphocytes was analyzed for each blood sample. The net amount of induced DNA damage was considered as the difference in the amount of yH2AX foci per cell before and after the CCTA scan, and was normalized to the CTDIvol (mGy). Iodine concentration in the left ventricle was determined by measuring the CT signal (HU) in a 477.5×408.9 mm² ROI and by applying a HU-iodine calibration curve obtained from phantom experiments. Correlation between the iodine concentration in the left ventricle and the CTDIvol normalized amount of DNA damage per cell was investigated using a Spearman's rank-order test.

RESULTS
We report results of the first 15 patients (median age 66 y, 9M/6F) included in the study. Patients were scanned with a median CTDIvol of 10.8 mGy (95% CI: 8.4–15.8 mGy). Due to differences in patient physiology, the left ventricle iodine concentrations ranged from 13.7 till 25.2 mg I/mL. The CCTA scans caused a net increase in DNA damage ranging from 0.00041 to 0.0074 foci/cell. We observed a significant exponential correlation (r=0.55 , p-value=0.035) between dose normalized DNA damage and left ventricle iodine concentration.

CONCLUSION
The amount of iodine contrast concentration in the left ventricle has an impact on the amount of radiation induced DNA double strand breaks.

CLINICAL RELEVANCE/APPLICATION
In CCTA, iodine contrast concentration has an impact on radiation safety. A reduction in iodine concentration reduces radiation induced DNA damage.

SSQ03-04 3D Multiparametric Image Fusion in Coronary Artery Disease

Thursday, Dec. 5 11:00AM - 11:10AM Room: E450B

Participants

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PURPOSE
To allow for comprehensive non-invasive diagnostics of coronary artery disease (CAD) by 3D image fusion of CT coronary angiography (CT-CA), CT derived fractional flow reserve (CT-FFR), whole-heart dynamic 3D cardiac MR perfusion (CMR-Perf), and 3D cardiac MR late gadolinium enhancement (CMR-LGE).

METHOD AND MATERIALS
17 patients (54±10 years, one female) who underwent both cardiac CT and CMR imaging due to suspected or known CAD were included. A software facilitating 3D fusion of multimodal, multiparametric cardiac image data was developed. Post processing of CT data included: a) segmentation of the coronary tree and heart contours; b) calculation of CT-FFR values; c) color-coding of the coronary tree according to CT-FFR. Post processing of CMR data included: a) segmentation of the left ventricle (LV) in CMR-Perf and CMR-LGE; b) co-registration of CMR to CT data; c) mathematical projection of CMR-Perf and CMR-LGE values onto the high-resolution LV from CT. Algorithms adopted from the animation movie industry were applied yielding photorealistic rendering. Results from 3D image fusion were compared to separate 2D readouts of CT and CMR.

RESULTS
Image quality of CT-CA, CMR-Perf, and CMR-LGE was rated good to excellent (scores 2.6, 2.6, and 2.5 on four-point Likert scale, 3 = excellent). CT-CA revealed significant stenoses (i.e., >50%) in 7/17 cases (41%). CT-FFR was possible in 16/17 cases (94%) and showed pathologic flow in 7/17 cases (41%). CMR-Perf identified 8/17 patients (47%) with hypoperfusion; average ischemic burden was 17±5%. CMR-LGE showed myocardial scar in 3/17 cases (18%); average scar burden was 7±4%. Conventional 2D readout of all imaging modalities resulted in 9/17 cases (53%) with inconsistent findings. Multimodal 3D image fusion was feasible in all patients. Perfusion deficits and myocardial scar could be correlated to culprit coronary lesions where applicable. Most (7/9=78%) of the problems with separate 2D readout could be solved by 3D image fusion, with two cases remaining controversial or incomplete, respectively.

CONCLUSION
Multimodal, multiparametric 3D cardiac image fusion of CT and CMR image data is feasible and helps for comprehensive non-invasive CAD diagnostics.
CLINICAL RELEVANCE/APPLICATION

Comprehensive, non-invasive diagnostic workup of coronary artery disease involves a multitude of pathologic aspects, which are all combined within one 3D visualization approach for the first time.

SSQ03-05 A Randomized Controlled Clinical Trial of Prolonged Stent Deployment Strategy in Primary Percutaneous Coronary Intervention for ST-Segment Elevation Myocardial Infarction

Thursday, Dec. 5 11:10AM - 11:20AM Room: E450B

Participants
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PURPOSE

The aim of this study was to evaluate whether prolonged inflation would decrease the no-reflow phenomenon in primary percutaneous coronary intervention (PPCI) compared with the conventional strategy.

METHOD AND MATERIALS

This was a prospective, single-center, blinded, randomized controlled trial. The primary outcomes were the number of patients with Thrombolysis in myocardial infarction (TIMI) flow grade 3, the incidence of intraoperative no-reflow/slow flow, the corrected TIMI frame count, the myocardial blush grade (MBG), and the number of patients with ST-segment resolution >50%. The procedural time and radiation exposure time were also assessed. A subset of patients was included in a cardiac magnetic resonance (CMR) examination approximately 3 to 5 days after the index procedure to assess extent of microvascular obstruction (MVO).

RESULTS

Sixty patients were randomized into a prolonged inflation strategy group (A group, n=30) and a rapid inflation/deflation strategy group (B group, n=30). TIMI flow grade 3 was found in 96.7% (29/30) of the A group and 63.3% (19/30) of the B group (p=0.005). The A and B group respectively showed the following parameters: 0% (0/30) vs 30% (9/30) no-reflow or slow flow (p=0.002); 90% (29/30) vs 66.7% (20/30) ST-segment resolution >=50% (p=0.028); 35.6±14.5 frames vs 49.18±25.2 frames on corrected TIMI frame count (p=0.014); and 60% (16/30) vs 20% (6/30) MBG 3 (p=0.001). The major cardiovascular adverse event rate was 3.3% (1/30) in both groups (p=1.0) at one month and 3.3% (1/30) for the A group vs 6.7% (2/30) for the B at one year (p=1.0). There were no statistically significant differences in the procedural time, the radiation exposure time and major bleeding events between the two groups. In the CMR substudy, the presence of MVO was detected in 6.7% (1/15) of patients in the A group and in 50% (5/10) of patients in the B group (p=0.023).

CONCLUSION

The effect of the prolonged inflation strategy could prevent the no-reflow phenomenon and reducing the incidence of MVOs and improve myocardial microcirculation perfusion. In addition, long term follow-up and large-sample, randomized controlled clinical trials with a long-term follow-up period are needed to confirm this preliminary result.

CLINICAL RELEVANCE/APPLICATION

The effect of the prolonged inflation strategy may be an effective way to reduce microvascular obstruction. CMR modality is an effective technique to prove this phenomenon.

SSQ03-06 Implementation of Transdermal versus Sublingual Nitroglycerin Administration to Optimize Coronary CT Angiography Scanner Utilization

Thursday, Dec. 5 11:20AM - 11:30AM Room: E450B

Participants
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PURPOSE

Coronary CT angiography (CCTA) requires patient preparation including nitroglycerin (NTG) administration, which improves coronary artery assessment. We compared CCTA exam times when using sublingual vs. transdermal NTG administration.

METHOD AND MATERIALS

This retrospective, single-center study included outpatients who underwent elective CCTA between 4/2016 and 3/2019 and received NTG. Until 5/2018, patients received sublingual NTG tablets (0.6 mg), administered by the supervising physician on the CT scanner table. After 6/2018, patients received transdermal NTG patches (0.8 mg/h), placed at least 45 minutes prior to the exam outside the scanner room by a qualified nurse. CCTA time slots were 20 minutes. We compared number of exams exceeding allotted time slots and CCTA exam times subcategorized by room time (patient time inside the scanner suite), preparation time (time from registration to start of room time), and total appointment time (arrival in the radiology department to dismissal) between the two NTG delivery methods by Wilcoxon Rank Sum Test. Severity of coronary artery disease (CAD) burden was also recorded.

RESULTS
The study population included 3,180 patients of whom 2,341 (73.6%) received NTG by tablets and 839 (26.4%) by patches. Mean age was 59.8±13.1 years, 1,388 (43.6%) were females and average BMI was 29.0±6.0 kg/m². Patient characteristics and CAD burden were not significantly different between NTG delivery methods (>50% luminal coronary stenosis: n=716 [22.5%], p=0.770). Room time was significantly shorter when using NTG patches compared to tablets (18 min [95% confidence interval (CI): 10-37 min], 27 [15-54] min, p<0.001). Preparation time was significantly longer in patients receiving NTG patches compared to tablets (107 min [68-160] min, 87 [51-151] min, p<0.001). Only 36.6% (n=307) of the exams following patient preparation with NTG patches exceeded the 20-min exam time slot limit compared to 73.0% of exams (n=1,709) using NTG tablets.

**CONCLUSION**

A workflow using transdermal NTG patches reduce exam times inside the scanner suite and results in less exams exceeding the allotted exam time slot.

**CLINICAL RELEVANCE/APPLICATION**

Using transdermal NTG patches for patient preparation prior CCTA reduces times in the scanner room and allowed the use of 20-minutes time slots.

**SSQ03-07 Automatic Coronary Artery Disease Reporting and Data System (CAD-RADSTM) in Cardiac CT Angiography Using Paired Convolutional Neural Networks**

**Thursday, Dec. 5 11:30AM - 11:40AM Room: E450B**

Participants
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**PURPOSE**

The coronary artery disease reporting and data system (CAD-RADSTM) was recently introduced for standard reporting and decision making. We aimed to assess the utility of an automatic post-processing and reporting system based on CAD-RADSTM in suspected coronary artery disease patients.

**METHOD AND MATERIALS**

A machine learning model was designed for CAD-RADS assessment categories with automatic coronary lumen segmentation algorithm based on convolutional neural networks. The model was trained in a derivation cohort encompassing 2000 patients who underwent coronary computed tomography angiography (CCTA). Patients with bypass grafts, stents were excluded from the training. Then compared to radiologists for classification of CAD-RADS with commercially-available automated segmentation and manual post-processing in a prospective validation cohort.

**RESULTS**

346 patients were included in the study among 360 patients with three poor CCTA images. Compared with radiologists, the positive predictive value, negative predictive value, sensitivity and specificity of AI for diagnosis of coronary heart disease were 80%, 70%, 80% and 70% respectively. There was no significant difference between the CNN-based CAD-RADS grading and radiologists based CAD-RADS grading in CCTA (P=0.87). The consistency test showed that the Kappa value of the two groups was 0.694 (P<0.05), the consistency was good.

**CONCLUSION**

The standardized report of CNN-based CAD-RADS in CCTA images can accurately evaluate suspected patients with CAD, and has good consistency with the radiologists.

**CLINICAL RELEVANCE/APPLICATION**

Report of CNN-based CAD-RADS has good consistency with the radiologists.

**SSQ03-08 Use of Salient Features to Optimize a Machine Learning Classifier of Coronary Artery Disease Severity**

**Thursday, Dec. 5 11:40AM - 11:50AM Room: E450B**

Participants
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**PURPOSE**

Machine learning-based methods have been proposed as an alternative to the current gold standard of determining the hemodynamic significance of coronary artery lesions, invasive Fractional Flow Reserve (FFR) measurements. In this work, we look to optimize the performance of a machine learning classifier that used coronary CT angiography image data to determine coronary artery disease severity.

**METHOD AND MATERIALS**

50 coronary CT angiographies (CTAs) were collected (Aquilion ONE, Canon Medical Systems) at 70% of the R-R cardiac cycle. Straightened curved planar reformations (SCPRs) of different artery branches were generated (Vitrea, Vital Images) using a slice thickness of 5.0 mm considering four rotational views around the vessel centerline per CTA for a total dataset size of 200. The dataset was split into a training cohort numbering 125 and a testing cohort numbering 75. FFR values were measured to create a labeled dataset. A convolutional neural network was developed to classify input SCPRs by the severity of the coronary lesion. The network synthesized class activation maps (CAMs) such that the most salient features (lesion and aorta) in the SCPRs were visualized. SCPR image data were modified such that the aorta was removed, rendering the lesion as the only salient feature present, and the network was re-trained using the optimized data. Network performance on both original and optimized test data was assessed using area under the receiver operating characteristics curve (AUC), classification accuracy, and a Student’s T-Test.

**RESULTS**

Mean AUC was 0.727 (95% confidence interval, 0.675-0.773) and 0.799 (0.761-0.837) using the original and optimized SCPR data respectively. Mean classification accuracy was 68.1% (63.8%-72.4%) and 79.1% (76.1%-82.1%) using the original and optimized SCPR data respectively. There was a statistically significant advantage to using the optimized SCPR data for classification of coronary disease severity in terms of both AUC ($p=0.001$) and classification accuracy ($p=0.0001$).

**CONCLUSION**

This work indicates the potential utility of CAMs for debugging and optimizing a machine learning algorithm to aid in clinical decision making.

**CLINICAL RELEVANCE/APPLICATION**

Machine learning provides a valuable alternative to invasive FFR measurements for the determination of coronary artery disease severity.

**SSQ03-09  Comparison of Post-Surgical Wall Shear Stress Values in Arterial and Venous Coronary Grafts Using Computational Fluid Dynamics Guided by CCTA and 4D Flow MR Imaging**

**Thursday, Dec. 5 11:50AM - 12:00PM Room: E450B**

Participants
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Laura Jimenez-Juan, MD, Toronto, ON (Presenter) Nothing to Disclose

**PURPOSE**

Graft failure is a major complication in coronary artery bypass graft (CABG) surgery, whose root causes are still unknown. In coronary arteries, growing evidence indicates that low and oscillatory values of wall shear stress (WSS) contribute to atherosclerosis plaque progression. The role of WSS in graft failure remains still unclear. In a pilot cohort of patients, we developed a computational fluid dynamics model to obtain WSS non-invasively from CCTA images, and compared WSS values in arterial and venous grafts. Differently from previous works, the study is prospective, with a uniform interval between CABG surgery and WSS analysis of one month. Furthermore, 4D flow MRI is used to incorporate patient-specific flow conditions into the computational model.

**METHOD AND MATERIALS**

Five participants were scanned using CCTA and 4D flow MRI 30±5 days after CABG surgery. Fluid dynamics simulations with appropriate coronaries and graft material properties were performed with Simvascular (Stanford University, Stanford, CA). WSS was spatially and temporally averaged (spatially-averaged TAWSS) for 5 arterial and 6 venous grafts. The oscillatory shear index (OSI) and the ratio between wall area exposed to adverse TAWSS (< 0.4 Pa) and total graft area were also analyzed.

**RESULTS**

No significant difference was found in spatially-averaged TAWSS between venous and arterial grafts (2.26±2.12 Pa in venous vs. 5.11±3.48 Pa in arterial grafts, $p=0.079$) and maximum OSI (0.27±0.20 in arterial and 0.25±0.20 in venous grafts, $p=0.495$). The relative area exposed to low TAWSS was significantly higher in venous grafts (22.4±20.0% in venous vs. 0.77±0.98% in arterial grafts, $p=0.022$).

**CONCLUSION**

One month after surgery, our study found larger areas of abnormal WSS in venous than in arterial grafts. This observation may be related to the higher failure rate of venous grafts.

**CLINICAL RELEVANCE/APPLICATION**

This work is a step forward towards understanding the root causes of graft failure in CABG patients, and identifying reliable biomarkers for the early prediction of graft failure.

Printed on: 10/29/20
SSQ08

Gastrointestinal (Advanced CT Technique)
Thursday, Dec. 5 10:30AM - 12:00PM Room: S102CD

Participants

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William C. Small, MD, PhD, Atlanta, GA (Moderator) Nothing to Disclose

Sub-Events

SSQ08-01  Adaptive Statistical Iterative Reconstruction Technique (ASIR-V) with Different Weights on Spectral CT Using Conventional 120kVp Scan: A Phantom Study

Thursday, Dec. 5 10:30AM - 10:40AM Room: S102CD

Participants

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PURPOSE

To explore image quality of spectral CT using conventional 120kVp scan under the different weight of ASIR-V by using abdominal model.

METHOD AND MATERIALS

The abdominal model (Body rings) was scanned by GE Revolution CT using conventional 120kVp scan. Images were reconstructed using 20% weight to 80% weight (10%-step) of ASIR-V. The CT value, SD and CNR of different tissues (liver and erector spinae) were measured. Anova test and regression analysis were used to compare the different tissues of noise values (SD) and CNR weights of ASIR-V. The post-processing images were evaluated by two radiologists on a 4-point scale using a double-blinded method.

RESULTS

With increasing of ASIR-V weight, the noise values of 7 groups generally exhibited a decreasing trend. By regression analysis, the linear regression equation of ASIR-V weight and image noise was $y = -0.84x +11.321(x=ASIR-V$ weight $y =$noise$), R^2 =0.977$ F =832.187 $P=0.000$. With increasing of ASIR-V, the CNR of 7 groups generally exhibited an increasing trend. By regression analysis, the linear regression equation of ASIR-V weight and CNR was $y = 0.98x + 3.425 (x = ASIR-V$ weight $y =$ contrast noise ratio), $R^2 =0.919$ F =163.690, P =0.000. There was no significant difference in 30% and 40% weight of ASIR-V between the seven groups ($P>0.01$), but 30% and 40% weight of ASIR-V were the best in the subjective scores. There was a significant difference in the subjective scores between the other groups ($P<0.01$).

CONCLUSION

Image noise reduces and image quality improves as ASIR-V weight increases in a linear relationship. At 60% weight of ASIR-V, the image noise was substantially reduced and the subject score was the best. At 70% and 80% weight of ASIR-V, the image noise was substantially reduced and the subject score was poor.

CLINICAL RELEVANCE/APPLICATION

When using spectral CT using conventional 120kVp scan for liver scanning, the image quality can be improved by increasing the weight of ASIR-V to an appropriate value for better display of anatomies.

SSQ08-02  Correlation between Hepatic Fatty Infiltration Degree and CT Number Measurement at Different Tube Voltages Using Animal Model

Thursday, Dec. 5 10:40AM - 10:50AM Room: S102CD

Participants

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Chuangbo Yang, MMed, Xianyang City, China (Abstract Co-Author) Nothing to Disclose

PURPOSE

To investigate the correlation between the hepatic fatty infiltration degree and CT number measurement at different tube voltages (kVp).
METHOD AND MATERIALS

28 healthy SD rats weighing 200g-300g were used for the study. After 2 weeks of adaptive feeding, rats were divided into two groups: normal control group (n=5 with normal diet); experimental group (n=23 with high fat diet). After 4, 6 and 8 weeks, 8, 8 and 7 rats in the experimental group and 1, 1 and 3 rats from the control group, respectively underwent CT scans with 80kVp, 100kVp, 120kVp and 140kVp tube voltage. Rats were sacrificed after the CT scans to obtain liver specimens. CT number was measured on the conventional CT images of all tube voltages. Correlation between CT number measurement and pathologic findings was obtained.

RESULTS

There were 8, 11 and 9 normal, mild, moderate fatty liver rats based on pathology. The CT numbers for these 3 groups of rats were 69.48±1.12HU, 68.12±1.23HU and 66.57±1.08HU at 80kVp; 69.81±0.98HU, 68.56±1.72HU and 66.64±1.31HU at 100kVp; 69.24±1.42HU, 67.78±1.68HU and 65.92±1.50HU at 120kVp; and 68.58±1.63HU, 66.90±1.69HU and 64.82±1.47HU at 140kVp. The CT numbers at all tube voltages and pathology results were all negatively correlated with r values of -0.73, -0.71, -0.71 and -0.71.

CONCLUSION

CT number measurements at all 4 tube voltages (80, 100, 120 and 140kVp) all have good and similar correlation with pathologic findings for fatty infiltration degree, and changing tube voltage settings may not change the ability to differentiate normal and fatty liver tissues.

CLINICAL RELEVANCE/APPLICATION

CT number measurements at all 4 tube voltages (80, 100, 120 and 140kVp) all have good and similar correlation with pathologic findings for fatty infiltration degree, and changing tube voltage settings may not change the ability to differentiate normal and fatty liver tissues, it has a certain value in clinic fatty liver patients.

SSQ08-04 Automated Organ Segmentation Using Deep Learning with Window Setting Optimization

Thursday, Dec. 5 11:00AM - 11:10AM Room: S102CD

Participants
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PURPOSE

Window display settings is a key feature of clinical CT interpretation. A Window setting optimization (WSO) module can be combined with any deep convolutional neural network to automatically find the optimal window range in CT images. In this study, we aim to find the optimal window setting values for segmentation of four different organs and to improve the performance of the segmentation models.

METHOD AND MATERIALS

We collected whole-body CT scans (both contrast & non-contrast axial series) of 21 patients. We randomly selected 33 CT series for training and 6 for testing. Manual segmentation was done for four organs (lungs, liver, spleen, and kidneys) on the CT scans by a board-certified radiologist. We only included the CT slices that had at least one pixel of each organ for experiments. For this segmentation, we developed a deep convolutional neural network module with a WSO module, comprised of a 1x1 convolutional layer and an activation function. We trained the model with a WSO module and obtained an optimal windowing level and width through learning. To explore the effect of WSO module, we trained segmentation models with two types of WSO using ReLU and sigmoid activation functions and compared against model without a WSO module.

RESULTS

For a model without a WSO module, the mean dice scores of kidneys, spleen, liver, and lungs were 0.737, 0.926, 0.947, and 0.971, respectively. For a model with a sigmoid type of WSO module, the mean dice scores of kidneys, spleen, liver, and lungs were 0.758, 0.926, 0.944, and 0.969, respectively. For a model with a ReLU type of WSO module, the mean dice scores were 0.778, 0.953, 0.974, and 0.947, respectively. Optimized window values (level, width) of kidneys, spleen, liver, and lungs with the sigmoid activation function were (-45, 454), (-37, 371), (-35, 359), and (-188, 2177), respectively. In case of using the ReLU activation function, values were (39, 388), (39, 388), (38, 375), and (43, 429) for kidneys, spleen, liver, and lungs, respectively.

CONCLUSION

We developed deep learning models for segmentation of 4 organs (lungs, liver, spleen, and kidneys) and improved performance with a WSO module.

CLINICAL RELEVANCE/APPLICATION

WSO modules can improve AI applications, which are convolutional neural networks, and can give readers an optimized window setting for target organs.

SSQ08-05 Quantitative and Qualitative Evaluation of Imaging Quality of Hepatic Multiphase CT with Four Different Image Reconstruction Techniques including FBP, Hybrid IR, MBIR, and DLR

Thursday, Dec. 5 11:10AM - 11:20AM Room: S102CD

Participants
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ABSTRACT

To assess the latest technology intraprocedural robotic cone beam CT (IP-CBCT) versus postprocedural most recent multi-detector CT (MDCT) for volume imaging after conventional transarterial chemoembolization (cTACE) regarding diagnostic image quality in patients with liver lesions and tumor enhancement by ethiodized oil (Lipiodol).

METHOD AND MATERIALS

114 patients (63 females / 51 males) treated with 126 cTACE procedures underwent postinterventional Lipiodol-enhanced robotic IP-CBCT (4s, 220°, 366 images, scan length 17.5 cm) and 4 to 6 hours later native MDCT (120 kV, 76 mAs, 273 images, scan length 22.6 cm). 18 patients were treated for HCC, 96 patients for hepatic metastases of different primaries. Retrospectively, number and size of lesions and Lipiodol enhancement were evaluated and compared with the pre-interventional MRI. Image quality (IQ) was qualitatively evaluated in consensus with two experienced radiologists using a Likert scale (0-4).

RESULTS

For IP-CBCT significantly superior qualitative IQ scores of 3.1±0.7 were received for lesion delineation vs. 2.4±0.9 for MDCT (p<0.05). For general IQ IP-CBCT was evaluated with 3.0±0.6 vs. 3.1±0.4 for MDCT (p>0.05). Lipiodol-enhanced lesion volume correlated in 95.5% with the MRI in IP-CBCT vs. 78.33% in MDCT (p<0.05) due to a washout phenomenon. Complete washout was observed after a mean of 3.2h for 14% of patients (n=16). The MDCT provided no additional diagnostic information on non-target Lipiodol accumulation or other new damage.

CONCLUSION

Post-Lipiodol CBCT allows sufficient diagnostic image quality and precise information on target and non-target embolization, while enabling the radiologist to immediately adjust the therapy or react to complications. A prospective randomized trial is recommended.
**Clinical Relevance/Application**

Post-Lipiodol CBCT results in improved diagnostic and therapeutic information in TACE patients with malignant liver lesions.

### SSQ08-07 Delayed Bolus Trigger Timing at CT Correlates with Reduced Ejection Fraction and Suboptimal Early Portovenous Contrast Phase

**Thursday, Dec. 5 11:30AM - 11:40AM Room: S102CD**

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**Purpose**

To assess whether the delayed time to Hounsfield unit trigger during bolus-tracking for CT correlates with reduced heart function on echocardiography and suboptimal portovenous contrast timing in the abdomen.

**Method and Materials**

The health record was searched for patients who underwent portovenous CT evaluation of the abdomen using bolus-tracking and who were also evaluated by echocardiography within 2 weeks of CT. Patients were excluded if there was an abnormal contrast injection curve related to poor IV access. The time of bolus trigger at 100 Hounsfield unit in the abdominal aorta at the celiac axis, patient age, and the ejection fraction from echocardiography were recorded. Two radiologists carried out consensus scoring of the liver contrast phase in each examination with a 5 point Likert score, 5 representing an optimal portovenous phase with proper contrast in the hepatic veins. Simple linear regression (univariate) was used to test for linear associations with bolus trigger time.

**Results**

116 patients with a mean age of 60 ± 14 years fulfilled study criteria. The mean bolus trigger time was 18 ± 6 seconds (Range: 6-36 seconds) and the mean ejection fraction was 52 ± 12% (Range: 20-69%). A longer time to bolus trigger had a significant linear association with lower ejection fraction (P=0.020), lower hepatic contrast score (P=0.007) and older age (P=0.009).

**Conclusion**

Delayed time to Hounsfield unit trigger during routine bolus-tracking for CT can indicate reduced heart function and bolus-tracking often does not adequately adjust to provide an optimal portovenous contrast phase in the abdomen in the setting of reduced heart function.

**Clinical Relevance/Application**

Bolus-tracking can provide data to aid in the diagnosis of reduced heart function; tailored protocols should be made for patients with suspected cardiac dysfunction to ensure that proper contrast phases are obtained in the abdomen.

### SSQ08-08 Pancreatic CT Imaging With an Ultra-High Resolution CT Scanner and a New Denoising Reconstruction Algorism Using Deep Learning Technology: Intraindividual Comparative Study with Conventional CT Imaging

**Thursday, Dec. 5 11:40AM - 11:50AM Room: S102CD**

Participants
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**Purpose**

To evaluate the image quality of pancreatic CT imaging with an ultra-high resolution (UHR) CT scanner and a new denoising reconstruction algorism using deep learning technology compared with conventional CT imaging.

**Method and Materials**

Twenty consecutive patients with cystic pancreatic lesions, who underwent follow-up CT examinations with both a UHR CT scanner and a conventional CT scanner, constituted the study population. High resolution CT images with a matrix of 1024 x 1024 and a thickness of 0.25 mm were reconstructed with deep learning reconstruction algorism at the UHR CT scanner. Conventional CT images were reconstructed with a matrix of 512 x 512 and a thickness of 0.5 mm using a hybrid iterative reconstruction algorism. Image noise (standard deviation of CT values) and contrast-to-noise ratio (CNR) were measured and compared between the two CT image sets by using the paired t-test. Subjective image noise, sharpness of structural contour, delineation of the main...
pancreatic ducts and cystic lesions, and overall image quality were assessed using a 5-point scale and compared by using the Wilcoxon signed rank test.

RESULTS

Image noise at UHR CT (9.4 ± 1.6) was significantly lower than that at conventional CT (13.0 ± 4.7, P < .01). CNR at UHR CT (12.7 ± 3.7) was significantly higher than that at conventional CT (8.8 ± 3.0, P < .01). Subjective image noise at UHR CT was lower than that at conventional CT images (P < .01). Sharpness, delineation of the main pancreatic duct, and overall image quality at UHR CT were significantly superior to those at conventional CT (P < .01, P < .05, P < .01, respectively). Delineation of the cystic lesions at UHR CT were also superior to those at conventional CT, although the difference did not reach statistical significance (P = .1).

CONCLUSION

Combination of a UHR CT scanner and a denoising reconstruction algorithm using deep learning technology can provide high quality pancreatic CT images with less image noise and higher spatial resolution and improve the delineation of anatomical structures compared with conventional CT imaging technique.

CLINICAL RELEVANCE/APPLICATION

Ultra-high resolution CT enhanced by deep learning-based denoising reconstruction algorithm may contribute to a precise evaluation of the pancreatic neoplasms due to its excellent image quality.

SSQ08-09 Determining the Use of Water Oral Contrast Based on Visceral Fat Index and Body Mass Index for CT Abdomen Pelvis Exams in the Outpatient Oncology Setting

Thursday, Dec. 5 11:50AM - 12:00PM Room: S102CD

Participants
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PURPOSE

Assess effect of visceral fat in the CT evaluation of bowel and peritoneum with oral water versus positive density oral contrast in the outpatient oncology setting.

METHOD AND MATERIALS

100 consecutive subjects (54 males median age 64±14 years) had outpatient oncologic follow up CT abdomen pelvis exams with water used as oral contrast and available prior CT with gastrografin/barium. 500ml oral water was given 30 minutes prior to each outpatient CT scan as part of a department patient quality improvement initiative. CT exams were retrospectively evaluated and visceral fat area was segmented and thresholded (-274 to -49HU), at axial L2-3 level using a custom MATLAB (The Mathworks, Natick, MA) script, and divided by body surface area to provide visceral fat index (VFI). Bowel visualization adequacy was scored on a Likert scale (1-4) based on prior research. Confidence in ruling out peritoneal metastases and abscess were each scored on a Likert scale (1-3). Patient satisfaction surveys were obtained rating exam and wait time satisfaction on a Likert scale (1-10). Univariate receiver operating curve analysis was performed on VFI and body mass index (BMI) to predict excellent bowel visualization on a Likert scale (1-4). Mann Whitney U test was used to compare continuous variables, and Pearson correlation coefficient was used for correlation.

RESULTS

CT water oral contrast bowel visualization scores:1 (n=83), 2 (n=14), 3 (n=3), 4(n=0). CTs scored 1 had higher VFI 68±36 cm/m2 than CTs scored >=2; 17±16 cm/m2, p<.00001 and higher BMI 30±7 vs. 23±2 respectively p<.00001. Higher VFI was predictive of (Likert 1) excellent bowel visualization with AUC 0.91 (95%CI 0.84-0.98) p<.001, while higher BMI had AUC 0.89 (95%CI 0.83-0.96) p<0.001. VFI threshold >= 23.76 cm/m2 sensitivity 0.92 and specificity 0.77 while BMI threshold >= 24 sensitivity 0.89 and specificity 0.82. BMI had only moderate correlation with visceral fat, R=0.62, p<.00001. Patient satisfaction was significantly higher with water compared to positive density oral contrast p<.00001.

CONCLUSION

Our results suggest VFI >23.76 cm/m2 and BMI >24.37 are predictive of adequate CT bowel and peritoneal evaluation with oral water contrast. VFI had better diagnostic accuracy than BMI in predicting optimal CT evaluation, yet these are only moderately correlated.

CLINICAL RELEVANCE/APPLICATION

There is benefit to including VFI in addition to BMI when determining which CTs will benefit most from receiving positive density oral contrast versus water. Additionally, oral water significantly improves patients' experience compared to positive density contrast.

Printed on: 10/29/20
**PURPOSE**

Dual-energy CT (DECT) strengthens the material characterization and quantification due to its capability of material discrimination. The image-domain multi-material decomposition (MMD) via matrix inversion suffers from serious degradation of the signal-to-noise ratios (SNRs) of the decomposed images and thus the clinical application of DECT is limited. In this work, we propose a noise suppression algorithm based on the noise propagation for image-domain MMD.

**METHOD AND MATERIALS**

The noise in the decomposed images only distributes in two perpendicular directions. The noise perturbation is minimal along the principal axis and is thus suppressed along the principal axis by estimating the center of mass of the same-material pixel group. The proposed method is evaluated using the line-pair and contrast-rod slices of the Catphan®600 phantom and one patient data. We compared the proposed method with the direct inversion and the block-matching and three-dimensional (BM3D) filtration methods.

**RESULTS**

The results of Catphan®600 phantom and the patient show that the proposed method successfully suppresses the noise of the basis material images by one order of magnitude and preserves the spatial resolution of the decomposed images. Compared with the BM3D filtration method, the proposed method maintains the texture distribution of the decomposed images at the same SNR and the accuracy of the electron density measurement.

**CONCLUSION**

The algorithm achieves effective noise suppression compared with the BM3D filtration while maintaining the spatial distribution of the decomposed material images. It is thus attractive for advanced clinical applications using DECT.

**CLINICAL RELEVANCE/APPLICATION**

Improve the accuracy of dual-energy CT material decomposition and can be used for iodine removal in CTPA.
**Purpose**

To implement triple-beam energy-integrating-detector multi-energy CT (EID-MECT) on a dual-source (DS) CT scanner and compare its material decomposition (MD) performance with EID dual-energy CT (EID-DECT) and photon-counting-detector CT (PCD-CT) for two potential multi-contrast clinical tasks: biphasic liver imaging with iodine (I) and gadolinium (Gd), and small bowel imaging with iodine (I) and bismuth (Bi).

**Method and Materials**

The EID-MECT was implemented on a DSCT platform by mounting a z-axis split filter (0.05 mm Au, 0.6 mm Sn) on Tube A, which was operated at 120 or 140 kV. With Tube B operated at 70 or 80 kV, four triple-beam configurations were calibrated for MECT measurements: 70/Au120/Sn120, 70/Au140/Sn140, 80/Au120/Sn120, and 80/Au140/Sn140 kV. Mixed I/Gd samples were prepared, where the I/Gd enhancement values corresponded to late arterial/portal-venous phases, respectively, for biphasic liver imaging. Mixed I/Bi samples were prepared, where the I/Bi enhancement values corresponded to arterial/enteric enhancement, respectively, for small bowel imaging. Samples were placed in a 25-cm wide water phantom and scanned using the four configurations. The same phantom was scanned using twin-beam DECT (TB-DECT) (Au120/Sn120 kV), DS-DECT (80/Sn140 kV), and PCD-CT (80 kV: 25/35/50/55 keV for I/Gd; 140 kV: 25/50/75/90 keV for I/Bi), all at equivalent CTDIvol. Image-based MD was performed and mean (± std dev) material concentrations measured.

**Results**

The optimal triple-beam configuration was 70/Au120/Sn120 and 70/Au140/Sn140 kV for I/Gd and I/Bi quantification, respectively. At equivalent radiation dose, noise in material concentration measurements was reduced for the triple-beam by 93%, 46%, and -2% for I/Gd quantification, and 62%, 24%, and 40% for I/Bi quantification, compared to TB-DECT, DS-DECT, and PCD-CT, respectively.

**Conclusion**

For the first time, the use of EIDs to perform MECT was experimentally demonstrated. Implemented with use of a Au/Sn split filter, three unique energy spectra were simultaneously measured using a DS system. Noise measured in material concentration was decreased relative to EID-DECT and comparable to or better than PCD-CT for two potential multi-contrast clinical tasks.

**Clinical Relevance/Application**

With the triple-beam technique, the wide availability of DS-DECT in academic radiology departments can facilitate investigations of multi-contrast clinical tasks.

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**Purpose**

Multi-energy data acquired on photon counting detector (PCD) suffer from considerable energy overlap due to imperfect detector response. This work aims to use dual source (DS)-PCD-CT to improve energy separation of multi-energy data, and a recently developed material decomposition method (MD-PKAID) to enable high fidelity simultaneous multi-contrast imaging of iodine (I), gadolinium (Gd), and bismuth (Bi).

**Method and Materials**

Head/body phantoms including solution vials containing I/Gd/Bi contrast agents of different concentrations were scanned on a single-source (SS) whole-body PCD-CT (chess mode with 4 thresholds = 25/50/75/90keV) and two times of clinical doses. The energy thresholds were chosen to capture the K edges of Gd/Bi. Energy bin images were reconstructed using a quantitative kernel (D30). An image-domain least-square material decomposition (MD-LS) was used to generate I/Gd/Bi specific images. Next, the same phantoms were scanned on DS-PCD-CT which was emulated by two consecutive scans with 80 kV / Sn140 kV for low/high energy tubes (Sn=tin filter). Total radiation dose of DS-PCD was 52.8/14.0 mGy for the head/body scans, similar to clinical exams. The energy thresholds were set as 25/50 keV for 80kV scan, and 25/90 keV for Sn140 kV scan. A recently developed material decomposition method (MD-PKAID) was applied, which used the energy threshold-low images as a prior image to denoise individual material-specific images. The root-mean-square-errors (RMSE) of material concentration relative to the true concentrations were measured for each material.

**Results**

The improved energy separation offered by DS-PCD-CT, combined with MD-PKAID, was able to achieve excellent performance of multi-contrast imaging of I/Gd/Bi contrasts. The material concentration RMSEs for I/Gd/Bi were 0.26/0.11/0.21 mg/mL for head phantom, and 0.50/0.31/0.29 mg/mL for body phantom, in comparison to the RMSEs of 1.82/1.44/0.63 mg/mL (head) and 10.88/7.54/1.76 mg/mL (body) using SS-PCD with MD-LS.

**Conclusion**

The combination of DS approach and PCD technology, coupled with an iterative material decomposition algorithm, allowed simultaneous multi-contrast imaging using I/Gd/Bi with low (<0.50mg/mL) quantification error.
KES-PCD-CT and a novel material decomposition algorithm may allow successful multi-contrast imaging, which may enable novel molecular imaging with nanoparticles and extend the frontier of clinical CT.

**SSQ18-04 Evaluation of a Novel Multi-Energy CT Phantom with High-Precision Low Iodine and Calcium Concentration Inserts Using a Third Generation Dual-Source CT System**

**Thursday, Dec. 5 11:00AM - 11:10AM Room: E353A**

**Participants**
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**PURPOSE**
To evaluate a novel multi-energy CT (MECT) phantom with multiple radiologically relevant inserts representing blood and water with contrast elements at low concentrations.

**METHOD AND MATERIALS**
A prototype of MECT phantom Model 662 (CIRS Inc, Norfolk, VA), with dimensions 33 x 27 x 25 cm was designed based on CIRS standard Electron Density Phantom Model 062 and comprised of the 5 cm thick target section in between two scatter 10 cm sections. It can be used in the 'head' configuration Ø18 cm or full-size 'body' configuration. The phantom is manufactured from Plastic Water-LR® and includes numerous material targets encapsulated inside the Ø1cm inserts made of PW-LR. Solid iodine inserts in water and blood included 0, 0.2, 0.5, 1.0, and 2.0, 5, 10 and 15mg/cc. Calcium inserts included 10, 20, 40, 60, 120 and 240 mg/cc concentrations. The phantom was scanned using dual-source CT (SOMATOM Force, Siemens) in the conventional SECT mode to assess linearity with kV ranging 70-150 (plus 100Sn and 150Sn). The iodine inserts were also evaluated with the MECT technique using kV pair combinations: 80/Sn150, 90/Sn150, and 100/Sn150 kV.

**RESULTS**
The HU values of all materials (including background ‘water’) in the phantom behaved as expected in the investigated kV range. The HU vs. concentration curves measured in the 'head' phantom showed excellent linearity with R2 values of 0.9990 (iodine in water), 0.9995 (iodine in blood) and 0.9998 (calcium in water). Iodine accuracy in the 'body' phantom varied from -0.5 to +0.2 mg/cc under all conditions except the highest iodine concentration (15 mg/cc) measured with 90/150Sn and 80/150Sn kV pairs where the absolute error increased to -0.8 and -1.1 mg/cc, respectively. With exception of the lowest concentrations <=0.5 mg/cc, percent errors were consistently below 10%. At lower concentrations, the 100/Sn150 kV had the highest accuracy. Iodine DE ratio values in the 'body' phantom were in excellent agreement with the previously published results (Krauss et al, Invest Radiol 2015).

**CONCLUSION**
The evaluated MECT phantom showed excellent characteristics in terms of concentration linearity, expected kV dependence of all clinically relevant materials, appropriate iodine DE ratio values, and enabled evaluation of low concentrations of materials.

**CLINICAL RELEVANCE/APPLICATION**
With MECT gaining more clinical attention, carefully designed phantoms are desired for assessing performance of state-of-the-art MECT systems.

**SSQ18-05 K-Edge Subtraction Imaging with a Mono-Energetic Compact Synchrotron X-Ray Source**

**Thursday, Dec. 5 11:10AM - 11:20AM Room: E353A**

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**PURPOSE**
X-ray computed tomography (CT) is one of the most important diagnostic techniques in clinics. Yet, this method lacks the ability to differentiate similarly absorbing substances like commonly used iodine contrast agent and calcium, which is contained in calcifications, kidney stones and bones. K-edge subtraction (KES) imaging overcomes this limitation by subtracting two CT scans recorded at X-ray energies above and below the K-edge of the element in question. Thereby, reliable discrimination of contrast agent and calcium is achieved.

**METHOD AND MATERIALS**
KES benefits from monochromatic X-rays. Therefore, it has been mainly applied at synchrotron facilities. Here, we present the first proof-of-principle experiment of a filter-based KES CT performed at a compact synchrotron X-ray source based on inverse-Compton scattering, which provides a quasi-monochromatic X-ray beam of tunable energy in a laboratory setup. Two CT scans of an excised porcine kidney containing a kidney stone were performed. One scan was done with an iodine filter in the beam shifting the mean X-ray energy below the iodine K-edge energy, while the other one was performed with the full spectrum of the X-ray source.

**RESULTS**
KES CT allows for iodine contrast agent and calcium to be clearly separated, c.f. Figure 1. While both materials show almost the
The results show that KES CT is feasible at a compact inverse-Compton scattering X-ray source, which is going to provide benefits for contrast enhanced 3D imaging in a pre-clinical setting. KES CT allows for a discrimination of iodine and calcium, which will be of special interest in various clinical situations like kidney stones, atherosclerosis and bone imaging. We believe that KES at a compact synchrotron source can become an important tool in pre-clinical research and possible future clinical diagnostics.

**CONCLUSION**

The results show that KES CT is feasible at a compact inverse-Compton scattering X-ray source, which is going to provide benefits for contrast enhanced 3D imaging in a pre-clinical setting. KES CT allows for a discrimination of iodine and calcium, which will be of special interest in various clinical situations like kidney stones, atherosclerosis and bone imaging. We believe that KES at a compact synchrotron source can become an important tool in pre-clinical research and possible future clinical diagnostics.

**CLINICAL RELEVANCE/APPLICATION**

KES CT solves the clinically faced issue of the discrimination of iodine contrast agent and calcium, providing two CT volumes only showing one of the two materials, respectively.

**SSQ18-06 The Potential Effects of Scout Scan Parameters on Image Quality and Radiation Dose in Chest CT on a 16cm Wide-Detector Dual-Energy CT**

**PURPOSE**

To explore the effects of scout scan parameters (tube position, tube voltage, mA) on image quality and radiation dose of chest CT scan under Smart mA and KV Assist modes on a chest phantom

**METHOD AND MATERIALS**

The CT scan was performed on a chest phantom by a 16cm wide-detector dual-energy CT (Revolution CT, GE Healthcare, Milwaukee) under Smart mA and KV Assist modes. During the scout scanning, the tube was positioned at 0°, 90 and 180°, separately corresponding to 5 different tube voltages (70, 80, 100, 120 and 140kV); 5-6 mA values were selected from a range of 10-110mA. Scan parameters were set as follows: KV Assist, Smart mA, detector width: 80mm, pitch: 0.992:1, rotation time: 0.5s/r, slice thickness: 5mm, Nt: 10. The mA values at pulmonary apex, tracheal bifurcation, nipple, and right diaphragmatic dome were recorded. The CT dose index-volume (CTDIvol) in each scan was recorded as well. The radiation dose of breast in each scan was measured by the thermal leak detector (TLD). The regions of interest (ROIs) were placed at the tracheal bifurcation and right diaphragmatic dome to calculate the contrast-to-noise ratio (CNR).

**RESULTS**

Under Smart mA and KV Assist modes with tube positions at 90° and 180°, a tube voltage of 100kV was automatically selected for scanning. With the scanning parameters of 70kV and 10mA at the tube position of 0°, the automatically selected tube voltage was 100kV as well. For other scanning conditions, tube voltage was automatically selected as 80kV. At the tube position of 0°, the mean CTDIvol was 3.33mGy, the mean breast dose was 6.79mGy, and the mean CNR were 120.34 and 124.81 at a level of tracheal bifurcation and diaphragmatic dome, respectively. At the tube position of 90°, the above measurements were 4.87mGy, 8.42mGy, 168.00 and 144.33, respectively. At the tube location of 180°, measurements were 4.38mGy, 7.45mGy, 143.35 and 141.48, respectively.

**CONCLUSION**

In chest CT scout scan, the tube position has great influence on the radiation dose and particularly the organ dose of breast.

**CLINICAL RELEVANCE/APPLICATION**

A proper scan mode shall be selected according to the specific requirements of clinical examinations.

**SSQ18-07 Assessment of Texture Feature Reproducibility in Dual-Energy Computed Tomography Virtual Monoenergetic Images**

**PURPOSE**

To assess the reproducibility of texture features derived from dual-energy CT images in a virtual monoenergetic reconstruction

**METHOD AND MATERIALS**

Participants
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**PURPOSE**
To explore the reproducibility of radiomic texture features across virtual monenergetic images generated from dual-energy CT (DECT) acquisitions used in clinical practice and clinical trials at our institution.

**METHOD AND MATERIALS**
A phantom containing liver and lung texture modules was scanned in triplicate with a clinical dual source DECT scanner. Three fixed volumes of interest (VOIs) were drawn in mixed images (weighted images of low (90kV) and high (150kV) energy acquisitions) and monoenergetic images at 8 different energy levels (40,50,60,70,80,100,120,140 keV) to compare four Harlick texture features (energy, entropy, contrast, and homogeneity). Percentage difference of texture values from the mixed image was calculated for each VOI and keV level.

**RESULTS**
For VOIs placed in the lung portion of the phantom, texture value difference from mixed the image was on average 10% (range:1-17%) for energy, 4% (range:0.5-8%) for contrast, 3% (range:0.3-6%) for correlation, and 1% (range:0.1-2%) for homogeneity. In liver these values included 7% (range: 0.4-16%) for energy, 11% (range: 0.4-39%) for contrast, 10%(range: 2-29%) for correlation, and 2%(range: 0.3-6%) for homogeneity.

**CONCLUSION**
All four texture features reviewed showed variance across monoenergetic images of DECT.

**CLINICAL RELEVANCE/APPLICATION**
Defining imaging device characteristics and their effect on imaging features with an empirical manner is a critical step for utilization of radiomics in the precision medicine era.

**Participants**
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**PURPOSE**
To develop a deep convolutional neural network (CNN) based technique to synthesize virtual monoenergetic images (VMIs) from spectral CT data and to compare results to conventional VMIs created from the same data.

**METHOD AND MATERIALS**
The developed technique consists of a VMI-synthesis CNN (CNNVMI) and a texture-synthesis CNN (CNNTEXT), with fully-customized architecture and loss functions. A two-stage training strategy was used. CNNVMI was trained using spectral CT polychromatic images and theoretical monoenergetic linear attenuation coefficients as inputs and labels, respectively. After CNNVMI training, the parameters were fixed, and CNNTEXT was stacked to the end of CNNVMI. CNNTEXT was trained to synthesize the image noise texture of a low noise image, using water phantom images as labels. CT images of an abdomen-sized water phantom with varying inserts were used to train and validate the CNNs. Additional porcine CT images were acquired to evaluate the generalizability of the CNNs for anatomical features. Images were acquired on a whole-body research photon-counting-detector (PCD) CT, using 140 kV and a two-threshold (25 and 65 keV) data acquisition mode. Phantom scans were acquired multiple times across three radiation dose levels (CTDIVOL: 23 mGy, 11.5 mGy, 5.75 mGy) and animal scans were acquired with 23 mGy. Results were compared with baseline images created using a conventional least-squares-based two-material decomposition.

**RESULTS**
Relative to baseline VMIs, CNN-synthesized VMIs demonstrated substantially lower noise and improved contrast resolution at all dose levels, especially for low-contrast inserts or tissues. Image details and noise texture were well maintained using the CNN synthesis compared to that of routine dose input images. The proposed CNNs accurately estimated the CT numbers of all inserts (mean absolute percent difference <5%), across all dose levels. Importantly, noise of the CNN VMIs was not substantially affected by the dose level of the input CT images (noise in water 12.6±0.14 HU across all dose levels).

**CONCLUSION**
The proposed CNN-based VMI synthesis provided high quality VMI images with accurate CT number, suppressed image noise, and improved contrast resolution.

**CLINICAL RELEVANCE/APPLICATION**
The clinical value of low keV VMIs could be dramatically increased by use of the described method to suppress image noise with maintaining CT number accuracy.

Printed on: 10/29/20
SSQ19

**Physics (Deep Learning - Dose Reduction and Image Quality)**

Thursday, Dec. 5 10:30AM - 12:00PM Room: E353B

**SSQ19-01**  
Radiation Dose Reduction for CT Assessment of Urolithiasis Using Deep Learning Reconstruction Algorithm: A Prospective Intra-Individual Study

**Participants**  
Xiaohu Li, MD, Hefei, China (Presenter) Nothing to Disclose  
Jianying Li, Beijing, China (Abstract Co-Author) Employee, General Electric Company  
Huayang Liu, MD, Beijing, China (Abstract Co-Author) Employee, General Electric Company  
Yongqiang Yu, MD, Hefei, China (Abstract Co-Author) Nothing to Disclose

**PURPOSE**  
To assess the performance of ASIR-V and Deep learning reconstruction algorithm (DL) in patients with urolithiasis at ultralow-dose CT

**METHOD AND MATERIALS**

13 patients scheduled for unenhanced abdominal CT for follow-up of urolithiasis were prospectively included. Routine dose acquisition was followed by two low-dose acquisitions at 60% and 90% reduced doses. All images were reconstructed with FBP, ASIR-V and DL. Urolithiasis detection rates, gall bladder, appendix and rectosigmoid evaluation and overall subjective image quality were evaluated by two observers.

**RESULTS**

52 stones were present in 13 patients. 65% stones were not detected on FBP at the lowest dose level, but this improved with DL to a sensitivity of 100%. ASIR-V resulted in a slight decrease in sensitivity at the lowest dose to 82%, but out performed FBP. Evaluation of other structures with ASIR-V at 60% and with DL at 90% dose reductions was comparable to FBP at routine dose, but 80% and 90% dose reduction resulted in non-evaluable images.

**CONCLUSION**

CT radiation dose for urolithiasis detection can be safely reduced by 60(ASIR-V)-90(DL)% without affecting assessment of urolithiasis, possible extra-urinary tract pathology or overall image quality.

**CLINICAL RELEVANCE/APPLICATION**

The most frequent cause of acute flank pain is urolithiasis, which affects 3-5% of the population. Technical advancements like iterative reconstruction (IR) algorithms have resulted in substantial radiation dose reductions. IR results in reduced noise, allowing acquisition of images at reduced radiation dose levels without intrinsically hampering image quality.

**SSQ19-02**  
Radiation Dose Reduction in Chest CT at a Micro-Dose (mD) Level by Noise Simulation and Noise-Specific Anatomic Neural Network Convolution (NNC) Deep-Learning (DL) with K-Means Clustering

**Participants**  
Yuji Zhao, MSc, Chicago, IL (Abstract Co-Author) Nothing to Disclose  
Amin Zarshenas, MSc, Chicago, IL (Abstract Co-Author) Nothing to Disclose  
Toru Higaki, PhD, Hiroshima, Japan (Abstract Co-Author) Nothing to Disclose  
Kazuo Awai, MD, Hiroshima, Japan (Abstract Co-Author) Research Grant, Canon Medical Systems Corporation; Research Grant, Hitachi, Ltd; Research Grant, Fujitsu Limited; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Eisai Co, Ltd;  
Kenji Suzuki, PhD, Chicago, IL (Presenter) Nothing to Disclose

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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 develop new noise-specific 3D NNC DL experts by means of K-means clustering with mDCT simulation to convert mDCT to 'virtual' high-dose (HD) CT where noise and artifacts are significantly reduced.

METHOD AND MATERIALS
We developed a mixture of noise-specific, anatomical NNC experts, employing volume-based neural network regression in a convolutional manner, with soft-gating layers to convert mDCT to HD-like CT. We trained 9 noise-specific, anatomical NNC models for 3 noise-specific clusters in 3 anatomic areas of means of K-means clustering. We trained our NNCs with simulated mDCT as input and corresponding HDCT (120 kVp, 92 mAs, 3.0 mSv) from our diagnostic CT database as 'teaching' images. Our mDCT simulation consisted of forward-projection of HDCT, addition of photons and electric noise to sinogram images, filtered back-projection of the noise component, and addition of the noise image to the original HDCT. Through training, our noise-specific, anatomical NNCs learned to convert lower-dose CT to HD-like CT, where noise and artifacts are substantially reduced; thus, termed 'virtual' HD (VHD) CT. To evaluate the performance, we collected mD (120 kVp, 5 mAs, 0.2 mSv) and full-dose (120 kVp, 50 mAs, 2.0 mSv) CT (Aquilion One, Toshiba, Japan) of 50 clinical cases including 30 cases with solid nodule and ground-glass (GG) nodule.

RESULTS
Our new VHD technology with clustering converted mDCT to 'virtual' HDCT and improved the image quality by reducing noise and artifacts substantially, while anatomic structures and pathological characteristics of both solid and GG nodules were well preserved. With our NNCs trained with simulated mDCT, contrast-to-noise-ratio (CNR) of mDCT of clinical cases was improved from 4.1±3.9 dB to 22.9±3.4 dB, which was also higher than that of 'reference-standard' full-dose CT (CNR: 13.4±5.1 dB).

CONCLUSION
Our noise-specific anatomical NNC models trained with simulated mDCT images was able to convert thin-slice mDCT of clinical cases to VHDCT that have higher image quality (in terms of CNR) than 'reference-standard' full-dose CT, achieving 90% dose reduction.

CLINICAL RELEVANCE/APPLICATION
Substantial reduction of radiation dose in CT by our new noise-specific VHD technology would potentially make mDCT screening possible, and it would be beneficial to screening population.

SSQ19-03 A Deep-Learning-Based Framework for Synthesizing Virtual CT Exams in the Image Domain
Thursday, Dec. 5 10:50AM - 11:00AM Room: E353B

Participants
Hao Gong, PhD, Rochester, MN (Presenter) Nothing to Disclose
Shuai Leng, PHD, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Joel G. Fletcher, MD, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (Abstract Co-Author) Nothing to Disclose
Lifeng Yu, PhD, Rochester, MN (Abstract Co-Author) Nothing to Disclose

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PURPOSE
To develop a deep convolutional-neural-network (CNN) based framework to synthesize virtual patient CT exams having varying lesion characteristics and simulating varying radiation dose levels.

METHOD AND MATERIALS
The developed framework consists of a lesion-insertion CNN (CNNLesion) and a noise-insertion CNN (CNNNoise). Both CNNs were implemented with in-house-developed network architectures. CNNLesion inserts lesions into different locations of patient images by fusing multi-scaled features of patient lesion models with anatomical background. A cohort of lesion-free abdominal CT patient cases (n=10) was used to generate training data and validate CNNLesion. A previously-validated projection-based lesion insertion technique was used to generate reference images across 10 conditions: lesion sizes 5 - 11 mm, contrast levels 15 - 25 HU, and reconstruction types (filtered-backprojection and iterative reconstruction). CNNNoise used routine dose CT images and white noise as inputs to synthesize image noise magnitude and texture at lower dose levels. The architecture of CNNNoise approximates the underlying noise correlation in CT images. The loss function of CNNNoise consisted of a perceptual loss, a frequency-spectrum loss, and a diversity loss. Patient cases from the NIBIB/AAPM Low Dose CT Grand Challenge and water phantom scans were used to train and validate CNNNoise.

RESULTS
The CNNLesion-synthesized lesion-present images showed strong perceptual similarity compared to the reference images. The mean structural similarity index and the mean absolute CT number difference between the CNNLesion-inserted lesions and the reference were 0.983±0.004 and 1.9±0.3 HU, respectively. The CNNNoise-synthesized low-dose images had comparable noise texture to that of the reference images. The mean absolute percent difference of noise measured in the liver parenchyma was <3%. The noise power spectra measured from CNNNoise-synthesized water phantom scans were very close to those from real scans (mean absolute difference < 1.1 HU2cm2).

CONCLUSION
The developed deep CNN-based framework accurately and efficiently synthesized virtual patient CT exams with prescribed lesion characteristics and radiation dose levels.

CLINICAL RELEVANCE/APPLICATION
The developed CNN-based method can accurately and efficiently create patient cases with known pathology and dose to perform virtual clinical trials in CT for radiation dose and protocol optimization.
SSQ19-04  Nonlinear Analysis of Machine Learning in CT Image Formation

Thursday, Dec. 5 11:00AM - 11:10AM Room: E353B

Participants
Grace J. Gang, PhD, Baltimore, MD (Presenter) Nothing to Disclose
Xueqi Guo, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Cheng Ting Lin, MD, Baltimore, MD (Abstract Co-Author) Nothing to Disclose
Joseph W. Stayman, PhD, Baltimore, MD (Abstract Co-Author) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc; Research Grant, Elekta AB; Research Grant, Fischer Medical; Research Grant, Medtronic plc; Research collaboration, Koninklijke Philips NV; Research collaboration, Varex Imaging Corporation; Research Grant, Siemens AG; Research Grant, General Electric Company;

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PURPOSE
The proliferation of nonlinear machine learning algorithms poses significant challenges to image quality assessment. Performance characterization typically relies on qualitative 'beauty contests' or metrics like resolution and structural similarity which may not relate to diagnostic outcome. We propose a quantitative image quality metric for nonlinear algorithm analysis and present example applications in a neural network denoising algorithm in low dose CT imaging of the lung.

METHOD AND MATERIALS
We propose perturbation response analysis as a quantitative measure of image quality suitable for general nonlinear algorithms. Perturbation response is defined as the difference in the mean output between an image with a stimulus and an image without. Such analysis captures the various dependencies of the algorithms, including that on the stimulus itself. We performed the analysis for an example denoising algorithm based on a convolutional neural network. For stimuli inputs, we developed procedurally generated lesions to systematically sample ranges of clinically relevant features, including size, contrast, and speculcation characteristics. The lesions were inserted into the projection data and propagated through the imaging chain.

RESULTS
The perturbation response for FBP reconstruction exhibits linear behavior. The denoising algorithm is effective in reducing noise in the image. However, perturbation response analysis reveals highly nonlinear behavior on the lesion stimuli. Spherical lesions of lower contrast may disappear completely (for contrast at ~0.001 mm-1) or appear at the right contrast but smaller in size (for contrast at ~0.005 mm-1). Lesions with thinner and shorter speculations can appear with smooth boundaries. These results allow quantitative characterization that identify the range of lesion features that cannot be admitted or faithfully represented by the algorithm.

CONCLUSION
We applied perturbation response analysis in identifying the performance limits of an algorithm in terms of lesion contrast, size, and speculcation. This work provides a quantitative method for characterizing the performance of nonlinear algorithms in relation to clinically relevant features.

CLINICAL RELEVANCE/APPLICATION
This work provides an image quality analysis method that is generally applicable to nonlinear image processing. The analysis allows quantitative image quality assessment and can be used to guide algorithm development.

SSQ19-05  Quantitative Comparison of a Deep Learning-Based CT Reconstruction Algorithm (AiCE) to Other Reconstruction Techniques

Thursday, Dec. 5 11:10AM - 11:20AM Room: E353B

Participants
Samuel L. Brady, PhD, Cincinnati, OH (Presenter) Nothing to Disclose
Elanchezhan Sornasundaram, Cincinnati, OH (Abstract Co-Author) Nothing to Disclose
Andrew T. Trout, MD, Cincinnati, OH (Abstract Co-Author) Author, Reed Elsevier; Author, Wolters Kluwer nv; Research Grant, Canon Medical Systems Corporation; Board Member, Joint Review Committee on Educational Programs in Nuclear Medicine Technology; Speakers Bureau, Reed Elsevier; Speakers Bureau, iiCME
Jonathan R. Dillman, MD, MSc, 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

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PURPOSE
To compare, in pediatric patients, a deep learning-based (DL) CT reconstruction algorithm (AiCE) to filtered back projection (FBP), statistical-based (AIDR3D), and model-based iterative (FIRST) reconstruction algorithms at different contrast levels and object sizes using quantitative image analysis.

METHOD AND MATERIALS
Patient raw image data acquired on a Genesis CT scanner (Canon Medical Systems) were reconstructed axially using FBP, AIDR3D, FIRST, and AiCE at 0.5mm and 3mm thicknesses. AiCE used a Deep Convolutional Neural Network (DCNN) in the regularization term of its iterative reconstruction algorithm. The DCNN was trained to differentiate signal from noise to reduce noise in the image. A non-prewhitening matched observer model with eye filter (dNPWE) was used to characterize the signal-to-noise ratio (SNR) of objects of varying sizes (1-10mm) at three different CT contrast levels (-100, 100, & 350HU). To calculate dNPWE, a Task Transfer Function for each reconstruction algorithm and contrast level was calculated using a water phantom with sensitometry inserts. A power spectrum was calculated by sampling noise characteristics from uniform regions of the patients’ liver parenchyma.
Object signal differentiation due to reconstruction algorithm was estimated by calculating the area under the curve (AUC). AUC results for FBP, FIRST, and AICE were normalized to AIDR3D, the routinely clinically employed reconstruction algorithm for this scanner.

RESULTS

Power spectrum magnitude for 3mm AICE images were an average 58% lower (range: 45-70%) than 3mm AIDR3D images. Power spectrum frequency content of AICE agrees to better than 28% with AIDR3D compared to 50% for FIRST. On average, AICE 3mm images demonstrated greater distinction for all object sizes and contrast levels than all other algorithms. AICE 0.5mm SNR agreed with 3mm AIDR3D to better than 0.4%.

CONCLUSION

Analysis demonstrates substantial improvement of object signal detection and noise magnitude using DL CT reconstruction (AICE) leading to less noisy images with noise texture comparable with AIDR3D. Noise magnitude of AICE 0.5mm images is comparable to AIDR 3mm images showing substantial dose reduction potential of AICE.

CLINICAL RELEVANCE/APPLICATION

Deep learning-based CT reconstruction (AICE) improves image signal detection of objects down to 1 mm in diameter at all contrast levels with the potential to substantially reduce dose without compromising image quality.

SSQ19-06  The Image Quality of the Newest Deep Learning Image Reconstruction on Chest CT

Thursday, Dec. 5 11:20AM - 11:30AM Room: E353B

Participants
Akinori Hata, MD, Suita, Japan (Presenter) Support, Canon Medical Systems Corporation
Masahiro Yanagawa, MD, PhD, Suita, Japan (Abstract Co-Author) Nothing to Disclose
Yuiko Yoshida, Osaka, Japan (Abstract Co-Author) Nothing to Disclose
Tomo Miyata, MD, Suita, Japan (Abstract Co-Author) Nothing to Disclose
Osamu Honda, MD, PhD, Amagasaki, Japan (Abstract Co-Author) Nothing to Disclose
Noriyuki Tomiyama, MD, PhD, Suita, Japan (Abstract Co-Author) Nothing to Disclose
Noriko Kikuchi, Suita, Japan (Abstract Co-Author) Nothing to Disclose

PURPOSE

To assess the image quality of the newest deep learning image reconstruction (DLIR) on chest CT in comparison with filtered back projection (FBP) and iterative reconstruction (IR).

METHOD AND MATERIALS

Thirty-six patients were evaluated retrospectively. All patients underwent routine contrast enhanced CTs (Revolution CT, GE Healthcare, WI) and images with 0.625-mm slice thickness were reconstructed using FBP, hybrid IR (ASiR-V), and DLIR (Truefidelity, GE Healthcare). The three settings of DLIR (low, medium, and high) and ASiR-V 60% were used. Regions of interest were placed at the axillary fat and the pectoralis major muscle, and the standard deviation (SD), the signal-to-noise ratio (SNR), and the contrast-to-noise ratio (CNR) were calculated objectively on the five image sets (FBP, ASiR-V, DLIR-low, DLIR-med, and DLIR-high). Two independent radiologists evaluated ASiR-V, DLIR-low, DLIR-med, and DLIR-high comparing with FBP on a 5-point scale (1=worst<2<3<4<5=best) in terms of noise, streak artifact, the visibility of lymph nodes, the clarity of small vessels in the chest wall, and overall image quality on mediastinum window setting (width 400 HU; level 60 HU). The objective parameters were analyzed statistically using one-way repeated measures ANOVA and the post hoc Tukey-Kramer test. The subjective scores were analyzed using the Wilcoxon signed-rank test with the Bonferroni correction.

RESULTS

DLIR-high significantly showed the least SD and the largest SNR and CNR among the reconstructions (p<0.001). The higher the DLIR setting, the lower the SD and the higher the SNR and CNR (p < 0.01). In the subjective analysis, DLIR-high showed the best score in terms of noise, streak artifact, and overall image quality among the reconstructions (significant in both readers’ result: p < 0.001). The scores of DLIR-med and DLIR-high tended to be better in terms of lymph nodes and poor in terms of small vessels compared with ASiR-V (significant in 1 reader's result: p <= 0.005).

CONCLUSION

DLIR-high improved the objective parameters and the subjective image quality compared with ASiR-V by reducing noise and streak artifact on chest CT.

CLINICAL RELEVANCE/APPLICATION

With improved image quality, the DLIR may contribute to the diagnosis and the clinical practice on the chest CT.

SSQ19-07  Quantitative Comparison of Noise Texture between CT Images Reconstructed Using Filtered Back-Projection (FBP), Iterative Reconstruction, and Deep Learning Techniques

Thursday, Dec. 5 11:30AM - 11:40AM Room: E353B

Participants
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Meghan Yue, BS, Waukesha, WI (Abstract Co-Author) Employee, General Electric Company
Ray A. Nilsen, BS, Waukesha, WI (Abstract Co-Author) Employee, General Electric Company
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Jiang Hsieh, PhD, Waukesha, WI (Abstract Co-Author) Employee, General Electric Company

For information about this presentation, contact:
The DL-MAR technique has been successfully developed and shown comparable performance with conventional projection.

**CONCLUSION**

Two MAR protocols (P = 0.054), and DL-MAR showed unusual blurring of periarticular soft tissue. However, there was no significant difference in the assessment of soft tissue between O-MAR (P < 0.001). In qualitative analysis, DL-MAR showed significantly lower overall metal artifacts (P = 0.008) and better bone delineation (P = 0.020) compared to O-MAR. In terms of mean attenuation and AI, DL-MAR also showed better performance than O-MAR from 0.01mm2.

**RESULTS**

O-MAR showed a 24% reduction in metal artifact area, while the DL-MAR showed an area reduction of more than 99%, almost completely eliminating the dark streak artifact. In terms of mean attenuation and AI, DL-MAR also showed better performance than O-MAR (P < 0.001). In qualitative analysis, DL-MAR showed significantly lower overall metal artifacts (P = 0.008) and better bone delineation (P = 0.020) compared to O-MAR. However, there was no significant difference in the assessment of soft tissue between two MAR protocols (P = 0.054), and DL-MAR showed unusual blurring of periarticular soft tissue.

**CONCLUSION**

The DL-MAR technique has been successfully developed and shown comparable performance with conventional projection.
CLINICAL RELEVANCE/APPLICATION

The DL-MAR can effectively reduce severe metal artifacts caused by large TKA components, hence enabling its use in the diagnosis of postoperative complications of TKA.

SSQ19-09  Basic CT Physics Scaling Laws for Noise and CNR as a Function of Slice Thickness and Dose for a New Deep-Learning CT Image Reconstruction Method

Thursday, Dec. 5 11:50AM - 12:00PM Room: E353B

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; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Brian E. Nett, PhD, Wauwatosa, WI (Abstract Co-Author) Employee, General Electric Company
Jie Tang, PhD, Madison, WI (Abstract Co-Author) Employee, General Electric Company
Jiang Hsieh, PhD, Waukesha, WI (Abstract Co-Author) Employee, General Electric Company

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PURPOSE

The relationships between noise, slice thickness, and dose in CT are well understood for filtered back projection. This work characterizes these relationships for an implementation of TrueFidelity, a new deep learning image reconstruction (DLIR) approach.

METHOD AND MATERIALS

We imaged an ACR phantom at 5 slice thicknesses: 0.625, 1.25, 2.5, 3.75, and 5 mm. We imaged at doses of 16, 8, and 4 mGy using 120 kV, 80 mm collimation, and 0.992:1 pitch. All measurements were repeated 5 times. Images were reconstructed using: filtered back projection (FBP), two levels of a statistical iterative reconstruction (ASiR-V), and three levels of a vendor's deep learning image reconstruction (DLIR) approach. The ASiR-V levels were chosen based on institution (20%) and vendor (50%) recommendations. We fit image noise and CNR as a function of dose and slice thickness. Confidence intervals for all fit parameters were determined.

RESULTS

FBP and ASiR-V 20%/50% had similar scaling exponents: for CNR as a function of slice thickness 0.47(0.43-0.51) and 0.46(0.43-0.50)/0.45(0.36-0.54) and for noise as a function of slice thickness -0.49(-0.50 -0.48) and -0.49(-0.52 -0.47)/-0.49(-0.59 -0.39) respectively. DLIR low/medium/high had exponents of 0.37(0.23-0.51)/0.37(0.20-0.53)/0.36(0.15-0.56) for CNR as a function of slice thickness and of -0.39(-0.51 -0.28)/-0.38(-0.51 -0.26)/-0.37(-0.51 -0.23) for noise as a function of slice thickness. For noise and CNR as a function of dose, all methods had similar scaling exponents across slice thickness. As a function of dose at 5 mm, the image noise exponents for FBP and ASiR-V 20%/50% were: -0.48(-0.66 -0.30) and -0.48(-0.65 -0.31)/-0.47(-0.65 -0.29). DLIR low/medium/high for noise as a function of dose at 5 mm had scaling exponents of -0.44(-0.72 -0.17)/-0.44(-0.88 0.00)/-0.42(-1.08 0.23).

CONCLUSION

The CNR and noise scaling laws for FBP were found to hold for all recon methods. TrueFidelity DLIR did tend to have smaller changes in CNR and noise as the slice thickness/dose was reduced. The performance of DLIR was predictable and better than FBP and ASiR-V at all slice thicknesses and doses.

CLINICAL RELEVANCE/APPLICATION

New deep-learning based CT reconstruction (TrueFidelity, GE Healthcare) follows the noise and CNR rules of FBP reconstruction. This new reconstruction approach can mitigate some of the noise penalty incurred by reducing slice thickness or dose.

Printed on: 10/29/20
AI Theater: Is AI Enough? From Research to Daily Practice for Better Patient Care in Stroke: Presented by Cercare Medical

Thursday, Dec. 5 11:00AM - 11:20AM Room: AI Showcase, North Building, Level 2, Booth 10724

Participants
Ronald J. Borra, MD, PhD, Turku, Finland (Presenter) Nothing to Disclose

Program Information
Artificial intelligence is a technology that opens up new horizons in many areas of our lives, especially radiology. However, machine learning on its own does not guarantee higher performance or precision. Cercare Medical uses AI as a tool to make the results of years of research available to doctors in their daily practice and support their life-changing decisions in acute ischemic stroke. Cercare Medical is a software company founded in 2013 as a spin-out of the Center of Functionally Integrative Neuroscience at Aarhus University, Denmark. Cercare Medical extends more than 10 years of research, led by Professor Leif Østergaard and Professor Kim Mouridsen, in neuroimaging and artificial intelligence. The Cercare Medical Neurosuite stroke solution provides automated, AI-powered oxygenation analysis, segmentation and quantification of brain tissue status for fast decision making in acute stroke. Note: Cercare Medical products are not commercially available for the U.S.

Printed on: 10/29/20
RSNA AI Deep Learning Lab: Segmentation

Thursday, Dec. 5 1:00PM - 2:30PM Room: AI Showcase, North Building, Level 2, Booth 10342

AI CT MR NR

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

Participants
George L. Shih, MD, New York, NY (Presenter) Consultant, MD.ai, Inc; Stockholder, MD.ai, Inc;

Special Information
In order to get the best experience for this session, it is highly recommended that attendees bring a laptop with a keyboard, a decent-sized screen, and the latest version of Google Chrome. Additionally, it is recommended that attendees have a basic knowledge of deep learning programming and some experience running a Google CoLab notebook. Having a Gmail account is also helpful. Here are instructions for creating and deleting a Gmail account.

ABSTRACT
This session will focus on the use of deep learning methods for image segmentation, applied to the challenge of CT or MR brain segmentation. While focused on this particular problem, the concepts should generalize to other organs and image types.

Printed on: 10/29/20
**RC703**  
**CT of Structural Heart Disease: Guiding Interventional Procedures**  
Thursday, Dec. 5 4:30PM - 6:00PM Room: E350

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

**Participants**
Eric E. Williamson, MD, Rochester, MN *(Moderator)* Nothing to Disclose

**LEARNING OBJECTIVES**
1) Identify the changes in the most recent guidelines for the use of CTA in TAVR. 2) Apply these to reproducibly quantify the annulus, root, and sinus features of the valve. 3) Develop a technique to translate these techniques into non-standard root anatomy such as in patients with bicuspid aortic valves. 4) Stratify the risk of complications from TAVR based on the CT features. 4) To review the role of MDCT for the diagnosis and characterization of mitral regurgitation. 5) Discuss the role of MDCT to guide transcatheter mitral interventions. 6) Review the ongoing limitations and challenges with regards to procedural planning and resultant opportunities for improved imaging guidance.

**Sub-Events**

**RC703A  TAVR Planning: Review of the Guidelines**

Participants
Jonathan Weir-McCall, MBBCh, FRCR, Vancouver, United Kingdom *(Presenter)* Nothing to Disclose

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**LEARNING OBJECTIVES**
1) Identify the changes in the most recent guidelines for the use of CTA in TAVR. 2) Apply these to reproducibly quantify the annulus, root, and sinus features of the valve. 3) Develop a technique to translate these techniques into non-standard root anatomy such as in patients with bicuspid aortic valves. 4) Stratify the risk of complications from TAVR based on the CT features.

**RC703B  Planning Mitral Interventions**

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, Samsung Electronics Co, Ltd
Consultant, Koninklijke Philips NV Consultant
Arineta Ltd Consultant, Pi-Cardia Ltd

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**LEARNING OBJECTIVES**
1) To review the role of MDCT for the diagnosis and characterization of mitral regurgitation. 2) Discuss the role of MDCT to guide transcatheter mitral interventions. 3) Review the ongoing limitations and challenges with regards to procedural planning and resultant opportunities for improved imaging guidance.

**RC703C  Left Atrial Appendage Closure**

Participants
Prabhakar Rajiah, MD, FRCR, Dallas, TX *(Presenter)*
Royalties, Reed Elsevier

Printed on: 10/29/20
**Advances and Updates in SPECT/CT**

Thursday, Dec. 5 4:30PM - 6:00PM Room: S504CD

**CT NM**

**AMA PRA Category 1 Credits™:** 1.50

**ARRT Category A+ Credit:** 1.75

FDA Discussions may include off-label uses.

### Sub-Events

**RC711A SPECT/CT in Infection and Inflammation**

**Participants**
Christopher J. Palestro, MD, New Hyde Park, NY (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) Interpret SPECT/CT performed for suspected inflammation/infection to determine their precise location and extent. 2) Compare available radiopharmaceuticals and imaging modalities for specific clinical indications in the assessment of inflammation and infection. 3) Recognize and avoid pitfalls in interpretation of SPECT/CT studies performed for inflammation and infection.

**RC711B SPECT/CT Oncology and Endocrinology**

**Participants**
Esma A. Akin, MD, Washington, DC (Presenter) Nothing to Disclose

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**LEARNING OBJECTIVES**

1) To describe indications of using SPECT-CT imaging in endocrine and neuroendocrine tumors. 2) Observe case examples of common and uncommon presentations of these disease entities in daily clinical practice.

**RC711C SPECT/CT Technology: State of the Art**

**Participants**
Timothy Turkington, PhD, Durham, NC (Presenter) Consultant, Data Spectrum Corporation

**LEARNING OBJECTIVES**

1) To be able to provide a basic description of SPECT imaging. 2) To be able to describe at least two factors that limit SPECT imaging and how new technologies are helping to mitigate those factors.

Printed on: 10/29/20
CTA for TAVR and Other Aortic Valve Replacements

Thursday, Dec. 5 4:30PM - 6:00PM Room: E352

Participants
Karen G. Ordovas, MD, Seattle, WA (Moderator) Advisor, Arterys Inc;
Jean Jeudy JR, MD, Baltimore, MD (Moderator) Nothing to Disclose

For information about this presentation, contact:
jjeudy@som.umaryland.edu

Sub-Events

RC712A Pre-TAVR CT Imaging Protocols

Participants
Dominique C. DaBreo, BMedSc,FRCPC, Kingston, ON (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Develop optimal protocols for performance of CT angiograms for pre-TAVR planning. 2) Describe ways to approach pre-TAVR CT scans in the challenging, such as in the setting of arrhythmias or renal dysfunction.

RC712B CTA for Sizing Transcatheter Heart Valves

Participants
Karen G. Ordovas, MD, Seattle, WA (Presenter) Advisor, Arterys Inc;

RC712C 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:
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RC712D CT for the Evaluation of Surgical Bioprostheses

Participants
Dominika Sucha, MD,PhD, Utrecht, Netherlands (Presenter) Nothing to Disclose

Printed on: 10/29/20
Innovations in MR and CT Perfusion

Thursday, Dec. 5 4:30PM - 6:00PM Room: S103AB

MR and CT Perfusion and Pharmacokinetic Imaging

Participants
Roland Bammer, PhD, Parkville, Australia (Coordinator) Founder, iSchemaView, Inc; Director, iSchemaView, Inc; Stockholder, iSchemaView, Inc; Founder, HobbitView, Inc; Director, HobbitView, Inc; Stockholder, HobbitView, Inc

LEARNING OBJECTIVES
1) A survivors guide for perfusion methodology. 2) Practical considerations of perfusion imaging and leakage measurements in tumors. 3) How to use and interpret perfusion imaging in cerebro-vascular disease.

Sub-Events

MR and CT Perfusion and Pharmacokinetic Imaging

Participants
Roland Bammer, PhD, Parkville, Australia (Presenter) Founder, iSchemaView, Inc; Director, iSchemaView, Inc; Stockholder, iSchemaView, Inc; Founder, HobbitView, Inc; Director, HobbitView, Inc; Stockholder, HobbitView, Inc

Evidence-Based Best Acquisition Protocols for DSC-MRI in Brain Tumors

Participants
Jerrold L. Boxerman, MD, PhD, Providence, RI (Presenter) Nothing to Disclose

For information about this presentation, contact:
jboxerman@lifespan.org

LEARNING OBJECTIVES
1) Explain the DSC-MRI contrast mechanism and vessel size dependence of gradient-echo and spin-echo signal changes. 2) Identify the major protocol decisions for single-echo, gadolinium-based DSC-MRI. 3) Describe techniques for reducing contrast agent leakage effects in DSC-MRI. 4) Recommend an evidence-based best-practice protocol for DSC-MRI applications in neuro-oncology and clinical trials.

Perfusion Imaging in Cerebrovascular Disease

Participants
Shalini A. Amukotuwa, BMedSc, MBBS, Melbourne, Australia (Presenter) Spouse, Founder, iSchemaView

Printed on: 10/29/20
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

RC723A  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, Elekt a AB; Research Grant, Fischer Medical; Research Grant, Medtronic plc; Research collaboration, Koninklijke Philips NV; Research collaboration, Varex Imaging Corporation; Research Grant, Siemens AG; Research Grant, General Electric Company;

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.

RC723B  Dose Optimization Strategy and Clinical Implementation in Adult CT
Participants
Lifeng Yu, PhD, Rochester, MN (Presenter) Nothing to Disclose

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.

RC723C  Dose Reduction and Protocol Optimization in Pediatric CT
Participants
Robert MacDougall, PhD, Boston, MA (Presenter) Nothing to Disclose

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.

Printed on: 10/29/20
Avulsion Injuries of the Upper and Lower Extremities

Friday, Dec. 6 8:30AM - 10:00AM Room: E451B

Participants
Zehava S. Rosenberg, MD, Hoboken, NJ (Director) Nothing to Disclose

Sub-Events
RC804A  Upper Extremity

Participants
Lee F. Rogers, MD, Tucson, AZ (Presenter) Nothing to Disclose

For information about this presentation, contact:
lfrogers@comcast.net

LEARNING OBJECTIVES
1) Obtain appropriate radiographs, AP, lateral and obliques; oblique views are essential as certain fractures may be visible only on this projection. 2) Certain fractures and dislocations are notorious for being overlooked; know these injuries and be certain to identify or exclude them. 3) Certain ligamental avulsion of the digits are associated with characteristic deformities allowing a definitive diagnosis of the underlying abnormality. 4) Be aware of the potential for satisfaction of search and the potential of diagnostic oversights in certain injuries; once such an injury is noted look closely for the commonly associated injury. 5) When the clinical diagnosis is not apparent or uncertain on the initial radiographs, do not hesitate to obtain CT or MRI to confirm or exclude an injury.

RC804B  Avulsion Injuries of the Pelvis and Hip

Participants
Omer A. Awan, MD, Baltimore, MD (Presenter) Nothing to Disclose

ABSTRACT
n/a

RC804C  Knee

Participants
Thomas L. Pope, MD, Denver, CO (Presenter) Nothing to Disclose

For information about this presentation, contact:
thomaspopemd@gmail.com

LEARNING OBJECTIVES
1) Outline the spectrum of avulsive injuries in the pelvis and hip. 2) Delineate imaging characteristics of pelvic and hip avulsive injuries, with emphasis on radiography and MRI. 3) Elucidate practical and clinical applications to pelvic and hip avulsive injuries.

RC804D  Foot and Ankle

Participants
Zehava S. Rosenberg, MD, Hoboken, NJ (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) Familiarize the radiologist with radiographic findings of common avulsion injuries of the ankle and foot with emphasis on frequently missed entities. 2) Provide cross sectional imaging correlation for all the described entities. 3) Provide the radiologist with tools for distinguishing radiographic evidence of pathology from mimickers of disease.

Printed on: 10/29/20
Body CT Angiography: 2019 Update

Friday, Dec. 6 8:30AM - 10:00AM Room: E351

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

Participants
Alan H. Stolpen, MD, PhD, Iowa City, IA (Moderator) Nothing to Disclose
Gregory Kicska, MD, PhD, Seattle, WA (Moderator) Nothing to Disclose

For information about this presentation, contact:
alan-stolpen@uiowa.edu

Sub-Events

RC812A  Thoracic CTA

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

For information about this presentation, contact:
kicskag@uw.edu

LEARNING OBJECTIVES
1) Diagnosis of aortic dissection, intramural hematoma and aortic aneurysm. 2) To discuss imaging features that suggest prognosis in acute aortic syndromes. 3) To discuss common pitfalls in diagnosis.

RC812B  Abdominal CTA

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

For information about this presentation, contact:
Williamson.eric@mayo.edu

LEARNING OBJECTIVES
1) Identify common clinical indications for abdominal CT angiography, 2) Describe techniques for performing abdominal CTA, 3) Discuss how recent developments in CT have influenced these techniques and the resulting imaging findings.

RC812C  Peripheral CTA

Participants
Alan H. Stolpen, MD, PhD, Iowa City, IA (Presenter) Nothing to Disclose

For information about this presentation, contact:
alan-stolpen@uiowa.edu

LEARNING OBJECTIVES
1) Identify common clinical indications for peripheral CTA. 2) Describe protocols for performing and strategies for reviewing peripheral CTA. 3) Recognize a variety of vascular pathologies. 4) Understand the strengths, weaknesses and pitfalls of peripheral CTA.

Printed on: 10/29/20
International Symposium on Cardiothoracic Imaging

Friday, Dec. 6 8:30AM - 12:00PM Room: E353C

SPIS61A  Diffuse Lung Disease

Friday, Dec. 6 8:30AM - 9:20AM Room: E353C

Participants
Jeremy J. Erasmus, MD, Houston, TX (Director) Nothing to Disclose
Carol C. Wu, MD, Houston, TX (Director) Author, Reed Elsevier

For information about this presentation, contact:
carolcwu@gmail.com

LEARNING OBJECTIVES
1) Define the role of imaging in the diagnosis and characterization of cardiothoracic diseases. 2) Describe available advanced imaging techniques in the evaluation of cardiothoracic diseases.

Sub-Events

SPIS61B  Introduction to Idiopathic Pulmonary Fibrosis: What Radiologists Need to Know

Friday, Dec. 6 8:30AM - 9:20AM Room: E353C

Participants
Noriyuki Tomiyama, MD,PhD, Suita, Japan (Moderator) Nothing to Disclose
Santiago E. Rossi, MD, Buenos Aires City, Argentina (Moderator) Speaker, Boehringer Ingelheim GmbH; Speaker, Novartis AG

For information about this presentation, contact:
santirossi@cdrossi.com

LEARNING OBJECTIVES
1) To introduce most common imaging features of ILD. 2) To introduce ATS / ERS / JRS /ALAT guidelines.

SPIS61C  Imaging Diagnosis of Idiopathic Pulmonary Fibrosis: Status and Challenges

Friday, Dec. 6 8:30AM - 9:20AM Room: E353C

Participants
Qihang Chen, MD, Beijing, China (Presenter) Nothing to Disclose

LEARNING OBJECTIVES
1) To compare the white paper of the Ferschner society with ATS/ERS/JRS/LATA guidelines. 2) To differentiate the honeycomb and mimic honeycomb. 3) To introduce the status of diagnosis of IPF in China.

SPIS61D  Staging and Prognostication of Idiopathic Pulmonary Fibrosis

Friday, Dec. 6 8:30AM - 9:20AM Room: E353C

Participants
Nicola Sverzellati, MD, Parma, Italy (Presenter) Consultant, PAREXEL International Corporation; Consultant, Biomedic System; Consultant, F. Hoffmann-La Roche Ltd; Consultant, Boehringer Ingelheim GmbH; Consultant, Galapagos; Advisory Board, F. Hoffmann-La Roche Ltd; Advisory Board, Boehringer Ingelheim GmbH; Speaker, F. Hoffmann-La Roche Ltd; Speaker, Boehringer Ingelheim GmbH;

LEARNING OBJECTIVES
1) To understand the most accurate visual and computer-based CT indexes for IPF staging and prognostication. 2) To describe some of the current technologies and cutting edge perspective for objective quantification of IPF on CT.

SPIS61E  Quantitative Assessment of Interstitial Lung Disease on CT


LEARNING OBJECTIVES

1) To understand why quantitative assessment of interstitial lung disease on CT is necessary. 2) To know the basic technical concept of various software methods for quantification of interstitial lung disease. 3) To acknowledge the potential clinical values of using quantitative imaging biomarkers in practice.

SPIS61F Lung Nodules and Cancer

Participants
Joon Beom Seo, MD, PhD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose
For information about this presentation, contact:
joonbeom.seo@gmail.com

LEARNING OBJECTIVES

1) Compare and contrast lung cancer screening strategies in the United States and Asia. 2) Describe the role of computer softwares, CT and MRI in the detection and characterization of lung nodules.

SPIS61G Lung Cancer Screening in the US

Participants
Carol C. Wu, MD, Houston, TX (Presenter) Author, Reed Elsevier
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carolcwu@gmail.com

LEARNING OBJECTIVES


SPIS61H Lung Cancer Screening in Asia

Participants
Yeun-Chung Chang, MD, Taipei, Taiwan (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the incidence and some screening programs of lung cancer in Asia. 2) To know the characteristic CT findings of screen detected lung cancer in Asian and how it is managed.

ABSTRACT

Lung cancer is the leading cause of cancer death worldwide so does it in Asia. There is a much higher prevalence of epidermal growth factor receptor (EGFR) mutation, predominantly among patients with adenocarcinoma and never-smokers. Some reports of lung cancer screening in Asia show a cancer detection rate about 1.0-2.5% in Asia. CT characteristic of lung cancer with EGFR mutation and clinical management of the screen detected lung cancer in Taiwan will be described.

Active Handout: Yeun-Chung Chang

SPIS61I Pulmonary Nodules: Impact of Computer Support

Participants
Cornelia M. Schaefer-Prokop, MD, Amersfoort, Netherlands (Presenter) Researcher, Thirona; Researcher, Varian Medical Systems, Inc; Spouse, Speaker, Bracco Group; Spouse, Speaker, Bayer AG; Spouse, Speaker, Canon Medical Systems Corporation; Spouse, Speaker, Siemens AG; Spouse, Research support, Siemens AG; Spouse, Research support, Canon Medical Systems Corporation; Spouse, Researcher, Thirona; Spouse, Researcher, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) To learn about available computer tools for detection and characterization of pulmonary nodules. 2) To understand the potential but also shortcomings of current computer tools for nodules. 3) To learn about various models for malignancy risk assessment and how they are implemented in computer tools.

SPIS61J Role of PET and MRI for Lung Nodule Characterization
LEARNING OBJECTIVES

1) To deliver the updates of PET, PET/CT and MRI for lung nodule characterization and management of pulmonary nodule.

ABSTRACT

In this lecture, I will talk about 1) lung nodule detection capability, 2) morphological evaluation of lung nodule characterization and 3) quantitative potential for lung nodule characterization on PET, PET/CT and MRI. I hope this lecture will contribute your daily clinical practice.

SPIS61K  Infection
Friday, Dec. 6 10:25AM - 11:10AM Room: E353C

Participants
Tomas C. Franquet, MD, Barcelona, Spain (Moderator) Nothing to Disclose
Joannis Vlahos, MRCP, FRCR, Houston, TX (Moderator) Director, Grayscale Ltd; Co-owner, Grayscale Ltd

LEARNING OBJECTIVES

1) To become familiar with the variable imaging findings related to CAP. 2) To discuss the role of HRCT in the diagnosis of CAP. 3) To discuss a general approach to CAP diagnosis using the predominant imaging pattern.

ABSTRACT

Community-acquired pneumonia refers to an acute infection of the lung in patients who did not meet any of the criteria for HCAP and associated with at least some symptoms of acute infection, accompanied by the presence of an acute infiltrate on a chest radiograph. Chest radiography remains an important component of the evaluation of patient with a suspicion of pneumonia, and usually is the first examination to be obtained. The diagnosis of CAP is based on the presence of select clinical features and is supported by imaging of the lung, usually by chest radiography. Infection of the lower respiratory tract typically presents radiologically as one of three patterns: a) focal nonsegmental or lobar pneumonia, b) multifocal bronchopneumonia or lobular pneumonia, and c) focal or diffuse 'interstitial' pneumonia. Bacterial and viral micro-organisms are the most common etiologic agents responsible for CAP. Identification of causative micro-organisms in CAP remains challenging and in 30% to 65% of cases.

SPIS61T  Thoracic Manifestations of HIV Infection
Friday, Dec. 6 10:25AM - 11:10AM Room: E353C

Participants
Hongjun Li, Beijing, China (Presenter) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the imaging characteristics of HIV infection related thoracic manifestations. 2) To emphasize the importance and urgency in medication of HIV related thoracic manifestations. 3) To introduce the research development of HIV infection pulmonary disease.

ABSTRACT

Pulmonary lesions in HIV/AIDS patients are most common with opportunistic infections and tumors. Pulmonary infection is a common complication and cause of death in HIV/AIDS patients. The pathogens mainly include Pneumocystis jirovecii, Cryptococcus, Mycobacterium tuberculosis and so on. Imaging findings are varied and nonspecific. HIV/AIDS complicated with Pneumocystis pneumonia is typically characterized by a frosted glass-like shadow symmetrically distributed around the hiliar; pulmonary cryptococcosis is characterized by a single, multiple nodule or mass near the pleura with wide base. The nodule cavity is a characteristic CT manifestation of pulmonary cryptococcosis. The imaging patterns of tuberculosis in HIV-infected patients are upper lung consolidation and multiple nodules, which may cavitate. Centrilobular nodules are presented in endobronchial spread of tuberculosis. Kaposi sarcoma (KS) is the most common AIDS-defining malignancy. A characteristic CT finding in AIDS-related KS is the presence of bilateral and symmetric ill-defined nodules in a peribronchovascular distribution (flame-shaped lesions) and ground-glass opacities may be seen surrounding the nodules. AIDS-related lymphoma is another common malignancy in HIV infected patients. Compared to KS, it is peripheral and air-bronchograms can be seen with unusual cavitation. Imaging examination is a powerful and effective tool of examination for AIDS-related lung lesions. The diagnosis combined with clinical and laboratory tests
is helpful to medical treatment.

**Pulmonary Tuberculosis and Nontuberculous Mycobacterial (NTM) Infection: An Overview**

Friday, Dec. 6 10:25AM - 11:10AM Room: E353C

Participants
Kyung S. Lee, MD, PhD, Seoul, Korea, Republic Of (Presenter) Nothing to Disclose

For information about this presentation, contact:
kyungs.lee@samsung.com

**LEARNING OBJECTIVES**

1) To deliver the updates in pulmonary tuberculosis and nontuberculous mycobacterial (NTM) pulmonary infection in terms of pathogenesis and imaging findings.

**ABSTRACT**

In this overview of pulmonary tuberculosis and nontuberculous mycobacterial (NTM) infection, this speaker will talk about 1. Mode of tuberculous pulmonary infection, 2. Identification of latent tuberculous infection, 3. Serial CT features in primary multidrug-resistant pulmonary tuberculosis, 4. Prevalence of nontuberculous mycobacterial (NTM) infection in US and Canada, 5. Clinical and radiological findings of Mycobacterium avium-intracellulare (MAC) infection, 6. Natural course of MAC pulmonary infection, 7. Chronic pulmonary aspergillosis in NTM infection.

**Cardiovascular Imaging**

Friday, Dec. 6 11:15AM - 12:00PM Room: E353C

Participants
Yung-Liang Wan, MD, Tao-Yuan, Taiwan (Moderator) Nothing to Disclose
Marie-Pierre Revel, Paris, France (Moderator) Nothing to Disclose

For information about this presentation, contact:
ylw0518@CGMH.ORG.TW

**LEARNING OBJECTIVES**

1) The learn the CT features of aortic intramural hematoma. 2) The learn the types of focal contrast enhancement in the hematoma and their differential prognosis impacts. 3) The learn the CT predictors of poor prognosis of aortic intramural hematoma.

**ABSTRACT**

Aortic intramural hematoma (AIMH) is one major component of acute aortic syndrome, esp. in Asia. We will review the CT characteristic of AIMH, including the inframural focal contrast enhancement. Two types of the intramural lesions will be introduced. One is ulcer-like projection, one is intramural blood pool. Their prognosis is different. We will also review the prognosis predictor of AIMH, and the nature course of the AIMH on the follow-up CT.

**Role of CT in Pulmonary Hypertension**

Friday, Dec. 6 11:15AM - 12:00PM Room: E353C

Participants
Marie-Pierre Revel, Paris, France (Presenter) Nothing to Disclose

For information about this presentation, contact:
marie-pierre.revel@aphp.fr

**LEARNING OBJECTIVES**

1) Detect CT signs of pulmonary hypertension. 2) Identify CT features suggesting a thromboembolic origin. 3) Differentiate the various causes of pulmonary hypertension on CT.

**ABSTRACT**

CT allows depicting pulmonary hypertension (PH), helps identifying its cause and therefore plays a crucial role in the diagnostic work-up of PH. CT features of pulmonary hypertension include dilatation of the main pulmonary artery, with a diameter greater than or equal to 29 mm, a ratio to the aortic diameter greater than 1:1 and a segmental artery-to-bronchus ratio greater than 1:1 in at least three lobes. On ECT-gated CT, loss of pulmonary artery distensibility with a cut-off value of 16.5% has 86% sensitivity and 96% specificity. CT is especially useful for detecting signs of chronic thromboembolic pulmonary hypertension, that must be recognized and distinguished from idiopathic pulmonary artery hypertension. These signs include wall adherent thrombi, bands webs or chronic arteri occlusion, mosaic perfusion and systemic collateral supply. Signs of pulmonary edema, such as thickening of the interlobular septa, centrilobular ground glass, mediastinal lymph node enlargement and plural effusion are seen on CT in PH due to venoocclusive disease, left heart diseases or fibrosing mediastinitis. Signs of lung parenchyma diseases can be identified on CT. PH
is a late complication in patients with lung fibrosis, sarcoidosis or COPD but may affect systemic sclerosis patients with limited lung parenchyma involvement. Congenital cardiac abnormalities with untreated right-to-left shunting resulting in Eisenmenger syndrome can also be identified, especially ventricular septal defect. Conversely, signs of peripheral arteriovenous shunting in hepatopulmonary syndrome are more difficult to assess.

**Comprehensive Multi-chamber Cardiac Function Evaluation by CT**

Friday, Dec. 6 11:15AM - 12:00PM Room: E353C

Participants
Jongmin J. Lee, MD, PhD, Daegu, Korea, Republic Of (Presenter) Nothing to Disclose

**LEARNING OBJECTIVES**

1) The global cardiac function depends on four cardiac chambers’ function and their interactions. 2) Left and right ventricular function evaluation by cardiac CT has been validated favorably. 3) Three or four chamber function evaluation techniques are developed and equipped in available image-processing workstations. 4) In cardiac CT with retrospective ECG-gating, multi-chamber function evaluation supports comprehensive cardiac evaluation.

**ABSTRACT**

By evaluating the adjacent cardiac chambers, more reliable information about single chamber function and inter-related compensatory functional mechanism may be acquired. Based on cardiac CT data with multi-phase reconstruction, morphological image markers are useful for evaluating the levels of the preload, inotropy, and afterload in each cardiac chamber as well as the global multi-chamber cardiac function. In the clinical practice, the inotropic function and the afterload of left ventricle are major concerns. The left ventricular ejection fraction and the cardiac output are good markers for the inotropy. The left ventricular end-systolic volume, the peripheral vascular resistance, and the aortic distensibility are useful markers for the afterload of left ventricle. The second major concern may be the afterload of right ventricle, which can be evaluated by the right ventricular end-systolic volume, the pulmonary vascular resistance, and the structural deformations. As we have been aware through multinational cohort studies, the left ventricular function and volume with cardiac CT improves risk stratification and identification of patients at risk for incident mortality. The left ventricular function has been recognized a representative cardiac function in academic and practical fields. However, the global cardiac function should depend on four cardiac chambers’ function and their interactions. For example, in a case with systemic hypertension, left ventricular concentric remodeling with accentuated left atrial late contraction and normal right ventricular function can be depicted in cardiac CT function study. This case suggests an early-stage hypertensive heart disease with compensated global cardiac function during resting state by left atrial inotropy. If the information about the cardiac function and the chamber volume could be acquired additionally on the CT coronary angiography in cases with retrospective ECG-gating, it may be useful for clinical management of diverse cardiac diseases including ischemic heart disease, essential or secondary cardiomyopathies, and heart failure. In this lecture, we will discuss about background concept of multi-chamber cardiac functions, image-based parameters for the comprehensive cardiac function, and clinical application of this methodology.

**Active Handout:** Jongmin John Lee


Printed on: 10/29/20
CONCLUSION

Our proposed deep learning model yields better metal artifact reduction performance than other state-of-the-art methods and can be applied in the real world.

Background

Metallic implants cause severe streak and beam hardening artifacts in CT scans. Traditional methods, like linear interpolation (LI) and NMAR, inpaint affected sinogram to reduce artifact, but induce secondary artifacts or suffer from false tissue segmentation. Recently, deep learning based method, cGan-CT, tries to reduce artifacts in image domain but the effect is limited. Here, we propose a Dual-Domain Network (DuDoNet) and demonstrate its application to clinical data.

Evaluation

DuDoNet consists of a sinogram enhancement network (SE-Net), a differentiable Radon inversion layer (RIL) and an image enhancement network (IE-Net). The SE-Net learns to restore sinogram data via a mask pyramid U-Net. RIL reconstructs images from sinograms and allows joint learning of the two networks. The IE-Net further refines the images by a U-Net with residual learning. The learning of DuDoNet, which takes metal affected sinograms and corresponding metal traces as inputs, is supervised with clean sinograms and images. We synthesize 360,000 training and 2,000 validation samples based on DeepLesion. In synthesized data, DuDoNet restores the most details among all methods, with a PSNR of 32.29dB and a SSIM of 0.959. Our model successfully reduces the streak and shadowing artifacts and alleviates drawbacks of single domain methods. Then, DuDoNet trained on simulated data is applied to a total of 100 clinical images from DeepLesion and SpineWeb. Visual comparison shows that DuDoNet effectively suppresses the secondary artifacts and avoids false structural segmentation problem in prior based methods. Blinded qualitative evaluation by radiologists shows DuDoNet achieves the best performance (rank: 3.13) and significantly outperforms LI, NMAR, cGan-CT (p<0.028).

Discussion

In DuDoNet, SE-Net first recovers inconsistent sinograms and IE-Net further reduces secondary artifacts. Our model effectively reduces metal artifacts in both simulated and clinical scans and achieves better image quality than other single domain approaches.
PURPOSE
Moving, high-density objects in the heart, including catheters and pacemaker leads, cause substantial artifacts in cone beam CT (CBCT) images. The purpose of this work was to exploit a deep learning method to efficiently segment and remove these objects from projection rotational angiography (RA) images, thereby reducing artifacts in cardiovascular CBCT images.

METHOD AND MATERIALS
Segmentation of the high-density objects from the RA images was performed using a deep convolutional neural network with an encoder-decoder architecture based on the VGG-16 network. Synthetic training (3,000) and validation (2,000) images were created by adding augmented RA images of a pigtail catheter to RA images of an anthropomorphic phantom acquired with a clinical angiography system. The model trained with the synthetic images was then used as a starting point to learn to label pacemaker leads and different types of catheters in two real patient data sets. The new image set consisted of 450 and 50 RA images in total for training and validation, respectively. Data was augmented by reflection, translation, size scaling, rotation, and noise addition in both image sets. To remove high-density object artifacts, the segmented image pixels were inpainted by solving the Dirichlet boundary value problem. Correlated Poisson noise was then added to the inpainted pixels to match image texture. The original and modified RA images were reconstructed using filtered back-projection to create CBCT images.

RESULTS
Training for the synthetic and patient images took 25 and 2 hours, respectively. A Sørensen-Dice coefficient of 80.8% and 75.6% was obtained for each set, respectively. These values are partly explained by the model output which extended modestly beyond the edges of the ground truth representation of the objects. Visual inspection of the resultant patient CBCT images demonstrated that artifacts associated with moving catheters and pacemaker leads were nearly completely resolved without introduction of other image defects.

CONCLUSION
A deep learning method to segment catheters and pacemaker leads in projection RA images of the heart was implemented and used to mitigate associated artifacts in CBCT images of the heart.

CLINICAL RELEVANCE/APPLICATION
This work demonstrates a deep learning segmentation method to mitigate the artifacts caused by moving high-density objects in the heart, thereby providing substantially improved CBCT images.
Quantitative analysis of GSI MAR indicated an improvement of image quality across all energy levels. Lowest noise was found at higher energy levels and highest CNR and SNR was found at lower energy levels. Furthermore, subjective review indicated that MAR reconstructions provided higher quality images. Finally, GSI MAR was found to improve iodine concentration estimation.

CLINICAL RELEVANCE/APPLICATION

Dental artifact remains a significant challenge on neck computed tomography. This study evaluates the effectiveness of a novel metal artifact reduction algorithm.

SST09-04  CT Image Quality for Five Different Metal Artifact Reduction Algorithms

Friday, Dec. 6 11:00AM - 11:10AM Room: E351

Participants
Mercy Victoria Kataike, Oslo, Norway (Abstract Co-Author) Nothing to Disclose
Matt Whitaker, Salem, NY (Abstract Co-Author) Employee, Image Owl, Inc
Hilde K. Andersen, MSc, Oslo, Norway (Abstract Co-Author) Nothing to Disclose
Caroline Stokke, PhD, Oslo, Norway (Abstract Co-Author) Nothing to Disclose
Anne C. Martinsen, Oslo, Norway (Presenter) Nothing to Disclose

PURPOSE

To evaluate the effectiveness of five CT Metal Artifact Reduction (MAR) Algorithms from four vendors in improving the image quality using a novel phantom for Metal Artifact Analysis.

METHOD AND MATERIALS

A Catphan 605 phantom with extension ring was scanned with different inserts (Hard Steel, Titanium, and Water) on 5 CT scanners reconstructed with and without MAR algorithms. The MAR algorithms used; GSI MAR (GE Revolution CT), Smart MAR (GE Revolution Frontier), O-MAR (Philips Ingenuity CT), iMAR (Siemens Somatom Drive) and SEMAR (Toshiba Aquilion One Genesis). Phantom was scanned at 120kV and at 120 kVp equivalent for GSI MAR and iMAR. Image quality was assessed by obtaining Contrast to Noise Ratio (CNR), Metal Artifact Analysis and Noise Power Spectrum (NPS). The parameters were obtained from ImageOwl Catphan QA software and Matlab.

RESULTS

For Titanium, Smart MAR, IMAR and SEMAR images had more noise than the images without MAR algorithms, while GSI MAR and O-MAR images had less noise than the images without MAR. MAR images had a lower CNR than the corresponding images without MAR, except GSI MAR images which had higher CNR than the images without MAR. For water, there was no difference in CNR for images with and without MAR, except IMAR and SEMAR. Metal Artifact Analysis showed artifact reduction around the insert and at a distance from the insert for all MAR algorithms in like manner. For titanium, GSI MAR showed the largest artifact reduction (87%, 73% respectively) followed by Smart MAR, SEMAR, O-MAR and IMAR. For hard steel, Smart MAR showed the largest artifact reduction (92%, 82%) followed by GSI MAR, SEMAR, IMAR, and O-MAR. There was no difference in NPS with and without MAR.

CONCLUSION

GSI MAR showed the most consistent performance under different conditions. Different MAR algorithms compensate differently for metal artifacts under different conditions. Thus, it is important to know the effects of the algorithms on image quality. Images obtained with MAR algorithms should be compared with those without MAR algorithms.

CLINICAL RELEVANCE/APPLICATION

Different MAR algorithms compensate for metal artifacts differently under different conditions. Thus, it is important to know the effects of the algorithms on image quality.

SST09-05  Image Quality Assessment of Metal Artefact Reduction in CT Using a Novel Abdominal Phantom

Friday, Dec. 6 11:10AM - 11:20AM Room: E351

Participants
Mercy Afadzi, PhD, Oslo, Norway (Presenter) Nothing to Disclose
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PURPOSE

To evaluate a novel anthropomorphic abdominal phantom specially designed for qualitative and quantitative metal artefact assessment in CT for two different metal artefact reduction technologies.

METHOD AND MATERIALS

A anthropomorphic abdominal phantom with different inserts (bone with metal, low contrast, spatial resolution and homogeneity) was used in this study. Titanium, Hard and stainless steel inserts were placed in the center of the bone insert. All scans were performed on a GE Revolution CT at 15 and 20 mGy CTDIvol, 40 mm collimation, 120 kVp (+/- HiRes) and spectral imaging (GSI). Images were reconstructed with standard kernel, 2.5 mm slices, ASIR-V 50% and +/- MAR. Four observers evaluated lesion conspicuity and scored artefacts on a 4-point scale for all reconstructions. HU uniformity, coefficient of variation, reduction in noise, range and standard deviations (SD), noise power spectrum (NPS) and modulation transfer function (MTF) were evaluated for all reconstructions.

RESULTS

Preliminary quantitative and qualitative results showed that both single energy MAR (SMAR) and GSI MAR (GSIMAR) reduced streaks artefacts surrounding (2123-7019 vs 1267-5993 HU) and at a distance (196-251 vs 78-83 HU). Lesion conspicuity was not affected by MAR. HU uniformity and SD around the metals (223.08-438.76 vs 105.02-260.75 HU) and the bone insert (SD: 71.48 - 143.17 vs 39.59 - 69.97 HU) were improved by the use of both SMAR and GSIMAR. These improvements were independent of dose. The use of only HiRes without MAR did not reduce streaks artefact, noise or HU uniformity. MAR hardly affected the MTF@50%. NPS profile...
was not affected by MAR.

CONCLUSION

Both SMAR and GSIMAR reduced metal artefact and improved image quality. Anthropomorphic phantom designed for qualitative and quantitative image quality analysis evaluation of metal artefact reduction should be used to assess image quality and lesion detection when MAR is introduced in daily routine to ensure that pathology is not missing after MAR has been applied.

CLINICAL RELEVANCE/APPLICATION

New anthropomorphic phantom specially designed for qualitative and quantitative assessment of metal artefact reduction in CT is important to ensure that pathology is not missing when MAR is applied.

SST09-07  Reduction of Cone-Beam Artifacts in Axial CT Systems with Large Detector Coverage

Friday, Dec. 6 11:20AM - 11:30AM Room: E351

Participants
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PURPOSE

We report cone-beam artifact reduction on axial scans with a 16cm coverage CT system using a recursive application of 3D filtered backprojection (FBP).

METHOD AND MATERIALS

Axial CT for voxels outside the acquisition plane does not satisfy a fundamental completeness condition, which leads to cone-beam artifacts. This is particularly evident in systems with large detectors. Previously published re-projection based recursive application of FBP was used to improve image quality in large pitch helical scans. We revisit this approach, apply it to the axial 3D FBP reconstruction and explain the effectiveness of the algorithm using a new argument based on the minimization of Bregman distances. The theoretical result is tested with analytic simulations and clinical data sets, reused from the previous clinical trials.

RESULTS

Recursive FBP algorithm reduced the low frequency artifacts in simulations effectively, returning images which are approaching the analytic ground-truth with every repeated recursive step. In clinical data, cone beam artifacts were considerably reduced with a more pragmatic combination of image processing and one recursive FBP application.

CONCLUSION

Bregman distance minimization algorithm leads to a previously known recursive 3D FBP algorithm, which proves to be effective for axial scans on systems with large detector coverage, offering a strong, new theoretical foundation for this algorithm. A pragmatic combination of recursive FBP with image processing returns high quality results from single-shot axial scans with improved bone clarity and more accurate CT numbers in the soft tissue.

CLINICAL RELEVANCE/APPLICATION

Cardiac scans can be performed within a single heartbeat using an axial CT with 0.25s rotation time and 16cm detector coverage. Tilted single shot axial head scanning ensures an efficient protection against excessive x-ray dose delivered to the eye lenses. Efficient reduction of cone-beam artifacts for both of these protocols is necessary.

SST09-07  Reduction of Artifact Caused by Embolization Coil Implant in Spectral CT Examination by Means of Virtual Monochromatic Imaging (VMI) and Monochromatic Imaging Combined with Metal Artifact Reduction Software (MARS)

Friday, Dec. 6 11:30AM - 11:40AM Room: E351

Participants
Zhipeng Yao, Beijing, China (Presenter) Nothing to Disclose
Yahui Peng, PhD, Chicago, IL (Abstract Co-Author) Nothing to Disclose

PURPOSE

To evaluate the reduction of artifact from embolization coil implant using VMI and VMI combined with MARs in spectral CT.

METHOD AND MATERIALS

Embolization coil implant was placed in an intermediate tube of the Quantitative Standard Pulsating Phantom (QSP) that contained an Iodine solution of 7 mgI/ml (CT value = 160HU at 120 kVp, representing the portal vein attenuation in the portal vein phase). Subsequently, 20 ml of sodium chloride solution was contained in eight tubes and inserted into the QSP. Two spectral CT scan protocols were used for image acquisition: conventional CT scan with tube voltage of 120 kVp (Group A); Spectral Imaging scan (Group B). A conventional image (CI) and virtual monochromatic images (70 - 140 keV, of 10 keV interval) with and without MARs were reconstructed, respectively. In each of the images, a measurement region of interest (ROI) was placed around the tube, including all pixels contaminated by the metal artifact but excluding the pixels inside the tube(ROItube). Besides, a background ROI was placed above the tube not influenced by the artifact,from where mean CT number(NCT) and standard deviation (SD) were measured. ΔCT was defined as the absolute value of NCT in hyperdense or hypodense artifact minus NCT in background ROI.

RESULTS

VMIMARs showed a significant decrease of hyperdense artifact (p<0.05) and hypodense artifact (p<0.05) in terms of lower ΔCT as compared to 120kVp imaging. With increasing of KeV, ΔCT and SD of artifact were decreasing in VMIMARs. In addition, noise image in VMIMARs exhibited a decreasing trend with increasing KeV level. Whereas VMI only showed a significant decrease of hypodense artifact (p<0.05). VMIMARs at 70 keV - 140keV could show a better effect on the reduction of metal artifact as compared VMI at 140keV(p<0.05).
CONCLUSION

Compared with conventional CT scanning, VMIMARs by using spectral CT could significantly reduce metal artifacts caused by embolization coil implants and provide better image noise.

CLINICAL RELEVANCE/APPLICATION

When using spectral CT for patients underwent Gastric coronary vein embolization (GCVE) procedure, VMIMARs could significantly reduce metal artifacts caused by embolization coil implants in portal vein phase.

SST09-08 Ability of a Single Adaptive Iterative Metal Artifact Reduction Algorithm to Improve CT Image Quality in Patients with Multiple Metal Implants

Friday, Dec. 6 11:40AM - 11:50AM Room: E351

Participants
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PURPOSE

To compare performance of a single, adaptive iterative metal artifact reduction (AiMAR) algorithm applied to an entire patient's CT exam to 7 anatomically specific iMAR presets, in patients with multiple metal implants.

METHOD AND MATERIALS

In 30 patients with 72 types of implants, CT images were reconstructed with different strength settings of a single AiMAR algorithm and 2-3 iMAR presets (selected for body part/implant). The AiMAR algorithm enables real-time image-based measurements to adapt the degree and level of artifact reduction. In separate sessions, 2 trained radiologists evaluated artifacts (0-5), visualization of critical anatomic structures (1-5) and diagnostic confidence (1-5) in the region of each implant, also assigning an overall 'whole body' image quality score (1-5), considering all evaluated regions, with lower values for all scales being better. The optimal AiMAR strength was determined by comparing whole body image quality scores with individual iMAR presets in each body region. Significance was tested by Wilcoxon Signed rank test for paired samples.

RESULTS

Optimized results using AiMAR were achieved using strength settings 4 and 5 for head&neck, thoracic and extremity areas (dental, neuro, cervical spine, shoulder, thoracic spine, cardiac, arms/elbow, legs/knee). For abdomen/pelvis (hip, lumbar spine), preferred AiMAR strengths varied between 2-5, with the lower strengths providing higher diagnostic confidence and the higher strengths providing better artifact reduction. AiMAR strength 5 setting was preferred over lower strengths (p<0.05) when evaluating whole body image quality scores. For every body region, AiMAR strength 4 and 5 settings demonstrated widely overlapping (p>0.05) diagnostic confidence, visualization and artifact performance with the dedicated anatomically specific iMAR presets (figure).

CONCLUSION

In patients with multiple metal implants, a strength based adaptive implementation of artifact reduction (AiMAR) permits a single reconstruction of the entire body that provides a diagnostic quality anatomic evaluation and metal artifact reduction of similar quality compared to multiple reconstructions using separate body part specific iMAR presets.

CLINICAL RELEVANCE/APPLICATION

AiMAR can dramatically improve clinical workflow by minimizing the need for body-part specific iMAR reconstructions without compromising image quality, diagnostic confidence or artifact reduction.

SST09-09 Reproducibility and Validity of Approaches for Artifact Quantification in CT Imaging

Friday, Dec. 6 11:50AM - 12:00PM Room: E351

Participants
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PURPOSE

To objectify metal artifact reduction, numerous methods and approaches have been suggested. We aimed to compare results of such methods to visual perception of artifacts in order to establish a standard for artifact quantification in CT imaging.
METHOD AND MATERIALS

Two titanium rods (5 and 10mm) were examined with 25 different scanning and image reconstruction parameters to obtain a reference database of different types and extents of artifacts. 4 radiologists separately evaluated every image against each other (2-pair forced choice) using an in-house developed software. Rating was repeated two times (2400 comparisons = 2 times x 4 readers x 300 comparisons). Rankings were combined to obtain a reference ranking reaching from best to worst image. Proposed approaches for artifact quantification have been identified in literature, including manual measurement of artifact attenuation, standard deviation and noise as well as sophisticated algorithm-based approaches within the image- and frequency-domain (ImgD and FreqD, respectively). Two radiologists conducted manual measurements twice while the aforementioned algorithms were developed within the Matlab-Environment allowing for automated image analysis. The reference ranking was compared to all aforementioned methods for artifact quantification to identify suited and less-suited approaches. Besides visual analysis, Kappa-statistics were used to evaluate agreement between quantitative methods and visual perception. Intraclass correlation coefficients (ICC) indicated intra- and interreader agreement.

RESULTS

Intra- and Interreader agreement of visual artifact perception were excellent (ICC 0.85-0.92). No quantitative method was able to represent the exact ranking of visually perceived artifacts; however, ICC for manual measurements were low (ICC 0,25-0,97). The methods that showed best correspondence and reproducibility were ImgD and FreqD-based.

CONCLUSION

Artifact quantification in CT is challenging. Manual measurements show a limited reproducibility. We propose two methods that quantify artifacts in the image- and frequency-domain and that correspond closely to visual artifact perception.

CLINICAL RELEVANCE/APPLICATION

Automated measurements of artifact extent should be preferred over manual measurements as they correspond close to visual perception while the latter show a limited reproducibility.