Physics and Basic Science

ED026

CME Learning Checkpoint Exhibit ED026 (HU Knew? What You Need to Know about kVp, CT Numbers, Dose and Their Relationships)

All Day Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

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PH001-EB-X

Convenient Measurement Method Using Small-type OSL Dosimeters for Evaluation of Doses in CT Scans: Uncertainty Evaluation, Entrance-skin Dose of Phantom, and Organ Dose of Cadaver

All Day Room: PH Community, Learning Center

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TEACHING POINTS

(1) The OSL dosimeter can be applied to measure the entrance-surface dose and the organ dose in X-ray CT examinations.(2) We found that accuracy of 25% should be added when OSL dosimeter was used to dose measurements in CT scans.

TABLE OF CONTENTS/OUTLINE

(1) AimsBecause the OSL dosimeter used in this research is small in size, when the dosimeters are attached to the patients, it should be considered that certain dosimeters are directly irradiated by the collimated X-ray beam and others are not.(2) ExperimentsFirst, we investigated the precision and accuracy of the OSL dosimeters as functions of “number of detectors (rows)” and “pitch factor” using a CT scanner. In this experiment, the true entrance skin doses (ESDs) and its distribution of a water phantom was measured with Gafchromic film.(3) Results & DiscussionWe estimated that OSL dosimeters can measure doses within an uncertainty of 25% for most irradiation conditions. Additionally, we demonstrated the application of dose measurements using the OSL dosimeters; 1) ESDs of a body phantom were measured, and 2) organ doses of a cadaver were directly determined for the first time. These data are valuable for the education of dose reductions. Our method using the OSL dosimeter is convenient, therefore everyone can share our results for improvement of clinical CT examinations.

PH002-EB-X

Universal Calibration Curve for a Small-type OSL Dosimeter to be Used for Direct Dose Measurements of Direct, Scattered and Penetrating X-rays in the Diagnostic Region

All Day Room: PH Community, Learning Center

Awards
Certificate of Merit

Participants
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TEACHING POINTS

(1) The OSL dosimeter can be used for air-kerma measurements of direct, scattered and penetrating X-rays, and the ESD (entrance-skin-dose).(2) Accuracy of the proposed method is estimated to be 15%.

TABLE OF CONTENTS/OUTLINE

(1) Aims:We hope to find a suitable dosimeter, which can measure incident, scattered and penetrating X-rays. In this study, we propose a new procedure to calibrate the OSL dosimeter.(2) Experiment & results:Initially, we constructed a calibration curve of air-kerma (direct X-rays) with comparison between the OSL dosimeter and an ionization chamber. Second, we evaluated the accuracy of the above calibration curve when the following conditions were applied; 1) entrance-skin dose, and 2) air-kerma of scattered X-rays and 3) penetrating X-rays through a soft-tissue equivalent phantom. We then found that the above calibration curve can be used in all situations if we adopt 15% of uncertainty. Finally, the X-ray spectra related to those conditions were measured, and with the data on basic characteristics of the dosimeter, the result of 15% uncertainty was verified mathematically. (3) Conclusion:With 15% uncertainty, we can use the OSL dosimeter without considerations of energy dependence, angular dependence etc. This study enabled the OSL dosimeter to manage the exposure dose of medical staff, assistants and patients.

PH003-EB-X

Application of K-Means Clustering to Categorize Pelvic DCE MRI

All Day Room: PH Community, Learning Center

Participants

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TEACHING POINTS

To show the potential diagnostic value of k-means clustering methodology in quantitative DCE-MRI assessment of pelvic cancers. How k-means clustering in DCE-MRI of prostate and bladder cancer helps visualize and characterize the heterogeneity of tumor tissues. That the quantification of tumor heterogeneity and microcirculatory characteristics may provide a substantial improvement in the assessment of treatment response and patient prognosis.

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k-means clustering is one of the most widely used analytical methods in general data mining however still underutilized in imaging. Quantification by voxel-wise pharmacokinetic parameters; Amplitude (Amp) and Exchange rate (kep) between extracellular-extravascular space and the plasma (EES). Feasibility of applying k-means clustering of two pharmacokinetic parameters derived from 3T DCE-MRI to: predict the chemotherapeutic response in bladder cancer and to assess prostate cancer (PCa) risk stratification using k-means clustering of Dynamic Contrast-Enhanced (DCE)-MRI pharmacokinetic parameters to classify microcirculatory characteristics at the voxel level and correlate those findings with Gleason Score (GS) and pathologic (P)-stage. Establishing this analysis tool as an exciting, promising methodology to analyze functional MRI to in oncologic imaging.

PH004-EB-X

Artifacts of Cone-Beam CT during interventional neuroradiology: Causes and Countermeasures

All Day Room: PH Community, Learning Center

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TEACHING POINTS

-To understand the causes of cone-beam CT (CBCT) artifacts, and how to counter them.-To understand the importance of artifact (especially ring artifact) reduction during CBCT.-To demonstrate the importance of pre-calibration in terms of reducing ring artifacts in CBCT.-To understand the importance of protecting the patient from exposure to scattered radiation during pre-calibration, aimed at reducing CBCT artifacts.

TABLE OF CONTENTS/OUTLINE

Various artifacts of CBCT during neurointerventionsRing artifacts, beam hardening; a bright spot; *etc.* ***Reducing typical artifacts of CBCT Dose to the patient during pre-calibration, aimed at reducing CBCT ring artifacts***Scattered radiation and the distribution thereof during pre-calibration were measured using an ion survey meter.The patient protection afforded by an additional lead-shielding device was evaluated. **OUTLINE:** Artifact reduction is very important, especially during interventional neuroradiology. A ring artifact is a typical CBCT artifact caused by non-uniform pixel gain and memory effects in the detector. To reduce ring artifacts, pre-calibration is necessary before the actual CBCT scan. However, the additional radiation dose to the patient cannot be ignored. An additional shielding device is very helpful in terms of patient protection during pre-calibration.

PH005-EB-X

Biomarkers in Molecular Imaging: Intrinsic Prognostic Markers in Monitoring Breast Cancer

All Day Room: PH Community, Learning Center

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TEACHING POINTS

The purpose of this exhibit is to
1. Review molecular in vivo methods2. Review Specific Tumor Component marker of spectroscopy: physics of signal development, biochemical explanations, application in breast imaging3. Review spectral methods in monitoring neoadjuvant chemotherapy: generation of scatter-corrected absorption spectrum, the wavelength dependent changes during chemotherapy, implications for prognosis

TABLE OF CONTENTS/OUTLINE

The purpose of this exhibit is to1. Review molecular in vivo methods: focus on absorption spectroscopy, fundamentals of light, derivation of tissue characterization, patterns of functional changes in normal/disease states2. Review the Specific Tumor Component-Explain mathematics for quantification of the Specific Tumor Component marker-Demonstrate selection of the wavelength regions-Review the index signal for normal/cancerous tissues-Describe clinical implications of quantification of functional changes3. Review spectral methods in monitoring neoadjuvant chemotherapy: -Show scatter corrected absorption spectrum-Demonstrate main points of wavelength specific spectral variation-Explain clinical correlation of tissue absorber during neoadjuvant chemotherapy-Describe clinical utility for prognosis4. Summary5. Future directions of molecular imaging in breast cancer

PH006-EB-X

How do you Determine the Echo Time When Calculation of Quantitative Susceptibility Mapping (QSM)?

All Day Room: PH Community, Learning Center

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TEACHING POINTS

The purpose of this exhibit is to learn that

1. It is important to know dependence of signal loss due to T_2* decay, corresponding to echo time (TE) and susceptibility of biomaterial.

2. Magnetic susceptibility have paramagnetic and diamagnetic characterization, i.e., these indicate positive and negative values, respectively.

TABLE OF CONTENTS/OUTLINE

-Aims
The aim of our study is to investigate the difference in magnetic susceptibility for various TEs.

-Method
On a 3.0 T MR system, we performed a phantom experiment. The phantom consisted of Gd-DTPA and hydroxyapatite samples which were made using three different concentrations of each. In order to investigate the difference in the magnetic susceptibility of each TE, multiple TEs were acquired and several TE datasets were made. Then, we analyzed with each dataset.

-Results
The TEs = 3.1, 7.5 and 11.9 ms datasets indicated highest positive linearity for the Gd-DTPA samples (slope = 0.244, R^2 = 0.998, P = 0.021). Moreover, the TEs = 3.1, 7.5 and 11.9 ms datasets indicated highest negative linearity for the hydroxyapatite samples (slope = -0.001, R^2 = 0.997, P = 0.035).

-Conclusion
QSM makes it possible to accurately calculation of magnetic susceptibility by using the appropriate TE

PH007-EB-X

Metal Artifact Reduction in CT: Projection-based Methods or Dual-energy Virtual Monochromatic Imaging?

All Day Room: PH Community, Learning Center

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TEACHING POINTS

PURPOSE/AIM OF THE EXHIBIT1) Describe two major types of metal artifact reduction (MAR) methods in CT.2) Illustrate benefits and pitfalls of the two types of MAR methods using phantom and patient examples.

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CONTENT ORGANIZATION1) Introduce basic principles of projection-based methods and dual-energy (DE) virtual-monochromatic imaging methods for MAR.2) Compare the two MAR methods and a combination of the two in hip, knee, shoulder, dental, and spine metal prostheses. 3) Discuss benefits and pitfalls of MAR methods in different clinical areas. CONCLUSION/SUMMARY1) The preferred MAR method depends on the metal prosthesis and clinical application.2) Current MAR methods are not perfect and careful consideration is needed to implement them effectively in practice.

PH100-ED-X

Not to be Confused with kVp and keV in CT Imaging

All Day Room: PH Community, Learning Center

Participants
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TEACHING POINTS

To explain the concept of peak tube voltage (kVp, in kilo volts) and photon energy (keV, in kilo electro volts) in CT imaging. To point out the differences and relationship between the two parameters To demonstrate strategies in selecting appropriate kVp and keV for CT imaging

TABLE OF CONTENTS/OUTLINE

1) Concept of kVp and keV in CT imaging kVp: peak tube voltage applied between anode and cathode in x-ray tube to produce a polychromatic X-ray spectrum keV: energy of a X-ray photon2) Differences and relationship between kVp and keV X-ray tube produces a polychromatic spectrum with the highest photon energy defined by kVp. Polychromatic x-ray beam causes beam hardening in CT (Virtual) monochromatic keV images may be synthesized in dual-energy CT to minimize beam hardening and improve contrast resolution an average energy (keV) may be calculated for polychromatic (kVp) X-ray spectrum and is object dependent3) Strategies in selecting appropriate kVp and keV for CT imaging select kVp based on patient size and clinical tasks: low kVp for enhancing contrast and high kVp for high dose efficiency and less beam hardening use the image selection flexibility in dual-energy CT: low energy for enhancing contrast; high energy for less beam hardening and optimal energy for best CNR and image quality

PH102-ED-X

Clinical Applicability of Low B-value Diffusion Weighted Imaging Based on Field-of-view Optimized and Constrained Undistorted Single Shot as Flow Cine Magnetic Resonance Imaging

All Day Room: PH Community, Learning Center

Awards
Identified for RadioGraphics

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TEACHING POINTS

Diffusion-weighted imaging (DWI) provides signal proportional to the water molecular diffusion. Therefore, it means the extreme water motion-sensitive imaging. Currently, in order to obtain DWI, the single-shot echo-planar–imaging (SS-EPI) sequence is the most-used sequence. However, SS-EPI is highly prone to a susceptibility artifact and distortion image. The aim of this presentation is to show the clinical applicability of the flow cine imaging by low-b DWI magnetic resonance imaging based on field-of-view (FOV) optimized and constrained undistorted single shot (FOCUS).

TABLE OF CONTENTS/OUTLINE

1. Clinical finding in low b-value DWI 2. Theory of diffusion 3. Basic principles of FOCUS 4. Comparison of FOCUS with conventional DWI 5. Optimal FOCUS parameters 6.Clinical applications 7. Flow analysis 8. Conclusions

PH104-ED-X

A Pictorial Review of Digital Radiography Artifacts

All Day Room: PH Community, Learning Center

Awards
Cum Laude
Identified for RadioGraphics

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TEACHING POINTS

Along with the technological advances in flat panel detector radiography come new and unique image artifacts. This exhibit will present a series of digital radiographic images with identified artifacts to allow the reader to: 1) identify artifacts and circumstances that resulted in their appearance, 2) learn about the cause of the artifact and 3) understand methods to eliminate the artifact and improve image quality.

TABLE OF CONTENTS/OUTLINE

Artifact classification will be reviewed with sample clinical and quality control (QC) images, each including the artifact description, cause and resolution.1) Technologist error artifacts: wireless digital cassette drops, backscatter. 2) Equipment defect artifacts: inverse focal spot artifacts, tether connector defects, temperature variation, detector surface flaws. 3) Gain calibration errors: x-ray field not cleared, calibration conditions not matching clinical conditions. 4) Signal transmission artifacts: detector impact during readout. 5) Post-processing artifacts: grid removal software errors. 6) Technique selection errors: detector signal saturation, underexposure artifacts.

PH105-ED-X

Review of Virtual Nonenhanced Images Generated from Spectral Imaging in Abdominal CT and Clinical Application

All Day Room: PH Community, Learning Center

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TEACHING POINTS

To review the principle of different types of virtual nonenhanced(VNE) images derived from spectral CT and their advantages and disadvantages
To illustrate common evaluation parameters of VNE images and comparison with true nonenhanced(TNE) images
To demonstrate performance of these VNE images applied in abdominal CT by presenting clinical images

TABLE OF CONTENTS/OUTLINE

1. Different types of VNE images derived from spectral imaging water based image: acquired by water-
iodine material decomposition of spectral imaging and is sensitive in detecting urinary stone, but the unit of mg/mL is different from common Hounsfield units(HU)
140 keV monochromatic images: can reduce image noise and beam hardening artifact(metal implant and stent), the iodine subtracting is incomplete
material suppressed iodine(MSI) images: generated from 70 keV monochromatic image by suppressing iodine, has good subjective image quality and can provide CT number with HU
2. Common evaluation parameters of VNE images and comparison with TNE images subjective image quality
CT attenuation number and relative enhancement value of various regions image noise, SNR and CNR lesions detection rate and diagnosis accuracy 3.
Clinical applications of all kinds of VNE images in abdominal CT benign tumor malignant tumor liver metastasis and lymph node metastasis stone

PH106-ED-X

Need for Speed: A Beginner's Guide of Compressed Sensing for Radiologists

All Day Room: PH Community, Learning Center

Awards
Certificate of Merit

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TEACHING POINTS

The aims of this presentation are (1) to describe the basic principles of compressed sensing (CS), (2) to illustrate the sampling strategy and the reconstruction process, and (3) to show examples of CS images comparing with those of the conventional techniques, such as parallel imaging, partial Fourier or view sharing.

TABLE OF CONTENTS/OUTLINE

INTRODUCTION: Compressed sensing (CS) is a novel method for fast acquisition, recovering an accurate image from reduced measurements based on the reasonable assumption that images can be sparsely represented using appropriate encodings. Its applications are rapidly prevailing in medical imaging. However, its details are somewhat complex for radiologists. We will describe concisely the basics of CS related especially to MRI. SAMPLING STRATEGY: Patterns of k-space sampling is an important key factor of CS. We illustrate the difference between CS and other fast acquisition techniques, and a CS implementation to improve temporal resolution. RECONSTRUCTION: Another key is a non-linear reconstruction. Although the knowledge about reconstruction is technical and not directly useful for clinical practice, it will help us to understand imaging features and artifacts. CLINICAL APPLICATIONS: We will discuss features and advantages of CS with showing examples of the brain and body imaging of healthy volunteers and patients.

PH107-ED-X

Can Size-Specific Dose Estimates (SSDE) be Regarded as the Preferred Dose Index for the Detectability in Lung Cancer CT Screening?

All Day Room: PH Community, Learning Center

Awards
Certificate of Merit

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TEACHING POINTS

The purpose of this exhibit is: 1) To summarize the characteristic of the image quality and radiation doses at the level of apex, bifurcation and base for patients. 2) To show the differences among dose indices of CTDIvol, SSDE evaluated according to AAPM Report No. 204 and No. 220, respectively. 3) To evaluate absorbed doses at the level of apex, bifurcation and base based on Monte Carlo simulation. 4) To indicate the relationship between the absorbed doses and the dose indices from a lung cancer CT screening exam.

TABLE OF CONTENTS/OUTLINE

1. Background: Image quality (IQ) and radiation dose in low dose lung cancer screening CT (LCS)2. Effects of patient size on dose and image quality: Illustration of how IQ and the dose of CT change with image location within the chest (apex, mid-lung, base) Examples of how the size and shape of chest varies greatly within and among patients.3. Dose Descriptors in the context of LCS Illustration of differences in dose indices such as: CTDIvol which is standardized in IEC. SSDE220 reflects the size which accounts for attenuation Monte Carlo simulation-based estimates of dose Differences between SSDE220 and lung dose from Monte Carlo simulations.4. Image Quality and Dose Evaluations The role of Contrast to Noise Ratio and Image Noise Tradeoffs in dose and IQ metrics

PH108-ED-X

Non-enhanced MR Bone Angiography Vulnerable to Avascular Necrosis

All Day Room: PH Community, Learning Center

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TEACHING POINTS

1. To visualize typical extraosseous arterial sources and intraosseous small blood supply of susceptible bones vulnerable to avascular necrosis (AVN) by use of non-enhanced MR angiography.2. To understand those unique structures and pathological conditions.

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A. Visualization of typical extraosseous and intraosseous MR angiography (MRA) on susceptible bones vulnerable to AVN by use of non-enhanced MRA, such as a time-spatial labeling inversion pulse (time-SLIP) and a free-ECG-gating Flow-Sensitive Black Blood (FSBB) techniques.1. Femoral head MRA of the circumflex femoral artery as typical extraosseous arterial sources and the retinacular arteries as intraosseous blood supply.2. Scaphoid bone MRA of the radial carpal artery as typical extraosseous arterial sources and its intraosseous vessels.3. Talus bone MRA of the posterior tibial artery, dorsalis pedis artery or perforating peroneal artery as typical extraosseous arterial sources and its intraosseous vessels.B. MRA of osteoarthritis related with a congenital dislocation of the hip

PH109-ED-X

Case-based Approach to Understanding MRI Artifacts

All Day Room: PH Community, Learning Center

Awards
Identified for RadioGraphics

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TEACHING POINTS

Recognize MRI artifacts in common clinical scenarios Understand clinical causes of MRI artifacts and pitfalls in interpreting MRI images due to artifacts Learn ways to remedy MRI artifacts

TABLE OF CONTENTS/OUTLINE

Introduction of MRI physics Overview of different categories of MRI artifacts Clinical cases depicting common MRI artifacts Discuss ways to remedy MRI artifacts

PH111-ED-X

Current and Novel Techniques for Metal Artifact Reduction in Computed Tomography: A Practical Guide for Clinicians

All Day Room: PH Community, Learning Center

Awards
Certificate of Merit
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TEACHING POINTS

*Understand the mechanisms of metal artifact generation.*Know the basics of state-of-the-art artifact reduction techniques, namely, the dual energy CT (DECT) technique and the projection-based metal artifact reduction (MAR) technique.*Acknowledge the difference in their effects on various metallic hardware and iodine contrast.*Learn the optimal method for metal artifact reduction in various clinical situations.

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Why do metal artifacts occur? partial volume effect photon starvation beam hardening aliasing**How do you suppress metal artifacts?** imaging parameter adjustment (peak voltage, tube charge, collimation, section thickness) use of dual energy CT (DECT) techniques (monochromatic imaging) use of projection-based metal artifact reduction (MAR) algorithms**DECT and projection-based MAR techniques, how do they differ?** effects on different metallic hardware composition (aluminum, titanium alloy, cobalt-chrome alloy, brass, platinum) effects on iodine contrast enhancement (contrast-to-noise ratio)**How do these techniques affect diagnosis in clinical cases?** deep venous thrombosis, s/p total knee arthroplasty deep femoral abscess, s/p total hip arthoplasty cerebral aneurysm, s/p endovascular coiling interpretation pitfalls and limitation to the diagnosis

PH112-ED-X

How to Demonstrate Equivalence/Non-inferiority between Two Systems in ROC/FROC Study?

All Day Room: PH Community, Learning Center

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Junji Shiraishi, Kumamoto, Japan (*Abstract Co-Author*) Research Grant, FUJIFILM Holdings Corporation; Research Grant, Nihon Medi-Physics Co, Ltd
Fujiyo Akita, Shizuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Robert M. Nishikawa, PhD, Pittsburgh, PA (*Abstract Co-Author*) Royalties, Hologic, Inc; Research Consultant, iCAD, Inc;

TEACHING POINTS

The purpose of this exhibit is: To review the basic concept of a significant /not significant differences, equivalence, and non-inferiority To identify the procedure to demonstrate "a slight" but statistically significant difference by using net reclassification improvement (NRI) and integrated discrimination improvement (IDI). To learn the applications of equivalent and non-inferiority test for ROC/FROC study by using a 95% confidence interval of an average difference between two systems.

TABLE OF CONTENTS/OUTLINE

1. Basic concept Significant /not significant differences Net reclassification improvement (NRI) Integrated discrimination improvement (IDI) Equivalence Non-inferiority2. Demonstration of "a slight" but statistically significant difference by using NRI and IDI3. Equivalent and non-inferiority tests for ROC/FROC study

PH113-ED-X

Measurement of Low-contrast Modulation Transfer Function of CT Image: Revisit of Averaging Methods to Cope with Noise

All Day Room: PH Community, Learning Center

Participants

Chiaki Tominaga, BSc, Sendai, Japan (*Presenter*) Nothing to Disclose
Mitsunori Goto, MMedSc, RT, Natori, Japan (*Abstract Co-Author*) Nothing to Disclose
Masaaki Taura, BMedSc, RT, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroki Azumi, BSc, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriyasu Homma, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Issei Mori, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

Measurement of modulation transfer function (MTF) is often forced to be done at low-contrast and high-noise, such as the case of CT images reconstructed by iterative methods. Averaging effect by use of many images is essential to combat with noise.However, the MTF-averaging method, that takes average of MTFs obtained from each image, is dangerous. Image averaging method, in which averaged image is used for MTF calculation, must be used. The MTF-averaging gives wrongly high MTF. Why? The key is the magnitude operation in the MTF calculation. We provide a review of low-contrast MTF measurement, non-linearity of magnitude operation and mean-shift of nonlinear operation, by experimental data, simulation and conceptual explanation.

TABLE OF CONTENTS/OUTLINE

1. Two averaging methods; image averaging and MTF averaging 2. Basics of non-linear operation3. Magnitude operation is nonlinear.4. MTF measurement experiments a. test procedures b. result of MTF-averaging is overestimated c. dependence on contrast-to-noise ratio5. Basics and conceptual understanding of magnitude operation in a complex domain a. complex signal b. average of complex-noised signal c. average of magnitude d. mean-shift of magnitude operation6. Numerical simulation of magnitude operation using CT-like signal and noise

PH114-ED-X

Monoenergetic Imaging Using TwinBeam Dual Energy MDCT on Cancer Diagnosis

All Day Room: PH Community, Learning Center

Participants
Hiroyuki Horikoshi, MD, Otashi, Japan (*Presenter*) Nothing to Disclose
Aya Okayama, MD, Ota, Japan (*Abstract Co-Author*) Nothing to Disclose
Takeshi Kawakami, MD, Ota, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroaki Onaya, MD, Ota, Japan (*Abstract Co-Author*) Research Consultant, Otsuka Pharmaceutical Co., Ltd.
Nariyuki Oya, MD, PhD, Ota, Japan (*Abstract Co-Author*) Nothing to Disclose
Tsukasa Akiyoshi, MD, PhD, Ota, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

TwinBeam Dual Energy (TBDE)- MDCT allows simultaneous acquisition of high and low energy datasets using single source systems and virtual low energy monoenergetic imaging emphasizing iodine contrast. Furthermore, image acquisition is possible for all rotation times and for the full field-of-view. Therefore, it is possible to detect hypervascular cancers accurately on various phases of monoenergetic imaging for the use in clinical routine entirely without any compromises. The purpose of this exhibit is 1) To describe the technique of TBDE-MDCT. 2) To illustrate the virtual low energy monoenergetic imaging emphasizing iodine contrast. 3) To review the monoenergetic imaging of various cancer lesions using TBDE-MDCT.

TABLE OF CONTENTS/OUTLINE

The content organization of this exhibit is: 1. Principles of TBDE-MDCT using single source systems. 2. Imaging of the low energy virtual monoenergetic imaging using TBDE-MDCT. 3. Review of the various cancer lesions and distant metastases using the whole body low energy virtual monoenergetic imaging.

PH116-ED-X

What Should We Do for Calcification Found on CT?: What the Radiologist and Radiology Technologist Should Know

All Day Room: PH Community, Learning Center

Participants

Takuya Ishikawa, Tokyo, Japan (*Presenter*) Nothing to Disclose
Haruhiko Machida, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuzo Yamamoto, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Rika Fukui, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Isao Tanaka, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Yun Shen, PhD, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company Researcher, General Electric Company
Shinya Kojima, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Masami Hirata, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Eiko Ueno, MD, Chiyoda-Ku, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

To describe the clinical significance of calcification on CT To illustrate various techniques of calcification identification/evaluation/avoidance on CT To demonstrate the clinical applications of these techniques by presenting various clinical images

TABLE OF CONTENTS/OUTLINE

Clinical significance of calcification on CT Accurate definitive/differential diagnosis Appropriate patient management Techniques of calcification identification/evaluation/avoidance on CT a) Identification/evaluation True noncontrast CT Appropriate window setting CT number measurement Calcium scoring Morphological assessment (eg, egg-shell) Dual-energy CT (DECT): monochromatic imaging, material decomposition (iodine/calcium/uric acid/cystine/ calcium oxalate/ hydroxyapatite), effective Z b) Avoidance DECT/calcium subtraction CT perfusion (CTP)/MR angiography (MRA) Clinical applications of these techniques True/virtual noncontrast CT (detection), DECT (content analysis): urolithiasis, cholelithiasis Calcium scoring: coronary artery calcification Characteristic morphology: mucinous adenocarcinoma, teratoma, silicosis, constrictive pericarditis, sclerosing peritonitis DECT (differential diagnosis): gout/pseudogout, impending aortic rupture DECT/calcium subtraction, CTP/MRA: severe vessel calcification

PH117-ED-X

Detection Techniques of Ultrasound Cavitation Bubbles

All Day Room: PH Community, Learning Center

Participants
Zahra Izadifar, Saskatoon, SK (*Presenter*) Nothing to Disclose
Paul S. Babyn, MD, Saskatoon, SK (*Abstract Co-Author*) Nothing to Disclose
Dean Chapman, PhD, Saskatoon, SK (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

We will elaborate the basic principles of inertial and non-inertial cavitation and their effects in the body The effects of cavitation on safety and accuracy of ultrasound imaging and therapy are elaborated We comprehensively review the state of the art of medical microbubble detection techniques along with introducing a novel synchrotron-based x-ray imaging technique for detection of both endogenous and exogenous microbubbles

TABLE OF CONTENTS/OUTLINE

1. Basic principles of cavitation and their therapeutic effects in the body
2. Effect of cavitation/microbubble on tissue and body fluid
3. Basic principles of exogenous microbubbles along with their therapeutic, monitoring, and diagnostic applications. Ultrasound contrast agents HIFU-mediated drug or gene delivery Smart microbubbles in diagnosis applications4. Detection techniques of cavitation and microbubbles Detection of physical and chemical responses Optical detection techniques High speed photography Laser Scattering Microbubble oscillation ultrasound detection technique Acoustic detection of bubbles Synchrotron x-ray imaging technique5. State of the art of medical microbubble detection
6. A novel synchrotron x-ray based imaging technique for detection of both endogenous and exogenous microbubbles

Honored Educators

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Paul S. Babyn, MD - 2012 Honored Educator

PH118-ED-X

High Intensity Focused Ultrasound in Clinical Applications

All Day Room: PH Community, Learning Center

Awards
Identified for RadioGraphics

Participants
Zahra Izadifar, Saskatoon, SK (*Presenter*) Nothing to Disclose
Paul S. Babyn, MD, Saskatoon, SK (*Abstract Co-Author*) Nothing to Disclose
Dean Chapman, PhD, Saskatoon, SK (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

We review the fundamental principles behind High Intensity Focused Ultrasound (HIFU) A comprehensive and up to date review of available image-guided HIFU methods Magnetic Resonance guided Focused Ultrasound and Ultrasound guided Focused Ultrasound Clinical applications and outcomes of HIFU treatment including complications More recent horizons in HIFU applications in tumor treatment, drug delivery, vessel occlusion, histotripsy, movement disorders, vascular, oncologic, brain-based disorders, and psychiatric applications are also reviewed.

TABLE OF CONTENTS/OUTLINE

What is High Intensity Focused Ultrasound (HIFU) therapy?The fundamental principles of HIFUImaging-guided HIFU therapy Ultrasound guided Focused Ultrasound Therapy Magnetic Resonance guided Focused Ultrasound therapy Different bioeffect mechanisms of HIFU.Medical applications of HIFU technology Treatment of the pancreas, liver, kidney, bone, prostate, breast, uterine fibroids, and soft-tissue sarcomas tumor Open neurosurgical procedures for a wide variety of indications HIFU-mediated drug delivery, vessel occlusion, histotripsy, movement disorders, vascular, oncologic, and psychiatric applicationSuccess of HIFU applications to date (patient results)Complications and ConcernsFuture directions

Honored Educators

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Paul S. Babyn, MD - 2012 Honored Educator

PH119-ED-X

Computer-aided Detection of Normal Structures of Synovial Joints for Diagnosis of Rheumatoid Arthritis in Ultrasonography

All Day Room: PH Community, Learning Center

Participants

Haruyuki Watanabe, PhD, Maebashi, Japan (*Presenter*) Nothing to Disclose
Yongbum Lee, PhD, Niigata, Japan (*Abstract Co-Author*) Nothing to Disclose
Norio Hayashi, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshihiro Ogura, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Masayuki Shimosegawa, PhD, Gunma, Japan (*Abstract Co-Author*) Nothing to Disclose
Akio Ogura, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Eri Matsuyama, PhD, Fukuoka-City, Japan (*Abstract Co-Author*) Nothing to Disclose
Kaori Iwasaki, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Tomoki Kikuchi, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Masato Warita, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

Rheumatoid arthritis (RA) is a systemic autoimmune disease characterized by joint effusion, synovitis, and bone erosions. Ultrasonography (US) is playing an increasingly important role in the detection and assessment of patients with RA due to latest classification criteria. In particular, the findings of RA using B-mode US are important to classify stage of disease. However, diagnosis depend on observers and imaging techniques of operators in the US, it show variability of diagnostic accuracy. In order to solve this problem, a computer-aided detection (CAD) system is expected for the RA diagnosis in the US. We developed a novel CAD system to detect automatically normal tissue such as lipping, skin line, and soft tissue toward accuracy of the RA diagnosis. It is necessary to improve discrimination capabilities by comparing the normal tissue. The major teaching points of this exhibit is to: 1. Detect automatically normal structures of synovial joints in the US. 2. Understand how to segment scheme in the CAD system. 3. Be useful for the diagnosis of the RA.

TABLE OF CONTENTS/OUTLINE

To provide computer-aided detection scheme and to discuss clinical usefulness toward accurate diagnosis of the rheumatoid arthritis in ultrasonography.

PH120-ED-X

Clinical Impact of Automated Computer Aided Diagnosis Algorithms Development for Shear Wave Elastography Ultrasound in Liver: What the Radiologist Should Know

All Day Room: PH Community, Learning Center

Participants

Stavros Tsantis, PhD, BEng, Patra, Greece (*Abstract Co-Author*) Nothing to Disclose
Ilias Gatos, Rion, Greece (*Abstract Co-Author*) Nothing to Disclose
Dimitrios Karnabatidis, MD, PhD, Patra, Greece (*Abstract Co-Author*) Consultant, C. R. Bard, Inc Research funded, C. R. Bard, Inc
George Kagadis, PhD, Patras, Greece (*Presenter*) Nothing to Disclose

TEACHING POINTS

The purposes of this exhibit are: To describe the essential principles of Shear Wave Elastography (SWE) and novel CAD algorithms towards Chronic Liver Disease (CLD) evaluation. To illustrate advantages and limitations of SWE Imaging To illustrate the clinical impact of automated CAD algorithm techniques development on clinical data and images.

TABLE OF CONTENTS/OUTLINE

Shear Wave Elastography Physics, SWE Image Acquisition procedure,Shear Wave Elastography in the Liver, Clinical Approach, Advantages and DisadvantagesShear Wave Elastography in the Liver, Automatic Approach (1), RGB to Stiffness Conversion, Feature Extraction, Support Vector Machines model Classification, CLD Fibrosis Stages ClassificationShear Wave Elastography in the Liver, Automatic Approach (2), 5-Cluster Segmentation, Feature Extraction, Probabilistic Neural Network model Classification, CLD Fibrosis Stages ClassificationClinical *vs.* Automatic Approaches

PH123-ED-X

Material Decomposition using Dual Energy and Spectral CT: Principles, Physics and Clinical Applications

All Day Room: PH Community, Learning Center

Awards
Cum Laude

Participants
Robbert W. van Hamersvelt, MD, Utrecht, Netherlands (*Presenter*) Nothing to Disclose
Alain Vlassenbroek, PhD, Brussels, Belgium (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Martin J. Willemink, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Speakers Bureau, Koninklijke Philips NV
Arnold Schilham, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Pim A. De Jong, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Tim Leiner, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Speakers Bureau, Koninklijke Philips NV Research Grant, Bayer AG Research Grant, Bracco Group

TEACHING POINTS

To understand the basic physical principles underlying CT material decomposition imaging To understand differences between vendor specific material decomposition techniques for dual energy/spectral CT Exploring current and future clinical applications of material decomposition imaging

TABLE OF CONTENTS/OUTLINE

Tissues that cannot be distinguished based on attenuation number can be distinguished by using material decomposition (MD) algorithms based on dual energy/spectral CT (DECT/SDCT). Differentiation of material pairs by using DECT/SDCT material decomposition imaging (MDI) was first described by Housfield in 1973. However, due to various reasons, MDI was not widely applied in clinical practice until very recently. Over the past few years all major CT vendors have made DECT and SDCT commercially available in daily clinical practice. In this educational exhibit presentation, we will explain and review: The basic principles of MDI Vendor specific DECT/SDCT techniques and their corresponding MDI methods Advantages and disadvantages of projection based and imaged based material decomposition Concepts such as iodine and calcium density and effective atomic number (effective Z)The technical discussion will be supplemented with examples that highlight the clinical possibilities of quantitative DECT/SDCT, enabled by MD imaging.

PH124-ED-X

Physical Principles of Photon-counting CT

All Day Room: PH Community, Learning Center

Awards
Certificate of Merit

Participants
Justin R. Taylor, MD, Bethesda, MD (*Presenter*) Nothing to Disclose
Rolf Symons, MD, Washington, DC (*Abstract Co-Author*) Nothing to Disclose
Steffen Kappler, Dipl Phys, Forchheim, Germany (*Abstract Co-Author*) Researcher, Siemens AG
Matthew K. Fuld, PhD, Iowa City, IA (*Abstract Co-Author*) Researcher, Siemens AG
Tyler E. Cork, BS , Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Manu N. Lakshmanan, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG;
Veit Sandfort, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Mark A. Ahlman, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Amir Pourmorteza, PhD, Bethesda, MD (*Abstract Co-Author*) Researcher, Siemens AG
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG

TEACHING POINTS

1. Discuss the physical principles of photon-counting detector (PCD) computed tomography (CT). 2. Demonstrate the properties of a prototype dual-source whole-body PCD prototype which contains both a PCD and an EID.

TABLE OF CONTENTS/OUTLINE

1. Background: discuss the physical principles of PCD CT and explain the fundamental differences with conventional energy-integrating detector (EID) CT.2. Demonstrate the set-up of a whole-body PCD scanner prototype.3. Show examples of pre-clinical applications of PCD CT in phantoms and animals:- Differentiation of multiple contrast agents- Quantitative imaging with increased Hounsfield Unit (HU) accuracy- High-resolution imaging (250 micron)

PH125-ED-X

Advanced Visualization and Performance of a Cinematic 3D Rendering Prototype

All Day Room: PH Community, Learning Center

Participants

Ahmed Halaweish, PhD, Rochester, MN (*Presenter*) Employee, Siemens AG
Roy Marcus, MD, Rochester, MN (*Abstract Co-Author*) Institutional research agreement, Siemens AG; Research support, Siemens AG
Shuai Leng, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Juan Montoya, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Terri J. Vrtiska, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Max Schoebinger, Heidelberg, Germany (*Abstract Co-Author*) Employee, Siemens AG
Jane S. Matsumoto, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

TEACHING POINTS

Review roles of 3D volumetric rendering of anatomical data in clinical practice Summarize current volumetric rendering techniques utilized in clinical practice. Review advanced visualization and rendering capabilities of a prototype cinematography technique. Present clinical cases with improved rendering and visualization of anatomy of interest Review Future roles of advanced visualization

TABLE OF CONTENTS/OUTLINE

3D rendering in clinical practice Vascular | Bone | MSK Current techniques for 3D rendering of anatomical data Transfer functions and shading parameters Limitations of current 3D rending technique Cinematic Rendering – Bringing cinematography technologies/techniques to the medical field Advanced visualization of anatomical structures through incorporation of global illumination maps and camera model simulations Use cases from various clinical areas demonstrating improvement in visualization Flexible Settings: Light Map, Exposure, Aperture, Reflection, Windowing, Transfer Function. Future applications

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Terri J. Vrtiska, MD - 2016 Honored Educator

SPPH01

AAPM Medical Physics Tutorial Session 1

Saturday, Nov. 26 12:00PM - 2:00PM Room: E351

CT PH

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

Participants
Thaddeus A. Wilson, PhD, Memphis, TN (*Moderator*) Nothing to Disclose

Sub-Events

SPPH01A Fundamentals of CT

Participants
Zheng Feng Lu, PhD, Chicago, IL, (zlu@radiology.bsd.uchicago.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Explain the underlying physics of CT imaging; 2) Identify the main components of CT systems in diagnostic imaging; 3) Introduce the primary acquisition parameters and the operating modes; 4) Describe radiation dose descriptors for CT imaging.

SPPH01B Primer and Clinical Significance of Artifacts in CT

Participants
Jiang Hsieh, PhD, Waukesha, WI, (jhsieh@wi.rr.com) (*Presenter*) Employee, General Electric Company

LEARNING OBJECTIVES

1) Identify root-causes of major CT artifacts. 2) Explain approaches used in CT scanner to suppress or eliminate artifacts. 3) Develop appropriate clinical protocols and procedures to avoid or minimize artifacts.

URL

SPPH02

AAPM Medical Physics Tutorial Session 2

Saturday, Nov. 26 2:15PM - 4:15PM Room: E351

CT PH SQ

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

Participants
Thaddeus A. Wilson, PhD, Memphis, TN (*Moderator*) Nothing to Disclose

Sub-Events

SPPH02A Update on Current and Upcoming Technologies in CT

Participants
Norbert J. Pelc, ScD, Stanford, CA (*Presenter*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

SPPH02B CT Dose and Protocol Management in Clinical Practice

Participants
Dominik Fleischmann, MD, Palo Alto, CA, (d.fleischmann@stanford.edu) (*Presenter*) Research support, Siemens AG;

LEARNING OBJECTIVES

At the end of this activity, participants will be able to: define the current regulatory develop and assess current technologies for clinical dose monitoring, recording, and analyis; inluding challanges and limitations develop a protocol management system

Handout:Dominik Fleischmann

http://abstract.rsna.org/uploads/2016/16001016/Fleischmann_Dose and Protocol Mgm_2016.pdf

ED013-SU

Physics Sunday Case of the Day

Sunday, Nov. 27 7:00AM - 11:59PM Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants

David M. Gauntt, PhD, Birmingham, AL (*Presenter*) Patent agreement, Radcal Corporation
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Brad Kemp, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) The learner will be able to identify the causes of various imaging effects and artifacts, determine whether the effect is caused by equipment problems, and identify the necessary action to correct the effects or artifacts.

SSA20

Physics (CT-Techniques)

Sunday, Nov. 27 10:45AM - 12:15PM Room: S403B

CT PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.00

Participants
Norbert J. Pelc, ScD, Stanford, CA (*Moderator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;
Mats Danielsson, PhD, Stockholm, Sweden (*Moderator*) Stockholder, Prismatic Sensors AB; President, Prismatic Sensors AB; Stockholder, Innovicum AB; President, Innovicum AB; Stockholder, Biovica International AB; Board Member, Biovica International AB;

Sub-Events

SSA20-01 Development, Implementation, and Initial Experience of a Web-based CT Protocol Management System

Sunday, Nov. 27 10:45AM - 10:55AM Room: S403B

Participants
Andrea Ferrero, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Emily Sheedy, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Michele A. Powell, RT, CT, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jessica Ballantyne, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG
Henry Hernaez, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG
Matthew Hoiko, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG;
Drew Morris, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG
Hart Levy, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG
Sakeena Panju, Toronto, ON (*Abstract Co-Author*) Employee, Bayer AG
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shuai Leng, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

CT protocol review is a critical yet manual task that is labor intensive, error prone, and costly. This study aimed to develop and implement a web-based protocol management system and to quantify our initial experience using the system.

METHOD AND MATERIALS

A web-based system was developed and installed at our institute. The software included 4 main modules: 1) Import scanner protocols and automatically identify inconsistencies among master and scanner protocols, 2) Create reviews of specific protocols and track reviewers' decisions, 3) Summarize changes needed to be made on the scanners, 4) View and edit master protocols. An ongoing pilot study was performed for all abdominal protocols on 3 scanners of the same model (Somatom Force, Siemens Healthcare). Master protocols were built from the initial import of scanner protocols, with changes made as needed. Protocols from all 3 scanners were reviewed at the same time by lead techs and medical physicists. Inconsistencies between master and scanner protocols, or among scanner protocols from different scanners, were automatically identified and corrected by the reviewers.

RESULTS

163 protocols (52, 55, 56 per scanner) were imported and monitored. 558 inconsistencies were identified during the first 2 weeks of the pilot, including the initial import to build the master protocols. The inconsistencies covered every aspect of scanning and reconstruction, with series description (342, free text, consequently error-prone) and prep delay (109) the most frequent inconsistencies. Other scan inconsistencies included helical pitch (20), CTDIvol (17), kV (11), mA (11), automatic kV setting (4), automatic exposure control setting (4). Other reconstruction inconsistencies included recon kernel (12), slice increment (11), slice thickness (3), and recon axis (2).

CONCLUSION

The described protocol management system automatically monitored protocol changes and identified inconsistencies between the master protocols and those on the scanner, which is an otherwise tedious manual process. Initial evaluation demonstrated that CT protocol inconsistencies were frequent in our clinical practice, which provided strong motivation for the continued use of this automated system.

CLINICAL RELEVANCE/APPLICATION

The protocol management system greatly increased protocol consistency. It can also be used in lexicon enforcement, e.g. series description, that otherwise is extremely difficult to standardize.

SSA20-02 Super High Temporal Resolution Cardiac CT Imaging using Smart-Recon

Sunday, Nov. 27 10:55AM - 11:05AM Room: S403B

Participants
Yinsheng Li, BEng, Madison, WI (*Presenter*) Nothing to Disclose
Ximiao Cao, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Zhanfeng Xing, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Xuguang Sun, Beijing, China (*Abstract Co-Author*) Nothing to Disclose

Jiang Hsieh, PhD, Waukesha, WI (*Abstract Co-Author*) Employee, General Electric Company
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

Coronary CT angiography is a challenging task currently limited by the achievable temporal resolution of modern MDCT scanners. In this work, a highly innovative method has been developed and validated to improve temporal resolution of the MDCT by a factor of four with the newly developed Synchronized Multi-Artifact Reduction with Tomographic Reconstruction (SMART-RECON) method. The primary purpose of this work is to validate the feasibility of SMART-RECON using in vivo human subject data.

METHOD AND MATERIALS

Using data acquired from a short scan angular range, the entire cardiac window is divided into 4-5 narrower cardiac windows, each corresponding to a 60-degree angular sector. These 4-5 sub-cardiac phase image volumes can be jointly reconstructed with SMART-RECON to globally improve temporal resolution and noise properties. CT data of twenty human subjects were used to demonstrate that SMART-RECON can significantly improve the quality of CTA using a Discovery CT 750 HD (GE Healthcare, WI, USA) with 350 ms gantry rotation time.

RESULTS

The proposed SMART-RECON cardiac CT imaging method can systematically improve the temporal resolution and noise properties. In contrast, the currently available FBP cardiac reconstruction with Parker weights demonstrates significant motion artifacts. Human subject results also demonstrate the significant improvement of coronary CTA quality cross different heart beats, different vessel branches in all subjects. The noise standard deviations for FBP reconstruction within three selected ROIs are 34±4 HU, and for SMART-RECON with the same ROIs are 15±3 HU respectively.

CONCLUSION

With a single short-scan acquisition, SMART-RECON can be used to systematically improve the temporal resolution for MDCT cardiac CT imaging by a factor of 4 without prior knowledge of cardiac motion.

CLINICAL RELEVANCE/APPLICATION

The proposed new technique can systematically improve the image quality of coronary CTA in clinical practice.

SSA20-03 Automated Coronary Artery Motion Artifact Evaluation and Correction Identification for CT Angiography Images

Sunday, Nov. 27 11:05AM - 11:15AM Room: S403B

Participants
Hongfeng Ma, BEng, MS, Milwaukee, WI (*Presenter*) Nothing to Disclose
Eric Gros, BS, Waukesha, WI (*Abstract Co-Author*) Nothing to Disclose
Darin R. Okerlund, MS, Waukesha, WI (*Abstract Co-Author*) Nothing to Disclose
Taly G. Schmidt, PhD, Milwaukee, WI (*Abstract Co-Author*) Research Grant, General Electric Company

PURPOSE

This study developed and validated an algorithm to automatically evaluate a Coronary CT Angiography (CCTA) dataset for motion artifacts and to determine whether further motion correction is required. CCTA exams are usually reconstructed at low-motion phases, however motion artifacts may be present. Motion correction may require additional computation time. A motion evaluation algorithm is proposed to improve workflow by enabling automatic correction if needed and to save computation time if correction is not needed.

METHOD AND MATERIALS

A novel Motion Artifact Score (MAS) metric was developed and determined to have beneficial properties compared to previous motion artifact metrics. The MAS is the product of a vessel symmetry metric and a low-intensity shading metric. An automated algorithm was developed to calculate the MAS for the Right Coronary Artery (RCA), which included finding through-plane slices, locating the RCA position, segmenting the lumen by k-means clustering, segmenting low intensity regions by threshold transform, and then calculating the motion metrics. Motion correction was determined necessary if 5-mm of consecutive slices had an MAS score below a threshold. The threshold was determined by ROC analysis. The algorithm performance was evaluated on 34 CCTA exams (Revolution CT, GE Healthcare). Image slices were reconstructed at a low-motion phase, selected by an automated method (SmartPhase, GE Healthcare). The reconstructed images were input to the proposed algorithm, which output the decision of "need" or "does not need" motion correction. The algorithm decision was compared to the decision of a trained reader who was blinded to the algorithm results.

RESULTS

Seventeen of the 34 exams were determined as needing correction by readers. The algorithm sensitivity was 71% with 65% specificity. For the five cases missed by the algorithm, the reader decision was based on the left vessels, while the algorithm only evaluated the RCA.

CONCLUSION

When evaluating RCA image quality, the algorithm agreed with the reader in 23 out of 29 cases, with 100% sensitivity in identifying exams that required RCA motion correction. Additional improvements may be possible by evaluating left vessel motion.

CLINICAL RELEVANCE/APPLICATION

By automatically identifying exams for motion correction, the proposed algorithm may improve workflow and vessel image quality.

SSA20-04 Properties of Logarithm Function and Their Effect on Filtered Back Projection (FBP) Reconstruction in Low Dose Computed Tomography (CT)

Sunday, Nov. 27 11:15AM - 11:25AM Room: S403B

Participants
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PURPOSE

This report surveys disadvantageous properties of the logarithm function that impact the image quality in volumes reconstructed from the low dose acquisition data in X-ray CT and makes practical system design recommendations to avoid those problems.

METHOD AND MATERIALS

We analyze properties of the logarithm function: strict positivity of the domain and Jensen's inequality. The two properties are disadvantageous because they are causing two types of image domain biases that can shift the Hounsfield units in a CT image at the low dose acquisitions. Biases are illustrated using accurate computer simulations and various dose levels. We explore shifting of the logarithm application from before rebinning to after rebinning and draw conclusions about the bias behavior. In addition to that, we also explore the impact of the projection-based adaptive filtering.

RESULTS

Moving the logarithm application after the rebinning increases the raw data quality and reduces the image based biases by a factor of two on the average, without seriously affecting the noise. Application of the projection-based adaptive filtering eliminates the biases almost entirely and reduces the image noise dramatically. Biases are in practice often confused with beam hardening artifacts, but our monochromatic simulations show that the artifacts are purely caused by a disadvantageous combination of poor statistical quality of x-rays at low dose and logarithm options.

CONCLUSION

Detected non-positive quanta in CT systems is often discarded. Our research shows that the non-positive quanta carries some useful information that can be recovered by careful handling of the logarithm application. This leads to a specific system design recommendation in CT: non-positive quanta should be carried over to the reconstruction engine, where it can be properly treated.

CLINICAL RELEVANCE/APPLICATION

Since the logarithm properties are especially exaggerated at the low dose imaging, clinical benefit is clear since the proposed processing can stretch the limits of the low dose reduction. In addition, this work can explain some of the low dose artifacts seen in practice and raise awareness about the underlying causes to the clinical audience.

SSA20-05 CT Number Accuracy of Virtual Monoenergetic Images from a Whole-Body Research Photon Counting Detector CT

Sunday, Nov. 27 11:25AM - 11:35AM Room: S403B

Participants
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Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

CT numbers depend on the X-ray spectrum; hence CT numbers in conventional CT vary among scanner vendors and models. In virtual monoenergetic images (VMI), however, CT numbers have a predetermined value for a given keV, independent of vendor and scanner. This work evaluated the accuracy of CT numbers in VMIs obtained from a photon-counting-detector (PCD) CT scanner, and compared the performance to that of dual-source (DS), dual-energy (DE) CT scanners with energy integrating detectors (EID).

METHOD AND MATERIALS

Vials containing iodine solutions at 5 concentrations (2, 5, 10, 15, and 20 mgI/cc) were placed in a torso-shaped water phantom (lateral width 30 cm), which was scanned on PCD-CT using 140 kV, energy thresholds of 25 and 65 keV, 0.5 s rotation time, and 0.6 helical pitch. Tube current was set so that the CTDIvol matched that of clinical abdomen scans. The same phantom was also scanned on 2nd and 3rd generation DSDE scanners with the same CTDIvol. VMIs from 40 to 140 keV were generated in 10 keV increments using commercial software. CT numbers were measured for each vial and DE mode. The reference CT numbers were calculated based on the known iodine concentrations and mass attenuation coefficients obtained from NIST. Measured CT numbers were compared with reference values and errors calculated. Variation of VMI CT numbers among the three DE scanners for the same concentration (10mgI/cc) and keV (40) was also calculated.

RESULTS

CT numbers in VMIs from both PCD and EID scanners matched the reference values at each keV and concentration. The mean absolute percentage error (MAPE) was 3.7% for PCD, 8.0% and 9.7% for the two DE modes on the 2nd generation DSDE scanner, and 4.8% to 8.0% for the four DE modes on the 3rd generation DSDE scanner. Error was higher at lower concentrations (8.4% at 2 mgI/cc) than at higher concentrations (1.4% at 20 mgI/cc). VMI CT numbers for 10 mgI/cc at 40 keV ranged from 764.4 to 790.5 HU for the three scanners, with a coefficient of variance of 0.01.

CONCLUSION

Phantom studies demonstrated accurate VMI CT numbers for both PCD- and EID-based CT, with slightly lower errors for PCT-CT.

CLINICAL RELEVANCE/APPLICATION

The spectral performance of a research PCD-CT scanner was comparable to that of EID-CT scanners, each of which provided accurate VMI CT numbers.

SSA20-06 Low-dose CT for the Detection of Liver Lesions: A Grand Challenge to Compare Iterative Reconstruction and Denoising Techniques

Sunday, Nov. 27 11:35AM - 11:45AM Room: S403B

Participants
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PURPOSE

To host a low-dose CT Grand Challenge for the task of liver lesion detection and assess the diagnostic performance of iterative reconstruction or denoising techniques using common low dose patient datasets.

METHOD AND MATERIALS

Datasets from contrast-enhanced CT scans of the liver were provided to participants in an NIH- and AAPM-sponsored low-dose CT Grand Challenge. The training data included full-dose and quarter-dose scans of the ACR CT accreditation phantom and 10 patients; both projection and image data were provided. The testing data used to evaluate technique performance were 20 quarter-dose patient datasets, which were provided to each participant as projection or image data, but not both. Pre-processed projection data and a statistical noise map were provided to sites intending to perform iterative reconstruction. Only images were provided to sites intending to perform image domain denoising. Upon return of the denoised or iteratively reconstructed quarter-dose images, randomized and blinded interpretation of the cases was performed by radiologists and the locations of metastatic lesions were identified. The reader markings were scored against clinical or pathologically-demonstrated reference data to determine the percent correct in the test cohort, where cases were scored by lesion and by patient, with a penalty for a false-negative or a false-positive.

RESULTS

103 participants representing 26 countries and 90 unique sites registered during the 1 month enrollment period. 76 sites returned data sharing agreements and 39 sites downloaded the test data. Participants included 27% medical physicists, 23% electrical engineers, 23% computer scientists, 10% physicists, 6% mathematicians, and 11% other. 22% of participants had no experience with medical CT datasets and 60% had not collaborated with a radiologist to optimize image quality. 61% of participants requested projection data and the remainder requested image data.

CONCLUSION

An infrastructure was developed to assess the performance of liver lesion detection for low-dose CT examinations of the liver. The large number of participants indicated a great interest in low-dose CT techniques and in gaining access to medical CT data sets.

CLINICAL RELEVANCE/APPLICATION

An international effort to identify and test novel noise reduction/iterative reconstruction techniques using a common data set and human observers may rapidly accelerate CT dose reduction efforts.

SSA20-07 Improving Readers' Perception of Image Quality at Low keV Virtual Monoenergetic Images using Patient-specific Optimized Display Window Settings

Sunday, Nov. 27 11:45AM - 11:55AM Room: S403B

Participants
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PURPOSE

To investigate whether patient-specific optimization of display window settings improves readers' perception of image quality at low keV virtual monoenergetic images (VMI) in patients with hypervascular liver lesions.

METHOD AND MATERIALS

In this HIPAA-compliant, IRB-approved, retrospective study, we enrolled 21 patients with malignant hypervascular liver lesions who underwent a clinically–indicated dual energy CT (DECT) of the liver during the late hepatic arterial phase using a dual-source system (SOMATOM Definition Flash, Siemens Healthcare). Virtual monoenergetic images were reconstructed at energy levels of 40 keV, 70 keV, and linear blended images at 0.3 blending ratio (120 kVp equivalent). Additionally, 40 keV window-adjusted datasets were created for each patient using 3 different methods. Each method attempted to improve readers' perception of image quality at low keV by matching (on a per patient basis) different specific attributes of image quality between 40 and 70 keV datasets. This included matching of (a) the liver histogram distribution of pixel values; (b) the lesion-to-liver contrast; or (c) noise defined as the standard deviation in the background liver. The three metric values were transferred to display space as a function of window level and window width, and further equalized to derive the specific window setting for each patient. All datasets were presented in

random order to 3 readers with different experience in a blinded and independent fashion. Readers' assessment scores for image quality, lesion conspicuity, and observer performance were recorded.

RESULTS

Readers' perception of noise and lesion conspicuity was significantly worse at 40 keV compared to 70 keV and linear blended datasets. Readers' perception of noise and lesion conspicuity improved significantly at 40 keV with all window optimization methods (P<0.01). No significant differences were observed among the three methods, with the exception of contrast that was significantly better for noise-matched method (P<0.01).

CONCLUSION

Patient-specific optimization of display window settings may significantly improve readers' perception of image quality for low keV VMI.

CLINICAL RELEVANCE/APPLICATION

Improved readers' perception of image quality at low keV VMI may improve conspicuity of hypervascular liver lesions, which may translate in earlier lesion detection and improved patient outcomes.

SSA20-08 The Effect of Patient Diameter on the Dual-Energy Attenuation Ratio of Selected Contrast-Producing Elements

Sunday, Nov. 27 11:55AM - 12:05PM Room: S403B

Participants
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PURPOSE

The ratio of low- to high-kVp CT numbers (the dual-energy ratio; DER) of different contrast elements determines their separability at Dual-Energy CT (DECT). We assess whether the DER of selected elements is affected by patient diameter.

METHOD AND MATERIALS

Seven contrast-producing elements - calcium, iodine, barium, gadolinium, tantalum, tungsten, and bismuth - were housed sequentially in a vial within an abdomen phantom. Sequential fat ring encasements increased the phantom diameter from 26 to 32 to 38 to 44 cm. For each phantom size and contrast element configuration, the phantom was scanned using single-energy CT (SECT) at x-ray tube voltages of 80 and 140 kVp, and rapid-kVp-switching DECT using the same tube voltages, with virtual monochromatic reconstructions generated at 60 and 80 keV energy levels. For each configuration we measured contrast element CT numbers and calculated the DER for the SECT images (80:140 kVp) and for the DECT images (60:80 keV).

RESULTS

CT numbers decreased with increasing phantom diameter for both SECT and DECT. This decrease was proportional (~20% overall CT number reduction for both low- and high-energy acquisitions), and resulted in consistent DERs for each contrast element across all phantom diameters. The mean range in the DER for each element over the phantom sizes was 6.6%, with a maximum range of 16% for bismuth. The mean difference in DER between pairs of contrast elements within each phantom size was 35%. For 16 of the 21 material pair combinations, the difference in the DER between elements was greater than the range in DER over the phantom sizes, implying that separation should remain possible for these material pairs at all sizes. The exceptions were iodine-barium, iodine-gadolinium, tungsten-tantalum, tungsten-bismuth, and tantalum-bismuth pairs where elements showed highly similar DERs to each other, due to their similar atomic numbers.

CONCLUSION

The dual-energy ratio for different contrast elements is largely unaffected by changes in phantom diameter despite variation in absolute CT numbers. This should allow for robust separation of most contrast material combinations irrespective of patient size.

CLINICAL RELEVANCE/APPLICATION

The consistency of the dual-energy ratios over different phantom sizes increases confidence in current material decomposition methods, and highlights the potential of high-Z contrast agents at DECT.

SSA20-09 A Platform-Independent Method to Reduce CT Truncation Artifacts

Sunday, Nov. 27 12:05PM - 12:15PM Room: S403B

Participants
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PURPOSE

Large body size or patient offcentering may create truncation artifacts that severely degrade CT image quality and diagnostic performance. Conventional wisdom to reduce truncation artifacts is to extrapolate the truncated projection data based on certain a priori assumptions. The purpose of this work is to develop a novel CT truncation artifact reduction method that directly operates on

DICOM CT images.

METHOD AND MATERIALS

The blooming of pixel values introduced by truncation was found to be trackable using exponential decay functions, based on which a discriminative dictionary with a truncation artifact sub-dictionary and a nonartifact sub-dictionary was created: The truncation artifact sub-dictionary contains 1000 entries with different decay constants, while the nonartifact sub-dictionary contains 1000 entries with different Gaussian white noise realizations to maximize its exclusiveness with the artifact sub-dictionary. By sparely representing the artifact-contaminated CT images with the discriminative dictionary using the Greedy algorithm, the artifact components of the images were selectively segmented from the nonartifact image features. The proposed method was validated using both an anthropomorphic chest phantom and whole-body CT images of three trauma patients.

RESULTS

The proposed method reduced the relative RMSE from 43% (original images) to 24%, and improved the universal quality index from 0.34 to 0.80. Bloomings at the peripheral region of the scanner field of view were visibly reduced, revealing soft tissue and bony structured once buried in the truncation artifacts. For the whole-body CT images of the trauma patients, the proposed method demonstrated potential benefits in ruling out injuries at extremities and other truncation-prone sites of the body.

CONCLUSION

A discriminative dictionary representation method was developed to mitigate CT truncation artifacts directly in the DICOM image domain. Results of physical phantom experiment and human subject studies demonstrated that the proposed method can effectively suppress truncation artifacts and improve image quality.

CLINICAL RELEVANCE/APPLICATION

The proposed method operates directly on DICOM images, therefore it is vendor- and platform-independent, and it can be applied not only prospectively but also retrospectively upon physician’s request.

SSA21

Physics (CT-Dose I)

Sunday, Nov. 27 10:45AM - 12:15PM Room: S404AB

CT PH SQ

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

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Moderator*) Institutional research agreement, Siemens AG Research support, Siemens AG
Bruce R. Whiting, PhD, Pittsburgh, PA (*Moderator*) Nothing to Disclose

Sub-Events

SSA21-01 Diagnostic Reference Levels and Achievable Doses for Ten Commonly Performed US Adult CT Examinations from the ACR CT Dose Index Registry

Sunday, Nov. 27 10:45AM - 10:55AM Room: S404AB

Participants
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PURPOSE

Use the ACR CT Dose Index Registry (DIR) to recommend diagnostic reference levels (DRLs) and achievable doses (ADs) for the 10 most common adult CT examinations in the US as a function of patient size.

METHOD AND MATERIALS

Ten most commonly performed adult CT examinations in the United States were analyzed from the DIR - head brain without contrast, cervical spine without contrast, neck with contrast, chest without contrast, chest with contrast, chest with pulmonary embolism protocol, chest abdomen pelvis with contrast, abdomen pelvis with contrast, abdomen pelvis without contrast, and abdomen pelvis nephrolithiasis protocol without contrast. For the head exams, lateral thickness dimension was used as an indicator of patient head size. For neck, c-spine, chest, abdomen and pelvis exams, effective diameter was used. Descriptive statistics were calculated for 4 facility characteristics (facility category, location, census region, and average volume of examinations per month) for all the exams included. Data from over 1.3 million examinations were used to determine median (AD) as well as mean, 25th and 75th (DRL) percentiles of CTDIvol, DLP and SSDE. All analyses were done using SAS 9.3.

RESULTS

The abdomen pelvis exams made up the highest percentage (45%) of exams in the study. Over 46% of the facilities were from community hospitals and 13% from academic facilities. Over 48% were metropolitan followed by 39% suburban and 13% rural facilities. Over 50% of the facilities reported performing less than 500 exams per month.The median CTDIvol did not vary significantly but DLP increased with lateral thickness for head exams. For neck and c-spine, the median CTDIvol and the 75th percentile did not vary significantly but the median DLP did with effective diameter. Similar trends were seen for the median CTDIvol and SSDE for chest, abdomen and chest-abdomen-pelvis exams. Our data agrees well with the data from other resources.

CONCLUSION

This work provides DRLs and ADs for the 10 most common CT adult exams performed in the United States. The enormous volume of patient data, as well as the availability of automatically-determined patient size information, allows for the development of robust, size-specific ADs and DRLs.

CLINICAL RELEVANCE/APPLICATION

This work will enable facilities to compare their patient doses to size-specific national benchmarks and optimize their CT protocols resulting in lower dose at the appropriate image quality.

SSA21-02 Big Data and CT Dose: How a Dose Monitoring System Can Help in Updating and Benchmarking DRLs

Sunday, Nov. 27 10:55AM - 11:05AM Room: S404AB

Participants
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Federica Zanca, PhD, Leuven, Belgium (*Abstract Co-Author*) Employee, General Electric Company

PURPOSE

The new European Directive on Basic Safety Standard requires that Member States shall ensure the establishment, regular review and use of diagnostic reference levels (DRLs) for radiodiagnostic examinations, having regard to the recommended European DRls where available. The process to set and update DRLs should be both flexible and dynamic. The aim of this study was to assess the value of a dose monitoring system and access to big data in benchmarking and updating EU DRLs.

METHOD AND MATERIALS

Dose data were collected using the same dose management software (DoseWatch and DoseWatch Explore-cloud-based, GE

Dose data were collected using the Sentry dose management software (DoseWatch and DoseWatch Explore cloud-based, GE Healthcare) from 11 countries (Finland, Spain, Italy, Luxembourg, France, Belgium, UK, Germany, Sweden, Hungary and Switzerland), 61 CT (7 GE, 3 Siemens, 3 Toshiba and 2 Philips models) for a total of 12817 CT exams (19100 series). For each systems protocol Radlex mapping for the following anatomical region occurred: head (axial and spiral), sinus, chest, abdomen-pelvis and lumbar spine. The estimated European and national DRLs based on collected data (median CTDIvol and DLP) for the investigated RPIDs were compared to European (DataMed II) and national DRLs. The one-sample Wilcoxon signed rank test was used to assess statistical significant differences.

RESULTS

The overall median CTDIvol and DLP for all 11 countries per anatomical region compared to European DRLs were respectively: head -7.95% and -2.41 %, chest -17.30% and -29.48%, abdomen -56.56% and -43.25%, lumbar spine -29.63% and +8.67%. When comparing to national DRLs, CTDIvol and DLP were above in 14.3% and 0% of the countries for head CT (n = 3044), in 0% and 0 % for abdominal CT (n = 4761) and in 50% and 33% for chest CT (n = 2965), respectively. Preliminary analyses between CT protocols of the same body region show that radiation exposure varied up to 50 % of the DRLs across countries.

CONCLUSION

The implemented dose monitoring on several European sites enables large-scale CT automated benchmarking, in regard to national and international DRLs. The cloud-based approach offers great potential for a dynamic and flexible update of European and national DRL

CLINICAL RELEVANCE/APPLICATION

Using a large-scale and cloud-based dose monitoring system would allow for an easy update and use of DRLs as recommended by the new European directive, making them more representative of clinical practice and eventually update them linked to clinical indication.

SSA21-04 Dynamic Contrast-Enhanced CT Dose Optimization Using a Perfusion Phantom

Sunday, Nov. 27 11:15AM - 11:25AM Room: S404AB

Participants
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Robert Dekemp, PhD, Ottawa, ON (*Abstract Co-Author*) Royalties, FlowQuant; Royalties, Jubilant Life Sciences Ltd; Consultant, Jubilant Life Sciences Ltd
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PURPOSE

Dynamic contrast enhanced (DCE) CT can add functional information such as absolute blood flow to a wide range of clinical exams, but can result in high radiation exposure, which limits its clinical use. While much effort has been devoted to reduce radiation exposure, validation is hampered by a lack of a gold standard to which accuracy can be compared. Therefore we developed a DCE perfusion phantom and demonstrate its usability for optimizing radiation exposure.

METHOD AND MATERIALS

The DCE phantom (Shelley Medical) was imaged on a 320 slice Toshiba Aquillion One CT at a single bed position. Wash-in and wash-out flow to the phantom was set to 100 mL/min. 100 CT volumes were acquired over 360 seconds immediately after contrast (Omnipaque 300) injection at varying temporal sampling frequency between frames (45 × 1.5s, 35 × 3.5s, and 20 × 5s). Imaging was repeated at 80, 100 and 120 kVp with constant 300 mA tube current. Dynamic scans were retrospectively modified by excluding frames to simulate reduced temporal sampling (1/2, 1/4, 1/5, 1/10, 1/20 of frames). Dynamic images were processed using custom developed software to derive input and output time-attenuation-curves to which a modified 1-tissue-compartment kinetic model with wash-in (K1) and wash-out (k2) parameters were fitted along with transport time delay. Image derived flow estimates were compared to flow meter measured flow rates (ground truth) to determine flow accuracy.

RESULTS

Flow values agreed within 2% with varying tube voltage. The overall fit of the kinetic-model was excellent and did not suffer as the number of frames in the dynamic sequence was reduced ($r2 > 0.82$). The number of frames in the dynamic sequence was reduced by 75% (1/4 of frames) before the image derived flow estimates exceeds our error tolerance of ±5%. The estimated wash-in flow remained within tolerance up to a 80% dose reduction (1/5 of frames), with overestimation of wash-in increasing exponentially thereafter. All wash-out errors remained below 20%.

CONCLUSION

Dynamic CT can accurately quantify contrast kinetic parameters. Wash-in rate parameters are more susceptible to temporal under-sampling error than wash-out rate.

CLINICAL RELEVANCE/APPLICATION

The proposed phantom and image analysis software are useful for validating and optimizing DCE-CT imaging equipment and protocols. Furthermore, the phantom can be used to calibrate between alternative imaging modalities such as nuclear medicine and MRI.

SSA21-05 Automatic Anatomical Landmarks Recognition for Organ Dose Estimation with a Dose Monitoring System

Sunday, Nov. 27 11:25AM - 11:35AM Room: S404AB

Participants
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PURPOSE

Software estimation of organ doses is often based on standardized models that do not accurately represent the individual patient. The aim of this work is to develop a method for automatic anatomical landmarks recognition, to be used for matching a specific individual to voxelized phantom models for patient-specific organ dosimetry.

METHOD AND MATERIALS

Using the topograms collected through a dose tracking system (DoseWatch, GE Healthcare) an algorithm was developed to detect the following anatomical regions: head, shoulders, chest, abdomen, pelvis, lower limbs. Using a patient's anterior-posterior localizer we estimated patient contours, gray-scale intensity profile and bone symmetries, and edges. For each identified anatomical region, the percent of region detected was estimated and the percentage of region irradiated, through comparison with the scanned area. Extracted patient-specific landmarks from DoseWatch, along with exposure parameters, were used to estimate patient-specific organ doses for a sample of patients, to assess the workflow.

RESULTS

We analyzed landmark recognition in 30 prospectively selected patients who underwent a CT exam during a 7-month period. Of the 30 patients, 6 (16.7%) were chest exams, and an equal number of abdomen, pelvic abdominopelvic, kidney-to-bladder and chest-abdomen-pelvic exams were selected. The software correctly identified the percent of irradiated organ in 100% of chest exams, 80% of abdomen exams, 20% of pelvic exams, 40% of abdominopelvic exams, 80% of kidney-to-bladder exams, and 40% of chest-abdomen-pelvic exams. Failings were related to detection of lower limbs or when the patient was not fully in the field of view. Organ-doses were estimated for all patients.

CONCLUSION

The implementation of automatic detection of anatomical landmarks in a dose tracking system has high potential when combined with an MC framework. It accounts for the variation in patient size and improves the accuracy of the estimates.

CLINICAL RELEVANCE/APPLICATION

By improving the accuracy of organ dose estimation, dose monitoring can offer more accurate and representative indices of patient safety.

SSA21-06 Effective and Organ Dose Estimations from Low-Dose Lung Cancer Screening Chest CT Exams using Tube Current Modulation

Sunday, Nov. 27 11:35AM - 11:45AM Room: S404AB

Participants
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Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Abstract Co-Author*) Institutional research agreement, Siemens AG Research support, Siemens AG

PURPOSE

The purpose of this work was to estimate effective and organ doses from a low-dose lung cancer screening protocol using tube current modulation (TCM) and patient models of various sizes.

METHOD AND MATERIALS

Monte Carlo simulation methods were used to estimate effective and organ doses from a low-dose lung cancer screening protocol for a 64-slice CT (Sensation 64, Siemens Healthcare) that used TCM. Scanning parameters were from the AAPM's Alliance for Quality CT on-line protocols. Ten GSF voxelized patient models that had all radiosensitive organs identified were used to facilitate estimating both organ and effective doses. Predicted TCM schemes for each patient model were generated using a validated method wherein tissue attenuation and scanner limitations were used to determine the TCM output as a function of table position and source angle. The water equivalent diameter (WED) was determined by estimating the attenuation at the center of the scan volume for each patient model. Monte Carlo simulations were performed using the unique TCM scheme for each patient model. All organ doses were tallied and effective doses were estimated using ICRP 103 tissue weighting factors. All dose values were normalized by scan-specific dose-length product (DLP) from 32 cm CTDIvol values that used the average tube current across the entire length of the simulated scan. Absolute and normalized doses were reported as a function of WED for each patient model.

RESULTS

For all ten patient models, the effective dose using TCM protocols was below 1.5 mSv. Smaller sized patient models experienced lower absolute doses compared to larger sized patients. DLP-normalized effective, lung, thyroid, and breast doses possessed an exponential relationship with respect to patient size with coefficients of determination of 0.73, 0.72, 0.24, and 0.73, respectively.

CONCLUSION

Effective doses for a low-dose lung screening protocol using TCM were below 1.5 mSv for all patient models used in this study. Strong correlations existed between DLP-normalized effective, lung, and breast doses, while thyroid doses showed some dependence on patient size.

CLINICAL RELEVANCE/APPLICATION

These results, along with the scanner-reported DLP and WED, can be used to estimate effective, lung, thyroid, and breast doses from lung screening CT exams that use TCM.

SSA21-07 Automated Dose Tracking Software in a Clinical Setting: Radiation Dose Evolution Over Three CT Generations

Sunday, Nov. 27 11:45AM - 11:55AM Room: S404AB

Participants
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PURPOSE

To evaluate and compare the radiation dose and image quality of whole-body-CT (WBCT) performed on three CT generations using an automated CT dose tracking software.

METHOD AND MATERIALS

Patients undergoing a single post-venous phase WBCT exam on the 3rd and 2nd generation dual-source-CT (DSCT) (Siemens Somatom Force and Flash, Siemens Healthcare, Forchheim, Germany), as well as on the 64-slice single-source-CT (SSCT) (Siemens Sensation 64, Siemens Healthcare, Forchheim, Germany) were included into the retrospective study. Acquisitions on both DSCT-systems were performed with automated tube voltage selection and automated tube current selection, whereas SSCT protocol included solely the automatic tube current modulation. All images were reconstructed with a 3 mm slice thickness and an increment of 1.5 mm, using the iterative method on both DSCT-systems and filter-back-projection on the SSCT. Commercially available automated dose tracking software (Radimetrics, Bayer Healthcare, Whippany, NJ) was used to calculate the size-specific-dose-estimate. Subjective image quality of axillary and mediastinal lymph nodes, and adrenal glands was rated by two experienced radiologists in a blinded fashion: 5= Excellent image quality with excellent delineation, no blurriness; 4= Good image quality with good delineation, slight blurriness, diagnostically usable; 3= Acceptable image quality with acceptable delineation or blurriness, diagnostically still usable; 2= Insufficient image quality with non-definable delineation or blurriness and not recommended for diagnostic usage. 1= Non-usable image quality.

RESULTS

43 patients having the identical CT exam on all three modalities were included into the study. Subjective image quality was excellent throughout all three CT-generations ($p = 0.38$-0.98). Calculated patient dose in the 3rd generation DSCT was lower by 29% and 43%, when compared to the radiation dose on the 2nd generation DSCT and SSCT, respectively.

CONCLUSION

Modern CT-equipment substantially reduce radiation dose without affecting the image quality. Dose properties can be easily monitored by automated dose tracking software in daily routine.

CLINICAL RELEVANCE/APPLICATION

Automated dose tracking is an objective approach in monitoring patient radiation dose.

SSA21-08 CT Dose Comparison Between Two Academic Institutions: Complexities in Achieving an Apples to Apples Dose Comparisons

Sunday, Nov. 27 11:55AM - 12:05PM Room: S404AB

Participants
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CONCLUSION

Our efforts at multi-institutional comparative dose mapping encountered serious impediments early in the process. Specifically having to do with: (1) size based protocols and (2) protocols that are used for multiple indications.

Background

The aggregation of CT dose data on an institutional level has now become common place using 3rd party dose monitoring products or the ACR DIR. This work describes an attempt to use such a system to compare 13 single phase, adult and pediatric, chest, abdomen, and neuro CT protocols between two academic hospitals. We also explore challenges with dose comparison related to issues with naming conventions and differences in data aggregation. We hope that other sites can learn from this exercise and use our experience to better evaluate their own CT dose.

Evaluation

Doses were compared using the CTDIvol, DLP, and SSDE metrics for the mean and 25/50/75th percentiles. With the exception of

CTA for pulmonary embolism whose mean dose metrics varied by over 100% between the two institutions, all other indications differed by less than 75%. One institution tended to have higher neuro but lower abdomen and chest doses than the other. Cases in which the workflow for choosing protocols between the two institutions for the same indication will be presented. For example, institution A uses the same protocol for scans of the abdomen with and without contrast, while institution B uses two different protocols. For an accurate comparison, such differences must be taken into account. Additionally, institution A uses separate size based protocols (small/medium/large);institution B uses one protocol for non-bariatric adults (which are modified at scan time for patient size) plus a dedicated bariatric protocol.

Discussion

In this study, we focused on single phase exams to avoid dealing with series level dose mapping. Variability in technologist's workflow and the protocol disparity regarding anatomic coverage and patient body habitus add complexity to mapping protocols for dose comparison.

SSA21-09 Comparison of Standard Formulaic Calculations of Effective Dose Against Monte Carlo-Simulated Software Calculations for Various CT Exams on 64-Slice and 16-Slice CT Scanners

Sunday, Nov. 27 12:05PM - 12:15PM Room: S404AB

Awards
Student Travel Stipend Award

Participants
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PURPOSE

To compare the effective dose of various CT studies using standard formulas against Monte Carlo-simulated software calculations on 64-slice and 16-slice CT scanners.

METHOD AND MATERIALS

This is an IRB-approved retrospective study. Fifty non-contrast head CT's (NCHCT), non-contrast chest CT's (ChCT), non-contrast abdominopelvic CT's (ncCTAP), and contrast-enhanced abdominopelvic CT's (c+CTAP) performed on GE LightSpeed 64-slice and GE BrightSpeed 16-slice scanners from April 2015 to December 2015 were enrolled. Fifty CT pulmonary angiography (CTPA) studies from the 64-slice scanner and the 12 CTPA studies from the 16-slice scanner during the study period were enrolled.Radiation dose monitoring software, Radimetrics (Bayer, Whippany, NJ), was used to extract the exam dose length product (DLP). The effective dose (ED) was calculated using the standard formula (ED = DLP*k). Radimetrics software provided Monte Carlo-simulated calculations of ED for each exam using a library of phantoms with pre-run Monte Carlo simulations for various scan parameters best matched to the patient exam. The standard formulaic calculation of ED for each exam on each scanner was compared with the Monte Carlo calculation. Bland-Altman plots and paired t-test analysis were performed.

RESULTS

There were statistically significant differences ($p < 0.05$) between the standard formulaic and Monte Carlo-simulated calculations of ED for NCHCT's, ChCT's, CTPA's, and c+CTAP's on the 64-slice and 16-slice CT scanners. There was no significant difference between ED calculations for the ncCTAP on both scanners. The standard deviation of the difference between the Monte Carlo and formulaic calculations were 0.45 mSv for NCHCT, 2.2 mSv for ChCT, 3.1 mSv for CTPA, 1.9 mSv for ncCTAP, and 2.8 mSv for c+CTAP. With chest CT's, most of the formulaic calculations were less than the Monte Carlo calculations. With abdominopelvic CT's, most of the formulaic calculations were less than the Monte Carlo values in lower dose exams and greater than the Monte Carlo values in higher dose exams.

CONCLUSION

Standard formulaic calculations of ED differ significantly from Monte Carlo-simulated software calculations for most exams on GE 64- and 16-slice scanners.

CLINICAL RELEVANCE/APPLICATION

The difference between these methods should be considered when estimating patient dose.

SSA22

Physics (MR-Techniques)

Sunday, Nov. 27 10:45AM - 12:15PM Room: S405AB

BQ MR PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: .50

FDA Discussions may include off-label uses.

Participants
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Sub-Events

SSA22-01 Dual-Echo Dixon Imaging in the Presence of Large Field Inhomogeneities

Sunday, Nov. 27 10:45AM - 10:55AM Room: S405AB

Awards
Trainee Research Prize - Fellow

Participants
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PURPOSE

The purpose of this work is to demonstrate dual-echo Dixon imaging with a novel cost-based, graph-cuts-guided optimization that allows for successful separation of fat and water images in regions of high B0 inhomogeneity.

METHOD AND MATERIALS

Dual-echo Dixon imaging under a linear signal model is an inherently underdetermined problem with two complex knowns (the two images at different echo times) and five real-valued unknowns (magnitude and initial phase of both water and fat and the inhomogeneity in the main magnetic field, ΔB0). By constraining the initial phase, φ0, of the water and fat images to be equal, the now nonlinear problem has only four real-valued unknowns (magnitude of water and fat, φ0, and ΔB0). Therefore, to find the maximum likelihood solution, the minimum of a four-dimensional cost function must be found. Additionally, to avoid signal swaps, the solutions for ΔB0 and φ0 must be unwrapped before reconstructing the water and fat images.In this work, we utilize nested variable projection to reduce the four-dimensional cost function to that of one dimension (solved for ΔB0). When the maximum likelihood solutions have been found, ΔB0 and φ0 are unwrapped via minimization of a regularized cost function that promotes smoothness. The greedy binary optimization is guided by graph cuts, and allows for large B0 inhomogeneities to be resolved.This reconstruction algorithm was used to reconstruct dual-echo CE-MRA images for the thighs and pelvic images depicting perianal fistulas.

RESULTS

Images from a dual-echo CE-MRA study in the thighs depict a successful water/fat separation despite absolute ΔB0 values greater than 2500 Hz near the edge of the field-of view. The largest ΔB0 values in this thigh study represent field inhomogeneities of ~20 parts per million. Similar separation results are seen in the pelvis, demonstrating successful separation in a smaller field-of-view within which the field is more homogenous.

CONCLUSION

Dual-echo Dixon imaging with a constrained phase signal model and a regularized graph-cuts-guided optimization is able to successfully separate images of fat and water signals in the presence of large inhomogeneities in the main magnetic field.

CLINICAL RELEVANCE/APPLICATION

Fat suppression allows visualization of pathologies obscured by fat signal, but is confounded by large B0 inhomogeneities. The method described here performs well even with large B0 inhomogeneities.

SSA22-02 Magnetic Resonance Fingerprinting: Mitigating the Bias in the Quantification of T1 and T2 Caused by Macromolecules

Sunday, Nov. 27 10:55AM - 11:05AM Room: S405AB

Participants
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PURPOSE

In this work we aim to mitigate the bias in the quantification of T1 and T2 caused by macromolecules when using magnetic resonance fingerprinting (MRF).

METHOD AND MATERIALS

Magnetization transfer (MT) effects can bias the estimation of T1 and T2 in MR and are caused by dipolar effects and chemical exchange between free water and macromolecules. We used a radial MRF sequence to measure the T1 and T2 in the brain of a healthy volunteer at 3T. The same measurement was performed with three different RF pulse durations (5 ms, 2 ms, and an interleaved mix of both). The first two measurements were reconstructed using the traditional method, whereas the last scan was reconstructed using a new prototype algorithm which includes a specialized MT model.

RESULTS

In the conventional fingerprinting sequence, the white-matter T2 values show a dependence on the RF pulse duration (48 ms for the long and 35 ms the short pulses). Moreover, compared to the values reported in the literature (~60 ms), both configurations significantly underestimate the true T2. Using a mix of different RF pulse durations in combination with the proposed algorithm, an MT bias map can be extracted which enables a more accurate measurement of T2 (~60ms).

CONCLUSION

Here we demonstrate that the quantification of relaxation parameters using fingerprinting is sensitive to MT effects and show that this bias can be mitigated by varying the RF pulse duration in the sequence and incorporating a MT model into the reconstruction process.

CLINICAL RELEVANCE/APPLICATION

Unlike weighted images, quantitative imaging enables intra- and inter-subject comparison. Unbiased quantitative measures promise benefits to diagnosis, staging and monitoring of pathology and therapy.

SSA22-03 Motion Imaging in Thoracic and Abdominal MRI using a Self-Navigated Cartesian Compressed Sensing Acquisition and Reconstruction Scheme

Sunday, Nov. 27 11:05AM - 11:15AM Room: S405AB

Participants
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PURPOSE

Respiratory motion is a main source of image artifacts in thoracic and abdominal MRI that can strongly deteriorate image quality. The purpose of this study was to implement and evaluate a Compressed Sensing-based acquisition and reconstruction scheme for motion imaging in thoracic and abdominal MRI under free-movement (respiration, cardiac motion).

METHOD AND MATERIALS

The proposed method consists of an acquisition and a reconstruction step.
A 3D T1-weighted gradient echo (GRE) sequence is acquired using a sparse variable-density Poisson-Disc k-space sampling in a short scan time of 90s under free-movement. The acquired k-space data is retrospectively gated according to an extracted self-navigation signal which captures the periodic respiratory motion. An additionally acquired ECG signal allows performing a cardiac motion-correction simultaneously. The gates are subsequently jointly reconstructed using Compressed Sensing techniques yielding a respiratory and cardiac motion-resolved 4D (3D+time) image. A single 3D motion-corrected image can be derived by image registration.
The method is evaluated for 20 healthy volunteers on a 3T PET/MR scanner. Image quality of MR images acquired using the proposed method is compared to a standard GRE sequence without motion correction and to a breath-hold image using statistical features. In addition, subjective image quality is rated by five radiologists on a 3-point score (3:best).

RESULTS

The proposed method achieves significant quantitative and qualitative improvement in image quality with perceptible reduction of motion artifacts (respiration and heart). Motion-corrected images are of similar image quality as breath-hold/triggered acquisitions with an average score of 2.6 and good motion resolvability (liver-lung boundary slope steepness improvement over free-movement images of 288%±150%).

CONCLUSION

MR motion imaging using a Cartesian Compressed Sensing acquisition and reconstruction scheme with self-navigation is feasible and achieves a marked reduction of motion artifacts in free-movement acquisitions in a short scan time.

CLINICAL RELEVANCE/APPLICATION

The proposed method may contribute to more robust motion imaging and correction, yielding a better diagnostic image quality in anatomic areas with repetitive motion.

SSA22-04 Automated Quantification of Intermuscular Adipose Tissue on Thigh MRI of Varying Severities of Muscle Disease

Sunday, Nov. 27 11:15AM - 11:25AM Room: S405AB

Participants
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Isabella Nogues, BA, Bethesda, MD (*Presenter*) Nothing to Disclose

PURPOSE

Our goal is to develop a system capable of quantifying the amount of muscle, subcutaneous (SAT) and intermuscular (IMAT) adipose tissue on thigh MRI in cases of severe muscle disease.

METHOD AND MATERIALS

A sequence of advanced image processing algorithms is developed to classify tissues and identify fascia lata in the thighs. Our program first separates left and right thighs and applies the N4ITK algorithm to correct intensity inhomogeneities inherent in T1 weighted MRI. Fuzzy c-means is then used to separate muscle and adipose tissues. The bone is identified via histogram analysis and region growing. A thin-line gradient filter is passed over the image, and potential fascia lata points are identified as the max response along rays from the thigh's center to its boundary. A contour to separate the SAT and IMAT is constructed by checking each ray and connecting the potential fascia points. Outliers are removed in this contour based on neighborhood information, and a piecewise smooth Bernstein polynomial is fitted to obtain the fascia lata boundary.We tested our method on the T1 sequence of the thighs of 38 patients (aged 41±11, and 17 male and 21 female) with GNE myopathy at varying degrees of thigh muscle involvement (9 Mild, 23 Moderate, 6 Severe). Of these, 12 patients (4 of each group) had 3 slices manually segmented as reference.

RESULTS

Based on our automatic segmentation, we found that the IMAT percentage of the thigh was 13±3%, 24±7%, and 36±8% in mild, moderate, and severe groups, respectively. Comparisons between manual and automated segmentation reveal a varying amount of agreement depending on the level of severity of the muscle involvement. We achieved Dice coefficients of 0.95±0.01, 0.91±0.03, and 0.68±0.07 for muscle, SAT, and IMAT, respectively, in mild group, of 0.94±0.01, 0.92±0.05, and 0.83±0.03 in moderate group, and 0.76±0.23, 0.90±0.02, and 0.87±0.03 in severe group. The R2 value between manual and automated measurements for the percentage of muscle, SAT, and IMAT in the thigh were 0.99, 0.97, and 0.96, respectively for the validation set.

CONCLUSION

We have demonstrated an automated and robust method to distinguish between the SAT and IMAT of the thigh, thus making it capable of quantifying the different tissue types regardless of disease severity.

CLINICAL RELEVANCE/APPLICATION

The proposed system provides consistent quantification of thigh tissue composition and can be used to effectively study and track muscle disease.

SSA22-05 Automated Image Quality Assessment in Whole-Body MRI

Sunday, Nov. 27 11:25AM - 11:35AM Room: S405AB

Participants
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PURPOSE

MR image quality is highly variable due to numerous influencing factors and possible artifacts. Automated assessment of image quality may enable efficient optimization of MRI acquisition. The purpose of this study was to implement and evaluate a machine learning framework for automated analysis of whole-body MRI data.

METHOD AND MATERIALS

The proposed algorithm consists of a training phase with feature extraction, feature reduction and training of a classifier.
Image foreground and background were segmented prior to feature extraction using level set segmentation. A variety of image features (intensity-based, gradient-based and texture-based features) were obtained from each MR data set describing an image in a high-dimensional space. After feature reduction using principal component analysis, a Support Vector Machine was trained to categorize image quality into one of five classes (1: very high quality, 5: very poor quality). Subjective quality ratings given independently by 5 radiologists were used as ground truth labels in the training phase.
This method was applied on 2911 randomly selected MR images from different acquisition protocols of head/neck, thoracic and abdominal regions. 70% of these images were randomly used as a training set and 30% as test set.
Classification accuracy was measured as the percentage of correctly classified samples in the test set.

RESULTS

Ground truth image quality was classified by the radiologists with the following distribution: 1:10%; 2:21%; 3:29%; 4:28%; 5:12%. We observed varying classification accuracy depending on the amount and selection of features used. Optimal classification

accuracy of 92% was observed using a total of 3039 features and 36 principal components. Most classification errors occurred between classes 1 (very good quality) and 2 (good quality).

CONCLUSION

Automated assessment of MR image quality is feasible using a machine learning approach and yields a high classification accuracy.

CLINICAL RELEVANCE/APPLICATION

The presented method can contribute to automated optimization of MR image quality in clinical practice or assisted image acquisition and reading and thus possibly improve diagnostic efficacy.

SSA22-06 Changing Temporal Resolution of DCE-MRI Radial VIBE Data by ICTGV Reconstruction

Sunday, Nov. 27 11:35AM - 11:45AM Room: S405AB

Participants
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Rudolf Stollberger, PhD, Graz, Austria (*Presenter*) Nothing to Disclose

PURPOSE

To explore the adjustment of the temporal resolution of DCE-MRI after data acquisition by a new iterative reconstruction technique.

METHOD AND MATERIALS

his fully HIPAA-compliant study uses raw data of already acquired golden angle radial DCE-MRI scans and reconstructs dynamic image series with different temporal resolution with a new reconstruction technique based on infimal convolution total generalized variation (ICTGV). Data acquisition was performed for DCE liver scan at 3Tesla with a 12 element body array coil. A 3D radial VIBE sequence (stack of stars) was performed with 30 slice encodings and 600 spokes per slice. With a standard compressed sensing GRASP algorithm a spatial resolution of 1x1x3 mm (matrix = 384x384x30) and a temporal resolution of 2.6s would be obtained. ICTGV was used to retrospectively reconstruct a dynamic series with a higher temporal resolution by grouping number of consecutive spokes. This approach was compared for the same undersampled number of projections with low-rank sparse (L+S) reconstruction and the GRASP technique.

RESULTS

DCE-series were reconstructed by using 8, 14, and 21 spokes- per-frame (spf) resulting in a temporal resolution of 0.94, 1.7 and 2.6 s. For 8 and 14 spokes, the standard GRASP reconstruction delivered a noisy image quality suffering from aliasing artifacts. L+S and ICTGV suppressed the aliasing artifacts much better and preserved also tiny image details (see Fig. for 8 spokes). The analysis of the arterial input function shows a marked temporal blurring for the L+S reconstruction. The AIF determined from ICTGV reconstruction shows the best SNR, the highest peak value and a pronounced second pass (see Fig.).

CONCLUSION

ICTGV outperformed both alternative algorithms in spatial and temporal SNR and allows calculating dynamic 3D data with high temporal resolution to better characterize the contrast-agent related functional signal changes. Therefore ICTGV reconstruction is able to improve the data basis for subsequent quantitative analysis.

CLINICAL RELEVANCE/APPLICATION

The investigated method allows combining high spatial and high temporal resolution and a retrospective adjustment depending on specific patho-morphological requirements.

SSA22-07 Assessment of the Accuracy, Repeatability, and Efficiency of Accelerated Variable Flip Angle T1 Mapping Techniques Using a NIST-traceable MR System Phantom

Sunday, Nov. 27 11:45AM - 11:55AM Room: S405AB

Participants
Alexander Antolak, Madison, WI (*Presenter*) Nothing to Disclose
Edward F. Jackson, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Assess the accuracy and repeatability of a variable flip angle (VFA) 3D-FSPGR T1 mapping method using a recently commercialized NIST/ISMRM MR System Phantom with and without parallel imaging and with 2 to 7 flip angles.

METHOD AND MATERIALS

The NIST/ISMRM MR System Phantom, produced by High Precision Devices, Inc (Boulder, CO), contains, among other inserts, an array of 14 spheres with T1 values ranging from 23 to 2033 ms at 1.5 T. The NiCl2 solutions used to fill the spheres are prepared and maintained by NIST to ensure stability and accuracy. The phantom was imaged 3 times over 4 days on a GE HDxt 1.5 T MR scanner using a 3D-FSPGR sequence with 7 flip angles from 2 to 30 degrees and 4 averages. In addition, parallel imaging was applied with no averaging, and subsets of the 7 flip angle data, with and without parallel imaging, were used to investigate the impact of decreased acquisition times on T1 measurement accuracy and repeatability. T1 calculations were performed in Matlab using a nonlinear least squares fit. The mean T1 value, standard deviation, and percent deviation from nominal T1 values were computed for each T1 sphere in the phantom.

RESULTS

For all cases, the minimum deviation from nominal T1 values was 14%. The deviation increased for larger T1 values, up to a maximum of 30%. Total scan time for the 4 average T1 mapping protocol using 7 flip angles was approximately 18 minutes. Parallel imaging with an acceleration factor of 2 and no averaging provided similar results to the 7 flip angle, 4 average protocol while decreasing the imaging time by a factor of 8. T1 mapping accuracy was also maintained using only 3 flip angles instead of 7 (with

and without parallel imaging). Using 3 flip angles and parallel imaging together decreased the imaging time from approximately 18 minutes to 1 minute. The maximum coefficient of variation across all 3 acquisitions for any T1 sphere and acquisition strategy was 5%.

CONCLUSION

Highly repeatable estimates of T1 relaxation times can be obtained when using parallel imaging and as few as 3 flip angles, significantly improving the efficiency of T1 measurements. Parallel imaging, with acceleration factors of 2, have minimal impact on repeatability and accuracy.

CLINICAL RELEVANCE/APPLICATION

To be clinically relevant, T1 measurements should be acquired efficiently and with known accuracy and repeatability. Parallel imaging had no significant impact on the quality of such measures.

SSA22-08 fMRI in All Plane Orientations with Decreased Image Distortion Using A 2D RF Pulse for Field-of-View Reduction

Sunday, Nov. 27 11:55AM - 12:05PM Room: S405AB

Awards
Student Travel Stipend Award

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PURPOSE

To demonstrate the use of a 2D excitation radio-frequency (RF) pulse for fMRI over a reduced field-of-view (rFOV) to reduce image distortion in a focused region in not only an axial, but also sagittal and coronal planes that are conventionally prohibitive due to excessive image distortion.

METHOD AND MATERIALS

A 2D RF pulse was designed and incorporated into a single-shot echo planar imaging (ssEPI) sequence. The pulse features a tilted excitation profile to enable multi-slice imaging and simultaneous lipid suppression. With IRB approval, fMRI experiments were carried out on five healthy human subjects at 3T with a 32-channel head coil using a flashing checkerboard visual activation or a finger tapping task (5 epochs of 30s on and 30s off). For comparison, both a commercial full FOV (fFOV) and the proposed rFOV sequences were used. The visual cortex experiments (VCEs) were performed in the axial and sagittal planes with the same in-plane resolutions of $1.875\times1.875mm^2$. The motor cortex experiments (MCEs) were performed in the axial and coronal planes with in-plane resolutions of $1.875\times1.875mm^2$ and $1.875\times1.5mm^2$, respectively. The activation *t*-maps were calculated using SPM12 and superimposed on 3D T1-weighted anatomical or EPI images.

RESULTS

The activated voxels from the axial, sagittal, or coronal VCEs and MCEs in the rFOV images were substantially better registered to the T1-weighted images than those in the fFOV images due to the reduced image distortion. In the coronal-MCEs, the false positive activations on the skull decreased noticeably in the rFOV compared to the fFOV acquisition. The close resemblance between the rfOV coronal-MCE activation and the reformatted coronal view of the fFOV axial-MCE activation provides further evidence demonstrating the benefit of using the proposed rFOV technique over the fFOV sequence in the coronal plane without suffering from intensity discontinuity imposed by slice reformatting.

CONCLUSION

The proposed rFOV ssEPI sequence outperformed the conventional ssEPI sequence particularly in non-axial planes where the excessive distortion often makes EPI-based fMRI prohibitive.

CLINICAL RELEVANCE/APPLICATION

This rFOV technique provides flexibility in selecting acquisition planes without suffering from excessive image distortion, allowing fMRI to be performed in a plane that best matches the activation regions.

SSA22-09 Volumetric Respiratory-Resolved and Cardiac--Resolved MR Flow Imaging

Sunday, Nov. 27 12:05PM - 12:15PM Room: S405AB

Participants
Joseph Y. Cheng, PhD, Stanford, CA (*Presenter*) Research support, General Electric Company
Marcus T. Alley, PhD, Stanford, CA (*Abstract Co-Author*) Research funded, General Electric Company; Research Consultant, Arterys Inc
John Pauly, Stanford, CA (*Abstract Co-Author*) Research support, General Electric Company
Michael Lustig, PhD, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Shreyas S. Vasanawala, MD, PhD, Stanford, CA (*Abstract Co-Author*) Research collaboration, General Electric Company; Consultant, Arterys Inc; Research Grant, Bayer AG;

PURPOSE

Volumetric cardiac-resolved MR flow imaging (4D flow) enables the assessment of flow, function, and anatomy from a single sequence. This technique simplifies and shortens congenital heart disease (CHD) MRI exams. Modern accelerated imaging techniques enable the acquisition to be performed in a practical 5–15 min scan. With patients freely breathing, the impact of respiration on cardiac flow quantification is typically ignored. The purpose of this work is to develop an ultra-high-dimensional flow imaging technique (ND flow) to evaluate the impact of respiration on cardiac flow quantification.

METHOD AND MATERIALS

With IRB approval and informed consent, pediatric patients were imaged with MRI, ferumoxytol administration, and general anesthesia. A Cartesian 4D flow sequence is modified to include intrinsic navigators and pseudo-random variable-density k-t sampling. The EKG and navigation signals are used to retrospectively sort the data into respiratory and cardiac phases. A compressed-sensing-based parallel imaging method is used to reconstruct this highly-subsampled dataset. The proposed technique is compared to conventional 4D flow with and without respiratory motion compensation through soft-gating (SG). Velocity images are corrected for background phase errors, and flow is quantified in the superior and inferior vena cava (SVC and IVC).

RESULTS

Using the proposed ND flow in a 3-yr-old female, 0.75–0.84 L/min (mean 0.74 L/min) for the SVC and 0.15–0.69 L/min (mean 0.44 L/min) for the IVC were observed for total blood flow as a function of respiration. For conventional 4D flow, a flow of 0.40 L/min (with and without SG) in the IVC and a flow of 0.72 (no SG) and 0.75 L/min (with SG) in the SVC were measured. Respiratory-dependent flows were also measured in a 10-yr-old male: 0.72–2.0 L/min (mean 1.4 L/min) for SVC and 0.48–1.1 L/min (mean 0.9 L/min) for IVC. For conventional 4D flow, 1.33 and 1.49 L/min (without and with SG) in the SVC and 0.98 and 1.0 L/min (without and with SG) in the IVC were measured.

CONCLUSION

Respiratory-induced blood flow variations has been demonstrated using ND flow. This technique will provide a tool to investigate specific CHDs, how anesthesia impacts flow measurements, and the relationship between respiratory and cardiac systems.

CLINICAL RELEVANCE/APPLICATION

Respiration may impact cardiac flow quantification, and we present a tool to evaluate and study this effect for potentially more accurate blood flow measurements.

PHS-SUA

Physics Sunday Poster Discussions

Sunday, Nov. 27 12:30PM - 1:00PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Yulei Jiang, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

PH201-SD-SUA2 A Gradient- and Spin-echo (GRASE) Sequence for Breath-hold Three-dimensional (3D) Magnetic Resonance Cholangiopancreatography (MRCP) at 3.0 T

Station #2

Participants
Katsuhiro Kida, Okayama, Japan (*Presenter*) Nothing to Disclose
Sachiko Goto, PhD, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Ryutaro Matsuura, MSc, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuka Tanaka, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Tsutomu Kajitani, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiharu Azuma, PhD, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

These results suggest that the breath-hold 3D GRASE sequence can realize to obtain the MRCP quickly and surely.

Background

A respiratory-triggered (RT) three-dimensional (3D) fast spin-echo (FSE) sequence has been used to obtain high-quality magnetic resonance cholangiopancreatography (MRCP). However, this sequence has a long scan time because of using RT. Furthermore, the RT acquisitions are susceptible to motion artifacts and blurring in patients with shallow or irregular respirations, sleep apnea, or significant diaphragmatic drift. In this study, we evaluated a breath-hold (BH) MRCP using 3D gradient- and spin-echo (GRASE) sequence, which could shorten the scan time and be more reliably obtained.

Evaluation

Fifteen patients (10 males and 5 females, aged 40–88 years; mean age 69.5 years) underwent two examinations, one of the BH 3D GRASE sequence and the other of the RT 3D FSE sequence at 3.0 T MR system (Achieva 3.0T TX, Philips). Each MR image was reconstructed into maximum intensity projection (MIP) images. Four radiologists and two radiological technologists performed visual evaluation for overall reader confidence in the diagnosis using a five-point scale (5, excellent; 4, good; 3, moderate; 2, fair; 1, poor). The statistical significance of overall reader confidence of the two sequences were tested using the Wilcoxon signed rank test. Furthermore, we evaluated the images when breath-hold time was not long enough for the acquisition using BH 3D GRASE sequence.

Discussion

Figure shows the images for the BH 3D GRASE and the RT 3D FSE sequences. While the actual scan time of the RT 3D FSE sequence was about 5-10 min, that of the BH 3D GRASE sequence was only 19 sec. The overall reader confidence had no statistical significance between the sequences ($p = 0.67$). Though some images of the RT 3D FSE sequence had respiratory motion artifacts and blurring, the images of the BH 3D GRASE sequence had little those. Furthermore, if the breathing stops more than half of scan time, our method can obtain diagnosable image quality. We think the k-space sampling trajectory for the GRASE sequence has an effect of making the signal error related to motion-induced artifact inconspicuous.

PH202-SD-SUA3 Self-correction of Blood Flow Effect for Fluctuation MRI in Idiopathic Normal Pressure Hydrocephalus

Station #3

Participants
Naoki Ohno, PhD, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Tosiaki Miyati, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Marina Takatsuji, BS, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Mitsuhito Mase, MD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Tomoshi Osawa, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Hirohito Kan, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuta Shibamoto, MD, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshifumi Gabata, MD, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Arterial inflow into the cranium induces apparent diffusion coefficient (ADC) change of the brain during the cardiac cycle, ie., fluctuation of water molecules. The degree of water fluctuation assists in the diagnosis of idiopathic normal pressure hydrocephalus (iNPH). However, these changes depend on cerebral blood flow (CBF) as a driving force for fluctuating water-molecules. Therefore, we corrected the CBF effect by using the diffusion data itself to evaluate hemodynamic-independent water fluctuation in iNPH.

METHOD AND MATERIALS

On a 1.5 T MRI, we performed ECG-triggered single-shot diffusion echo-planar imaging with the following parameters: repetition

time, 2 R-R intervals; echo time, shortest; flip angle, 90°; section thickness, 4 mm; imaging matrix, 64×64 ; field of view, 256 mm; number of signals averaged, 2; cardiac phases (different phases acquired by varying the ECG trigger delay), 20; b-values, 0, 500, and 1000 s/mm2; separate measures in the X-, Y-, and Z-axis directions; parallel imaging factor, 2; and half-scan factor, 0.6. Next, we determined the peak ADC with b = 0-500 (ADCpeak: perfusion-related diffusion component) and maximum change in ADC with b = 0-1000 (ΔADC: water fluctuation component) in the cardiac cycle, and divided the ΔADC by the ADCpeak (Corrected-ΔADC). Then, we compared those values of the frontal white matter among iNPH (n=17), atrophic ventricular dilatation (atrophic VD group; n=9), and healthy volunteers (control group; n=8).

RESULTS

The Corrected-ΔADC was significantly higher in the iNPH group compared with the control and atrophic VD groups, whereas no significant difference was observed in the ADCpeak among the groups. These results indicate that hemodynamic-independent water fluctuation, ie., biomechanical property of the brain between the CBF (input) and water fluctuation (output), is increased in iNPH because of low compliance.

CONCLUSION

Hemodynamically independent analysis for water fluctuation MRI enabled us to obtain more detailed information on biomechanical properties in iNPH.

CLINICAL RELEVANCE/APPLICATION

Corrected-ΔADC analysis, as a noninvasive MRI method to assess the degree of fluctuation of the water molecules hemodynamic-independently, makes it possible to obtain more detailed information on biomechanical properties in iNPH.

PH203-SD-SUA4 MR Fibrography: An Application of Correlation Time Diffusion Synthetic MRI (1.5T and 3.0T)

Station #4

Participants
Hernan Jara, PhD, Belmont, MA (*Presenter*) Patent holder, qMRI algorithms; Research Grant, General Electric Company; Royalties, World Scientific Publishing Co; ; ;
Osamu Sakai, MD, PhD, Boston, MA (*Abstract Co-Author*) Consultant, Guerbet SA
Stephan W. Anderson, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Jorge A. Soto, MD, Boston, MA (*Abstract Co-Author*) Royalties, Reed Elsevier

CONCLUSION

A complete MRI technique for rendering the full white matter fibrogram (Fig. 1) has been developed and tested at 1.5T and 3.0T with standard clinical scanners.

Background

Conventional diffusion weighted MRI is based on the pulsed field gradient (PFG) experiment. Alternatively, correlation time diffusion (DCT) MRI is based on T1 relaxometry and therefore probes water diffusion at the very short time scale of the correlation time: ~20ps for brain tissue. The purpose of this technical presentation is to describe a complete multispectral image acquisition technique and image processing pipeline for generating heavily DCT–weighted synthetic MR images starting with the quadraFSE pulse sequence leading to MR Fibrography (MRF), a terminology adopted herein to differentiate it from diffusion tensor imaging based MR Tractography.

Evaluation

A volunteer (male, 35yo) was scanned at 3.0T (Discovery MR750, GE Healthcare, Waukesha, WI) and a week later at 1.5T (Optima MR450w, GE Healthcare, Waukesha, WI) using the quadraFSE pulse sequence. This is the concatenation of two dual-echo fast spin echo scans differing only in their different repetition time TR.The acquired images were qMRI processed with Mathcad (version 2001i, PTC, Needham, MA) at full spatial resolution (0.47 x 0.47 x 3mm3) to generate coregistered maps of PD, T1, T2, and DCT. These maps were used to generate diffusion-weighted synthetic MR images at arbitrarily large b values: 0-30,000s/mm2. At b values above 3,000s/mm2, an irregular "cobblestone" texture develops in white matter and the acuity of this texture improves as a function of increasing diffusion weighting. The cobblestone texture is observed at 1.5T and 3.0T.

Discussion

Developments in ultra-powerful magnetic field gradient technologies have been reported in the context of the of the Human Connectome Project. With a maximum gradient strength of 300mT/m, probing the diffusion of water in tissue with very high b-values and short diffusion times of less than 21ms becomes possible. The technique described herein enables probing motion of water in tissue at the tens of picoseconds time scale and therefore provides complementary information.

Honored Educators

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

Hernan Jara, PhD - 2014 Honored Educator
Osamu Sakai, MD, PhD - 2013 Honored Educator
Osamu Sakai, MD, PhD - 2014 Honored Educator
Osamu Sakai, MD, PhD - 2015 Honored Educator
Jorge A. Soto, MD - 2013 Honored Educator
Jorge A. Soto, MD - 2014 Honored Educator
Jorge A. Soto, MD - 2015 Honored Educator

PH204-SD-SUA5 MDCT of the Abdomen Using a Wide Volume (WV) Scan Mode with a 320-Detector Row Scanner: Which is the Best Collimation in Terms of Radiation Dose and Image Quality?

Station #5

Participants
Catherine Roy, MD, Strasbourg, France (*Presenter*) Nothing to Disclose
Raphael Quin, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Aissam Labani, MD, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Guillaume Alemann, MD, MS, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Mickael Ohana, MD, MSc, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To optimize a protocol for WV scan mode on a 320 detector CT scanner by means of tests on phantom and CT console analysis of topograms using different collimations in terms of radiation dose and image quality in comparison with the helical mode (HM).

METHOD AND MATERIALS

We recorded the CTDIvol in WV mode with different collimations from 120x0.5mm (6cm) to 320x0.5mm (16cm) using topograms data of medium size patients on a 320-detector CT scanner (Aquilion ONE, Toshiba Medical Systems).A radiosensitive films Gafchromic® were positioned between two homogeneous PMMA (methyl methacrylate) phantom of 10cm in order to realize dose profiles in WV mode (collimation of 200x0.5mm, 0.5s/volume (3 volumes of 8cm) and HM (collimation of 100x0.5mm, 0.5s/turn). Both scans modes were performed at 120kVp with the same FOV, length of coverage and iterative reconstruction. Adaptive blending was used to stitch the wide volumes. Then these films were analyzed with an optical scanner and transcribed in the form of optical density curve.
Ten 100mm² ROI were drawn on the Workstation to measure signal to noise ratio (SNR) on each acquisition.

RESULTS

At constant parameters, the collimation of 10 cm (200x0.5mm) had the lowest CTDIvol. An increase of CDTIvol by 18% was observed for collimations of 16cm (320x0mm) and 14cm (280x0.5mm). Similarly an increase of CDTIvol by 27% was noted when a smaller collimation of 6cm (120x0.5mm) was used. On radiosensitive films, WV had a higher radiation dose at the site of overlapping volumes, but the overbeaming was clearly shorter compared to HM. In HM, the overranging is visible at both ends of the segment as a large zone. It is completely absent in WV. As we reduce the size of our volumes (from 16 to 4 cm), we increase proportionally the phenomenon of overlapping and overbeaming by repetition of smaller volumes. On the optical density curves, it was found at the ends of the explored segment, a more linear and faster decrease of the dose in WV than in HM. The signal to noise ratio measured on phantoms was not significantly less important in WV than in HM 16.5 +/- 0.7 vs 18.8 +/-1.1, respectively.

CONCLUSION

In WV mode, the optimal collimation to decrease radiation dose is obtained at 10cm instead of 16cm while keeping a quite similar signal to noise ratio.

CLINICAL RELEVANCE/APPLICATION

A 10cm collimation instead of 16cm in WV mode is the best compromise. This dose reduction is related to various factors.

PH205-SD-SUA6 Conversion of Ultra-low-dose (ULD) to "Virtual" High-dose (VHD) Thin-slice Chest CT by means of 3D Supervised Volume-based Artificial Neural Network (ANN)

Station #6

Participants
Nima Tajbakhsh, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Toru Higaki, PhD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Wataru Fukumoto, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Eisai Co, Ltd; Medical Advisor, General Electric Company; ; ; ; ;
Kenji Suzuki, PhD, Chicago, IL (*Presenter*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Stockholder, Alara, Inc; Stockholder, AlgoMedica, Inc.; ; ; ; ; ; ; ;

PURPOSE

Since current radiation dose in chest CT is still very high for lung cancer screening, radiation dose reduction is highly demanded. Our purpose was to develop a volume-processing technique to convert thin-slice ULDCT to VHDCT where noise and artifact are substantially reduced.

METHOD AND MATERIALS

We developed a VHDCT technology based on 3D volume-based massive-training ANNs to convert thin-slice ULDCT into VHDCT. Our technology relies on a new data sampling scheme to collect a representative set of training samples and a set of organ-specific models to achieve higher noise reduction capability. Our technology was trained with a large number of patches (or subvolumes) extracted from input ULDCT volumes and corresponding single voxels in "teaching" HDCT volumes. Through training, our technology learned the relationship between them to convert ULDCT into HDCT. We trained our technology with ULDCT (10 mAs, 120 kVp, 0.24 mSv, 0.5 mm slice thickness) and corresponding "teaching" HDCT (550 mAs, 120 kVp, 13.2 mSv, 0.5 mm) of an anthropomorphic chest phantom (Kyoto Kagaku, Kyoto, Japan). Once trained, our technology no longer requires HDCT, and it provides VHDCT where noise and artifact are substantially reduced. To test our technique, we acquired 4 more sets of CT scans of the same phantom at 4 different radiation doses (0.96, 1.92, 3.84, and 6.6 mSv) by changing tube currents (40, 80, 160, and 275 mAs). We used the structural similarity (SSIM) index for measuring the similarity between our VHDCT and "gold-standard" HDCT.

RESULTS

Our VHDCT technology reduced noise and artifacts in ULDCT substantially, while maintaining anatomic structures and pathologies such as vessels, bones, and nodules. With our technology, the average SSIM of ULDCT was improved by 0.62 (from 0.15±.07 to 0.77±.08) (two-tailed t-test; P<.05), which was equivalent to 96.7% dose reduction (from 7.34 to 0.24 mSv) without compromising image quality. The processing time for a CT scan was 4.8 min on a PC (Intel Core i7, 4.6GHz).

CONCLUSION

Our technology converted thin-slice ULDCT (0.24 mSv) to "virtual" HDCT with substantially less noise or artifact, which was equivalent to 7.34 mSv CT; and thus, radiation dose reduction in CT by up to 96.7% could be possible.

CLINICAL RELEVANCE/APPLICATION

Substantial reduction in radiation dose in CT by our technology would be beneficial to screening population. Short processing time is an advantage of our technology over iterative reconstruction.

PH101-ED-SUA7 Accelerated MR Imaging, Its Benefits in Daily Routine, Current Limitations and Future Developments

Station #7

Awards
Certificate of Merit

Participants
Johannes K. Richter, MD, Bern, Switzerland (*Presenter*) Nothing to Disclose
Val M. Runge, MD, Bern, Switzerland (*Abstract Co-Author*) Research Grant, Siemens AG
Reto D. Merges, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Markus Klarhofer, Basel, Switzerland (*Abstract Co-Author*) Employee, Siemens AG
Johannes T. Heverhagen, MD, PhD, Bern, Switzerland (*Abstract Co-Author*) Research Grant, Bracco Group; Research Grant, Guerbet DA; Research Grant, Siemens AG;

TEACHING POINTS

(1) To present and discuss the clinically relevant accelerated MR techniques currently available, focusing on: (a) improvements in 3D acquisition (CAIPIRINHA and radial VIBE, CAIPI-DIXON-TWIST-VIBE), (b) simultaneous multi-slice imaging (SMS), and (c) sparse imaging. (2) To provide guidance to the radiologist as to the implementation of the above mentioned techniques, with the intent to enable faster and improved clinical scan results.

TABLE OF CONTENTS/OUTLINE

The exhibit will focus on three major areas, using primarily patient images, to convey the benefits of accelerated MR sequences when compared to more conventional scans in day-to-day clinical routine. (1) CAIPIRINHA and radial techniques in 3D imaging - strengths and clinical utility (for example, acquisition of a 6 sec breath hold CAIPI scan at 3 T using a 60 channel body coil in comparison to a non breath hold 21 sec radial scan). (2) SMS - scientific basis and implementation for 2D DWI and T1, T2, and PD FSE/TSE sequences (for example, with DWI, permitting the entire neck to be scanned for lymph node evaluation in 1:54 min:sec, or the whole brain with a 1 mm slice thickness in 4:39 min:sec). (3) Sparse reconstruction techniques - principles, challenges, and current applications (for example in CE-MRA and musculoskeletal imaging, the latter for 3D imaging as well as metal artifact reduction).

PH008-EB-SUA Development of an Iterative Interior Reconstruction Method for Low Dose CBCT in Proton Therapy Patient Positioning

Hardcopy Backboard

Participants
Takashi Yamaguchi, PhD , Yokosuka-Shi, Japan (*Presenter*) Nothing to Disclose

Background

Cone Beam Computed Tomography (CBCT) determining patient position is used before every irradiation, which results in increased radiation exposure for the patient. To reduce the patient exposure, reduction of either X-ray imaging time or X-ray tube current is necessary. However, this leads to increased noise and reduced contrast in images. Furthermore, when the object do not fit to the size of Field of View (FOV), an interior reconstruction is required to reconstruct a part of a tomographic image. To meet these requirements, we have developed an interior image reconstruction method employing an iterative algorithm, which is robust to noise. Our method can achieve high image contrast, and that can visualize a part of a transaxial plane.

Evaluation

In the iterative image reconstruction process referred to as Ordered Subset Convex, a corresponding system matrix is required for a given measurement geometry. In a gantry-mounted CBCT, the X-ray tube and the detector positions deviate some from their ideal position, resulting in a different geometry at each measurement angle, but full calculation of system matrices requires a large data capacity or significant computation time. To overcome these issues, our method calculates the system matrix for an ideal geometry in advance and performs positional deviation correction on the measured data, also creates a buffer area around a FOV, estimates X-ray attenuations outside of the FOV, and removes the attenuation effect. These techniques allow to obtain an interior image corrected positional deviations.

Discussion

We applied the method to positional deviations and Poisson noise-added digital phantom data and verified the method, and were able to obtain noise reduction within the FOV in conditions of low-dose, compared to general iterative reconstruction.

CONCLUSION

We have developed an iterative interior reconstruction method for low-dose CBCT in proton therapy patient positioning. The method can perform positional deviation correction and remove the effect of attenuation in the outer of FOV. We expect the method to contribute to reduce radiation exposure to the patient.

FIGURE

http://abstract.rsna.org/uploads/2016/16011979/16011979_p3dn.jpg

PHS-SUB

Physics Sunday Poster Discussions

Sunday, Nov. 27 1:00PM - 1:30PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Yulei Jiang, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

PH206-SD-SUB1 Spiral-based 3D MR Thermometry for Brain Applications of MR-guided Focused Ultrasound in a Porcine Model

Station #1

Awards
Student Travel Stipend Award

Participants
Matthew G. Geeslin, MD, MS, Charlottesville, VA (*Presenter*) Nothing to Disclose
Sam Fielden, Charlottesville, VA (*Abstract Co-Author*) Nothing to Disclose
Xue Feng, Charlottesville, VA (*Abstract Co-Author*) Nothing to Disclose
Max Wintermark, MD, Lausanne, Switzerland (*Abstract Co-Author*) Advisory Board, General Electric Company;
Jason Druzgal, MD, PhD, Charlottesville, VA (*Abstract Co-Author*) Nothing to Disclose
Craig Meyer, Charlottesville, VA (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

Perform an in vivo evaluation of a newly developed, spiral-based 3D MR thermometry sequence, in preparation for clinical translation.

METHOD AND MATERIALS

MR-guided focused ultrasound (MRgFUS) was used in a porcine model to anatomically target and prescribe a range of temperature elevations in the thalamus, bilaterally. The temperature of sonications was monitored with two different MR-thermometry sequences: a 2D Cartesian based (clinical standard), and a 3D spiral based (experimental) acquisition. The 2D method employs a gradient echo sequence with Cartesian sampling of k-space, and the 3D method implements spiral in/out sampling of in-plane k-space with Cartesian phase encoding of the third dimension. To evaluate for hot-spot position shift between the 2D Cartesian and 3D spiral techniques, identical non-ablative power settings were used to produce sublethal temperature rises at identical thalamic sites. The in-plane position of the hottest voxel was then compared between the 2D Cartesian and 3D spiral methods. Spatial and temporal resolution were also compared between the 2D and 3D techniques.

RESULTS

Position-shift of the hot spot due to off-resonance from magnetic inhomogeneity is a known pitfall of Cartesian acquisitions. The consequence of such an artifact can be the ablation of an unintended target. The benefit of spiral in/out k-space sampling for this application, is that off-resonance manifests as image-blur, rather than position shift. Of 12 comparative in vivo sonications, each monitored with both 3D spiral and 2D Cartesian MR-thermometry, 6 Cartesian acquisitions demonstrated a position shift of the hottest voxel of greater than 1 mm, within the in-plane dimension. The spiral-based 3D MR thermometry sequence was able to monitor temperature in real-time, with a temporal resolution of 8.7 seconds and a spatial resolution of 1.5 mm2 (in-plane) by 2 mm (through-plane). By comparison, the 2D sequence has a temporal resolution of 3.5 seconds and a spatial resolution of 1.1 x 2.2 mm.

CONCLUSION

Spiral in/out acquisitions have demonstrated the ability, in vivo, to produce 3D temperature maps, in real-time, without suffering from position shift due to off-resonance.

CLINICAL RELEVANCE/APPLICATION

Real-time 3D temperature mapping without hot-spot position shift has significant efficiency and safety advantages, when compared with the Cartesian-based 2D MR thermometry presently in use.

PH207-SD-SUB2 The Effect of Continuous CT Dose Surveys and Feedback on Dose Optimization

Station #2

Participants
Yasuhiro Fukushima, RT, Maebashi, Japan (*Presenter*) Nothing to Disclose
Akiko Iriuchijima, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Ayako Taketomi-Takahashi, MD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Takayuki Suto, Gunma-Ken, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshito Tsushima, MD, Maebashi, Japan (*Abstract Co-Author*) Institutional Research Grant, Bayer AG ; Institutional Research Grant, DAIICHI SANKYO Group; Institutional Research Grant, Eisai Co, Ltd; Institutional Research Grant, Nihon Medi-Physics Co, Ltd; Institutional Research Grant, FUJIFILM Holdings Corporation ; Institutional Research Grant, Fuji Pharma Co, Ltd; Institutional Research Grant, Siemens AG ; Institutional Research Grant, OncoTherapy Science, Inc; Institutional Research Grant, Becton, Dickinson and Company; Speaker, Bayer AG ; Speaker, DAIICHI SANKYO Group; Speaker, Eisai Co, Ltd; Speaker, Fuji Pharma Co, Ltd; Speaker, Guerbet SA; .;

PURPOSE

To evaluate the effect of continuous CT dose surveys and their feedback on dose optimization

To evaluate the effect of continuous CT dose surveys and their feedback on dose optimization.

METHOD AND MATERIALS

From 2011 to 2015, we surveyed all institutions in our prefecture with CT units. The survey period varied between years and was either two weeks or one month. We collected and analyzed data from all CT units during the survey period. The data analyzed were for scans of patients 16 years of age or older, scans of the head, chest, abdomen, abdomen to pelvis, chest to pelvis, and coronary artery. The 25th percentile and 75th percentile of the dose distribution for each year were set as the diagnostic reference level. Each year, the diagnostic reference level was fed back to each institution, along with the dose distribution of the units used in that institution and the suggestion to reconsider imaging parameters. We evaluated the dose-length product (DLP) and compared data for 2011 and 2015 using the Mann-Whitney U test, and used a P-value of .05 to evaluate for significant difference.

RESULTS

The mean number of CT dose data per survey was 17,793 from 71.8 hospitals/clinics (84.6 CT scanners) for five surveys. The median DLP for chest, abdomen to pelvis, chest to pelvis and coronary arteries decreased during the survey period of 2011 to 2015. The differences between 2011 and 2015 were 20 mGy cm (5%, P = .005) for chest scans, 65 mGy cm (11.2%, P = 0.000) for abdomen to pelvis scans, 138 mGy cm (14.5%, P = .000) for chest to abdomen scans, and 347 mGy cm (44.8%, P = .000) for coronary artery scans. The interquartile range of DLP in all scan areas decreased during the survey period. The differences in DLP interquartile range between 2011 and 2015 were 114 mGy cm (22.0%) for brain scans, 38 mGy cm (13.7%) for chest scans, 116 mGy cm (25.9%) for abdomen scans, 141 mGy cm (24%) for abdomen to pelvis scans, 184 mGy cm (23.4%) for chest to pelvis scans, and 297 mGy cm (32.1%) for coronary artery scans.

CONCLUSION

Our method consists simply of continuous CT dose surveys and feedback of collected data. This leads to not only dose reduction, but also narrowing of dose distribution, which means dose optimization.

CLINICAL RELEVANCE/APPLICATION

We have shown the efficacy of a strategy for CT dose optimization that is low-cost, minimal effort, and does not involve large-scale training sessions.

PH208-SD-SUB3 Radiation Exposure of Contrast-enhanced Spectral Mammography Compared with Full-field Digital Mammography and 3D Tomosynthesis

Station #3

Participants
Bhavika K. Patel, MD, Phoenix, AZ (*Presenter*) Nothing to Disclose
William Pavlicek, PhD, Scottsdale, AZ (*Abstract Co-Author*) Nothing to Disclose
James Hanson, BS, Glendale, AZ (*Abstract Co-Author*) Nothing to Disclose
Thomas F. Boltz II, PhD, Scottsdale, AZ (*Abstract Co-Author*) Nothing to Disclose
Judy R. James, PhD, Scottsdale, AZ (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Contrast-enhanced spectral mammography (CESM) demonstrated favorable initial results with accuracy and sensitivity, however the incremental increased dose compared with 2D-FFDM) and 3D-tomo is a consideration. We aim to assess the dose increase of CESM in comparison to FFDM and 3D tomo with phantoms and clinical patients.

METHOD AND MATERIALS

A single LCC projection determined the breast dose for patients (6,214 FFDM, 3,662 3D-tomo and 173 CESM) in this IRB-approved study using Hologic Selenia-Dimension. Radiation dose data (compressed breast thickness and average glandular dose (AGD)) were obtained. Experiments were also conducted on regular (50/50) and dense (70/30) breast tissue phantoms. Descriptive statistics of the phantom and patient data were generated using Excel and SAS-JMP statistical software packages.

RESULTS

Patient mean AGD was 1.7 mGy for 2D-FFDM, 2.2 mGy for 3D-Tomo and 3 mGy for CESM exposures. CESM was ~72% higher than 2D-FFDM and ~34% higher than 3D-Tomo.. The 50/50 phantom gave a mean AGD of ~1 mGy for 2D-FFDM, 1.3 mGy for 3D tomo and 1.6 mGy for CESM. the 70/30 phantom gave a mean AGD of ~1.3 mGy for 2D-FFDM exposure, 1.4 mGy for 3D tomo exposure and 2.1 mGy for CESM. Phantom CESM is ~ 25 % more in a 70/30 breast phantom compared to a 50/50 at 4.5cm. CESM was ~42% higher for a 6 cm phantom.

CONCLUSION

Compared to FFDM and 3D tomo, mean AGD with CESM increased by 1.25 mGy and 0.76 mGy, depending upon breast size. Of note, CESM provides the reader with both a low energy image (similar to 2D FFDM) and a contrast-enhanced image that highlights areas of angiogenesis. Initial clinical studies demonstrate a clinical benefit with CESM due to added physiologic information that is provided. CESM shown was found below the MQSA constraints for routine breast dose. However, further studies must be performed, particularly to quantify CESM radiation dose as a function of varying breast density and the sub-populations of patients appropriate for this exam.

CLINICAL RELEVANCE/APPLICATION

CESM provided added physiologic information at doses that meets MQSA requirements. Compared to FFDM and 3D tomo, CESM breast dose increased by ~72% and ~34%, respectively.

Honored Educators

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

William Pavlicek, PhD - 2012 Honored Educator

PH209-SD-SUB4 Low and Consistent Noise Across the Energy Spectrum of Virtual Monoenergetic Images in a Novel Detector Based Spectral CT Scanner

Station #4

Participants
Kevin R. Kalisz, MD, Cleveland, OH (*Presenter*) Nothing to Disclose
Negin Rassouli, MD, Cleveland, OH (*Abstract Co-Author*) Institutional Grant support, Koninklijke Philips NV
Amar Dhanantwari, PhD, Highland Heights, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV
David W. Jordan, PhD, Cleveland, OH (*Abstract Co-Author*) Consultant, Petrone Associates, LLC; Consultant, Applied Medical Physics in Radiology, Inc; Advisory Board, Medical Technology Management Institute; Director, Medical Technology Management Institute; Speaker, Medical Technology Management Institute; Travel support, Sectra AB;
Prabhakar Rajiah, MD, FRCR, Dallas, TX (*Abstract Co-Author*) Institutional Research Grant, Koninklijke Philips NV; Speaker, Koninklijke Philips NV

PURPOSE

Virtual monoenergetic images (VMI) from dual-energy scanners are utilized for amplifying contrast signal, improving lesion visualization and decreasing artifacts. VMI from currently available dual energy technologies is limited by noise at high and low energies. The recently introduced detector based spectral CT (SCT) system accounts for and removes the anti-correlated noise in VMIs. We sought to evaluate VMI noise obtained from the novel SCT in both phantom and patients.

METHOD AND MATERIALS

A Catphan® 600 abdomen phantom was scanned on the SCT. Image noise, SNR and CNR were measured at VMI from 40-200 keV. 100 consecutive patients who had an abdominal scan on the SCT were retrospectively selected. VMI were generated from 40-200 keV at 10 keV intervals (Fig 1A). Two radiologists evaluated the image noise, SNR and CNR within the liver, pancreas, spleen, kidney, aorta, portal vein, muscle, bone, and fat. These were also compared to the standard polyenergetic (120 kVp) study. Paired t-test was used for analysis.

RESULTS

Phantom noise (Fig 1B) was low across all energies, highest at 40 keV (5.31 HU), gradually decreased until 70 keV, after which remained constant until 200 keV (3.45 HU). In the patient cohort, noise showed a similar low, consistent trend for all organs analyzed (Fig 1C). For example, liver noise was greatest at 40 keV (13.2 HU), steadily decreased and then remained constant until 200 keV (11.6 HU). Liver noise at all VMI energies was less than that of the 120 kVp scan ($p<.01$). Even at the lowest energy of 40 keV, all organs demonstrated noise less than 18 HU except bone (48.9 HU) and kidney (21.4 HU). Similarly, for all organs, SNR and CNR were highest at 40 keV (6.8-34.9; 18.3-44.9, respectively) after which they gradually decreased till 120 keV (3.4-8.7; 9.5-13.9) and remained constant until 200 keV (2.6-8.3; 8.5-12.5). SNR was greater for VMI at 40-70 keV than at 120 kVp for all organs ($p<.05$), and CNR was greater for VMI at 40-80 keV than at 120 kVp for all organs ($p<.01$).

CONCLUSION

VMI obtained from a novel detector based SCT has low and consistent noise across the entire spectrum of energies with significant SNR and CNR improvements compared to those of conventional images.

CLINICAL RELEVANCE/APPLICATION

The low and consistent noise in VMI from detector-based spectral CT scanner enables the use of VMI both at low and high energy levels, for increasing contrast signal and decreasing artifacts respectively.

Honored Educators

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

Prabhakar Rajiah, MD, FRCR - 2014 Honored Educator

PH211-SD-SUB6 Revisiting Dynamic Volume Perfusion CT from a Dose Perspective: A Comparison to Routine Protocols

Station #6

Participants
Joshua F. Gawlitza, Mannheim, Germany (*Presenter*) Nothing to Disclose
Thomas Henzler, MD, Mannheim, Germany (*Abstract Co-Author*) Research support, Siemens AG; Speaker, Siemens AG
Mathias Meyer, Mannheim, Germany (*Abstract Co-Author*) Speaker, Siemens AG Speaker, Bracco Group
Nils Vogler, MD , Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Sonja Sudarski, MD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Stefan O. Schoenberg, MD, PhD, Mannheim , Germany (*Abstract Co-Author*) Institutional research agreement, Siemens AG
Holger Haubenreisser, Mannheim, Germany (*Abstract Co-Author*) Speaker, Siemens AG Speaker, Bayer AG

PURPOSE

Reevaluating the concerns over high radiation doses in perfusion CT imaging by comparing the organ-specific-radiation-dose of a dose-optimized abdominal dynamic volume perfusion CT protocol (dVPCT) with three standard triphasic CT (sCT) protocols, performed on three scanners in patients with suspected hepatocellular carcinoma (HCC) using a Monte Carlo Simulation.

METHOD AND MATERIALS

50 patients with suspected HCC that underwent dVPCT examinations on a 3rd generation dual-source CT(DSCT) (Somatom Force, Siemens) with a dose optimized tube voltage of 70 kV were matched, using the calculated water-equivalent-diameter, with 3 reference groups of sCT examinations, which were performed on a clinical routine scanner (Somatom Emotion 16, Siemens), as well

as a 2nd and 3rd generation DSCT. Examination data was exported to an server based analysis platform (Radimetrics, Bayer). This Monte Carlo Simulation based tool was used for the calculation of the organ-specific effective dose (ED) as well as global radiation-dose parameters (e.g. ICRP103).

RESULTS

The ED of the dVPCT-liver-protocol was lower compared to the sCT on our routine scanner in 13 of 18, and non-inferior in a total of 16 of 18 metrics (all $p < 0.05$) - especially in dose sensitive organs such as the red marrow (17.3mSv vs 24.6mSv, $p=< 0.0001$) and the liver (33.3mSv vs 46.9mSv, $p=0.0003$). Compared to the sCT on the 2nd gen. DSCT, there was no significant difference in the ED in 14 of 18 metrics. All ED in the sCT performed on the 3rd gen. DSCT were lower than the dVPCT doses.

CONCLUSION

Our results suggest that the dVPCT compares favourably to the standard CT, performed on the widely spread routine scanner with regard to effective organ dose, especially in dose sensitive organs. Although tri-phasic protocols performed on newer scanners allow an even further dose reduction, the dVPCT provides additional, valuable information with a reasonable level of radiation.

CLINICAL RELEVANCE/APPLICATION

Dynamic volume perfusion CT on modern CT systems can be performed at lower dose levels than standard triphasic protocols on widespread routine CT systems, thus potentially providing more clinically relevant information for a similar radiation dose cost.

PH103-ED-SUB7 Potential Exposure Dose Reductions in Digital Breast Tomosynthesis and Synthetically Reconstructed Digital Mammogram: Selection of Appropriate Reconstruction Technique

Station #7

Participants
Tsutomu Gomi, PhD, Sagamihara, Japan (*Presenter*) Nothing to Disclose
Katsuya Fujita, BSc, Takasaki, Japan (*Abstract Co-Author*) Nothing to Disclose
Masami Goto, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Yusuke Watanabe, MSc, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose
Tokuo Umeda, PhD, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose
Akiko Okawa, MD, RN, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Tohoru Takeda, MD, PhD, Sagamihara-Shi, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) To use reconstruction techniques [filtered back projection (FBP) and iterative reconstruction (IR)] and processing of synthetically reconstructed digital mammogram (SDM, C-View; Hologic) to identify indications of digital breast tomosynthesis (DBT) at various exposure doses. 2) To compare FBP, IR, SDM, and radiography. 3) To select an appropriate reconstruction technique and exposure dose for breast microcalcifications and lesion detection.

TABLE OF CONTENTS/OUTLINE

1. Overview of FBP, IR [simultaneous iterative reconstruction techniques (SIRT), maximum likelihood expectation maximization (MLEM)], and SDM for DBT and radiography2. Diagnostic imaging properties Efficacy with respect to normal structure and lesion detection3. Parameter review Full width at half-maximum Signal difference–to-noise ratio Average glandular dose4. Clinical relevanceOutline:DBT (IR) and SDM provides improved visibility for superimposed structures and can improve resolution and contrast visibility after appropriate selection for reduced exposure dose. Hence, DBT (IR) and SDM, rather than FBP, should be further evaluated. The exposure dose could possibly be decreased by half with DBT (IR) and SDM. Understanding the potential of DBT and SDM for exposure dose selection may improve the diagnostic accuracy of this technique in clinical applications.

RC121

Advances in CT: Technologies, Applications, Operations-CT System Advances

Sunday, Nov. 27 2:00PM - 3:30PM Room: N230B

CT PH

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

FDA Discussions may include off-label uses.

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

LEARNING OBJECTIVES

1) Recognize the various forms of open gantry systems for volumetric CT, including C-arms and similar systems for interventional and diagnostic imaging. 2) Understand the image quality characteristics of such systems, including advantages and challenges associated with volumetric (cone-beam) CT. 3) Understand the clinical applications of such systems in interventional and diagnostic imaging. 4) Describe some of the latest CT acquisition techniques, including high pitch, gating, dynamic (shuttle), and automatic kV selection. 5) Explain the clinical applications of these novel acquisition techniques.

Sub-Events

RC121A Closed Gantry Systems Advances in X-ray Sources and Detectors

Participants
Norbert J. Pelc, ScD, Stanford, CA (*Presenter*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

LEARNING OBJECTIVES

RC121B Open Gantry Systems: Advances, Challenges, and New Applications

Participants
Jeffrey H. Siewerdsen, PhD, Baltimore, MD, (jeff.siewerdsen@jhu.edu) (*Presenter*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Elekta AB; ; ;

LEARNING OBJECTIVES

1) Recognize the various forms of open gantry systems for volumetric CT, including C-arms and similar systems for interventional and diagnostic imaging. 2) Understand the image quality characteristics of such systems, including advantages and challenges associated with volumetric (cone-beam) CT. 3) Understand the clinical applications of such systems in interventional and diagnostic imaging.

RC121C Novel CT Acquisition Techniques

Participants
Lifeng Yu, PhD, Chicago, IL, (yu.lifeng@mayo.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe some of the latest CT acquisition techniques, including high pitch, gating, dynamic (shuttle), and automatic kV selection. 2) Explain the clinical applications of these novel acquisition techniques.

RC122

Imaging for Proton Treatment Planning

Sunday, Nov. 27 2:00PM - 3:30PM Room: S403A

RO PH

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

Participants
Jon J. Kruse, PhD, Rochester, MN (*Moderator*) Research Grant, Varian Medical Systems, Inc

ABSTRACT

Proton therapy has the potential to deliver very conformal dose distributions which may lead to higher cure rates or lower treatment toxicities than conventional or intensity modulated x-ray therapy. Like modern photon modalities, proton therapy relies heavily on advanced imaging techniques for treatment planning and dose calculation. This course will describe imaging requirements which are unique to proton therapy treatment planning. Much of the advantage of proton therapy is derived from the particle beam's finite range, and calculation of proton range within a patient requires a conversion between CT Hounsfield Units (HU) and proton stopping power. This calibration process is significantly different from the HU to electron density conversion which is performed for x-ray dose calculation. Uncertainties in the stopping power conversion are currently managed by expanding normal tissue margins around the clinical target volume and through appropriate beam selection. Improved CT techniques and alternative imaging modalities promise to deliver a more reliable image of stopping power within the patient, allowing for reduced treatment volumes. Tumor motion also presents a unique challenge in proton therapy, as a moving target exhibits not only variable position within a beam's eye view, but varying range as well. Modern proton therapy facilities which deliver treatments via a scanning beam are additionally susceptible to the interplay effect, in which the time dependent dose delivery is altered by motion of the target and surrounding anatomy. Four-dimensional imaging and dose calculation are then critically important in proton therapy to ensure that the treatment plan is robust against tumor motion.

Sub-Events

RC122A Uncertainties in Imaging for Dose Calculations

Participants
Andrew Wroe, PhD, Loma Linda, CA, (awroe@llu.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

Describe the Bragg peak and the impact this has on treatment delivery Understand proton therapy clinical workflow Discuss imaging modalities used for proton therapy treatment planning Describe the CT number to proton stopping power calibration Understand sources of range uncertainty in proton therapy Discuss alternate imaging modalities that may impact proton range uncertainty

RC122B Uncertainties in Motion for Treatment Planning

Participants
Heng Li, Houston, TX, (hengli@mdanderso.org) (*Presenter*) Research funded, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Describe the impact of tumor motion on a proton dose distribution. 2) Compare the relative value of various four-dimensional imaging modalities in the evaluation of a proton plan for a mobile target. 3) Explain the process for incorporating four-dimensional imaging into dose calculation.

ABSTRACT

RC123

Digital Information Security and Medical Imaging Equipment: Threats, Vulnerabilities and Best Practices

Sunday, Nov. 27 2:00PM - 3:30PM Room: E350

IN PH SQ

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

Participants

LEARNING OBJECTIVES

1) Understand the changing environment of network and internet connected devices and software. 2) Be aware of the motivations and tatics of current threat actors. 3) Understand common security issues found in medical devices. 4) Know simple actions that can decrease risk. 5) Understand the vulnerabilities of imaging system modalities to security and privacy breaches. 6) Determine ways to protect and secure imaging systems from internal and external threats. 7) Describe institutional best-practices to maintain protection yet provide necessary accessibility for imaging modalities.8) Do medical devices contain cybersecurity vulnerabilities, and do they affect patient safety? 9) Are medical devices subject to ransomware threats? 10) What is the role and capabilities of the DHS ICS-CERT (Industrial Control Systems Cyber Emergency Response Team) in medical device security? 11) What are some steps that can be taken to protect medical devices?

Sub-Events

RC123A Medical Device Security in a Connected World

Participants

LEARNING OBJECTIVES

1) Understand the changing environment of network and internet connected devices and software. 2) Be aware of the motivations and tatics of current threat actors. 3) Understand common security issues found in medical devices. 4) Know simple actions that can decrease risk.

ABSTRACT

Medical devices are increasingly becoming dependent on technology and network connectivity, at a time that the electronic environment is becoming more dangerous. Because of this medical devices and systems can become easy targets for attackers attempting to access PHI, disrupt patient care or even harm a patient. When tested, these devices have been shown to have multiple vulnerabilities. These vulnerabilities range from hardcoded passwords, publically available service passwords and no encryption of patient data. Because of this institutions using these devices need to work with their vendors to improve the security of medical devices and take actions themselves to help protect their environment and patients.

RC123B Knowing if Your Imaging Systems are Secure and Keeping Them That Way

Participants
J. Anthony Seibert, PhD, Sacramento, CA, (jaseibert@ucdavis.edu) (*Presenter*) Advisory Board, Bayer AG

LEARNING OBJECTIVES

1) Understand the vulnerabilities of imaging system modalities to security and privacy breaches. 2) Determine ways to protect and secure imaging systems from internal and external threats. 3) Describe institutional best-practices to maintain protection yet provide necessary accessibility for imaging modalities.

ABSTRACT

Handout:J. Anthony Seibert

http://abstract.rsna.org/uploads/2016/15002845/Making sure your systems are safe_Seibert2016_final.pdf

RC123C The US Government and Medical Device Security

Participants
Kevin Hemsley, Idaho Falls, ID (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Do medical devices contain cybersecurity vulnerabilities, and do they affect patient safety? 2) Are medical devices subject to ransomware threats? 3) What is the role and capabilities of the DHS ICS-CERT (Industrial Control Systems Cyber Emergency Response Team) in medical device security? 4) What are some steps that can be taken to protect medical devices?

ABSTRACT

This session will discuss the current and emerging cyber threat landscape from the perspective NCCIC/ICS-CERT, including current and anticipated impact on healthcare; the ICS-CERT's role in coordinating vulnerabilities in medical devices and hospital equipment and providing incident response to US critical infrastructure. The role of the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) and how healthcare constituents can connect with ICS-CERT for assistance as well as informational and educational resources.

RC125

Perspectives on Exposure and Risk-Visions of Radiation Safety: What We Know and What is Coming

Sunday, Nov. 27 2:00PM - 3:30PM Room: N226

PH SQ

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

Participants
Madan M. Rehani, PhD, Boston, MA, (mrehani@mgh.harvard.edu) (*Moderator*) Nothing to Disclose
Martha S. Linet, MD, Rockville, MD (*Presenter*) Nothing to Disclose

Sub-Events

RC125A Radiation Doses and Safety Levels Today and Likely in 2020

Participants
Madan M. Rehani, PhD, Boston, MA, (madan.rehani@gmail.com) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Comprehend radiation dose in imaging in current practice to individual patient, cumulative and collective doses. 2) Explain radiation safety levels of patients in different imaging modalities. 3) Identify technological advances in pipeline with their implications on radiation safety.

RC125B What Can We Say About Risks with an Acceptable Level of Uncertainty

Participants
Martha S. Linet, MD, Rockville, MD, (linetm@exchange.nih.gov) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Have an evidence-based perspective on human low-dose radiation exposure and cancer risks. 2) Compare the relative size of adult and child radiation cancer risks.

ABSTRACT

Active Handout:Martha S. Linet

http://abstract.rsna.org/uploads/2016/16001105/Active RC125.pdf

RC125C Radiation Risk Scenario from CT Scans: Today and Likely in 2020

Participants
Donald P. Frush, MD, Durham, NC, (donald.frush@duke.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn current status of pediatric CT radiation risk communication. 2) Be able to disucss needs for improved communciation/education over next 5 years. 3) Understand evolving and potential strategies for understanding this risk.

RC125D Discussion

Participants

ABSTRACT

ED013-MO

Physics Monday Case of the Day

Monday, Nov. 28 7:00AM - 11:59PM Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants

David M. Gauntt, PhD, Birmingham, AL (*Presenter*) Patent agreement, Radcal Corporation
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Brad Kemp, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) The learner will be able to identify the causes of various imaging effects and artifacts, determine whether the effect is caused by equipment problems, and identify the necessary action to correct the effects or artifacts.

RC221

Advances in CT: Technologies, Applications, Operations-Functional CT

Monday, Nov. 28 8:30AM - 10:00AM Room: E451A

CT PH

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

Participants

Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

Sub-Events

RC221A Contrast Administration for Cardiovascular Imaging and Beyond

Participants
Dominik Fleischmann, MD, Palo Alto, CA (*Presenter*) Research support, Siemens AG;

Handout:Dominik Fleischmann

http://abstract.rsna.org/uploads/2016/16001080/RSNA2016_Contrast__FLEISCHMANN.pdf

RC221B Perfusion Techniques and Applications-Stroke and Cancer

Participants
Ting-Yim Lee, MSc, PhD, London, ON (*Presenter*) License agreement, General Electric Company

RC221C Perfusion Techniques and Applications-Cardiac

Participants
Aaron So, PhD, London, ON, (aso@robarts.ca) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Comprehend the theoretical basis and pitfalls of each myocardial CTP method (qualitative, semi-quantitative and quantitative). 2) Assess the sources and solutions of various image artifacts in myocardial CTP. 3) Evaluate the effectiveness of radiation dose reduction methods for low dose quantitative myocardial CTP. 4) Develop the optimal myocardial CTP protocol for assessing high-risk coronary artery disease. 5) Assess the recent advances in quantitative CTP for imaging myocardial edema and scar and their potential applications to guide therapy in post infarction settings.

ABSTRACT

RC222

Imaging for Proton Treatment Guidance and Verification

Monday, Nov. 28 8:30AM - 10:00AM Room: S102C

RO PH

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

Participants
Jon J. Kruse, PhD, Rochester, MN (*Moderator*) Research Grant, Varian Medical Systems, Inc

ABSTRACT

Proton therapy dose distributions are highly conformal and are often used to deliver therapeutic doses to tumors close to critical, radiosensitive normal anatomy. Precise daily reproduction and alignment of the patient anatomy is crucial, then, for successful outcome of proton radiotherapy. This course will describe modern approaches to pre- and intra-treatment imaging to align the patient for proton therapy as well as post-treatment modalities which can verify patient alignment and proton beam range. Pre-treatment image guidance for protons has evolved differently than many common approaches for standard external beam radiotherapy. One reason for this is the dissimilar impact of setup variations on the delivered proton dose distributions, while another is related to the expense of building a proton center and the need to maximize efficiency by moving as many complex processes out of the treatment room as possible. Additionally, the sensitivity of proton dose distributions to intra-fractional changes has led to the development of novel techniques to monitor patient anatomy throughout a treatment. Modest errors in patient positioning or in calculation of proton range could lead to tumor or healthy tissues receiving vastly different doses than were planned. This has led to the development of a number of approaches for post treatment verification of proton beam placement and range. Proton dose verification via positron emission tomography, prompt gamma imaging, and magnetic resonance imaging will be presented.

Sub-Events

RC222A Pre- and Intra-treatment Imaging Strategies for Patient Alignment

Participants
Jon J. Kruse, PhD, Rochester, MN (*Presenter*) Research Grant, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Explain the impact of inter- and intra- fractional variations in patient anatomy on proton dose distributions. 2) Describe proton specific approaches to pre-treatment and intra-treatment imaging for patient alignment. 3) Compare various imaging modalities for post-treatment verification of a delivered proton dose distribution.

RC222B Advanced Imaging Techniques for Range Verification

Participants
Brian A. Winey, PhD, MS, Boston, MA (*Presenter*) Research Grant, Elekta AB; Travel support, Elekta AB; Travel support, Ion Beam Applications SA

LEARNING OBJECTIVES

1) Explain the impact of inter- and intra- fractional variations in patient anatomy on proton dose distributions. 2) Describe proton specific approaches to pre-treatment and intra-treatment imaging for patient alignment. 3) Compare various imaging modalities for post-treatment verification of a delivered proton dose distribution.

Active Handout:Brian Andrew Winey

http://abstract.rsna.org/uploads/2016/15001741/ACTIVE RC222B RSNA_2016.pdf

RC223

ABR Maintenance of Certification for Medical Physicists

Monday, Nov. 28 8:30AM - 10:00AM Room: S102D

ED PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 0

Participants
G. Donald Frey, PhD, Charleston, SC, (dfrey@theabr.org) (*Director*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the recent changes in the ABR MOC program for physicists. 2) Understand simplified attestation. 3) Understand the new areas for PQI.

ABSTRACT

The ABR has made significat changes to the MOC program for medical physicists. These include 1) Simplified attestation, 2) an expanded range of PQI, 3) annual lookbacks & 4) changes to the cognitive exam requirement with the introduction of the OLA program. This refresher course will review the entire program with an emphasis on recent changes.

Sub-Events

RC223A MOC Requirements

Participants
G. Donald Frey, PhD, Charleston, SC, (dfrey@theabr.org) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) The learner will be able to prepare for the 2016 lookback. 2) The learner will understand the nature of the new OLA program as a replacement for the routine cognitive exam. 3) The learner will be able to use the changes in the MOC program.

ABSTRACT

The ABR MOC process has been in place for more than a decade. The process requires for elements. This presentation will review the four elements with an emphasis on some recent enhancements. Several years ago the ABR replaced the time limited certificates with a "continuous certification" process. Continuous certification is based on an annual "lookback." The first complete lookback was in March of 2016 and there will be one each year in March. This presentaion will help medical physicists be ready for their next lookback.

RC223B PQI Projects

Participants
Jerry D. Allison, PhD, Augusta, GA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) The learner will understand the context of and purpose for Performance Quality Improvement (PQI). 2) The learner will understand the "Plan, Do, Study, Act" PQI cycle. 3) The learner will understand requirements for PQI projects. 4) The learner will understand types of PQI projects.

ABSTRACT

Practice Quality Improvement (PQI) is a key element of the ABR MOC continuous certification process. This presentation will review the framework for PQI including the "Plan, Do, Study, Act" cycle for PQI project cycles, PQI project requirements, types of PQI projects and PQI project documentation.

RC223C The MOC Cognitive Exam

Participants
J. Anthony Seibert, PhD, Sacramento, CA, (jaseibert@ucdavis.edu) (*Presenter*) Advisory Board, Bayer AG

LEARNING OBJECTIVES

1) The learner will identify the content of the MOC cognitive exam for each of the specific Medical Physics disciplines (Therapy Medical Physics, Diagnostic Medical Physics, Nuclear Medical Physics). 2) The learner will understand the percentage of fundamental and current clinical question topics and how the exam is assembled. 3) The learner will know how to prepare for the examination based on reference materials used in developing questions, and when to consider taking the exam within the 10 year MOC cycle.

ABSTRACT

Part 3 of the MOC "Continuous Certification" policy represents the Cognitive Expertise component for participating diplomates of the American Board of Radiology, and is required to maintain the ongoing validity of the certificate (except for lifetime certificate holders). In order to fulfill this requirement, the Diplomate must pass the MOC cognitive exam within the past 10 years. The content of the exam is 30 percent fundamental core questions and the remainder represents recent advances in the field for each of the Medical Physics disciplines.Exams are offered each year at a testing center and can be taken at any time during the MOC process. The Diplomate must take an exam in each discipline in which certification is being maintained. Details of the exam, its content, any

study guides useful for preparing for the exam are discussed.

RC225

Perspectives on Exposure and Risk-Visions of Radiation Safety: What We Can, Should and Would Do to Make Patients and Staff Safer

Monday, Nov. 28 8:30AM - 10:00AM Room: S403B

PH SQ

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

FDA Discussions may include off-label uses.

Participants

Sub-Events

RC225A Setting Targets for 2020

Participants
Madan M. Rehani, PhD, Boston, MA, (madan.rehani@gmail.com) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Define what ideal situation of safety of patient and staff should be. 2) Identify actions that can be taken towards that goal of ideal safety. 3) Comprehend what we would be doing if wishful in safety happens.

RC225B Increasing Level of Appropriateness

Participants
James A. Brink, MD, Boston, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the principles of referral guidelines and appropriateness criteria for imaging examinations. 2) To review the mechanism and impact of clinical decision support for referring physicians on the appropriateness of imaging examinations. 3) To explore clinical decision support for radiologists and its potential impact on radiologists' recommendations for clinically significant imaging findings.

ABSTRACT

RC225C Reducing Doses and Risks in Nuclear Medical Procedures

Participants
Andrew J. Einstein, MD, PhD, New York, NY, (andrew.einstein@columbia.edu) (*Presenter*) Research Grant, Koninklijke Philips NV; Research Grant, Toshiba Corporation

LEARNING OBJECTIVES

1) Understand how radiation dose is estimated in nuclear medicine procedures. 2) Identify justification and optimization as the fundamental principles of radiological projection. 3) Apply dose-reduction techniques in nuclear medicine while ensuring image quality and diagnostic certainty.

ABSTRACT

This lecture will cover principles of radiation protection and how they can be practically applied in nuclear medicine.

RC225D The Broad Relevance of Safety Culture in Medical Imaging

Participants
Ehsan Samei, PhD, Durham, NC, (samei@duke.edu) (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Understand the broad concept of safety in medical imaging incorporating both the risk of sub-optimal and over-optimal imaging. 2) Understand the relevance of radiation safety in the patient well-being. 3) Understand the relative role of individual and cumulative dose.

ABSTRACT

RC225E Discussion

Participants

SSC13

Physics (CT-Dual-Energy/Spectral)

Monday, Nov. 28 10:30AM - 12:00PM Room: S403B

CT PH

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

FDA Discussions may include off-label uses.

Participants
Marc Kachelriess, PhD, Heidelberg, Germany (*Moderator*) Nothing to Disclose
Jerome Z. Liang, PhD, Stony Brook, NY (*Moderator*) Nothing to Disclose

Sub-Events

SSC13-02 Accurate Quantification of Percent Area Luminal Stenosis by Material Decomposition of Spectral CT Images

Monday, Nov. 28 10:40AM - 10:50AM Room: S403B

Participants
Zhoubo Li, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Zhicong Yu, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Lifeng Yu, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
Erik L. Ritman, MD, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

To evaluate the accuracy of a novel method for quantifying percent area luminal stenosis using spectral CT images.

METHOD AND MATERIALS

Current stenosis quantification methods rely on segmentation of lumen area, which suffers from partial volume effect and can be highly subjective and error-prone. To overcome these limitations, we utilized material decomposition of spectral CT images to quantify percent area luminal stenosis based on the ratio of mean iodine densities between vessel locations with and without a stenosis. To assess the accuracy of this method, four phantoms with different degrees of stenosis (30~51%), vessel diameters, and calcification densities were fabricated using hydroxyapatite cylinders and test tubes filled with iodinated solutions. Dual-energy CT (DECT) images were acquired using a commercial dual-source CT system (Somatom Flash, Siemens Healthcare). CT images were also acquired from a research photon-counting CT (PCCT) scanner (Somatom CounT, Siemens) using 4 energy bins in a single exposure. 3-basis material (calcium, iodine, and water) decomposition was performed on the spectral CT images and the iodine density maps were used for stenosis measurements. For comparison, conventional single-energy CT images were acquired using the commercial CT scanner and were analyzed with a commercial stenosis analysis software (Syngo Via, Siemens). The radiation dose levels were matched among all data acquisitions.

RESULTS

Phantom experiments showed accurate estimation of percent area luminal stenosis from spectral CT images at clinical dose levels. For DECT images, the mean estimation errors were 4.4~8.2%, 3.6~9.3%, 8.0~10.3%, and -4.6~-8.1% for the four stenosis phantoms (ground truth: 51%, 51%, 51%, and 30%), respectively. For PCCT images, the errors were 1.0~3.4%, 5.7~7.8%, 2.0~9.5%, and -0.1~5.6%, respectively. Errors using single-energy CT and the commercial software were much larger, ranging from 4.4% to 46%, and were especially worse in the presence of heavy calcifications.

CONCLUSION

For both dual-source DECT and PCCT systems, the developed method accurately and conveniently estimated the percent area luminal stenosis from spectral CT images using clinically relevant dose levels.

CLINICAL RELEVANCE/APPLICATION

Quantification of luminal stenosis by spectral CT at clinical dose levels provides accurate and reproducible measurements of important information for the management of atherosclerosis.

SSC13-03 Feasibility and Accuracy of Spectral CT Imaging in Measurement of Bone Mineral Density (BMD)

Monday, Nov. 28 10:50AM - 11:00AM Room: S403B

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

PURPOSE

To evaluate the feasibility and accuracy of spectral CT imaging in measurement of bone mineral density (BMD).

METHOD AND MATERIALS

Totally 147 female patients who underwent upper abdominal CT examination with spectral CT imaging mode were enrolled, 19 Patients the trauma, surgery, tumor or other diseases that affecting BMD were excluded. The patients were separated into 6 groups according to their ages: 18~30(23), 30~39(20), 40~49(22), 50~59(24), 60~69(19) and≥70(20). The hydroxyapatite and calcium concentration was measured at central level of L2 for 3 times, and then mean value was obtained. 119 female who underwent dual energy X-ray absorption (DEXA) examination were selected as the controls with same criteria and group division, and BMD was measured at L2. The measurement results of different ages in the study group were compared by the analysis of variance. Pearson correlation analysis was taken between age and hydroxyapatite, calcium concentration respectively. The hydroxyapatite, calcium concentration and BMD was analyzed by Pearson correlation analysis respectively.

RESULTS

There were significant differences in the hydroxyapatite and calcium concentration between different age groups($P<0.05$).Both calcium and hydroxyapatite concentrations showed positive relationship with BMD($r=0.796$ and $r=0.874$, both $P<0.05$). Females with age of 30~39 had the highest calcium concentration, hydroxyapatite concentration and BMD. As same as BMD, hydroxyapatite concentration and calcium concentration showed positive relationship to age in female≤39 years and negative relationship in >40 years.

CONCLUSION

The quantitative analysis for bone mineral density with spectral CT imaging, hydroxyapatite-based material decomposition technique was more accurate than calcium, spectral CT imaging can be used as a new and convenient method in measuring BMD.

CLINICAL RELEVANCE/APPLICATION

The hydroxyapatite-based images of spectral CT can reflect BMD as in DXA. In particular, there is a great value in the diagnosis of osteoporosis without symptoms in postmenopausal women, predict fracture risk and direct appropriate treatment to prevent fractures.

SSC13-04 Modified Dual Energy-based Three Material Decomposition for Calcium Plaque Removal Without Compromising Iodine Contrast

Monday, Nov. 28 11:00AM - 11:10AM Room: S403B

Participants
Bernhard Krauss, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Katharine Grant, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Thomas Allmendinger, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Thomas G. Flohr, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
U. Joseph Schoepf, MD, Charleston, SC (*Abstract Co-Author*) Research Grant, Astellas Group; Research Grant, Bayer AG; Research Grant, General Electric Company; Research Grant, Siemens AG; Research support, Bayer AG; Consultant, Guerbet SA; ; ;
Bernhard Schmidt, PhD, Forchheim, Germany (*Presenter*) Employee, Siemens AG

PURPOSE

Confident removal of calcified plaques from small vessels is one of the remaining challenges in CT. Threshold-based plaque removal techniques typically fail due to calcium blooming. Dual Energy (DE) based 2-material decomposition techniques into water and either iodine or calcium (virtual non-contrast imaging) are not applicable, since decomposition will either be successful for contrast agent or for plaque; corresponding to incomplete calcium removal or negative iodine contrast, respectively. We assessed the ability for the removal of calcium-related attenuation from iodinated vessels by applying a modified three-material decomposition algorithm.

METHOD AND MATERIALS

Base materials were modified to allow decompositions into calcium (first base material), soft tissue (second base material) and iodine (third base material). After calibration and algorithm adjustments to resolve ambiguities (e.g. fat), two image stacks are generated by the algorithm, one containing just calcium and the other, the soft tissue / iodine mixture. To evaluate our method, first tubes with different mixtures of calcium plaque equivalent solution and soft tissue / iodine were measured on a SOMATOM Force (Siemens, Germany) in an anthropomorphic environment and decomposed. Phantoms simulating vessels with iodinate contrast and calcified plaques at different stenosis level were evaluated. The obtained results were rated subjectively and also compared to the known gold standard.

RESULTS

After decomposing the images of the tubes containing material mixtures, the derived base material images show systematic deviations of the CT-value, which can be larger than for virtual non-contrast imaging, while image noise is comparable. Phantoms simulating vessels and plaques showed excellent results and confident calcium removal for medium and large calcifications. In case of dense calcifications and smaller vessels, small residual calcium components were observed in the iodine/soft-tissue image.

CONCLUSION

The obtained results indicate that these modified three material decomposition algorithms may be suitable for the improved visualization of the vessel lumen, and a confident removal of plaque.

CLINICAL RELEVANCE/APPLICATION

Quantification of the degree of stenosis might be challenging with CT, especially in the case of large or dense calcifications. The proposed technique might allow for a substantially improved confidence in stenosis quantification.

SSC13-05 An Image-Domain, Contrast Material Extraction Method for Dual-Energy CT

Monday, Nov. 28 11:10AM - 11:20AM Room: S403B

Participants
Jack Lambert, PhD, San Francisco, CA (*Presenter*) Nothing to Disclose
Rahi J. Kumar, MD, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Zhixi Li, MD, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Yuxin Sun, BS,MSc, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Robert G. Gould, DSc, San Francisco, CA (*Abstract Co-Author*) Scientific Advisor, AlgoMedica, Inc; Stockholder, GE
Benjamin M. Yeh, MD, San Francisco, CA (*Abstract Co-Author*) Research Grant, General Electric Company; Author with royalties, Oxford University Press; Shareholder, Nextrast, Inc;

PURPOSE

To define and implement a contrast material extraction process (CMEP) for Dual-Energy CT (DECT) that extracts positive contrast-producing materials directly from image data, using their low- to –high-energy CT number ratios (dual-energy ratios).

METHOD AND MATERIALS

Following generation of the virtual monochromatic (VM) images using commercial software (GSI Viewer), the CMEP is performed within image processing freeware (Fiji). We generate a 60:80 keV VM dual-energy ratio map to define masks corresponding to the dual-energy ratio intervals of the requisite contrast materials. These ratios can be measured directly from the DECT images themselves or retreived from literature. The masks are then applied to VM images (e.g. 70 keV) to yield material-specific images. We quantitatively tested the method using a water-based phantom containing formulations of iodine, tungsten and calcium. As the material-specific CT numbers should match those of the VM images chosen for separation, we evaluated errors in the masking process by comparing the absolute and percent difference in CT number between the two. Further qualitative evaluation of the CMEP was performed in vivo with a rabbit model scanned with enteric tungsten, intravascular iodine, and skeletal calcium as the three contrast materials.

RESULTS

The three chosen materials showed distinct, non-overlapping dual-energy ratios, independent of material concentration. As such, the CMEP was successful in both phantoms and in vivo. For the phantom, the maximum difference in CT number between the VM images and the extracted material-specific images was 15 HU, which corresponded to a percentage error of 6%. False positive contrast signals were minimal, with a maximum false positive signal of 13 HU. Material-specific images of the rabbit model clearly depicted the enteric tungsten, vascular iodine and skeletal calcium.

CONCLUSION

The CMEP is a robust and flexible, yet conservative approach to material-specific dual-energy imaging. With its image-domain implementation within freeware and with no requirement of a priori information, it circumvents many of the limitations associated with conventional material decomposition.

CLINICAL RELEVANCE/APPLICATION

Methods such as the CMEP enable material-specific imaging in studies where the attenuation coefficient profiles of contrast materials may be unknown, and for the extraction of novel high-Z contrast from iodine and calcium.

SSC13-06 Accuracy and Precision of Effective Atomic Number Estimates Across Patient Size in Various Tissues using Dual Energy CT

Monday, Nov. 28 11:20AM - 11:30AM Room: S403B

Participants
Gregory J. Michalak, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Bernhard Krauss, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Shuai Leng, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

To determine the achievable accuracy and precision for determining effective atomic number (Zeff) using dual-energy CT (DECT) and a commercial software tool for various tissue types and across a range of patient sizes.

METHOD AND MATERIALS

A 32 cm lateral width CIRS electron density phantom and four torso-shaped water tanks (lateral widths 15, 25, 35 and 45 cm) containing 6 tissue-simulating cylinders and one solid water cylinder, each having known elemental compositions, were scanned on a dual-source CT system (Somatom Force, Siemens Healthcare) in single-energy (SE, 120 kV) and DE (90/150Sn) modes. Additional scans were performed on the 15 and 25 cm water tanks using DE techniques of 70/150Sn and 80/150Sn, respectively. CTDIvol was matched for all SE and DE scans for a given phantom size. Images were reconstructed using quantitative kernels to preserve CT number accuracy. Zeff was estimated in each test cylinder and in the solid water cylinder using a DE Rho-Z algorithm (Syngo Via, Siemens) and compared with Zeff calculated using percent elemental composition.

RESULTS

Regression models through the origin showed excellent agreement between nominal Zeff and Zeff determined by Rho-Z, with slopes ranging from 0.9867 to 1.0124 and R2 ranging from 0.9772 to 0.9908. Mean percent error (bias) in Zeff across phantom size was 1.9%, while mean standard deviation (precision) in Zeff across phantom size was 1.4%. When compared to 90/150Sn, DE techniques of 70/150Sn and 80/150Sn showed mean differences in Zeff of 0.65% and 0.83%, respectively.

CONCLUSION

Our study demonstrated that DECT combined with Rho-Z analysis could estimate Zeff with little error or variability across patient size. The regression models comparing nominal Zeff and Zeff as determined by Rho-Z analysis show consistent slopes near unity across patient size, demonstrating independence on patient size. Additionally, in small patients, Zeff was independent of DE technique.

CLINICAL RELEVANCE/APPLICATION

Estimates of Zeff can reliably be determined across patient size using DECT. This could have clinical impact in applications requiring quantitative CT measurements, such as proton therapy planning.

SSC13-07 Equivalency Between Photon Energies (keV) in Spectral CT Imaging and Tube Voltages (kVp) in Traditional Polychromatic X-ray CT for Same CT Attenuation Values: An In Vitro Experiment

Monday, Nov. 28 11:30AM - 11:40AM Room: S403B

Participants
Ji Hang Sun, Beijing, China (*Presenter*) Nothing to Disclose
Yun Peng, MD, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Haruhiko Machida, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Isao Tanaka, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To find the equivalency between the photon energies (keV) in dual-energy spectral CT imaging and the tube voltages (kVp) in traditional polychromatic X-ray imaging (TPXI) where same CT attenuation values were obtained.

METHOD AND MATERIALS

A 1.2cm-diameter polypropylene phantom containing 4 inserts with different iodine concentrations (5, 10, 15 and 20 mg/mL) underwent both the dual-energy Spectral CT (with fast 80kVp and 140kVp switching) and traditional polychromatic X-ray scans (at the 80kVp, 100 kVp, 120 kVp and 140kVp tube voltages) at the same radiation dose level. The background was either air or soft tissue. The CT attenuation values of the iodine solutions under different kVp in traditional polychromatic x-ray imaging and at different energy levels in dual-energy spectral CT imaging were measured using the same size of region of interest and at the exact same level for both images. The keV and kVp values where CT measurements were the closest were recorded.

RESULTS

The average photon energies (in keV) corresponding to 80 kVp, 100 kVp, 120 kVp and 140kVp were 52±1.0keV, 58±1.3keV, 62±1.4keVand 66±1.3keV, respectively with air background; and 53±0.8keV, 59±1.0keV, 64±1.0keV and 68±1.0keV, respectively with the soft tissue background. The corresponding photon energies did not change significantly with the change of iodine concentration.

CONCLUSION

Monochromatic energy level in Spectral CT and kVp in traditional polychromatic x-ray imaging had good correlation and was not dependent on iodine concentration.

CLINICAL RELEVANCE/APPLICATION

The monochromatic Spectral CT images may be used to mimic traditional polychromatic x-ray CT at different tube voltage stations in terms of CT attenuation.

SSC13-08 Characterization of White and Gray Matter in the Brain by Spectral Analysis of Monoenergetic Images Derived From Dual-Layer Detector CT

Monday, Nov. 28 11:40AM - 11:50AM Room: S403B

Participants
Isaac Leichter, PhD, Jerusalem, Israel (*Presenter*) Nothing to Disclose
Eliel Ben-David, MD, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Jeffrey Fantl, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Chanoch Cohen-Aloro, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Zimam Romman, MSc, Haifa, Israel (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Jacob Sosna, MD, Jerusalem, Israel (*Abstract Co-Author*) Consultant, ActiViews Ltd Research Grant, Koninklijke Philips NV
John M. Gomori, MD, Jerusalem, Israel (*Abstract Co-Author*) Consultant, MedyMatch Technology, Ltd

PURPOSE

Dual-layer detector CT generates virtual mono-energetic (ME) images at different photon energies (keV). The purpose of this study is to evaluate characterization of white matter (WM) and gray matter (GM) in different areas of the human brain by spectral analysis of mean Hounsfield Unit (HU) as a function of the energy of the ME images.

METHOD AND MATERIALS

Brain CT images of 19 patients, derived from Dual-layer Detector CT (Philips Healthcare, Cleveland, OH, USA) were analyzed. Pairs of WM and GM regions of interest (ROIs) were marked in three areas of the brain: anterior and posterior cortex with adjacent white matter, and the thalamus with the adjacent internal capsule. For each patient, ME images were generated at energies between 40-140 keV, at 1 keV intervals. At each energy level, the mean HU value and the standard deviation (SD) in each ROI were calculated. For each ROI, the curve of the mean HU values as a function of keV of the ME image was evaluated. Wilcoxon signed-rank test was used to evaluate the significance of the difference between the obtained curves.

RESULTS

For all ROIs, inter-subject variability of mean HU was lower (mean SD=4.6) than intra-subject variability within each individual ROI (mean SD=5.4), indicating concordance of the mean HU in each ROI, for all 19 patients. In all ROIs, a power function represented the regression curve of the mean HU values versus the keV of the ME image with a high correlation coefficient (R= 0.963±0.009). In each regional GM/WM ROI pair, the curves of mean HU values versus keV were significantly different (P<0.001). For GM, the curves in the anterior and posterior regions were not significantly different (P<0.303), while both curves were significantly different (P<0.001) from the curve in the thalamus. For WM, the curves in the internal capsule and posterior region were not significantly different (P<0.552), while both curves were significantly different (P<0.041) from the curve in the anterior region.

CONCLUSION

Spectral analysis of HU vs keV of mono-energetic images derived from dual-layer detector CT enables characterization of white and gray matter in different areas of the brain.

CLINICAL RELEVANCE/APPLICATION

Characterizing GM and WM in the brain by spectral analysis of mono-energetic images generated by Dual-layer detector CT may assist in identifying abnormal gray matter, for example, in acute ischemic events.

Honored Educators

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

Jacob Sosna, MD - 2012 Honored Educator

SSC13-09 **The Value of Automatic Spectral Imaging Mode Selection Combined With Optimized ASIR Percentages in Upper Abdominal Enhanced CT Scan with Low Contrast Agent Dose**

Monday, Nov. 28 11:50AM - 12:00PM Room: S403B

Participants
Liying Zhang, Zhengzhou, China (*Presenter*) Nothing to Disclose
Peijie Lv, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Hua Guo, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate the value of automatic spectral imaging mode selection combined with adaptive statistical iterative reconstruction (ASIR) in upper abdominal enhanced CT scan with low contrast agent dose

METHOD AND MATERIALS

The study was approved by the institutional review board and informed consents were obtained from all patients. One hundred patients underwent abdominal enhancement CT during arterial phase (AP) and portal v
70keV, intervals of 5keV, 7levels) were reconstructed using 40-70%ASIR(4 levels) respectively. If the datum of image noise in HU, CT values and contrast-to-
noise ratio of the liver, pancreas, aorta and portal vein,radiation dose and qualitative visual parameters were normally distributed,they would be compared by using two independent samples t test,if not,qualitative v
point scale) they would bewas assessed by using mann whitney u test.

RESULTS

CT values in group B in the range of 40-60keV were similar or higher than group A. Imaging noise in group B at the level of 40keV with 70%ASIR, 45-50keV with 60-70%ASIR,55keV with 50-70%ASIR and 60-
70keV with 40-
70%ASIR were similar to or lower than group A. The CNR values of group B were similar to or higher than group A. In terms of overall image quality, group B at the level of 50keV with 40%ASIR and 60keV with 50%A
55keV with 60%ASIR in PVP showed similar values while 50keV with 50%ASIR, 55keV with 40-
50%ASIR,and 60keV with 40%ASIR in two phases showed higher values as compared with group A.There were no significant difference in CTDIvol [(10.9±3.8) mGy versus (11.7±2.7)mGy, P=0.19]and DLP [(244.0±1

CONCLUSION

With use of automatic spectral imaging mode selection, monochromatic images from 50 to 60keV with ASIR percentages from 40% to 50% can maintain or even improve overall image quality and reduce contrast age

CLINICAL RELEVANCE/APPLICATION

The application of low contrast agent dose can reduce adverse reactions caused by iodine contrast agent.

SSC14

Physics (Diagnostic X-rays I)

Monday, Nov. 28 10:30AM - 12:00PM Room: S404AB

PH

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

FDA Discussions may include off-label uses.

Participants
Guang-Hong Chen, PhD, Madison, WI (*Moderator*) Research funded, General Electric Company Research funded, Siemens AG
Joseph Lo, PhD, Durham, NC (*Moderator*) Research Grant, Siemens AG

Sub-Events

SSC14-01 X-ray Dark-Field Chest Radiography: A First Feasibility Study on Phantom Samples and In-Vivo Pigs

Monday, Nov. 28 10:30AM - 10:40AM Room: S404AB

Participants
Franz Pfeiffer, Munich, Germany (*Presenter*) Nothing to Disclose
Lukas Gromann, Garching/ Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Konstantin Willer, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Fabio De Marco, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Julia Herzen, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Peter B. Noel, PhD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Bernhard Renger, MSc, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Bernhard Gleich, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Alexander A. Fingerle, MD, Munchen, Germany (*Abstract Co-Author*) Nothing to Disclose
Daniela Muenzel, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Sigrid Auweter, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Katharina Hellbach, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Andrea Baehr, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Fabian Bamberg, MD, MPH, Tuebingen, Germany (*Abstract Co-Author*) Speakers Bureau, Bayer AG; Speakers Bureau, Siemens AG; Research Grant, Bayer AG; Research Grant, Siemens AG;
Maximilian F. Reiser, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Michaela Dmochewitz, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Tobias Schroeter, Karlsruhe, Germany (*Abstract Co-Author*) Nothing to Disclose
Frieder Koch, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Pascal Meyer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Danays Kunka, Karlsruhe, Germany (*Abstract Co-Author*) Nothing to Disclose
Juergen Mohr, Karlsruhe, Germany (*Abstract Co-Author*) Nothing to Disclose
Andre Yaroshenko, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
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Hendrik van der Heijden, Hamburg, Germany (*Abstract Co-Author*) Nothing to Disclose
Nataly Wieberneit, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV; ;
Thomas Koehler, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Karsten Rindt, Hamburg, Germany (*Abstract Co-Author*) Nothing to Disclose
Ernst J. Rummeny, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To demonstrate – for the first time – that x-ray dark-field radiography is feasible with clinically relevant x-ray energies and a field-of-view suitable for human chest x-ray imaging.

METHOD AND MATERIALS

The study was institutional review board (IRB) approved. An experimental setup for grating-based dark-field radiography has been constructed and equipped with a set of three gratings, to enable phase-contrast and dark-field contrast x-ray imaging. It operates at an acceleration voltage of up to 120 kVp and with a field-of-view large enough for clinical chest x-ray radiography (> 35 cm). The setup was tested and commissioned with phantom samples and test measurements were performed to evaluate the overall imaging performance of the system. Finally, first proof-of-principle imaging experiments on living pigs were performed, particularly to assess the imaging performance of the dark-field signal with respect to the visualization of the lungs.

RESULTS

The results from this first experimental dark-field radiography system demonstrate the feasibility of performing in-vivo dark-field chest radiographies with a field-of-view larger than 32 x 35 cm2 and with acceleration voltages used in clinical practice (≥ 70 kVp). The dark-field radiographies were obtained in a 40 sec scan and show that the dark-field signal obtained for the lungs is large enough to be used for future studies on lung diseases (e.g. chronic obstructive pulmonary disease (COPD), fibrosis, or pneumonia). These results represent a milestone in the translation of x-ray dark-field imaging from current small-animal and mammography prototypes at relatively low energies (< 40 kVp) to standard radiography applications in the clinic (≥ 70 kVp).

CONCLUSION

The results of this research project clearly indicate that in-vivo dark-field chest x-ray radiography is feasible at an x-ray energy and with a field-of-view compatible with clinical radiography applications.

CLINICAL RELEVANCE/APPLICATION

Dark-field chest x-ray radiography is feasible on the human scale, and thus enables future investigations on the clinical benefit with regard to improved diagnosis and staging of lung diseases, including COPD.

SSC14-02 Tomosynthesis-Based Real-time 3D Catheter Tracking Using a Scanning-Beam Digital X-Ray System

Monday, Nov. 28 10:40AM - 10:50AM Room: S404AB

Participants
David A. Dunkerley, Madison, WI (*Presenter*) Nothing to Disclose
Michael Speidel, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Scanning-beam digital x-ray (SBDX) is an inverse geometry fluoroscopy system designed for dose reduction and real-time tomosynthesis in interventional procedures. SBDX was recently upgraded with a multi-GPU image reconstructor with capacity for 3D catheter localization tasks. This work presents the implementation of real-time (RT) 3D catheter tracking on the SBDX system.

METHOD AND MATERIALS

SBDX performs digital tomosynthesis at 32 planes x 15 frame/s. A composite of each plane stack is formed for live image display. A tomosynthesis-based tracking algorithm designed to localize high-contrast catheter elements was implemented on an Nvidia GPU simultaneous with image reconstruction. The live fluoroscopic image and live 3D tracking results were displayed using an OpenGL framework. To verify the geometric accuracy of the RT tracking algorithm, an 8 x 8 planar array of 2.3 mm steel fiducials with 1 cm spacing was imaged at a 45º angle to the source plane such that the array spanned the imaging volume. The fiducial positions tracked in RT were registered to a CT scan of the array and fiducial registration error (FRE) was calculated. To demonstrate accurate tracking of a moving target, a catheter tip was tracked as it was pulled through a sheath within an anthropomorphic chest phantom at speeds of 10, 25, and 50 mm/s. The sheath volume and centerline were extracted from a CT scan of the phantom and the root-mean-squared distance (RMSD) between the tracked tip positions and the centerline was calculated.

RESULTS

Real-time 3D tracking coordinates were displayed and recorded at 15 frame/s with no dropped frames. The 8 x 8 fiducial array geometry was accurately reproduced in tracking (FRE = 0.43 mm). The 3D distance from the tracked catheter tip to the sheath centerline averaged 0.7 to 1.0 mm for the 3 pullback sequences (RMSD = 0.8 to 1.1 mm). Of the 328 tracked catheter tip points, 99.1% were located inside the catheter sheath volume.

CONCLUSION

Accurate real-time 3D tracking concurrent with fluoroscopy was performed at 15 frame/s using the SBDX system.

CLINICAL RELEVANCE/APPLICATION

SBDX real-time catheter tracking can provide 3D spatial information about catheter positions during fluoroscopic imaging which could potentially aid in the navigation of devices to anatomic targets.

SSC14-03 Construction of a Prototype Digital Breast Tomosynthesis System with Superior Spatial Resolution

Monday, Nov. 28 10:50AM - 11:00AM Room: S404AB

Participants
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PURPOSE

To construct a prototype digital breast tomosynthesis (DBT) system with superior spatial and contrast resolution.

METHOD AND MATERIALS

A prototype DBT system was constructed from basic materials. The system supports new designs for the motion of the x-ray tube and the detector. While clinical systems restrict the x-ray tube motion to the plane of the chest wall, the new design includes a component of motion perpendicular to the chest wall; i.e., along the posteroanterior (PA) direction. In addition, the prototype system supports detector motion along the direction between the x-ray source and the breast support. The prototype system was designed based on a theoretical model developed prior to this study. The model predicts an improvement in image quality for two test objects: (1) a Defrise phantom, and (2) a resolution bar pattern. The Defrise phantom simulates thick, low-frequency structures, while the bar pattern simulates thin, high-frequency structures. Reconstructions were prepared with a commercial software (Piccolo™, Real Time Tomography, Villanova, PA).

RESULTS

First, we report upon test frequencies oriented in the direction of conventional x-ray tube motion; this direction is left-to-right in a cranial-caudal (CC) view. As theoretically predicted, the gaps between plastic plates in the Defrise phantom were visualized clearly, and the bar pattern showed super-resolution (reconstruction of frequencies greater than the detector alias frequency of 5.9 lp/mm) with a limiting resolution of 9.0 lp/mm. Second, test frequencies were oriented along the PA direction. In conventional DBT, the Defrise phantom will not be properly visualized, and the bar pattern phantom will show aliasing at high frequencies. Using the new design, the x-ray tube motion along the PA direction gives rise to an improvement in low-frequency contrast in the Defrise phantom, and the use of detector motion along the source-to-support direction provides super-resolution. Overall, the new system design generates images with markedly improved image quality over conventional DBT systems.

CONCLUSION

The prototype DBT system offers an improvement in image quality for both low- and high-frequency objects.

CLINICAL RELEVANCE/APPLICATION

The prototype design offers superior image quality, as determined for small objects (e.g., calcifications) using a bar pattern and for large objects (e.g., dense tissue) using a Defrise phantom.

SSC14-04 Depiction of Pneumothoraces in A Large Animal Model Using X-Ray Dark-Field Radiography

Monday, Nov. 28 11:00AM - 11:10AM Room: S404AB

Participants
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Maximilian F. Reiser, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Franz Pfeiffer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The aim of this study was to assess added clinical value of dark-field radiography in pneumothorax diagnosis using a pig model.

METHOD AND MATERIALS

Experiments were performed using 2.5 months old, wild-type German landrace pigs (n=6). The animals were anesthetized, intubated and mechanically ventilated during the experiments. All pigs were imaged with an experimental grating-based large animal scanner to acquire x-ray transmission and dark-field radiographs before and after induction of a unilateral pneumothorax. All scans were performed in posterior-anterior (p.a.) direction under respiratory arrest. Image contrast ratios between lung tissue and the air filled pleural cavity were quantified for both, transmission and dark-field radiograms.

RESULTS

Images revealed that all animals had developed a unilateral pneumothorax. Pneumothoraces displayed as areas with no dark-field signal next to the adjacent lung parenchyma, which generated a strong dark-field signal. The contrast ratio between the air filled pleural space of the pneumothoraces and lung tissue was significantly higher in the dark-field (2.95 ± 0.93) than in the transmission images (0.95±1.04; $p < 0.05$) when images were acquired in p.a. direction. Consequently, detection of pneumothoraces was easier when analyzing the dark-field images.

CONCLUSION

This study shows increased contrast between lung parenchyma and air in the pleural space in x-ray dark-field radiography as compared to conventional chest x-ray in a large animal model in p.a. images. This makes this technique a promising tool for facilitated diagnosis of pneumothoraces.

CLINICAL RELEVANCE/APPLICATION

The detection of pneumothoraces can be challenging using conventional transmission images. Adding the information provided by dark-field images offers the chance to improve diagnostic sensitivity in detecting this potentially life-threatening disease.

SSC14-05 Low Dose Performance of a CdTe Single Photon Counting Detector and Its Application in Radiation Dose Reduction for X-ray Differential Phase Contrast Imaging

Monday, Nov. 28 11:10AM - 11:20AM Room: S404AB

Awards
Student Travel Stipend Award

Participants
Xu Ji, Madison, WI (*Presenter*) Nothing to Disclose
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Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

The phase stepping method used in x-ray differential phase contrast imaging (DPCI) divides the total x-ray exposure into a series of sub-images, each with a lower photon number. Compared with conventional x-ray imaging, DPCI is more sensitive to the detector performance at low exposure levels, particularly the electronic noise performance. The purpose of this work is to investigate the potential of radiation dose reduction in DPCI using a single photon counting detector (PCD) with excellent low dose performance.

METHOD AND MATERIALS

The DPCI benchtop system used in this study includes a hospital-grade x-ray tube, three gratings, and two interchangeable x-ray detectors: one is a conventional Gadox-based energy-integrating detector (EID) with 48 um pixel pitch, the other one is a CdTe-based PCD with 100 um pixel pitch and 16 cm x 14 cm detection area (XC-FLITE X1, XCounter). Both detectors use the CMOS technology. The PCD has adjustable energy thresholds to selectively reject electronic noise. DPCI images of an ACR Mammography Accreditation Phantom were acquired, first using the EID at 100% dose level, then using the PCD at 67% reduced dose level. Image quality was quantified in terms of DQE(f) and MTF.

RESULTS

At the mammographic energy range, the PCD demonstrated nearly fourfold improvement in DQE(0) and better DQE(f) up until 4 lp/mm when compared with the EID. Although the EID has half of the pixel pitch size of the PCD, the MTF of the PCD matched that of the EID up to the Nyquist frequency. When the pixels of the EID were 2 by 2 binned to match those of PCD, the improvement in DQE(f) and MTF of PCD was more evident. In all cases, almost no dark current and electronic noise were observed. The 67% dose DPCI acquired with the PCD demonstrated equivalent low frequency performance; besides that, the high frequency performance of PCD was more favorable, as the image of the PCD demonstrated a finer texture and less blurry appearance.

CONCLUSION

Radiation dose reduction by a factor of 33% was achieved in differential phase contrast imaging by using a single photon counting detector with excellent low dose performance.

CLINICAL RELEVANCE/APPLICATION

Application of the photon counting detector technology to x-ray phase contrast imaging can reduce dose by 33% without sacrificing the image quality.

SSC14-06 Dose Reduction in Digital Breast Tomosynthesis with DOS-SPART

Monday, Nov. 28 11:20AM - 11:30AM Room: S404AB

Awards
Student Travel Stipend Award

Participants
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Ke Li, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

The purpose of this study was to explore the dose reduction potential of the Denoised Ordered-Subset Statistically Penalized Algebraic Reconstruction Technique (DOS-SPART) in digital breast tomosynthesis (DBT).

METHOD AND MATERIALS

The DOS-SPART algorithm was adapted for use with DBT and carefully optimized using experimentally acquired phantom and cadaver breast datasets. DOS-SPART is a unique iterative reconstruction method that decouples spatial regularization and data consistency updates allowing for rapid reconstructions and application specific regularization. A 5.4 cm thick cadaver breast specimen with no known pathology was placed in a plastic container and imaged on a Hologic Selenia Dimensions DBT system at 32 kV and a range of dose levels. The reference dose (2.0 mGy mean glandular dose) was determined using the automatic exposure control; images were also acquired at 80%, 54%, 37%, and 15% of this reference dose. DBT image volumes were reconstructed at each dose level using both the commercial reconstruction engine and DOS-SPART. Spatial resolution was quantified using the full width half maximum (FWHM) of a measured profile through a microcalcification in the object. Noise performance was characterized

using the contrast-to-noise ratio (CNR) measured in a low contrast blood vessel in the breast.

RESULTS

At all dose levels, the high contrast spatial resolution attained with DOS-SPART was found to be improved relative to the full dose commercial reconstruction. Using DOS-SPART, the CNR for the vessel was improved at each dose level relative to the commercial reconstruction by an average of 41±14%. In addition, at 15% dose the measured CNR of the DOS-SPART reconstruction was still greater than the full dose reconstruction using the commercial reconstruction.

CONCLUSION

Since the major tasks of breast screening include calcification detection and low contrast mass detection, both high spatial resolution and good contrast/noise performance are crucial. The DOS-SPART reconstruction algorithm is able to maintain both spatial resolution and noise performance in DBT imaging at up to an 85% reduced dose. These results demonstrates the dose reduction potentials in DBT imaging with the DOS-SPART reconstruction method.

CLINICAL RELEVANCE/APPLICATION

With the DOS-SPART algorithm, radiation dose may be reduced by as much as 85% in digital breast tomosynthesis without sacrificing spatial resolution or noise performance.

SSC14-07 Evaluation of the Slice Sensitivity Profile for Quality Control in a Tomosynthesis Mammography Screening Trial

Monday, Nov. 28 11:30AM - 11:40AM Room: S404AB

Participants
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Martin J. Yaffe, PhD, Toronto, ON (*Abstract Co-Author*) Research collaboration, General Electric Company Founder, Matakina International Ltd Shareholder, Matakina International Ltd Co-founder, Mammographic Physics Inc

PURPOSE

To ensure consistent image quality in an ongoing multivendor clinical trial of tomosynthesis mammography for breast cancer screening, a harmonized QC program was developed using specially designed phantoms. The slice-sensitivity profile (SSP) is characterized to monitor the resolution and characterize the reconstruction artifacts in the z direction.

METHOD AND MATERIALS

A modular phantom containing a grid of 0.07 mm aluminum BBs that could be positioned at different heights was imaged at 6-month intervals as part of the physics evaluation. The slice-sensitivity profile of the BBs was examined in the reconstructed volumes. The data were summarized by reporting the full-width half-maximum values (FWHM) of Gaussians fitted to the SSPs. To reduce the variability in the FWHM values caused by BBs being located away from the perpendicular ray, reconstructed volumes that use a Cartesian coordinate system (CCS) were transformed to a cone beam coordinate system (CBCS) by resampling each slice to account for the amount of geometric magnification at that height. The phantom was imaged on 6 units from 3 different vendors.

RESULTS

The average FWHM values measured in the CBCS varied from 3.0 mm (+/-0.1) to 8.7 mm (+/-0.4) depending on the machine type. The FWHM values measured in the transformed CBCS were 10-20% larger than those measured in the original CCS volumes, because the artefact spread functions are parallel to the z-axis instead of angled toward the x-ray focal spot. The coefficient of variation (COV) between the BBs in the modular phantom decreased by 76% when evaluated in the CBCS.

CONCLUSION

For robust and repeatable assessment of the SSP, resampling of the reconstructed volume into a cone-beam coordinate system is advantageous. The FWHM values are less dependent on location of the BBs within the phantoms and on the positioning of the phantom on the detector. This results in less variation between BBs within the grid-phantom and less temporal variation. Fundamental differences in acquisition geometry and reconstruction methods between different vendors systems are clearly reflected in the magnitudes of the measured FWHM values.

CLINICAL RELEVANCE/APPLICATION

A platform-independent QC program is fundamental to ensuring consistent clinical image quality for DBT. Robust and repeatable assessment of the artefact spread function in the reconstructed volume will help monitor and assess system performance.

SSC14-08 Advances in Dark-Field Mammography: Breast Microcalcification Assessment

Monday, Nov. 28 11:40AM - 11:50AM Room: S404AB

Participants
Konstantin Willer, Garching, Germany (*Presenter*) Nothing to Disclose
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Julia Herzen, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To reduce the number of invasive procedures associated with breast microcalcification biopsies, by improving and refining conventional BIRADS microcalcification assessment with dark-field mammography.

METHOD AND MATERIALS

The institutional review board (IRB) has approved this study. A dedicated grating-based radiography setup (Mo-target, 40 keV, 70 mA) was used to investigate one breast mastectomy and 31 biopsies with dark-field mammography. By comparing the absorption and scattering properties of microcalcifications clusters, information on the interior morphology on the micron-scale can be retrieved in a non-invasive manner. Insights underlying the micromorphological nature of breast calcifications were verified by comprehensive high-resolution micro-CT measurements.

RESULTS

Dark-field mammography allows a micro-structural rather than chemical classification (as hypothesized by recent literature) of breast microcalcification as ultra-fine, fine, pleomorphic and coarse textured using conventional detectors. Dark-field mammography is thereby highly sensitive to minor structural deviations. Finally, the microtexture of microcalcifications may be an indicator for tissue malignancy.

CONCLUSION

Our results demonstrate that dark-field mammography yields the potential to enhance diagnostic validity of current microcalcification analysis - which is yet limited to the exterior appearance of microcalcification clusters - and thereby reduce the number of invasive procedures.

CLINICAL RELEVANCE/APPLICATION

Assuming large-area gratings, dark-field mammography has great potential for an application in future clinical routines as it expands conventional transmission based mammography by diagnostic valuable information about morphological properties. We believe it plays a decisive role in future breast cancer diagnosis.

SSC14-09 Theoretical Investigation of the Noise Performance of Polycrystalline Silicon Active Pixel Arrays

Monday, Nov. 28 11:50AM - 12:00PM Room: S404AB

Participants
Martin Koniczek, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Albert K. Liang, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Larry E. Antonuk, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Youcef El-Mohri, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Qihua Zhao, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Diagnostic and interventional x-ray imaging has greatly benefited from the adoption of active matrix, flat-panel imagers (AMFPIs), which incorporate a single thin-film transistor (TFT) per pixel. However, the DQE of AMFPIs at low exposures, such as those encountered in fluoroscopy and digital breast tomosynthesis (DBT), degrades due to the modest signal generated per interacting x-ray relative to electronic additive noise levels of ~1000 e, or greater. One strategy to overcome this limitation, while maintaining large-area capabilities, is to introduce an amplifier circuit based on low-temperature polycrystalline silicon (poly-Si) TFTs to each pixel. Such circuits, referred to as active pixels (AP), decouple pixel reset from readout, allowing correlated multiple sampling. Both amplification and multiple sampling can reduce noise and thus restore DQE at low exposures.

METHOD AND MATERIALS

The signal and noise performance of several single- and two-stage AP designs were explored through circuit simulations. Fluoroscopic operation of a 20×20 cm2 indirect-detection array configuration with a pitch of 150 µm at 30 image frames per second is assumed. Photodiode shot noise as well as resistor and TFT thermal noise were based on established theoretical models, while flicker noise characteristics of the poly-Si TFTs were modeled based on empirical measurements.

RESULTS

A strong dependence of both TFT flicker and thermal noise on the pixel circuit design, operating voltages, and the number of samples is observed. TFT flicker noise is generally found to be the dominant noise source. While for the best single-stage amplifier design, total noise performance is found to be only slightly better than the expected electronic additive noise of comparable single-TFT AMFPIs, the best two-stage amplifier design exhibits significantly better noise performance with values below 400 e.

CONCLUSION

A methodology based on circuit simulations allowing comprehensive exploration of signal and noise characteristics of poly-Si AP arrays is reported. The results suggest significant reduction of electronic noise through signal amplification and multiple sampling.

CLINICAL RELEVANCE/APPLICATION

Active pixel arrays based on poly-Si promise reduction in electronic noise, allowing operation at lower exposures in fluoroscopy and DBT compared to current flat-panel imagers.

PHS-MOA

Physics Monday Poster Discussions

Monday, Nov. 28 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
R. Jason Stafford, PhD, Houston, TX (*Moderator*) Nothing to Disclose
Chien-Min Kao, PhD, Chicago, IL (*Moderator*) Stockholder, Walgreens Boots Alliance, Inc

Sub-Events

PH212-SD-MOA1 High-resolution Diagnostic Protocol for Cochlear Implants Imaging through Flat-panel Angio CT (FPCT): Measurements of Organ Doses and Comparison with Software Calculations

Station #1

Participants
Mauro Campoleoni, BS, Milano, Italy (*Presenter*) Nothing to Disclose
Roberto Brambilla, PhD, Milan, Italy (*Abstract Co-Author*) Nothing to Disclose
Clara Sina, MD, Milan, Italy (*Abstract Co-Author*) Nothing to Disclose
Riccardo Biffi, MILANO, Italy (*Abstract Co-Author*) Nothing to Disclose
Luca Messaggi, MILANO, Italy (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate the dose to irradiated organs in a recently introduced angioCT procedure for the imaging of the cochlear implants and the middle ear, both with direct measurements and with software calculations.

METHOD AND MATERIALS

At the Neuroradiology Department of our insitution a new high-resolution diagnostic protocol for middle ear acquisition and cochlear implants visualization has been introduced. The technique is based on angio CT with Flat-panel detector and the equipment used is a Philips Allura Xper FD20. This equipment was chosen to lower patient doses and because it allows a better patient positioning compared to other available technologies, like dental cone beam with standing patient. To assess the relevant organ doses a Alderson RANDO anthropomorphic phantom was used; LiF TLD GR-200 were inserted into the cavities of the head according to a suitable and established scheme for the evaluation of the doses to the main organs. The acquisition protocol consists in a 240° rotation, symmetrically with respect to the midline of the head, passing through the back of the skull and saving the front part, with a small FOV of about 15cmx20cm which allows the simultaneous analysis of both ears. The standard protocol employs a pulsed X-ray beam at 80kV, 260mA, 25s acquisition time, 30 fps with a 7 ms pulse. The images are acquired with a 0.14 mm thickness while the reconstructed images are only 0.07 mm thick. The total DAP is about 10500 mGy*cm2. For comparison, it was also calculated the equivalent doses to the different organs through a simulation software (PCXMC-2.0 - Rotation Mode).

RESULTS

The measured doses in the phantom were averaged over 4 thermoluminescent dosimeters, with CV% less than 10%. The measurements have shown dose values to organs in the range 1 - 35 mSv: in particular bone marrow, which has the highest wT received 2.9 mSv, while the most exposed were the salivary glands with 31,7 mSv. For the most exposed organs the doses calculated with the PCXMC-2.0 software are in agreement with the measurements (20%).

CONCLUSION

The protocol studied has the advantage of using an angio equipment instead of a CT, and allows an optimal visualization of the inner ear. Its HR 0.07 mm thick images can better detail the structure of cochlear implants reducing exposure with respect to CT and saving dose to the eye lens.

CLINICAL RELEVANCE/APPLICATION

Optimal visualization of the inner ear and of cochlear implants with lower doses.

PH213-SD-MOA2 The Role of Contrast Media on Absorbed Radiation Dose in Cardiac CT: A Monte Carlo Simulation Study

Station #2

Participants
Nico Buls, DSc, PhD, Jette, Belgium (*Presenter*) Nothing to Disclose
Edilaine Honorio da Silva, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Toon Van Cauteren, MSc, Brussels, Belgium (*Abstract Co-Author*) Nothing to Disclose
Lara Struelens, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Gert Van Gompel, PhD, Brussel, Belgium (*Abstract Co-Author*) Nothing to Disclose
Filip Vanhavere, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Johan De Mey, Jette, Belgium (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate the impact of iodine concentration levels on absorbed radiation dose in blood for various incident photon energies in a cardiac CT model.

METHOD AND MATERIALS

A representative model for cardiac CT imaging was defined, including a cardiac-chest model and the exposure geometry of a wide-beam CT scanner (Revolution CT, GE Healthcare). In the chest model, the heart was represented by a volume filled with blood including six relevant iodine contrast fractions (c = 0-50, step 10 mg I/mL), surrounded by air (lungs) and water (soft tissue). A one-heartbeat CT acquisition was simulated by 8 rotational projections over 360° with 7 types of photon spectra: X-ray CT spectra 70, 80, 100, 120, 140 kVp and gamma spectra 137Cs (662 keV) and 60Co (1250 keV). For each energy-contrast combination, the absorbed dose (D), was calculated using the f6 tally of MCNPX code, with enough particles to maintain the uncertainties below 1%.

RESULTS

With X-ray energies, the presence of iodine in blood increased D between 70 and 140 kVp by 1.7 (70 kVp, c = 10 mg I/ml) and 2.9 (140 kVp, c = 50 mg I/ml) fold, following an exponential trend.On the other hand, for 662 and 1250 keV gamma energies, a negligible increase of less than 4% and 1% was observed, respectively, even for c = 50 mg I/ml. This underlines the fact that the elevated D with X-ray energies is caused by the photoelectric effect.

CONCLUSION

Our results indicate that the presence of iodine increases radiation dose in CT due to increased photoelectric effect, and that there is an exponential trend with iodine concentration.

CLINICAL RELEVANCE/APPLICATION

A reduction in iodine contrast administration load also reduces radiation dose to the patient.

PH215-SD-MOA4 Clinical Utility of SSDE vs CTDI as the Radiation Dose Index Used to Comply with the New Joint Commission Element of Performance on CT Dose Monitoring for Exams of the Abdomen and Pelvis

Station #4

Participants
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PURPOSE

A new element of performance for hospitals performing CT scans introduced by the Joint Commission in July 2015 requires that exams with a Radiation Dose Index (RDI) outside a defined range be reviewed. This work aims to determine if there is a difference in the clinical utility (identifying scans with poor image quality or higher than normal radiation dose) of using CTDI or SSDE as the RDI for abdomen and pelvis scans.

METHOD AND MATERIALS

CT scans performed at the institution are transmitted to a dose monitoring software program, Radimetrics (Bayer Healthcare). Radimetrics calculates the SSDE for each body acquisition in the scan using the WED determined from the localizer radiograph. CTDI and SSDE values were exported from Radimetrics for analysis from single phase scans of the abdomen and pelvis performed on 3 scanners of the same model for a 6 month period. Scans identified as being in the bottom and top 5th percentiles for each RDI were selected for image quality evaluation by a group of 4 Radiology residents. 440 exams were identifeid of which 173 were in both the SSDE and CTDI sets, giving a total of 267 unique exams. The readers were blinded to the group the scans fell into and were asked to evaluate the image quality on a scale of 1 (non-diagnostic) to 5 (low noise, excellent image quality). Example scans were provided to the readers for each of the categories.

RESULTS

Inter-reader reliability was evaluated using Fleiss' Kappa and found to be moderate for the non-diagnostic and poor image quality rankings and slight for the other 3 rankings. For the bottom 5th percentile the mean and standard deviation of the average image quality rankings for CTDI and SSDE were 3.27(0.58) and 3.20(0.67). For the top 5th percentile the CTDI and SSDE mean and standard deviation scores were 3.10(0.70) and 3.16(0.77).

CONCLUSION

The similar average scores for the scans in each of the percentile groups for both RDIs examined suggests that for abdomen and pelvis scans, CTDI and SSDE are of equivalent clinical utility to use as the dose index off which to identify exams exceeding a defined range. This result may not hold for examinations of other body regions, such as the thorax.

CLINICAL RELEVANCE/APPLICATION

CTDI and the existing recommendations on notification levels may continue to be used as a reasonable dose index off which to initiate investigations into exams exceeding a defined range to comply the new Joint Commission element of performance.

PH216-SD-MOA5 Exploring Iodine Quantification and Attenuation in Wide Detector DECT Technology: A Phantom Study

Station #5

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PURPOSE

To compare inter- and intra-scanner variability of iodine concentration, and attenuation values on virtual monochromatic (VMC) images between wide-detector (w) and narrow-detector (n) single-source and dual-source DECT technologies.

METHOD AND MATERIALS

A head and body CT phantom (Gammex 461A) with 9 cavities was used. Fifteen solutions were prepared with water and iodinated contrast media (ICM) (3 groups): high iodine: 15, 40, 70, 100mgI/ml; low iodine: 0.9, 1.8, 3.75, 7.5 mg/ml, and water; and ultra-low iodine: 0.06, 0.12, 0.25, 0.5, 1mgI/ml, and water. Each solution was stored in 50ml tubes and placed the phantom. The phantom was scanned on DECT mode (140/80kVp) on a wide-detector and narrow-detector ssDECT with fast KvP enabled (Revolution CT, GE. Not FDA approved), a narrow-detector ssDECT (Discovery CT 750HD ,GE), and a narrow-detector dsDECT (Somatom Definition Flash, Siemens). Iodine images and VMC images of 40-90KeV (10-KeV increments) were obtained. A total of 56 datasets were generated (8 scans, 7 per scan). Five ROIs were placed on each test tube; iodine was recorded in mgI/ml and attenuation in HU. Percentage measurement error were calculated for iodine quantification. Agreement between scanners was assessed with Bland-Altman plots. Inter- and intra-scanner variability and interaction of Iodine and HU measurements was compared with repeated-measures ANOVA and paired t-test.

RESULTS

There was a positive correlation for Iodine values, and for HU in MCI ($P<0.05$). For Iodine <1mgI/ml, there was 55% less overestimation in ssDECT/w compared to ssDECT/n, ssDECT, and dsDECT. For 1-7.5mgIml there was >28% of underestimation in ssDECT/w. For >40mgI/ml, there was similar underestimation in all DECT technologies (12%, 8%, 8%, and 15%). Attenuation values showed lower variability between ssDECT/w and ssDECT/n (15-50 HU), whereas higher variability between ssDECT and dsDECT (10-300 HU) in 40-60 KeV images ($P<0.05$).

CONCLUSION

Iodine Quantification with a wide detector ssDECT was more accurate in Iodine concentrations <1mgI/ml compared to other DECT technologies. There is significant intra-scanner variability in HU and Iodine values in VMC images that requires a careful interpretation in clinical practice.

CLINICAL RELEVANCE/APPLICATION

Wide detector DECT systems generate robust data acquisition and processing that may affect quantification parameters. Reliable iodine quantification and HU measurements is warranted for clinical decision-making.

Honored Educators

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

Dushyant V. Sahani, MD - 2012 Honored Educator
Dushyant V. Sahani, MD - 2015 Honored Educator
Dushyant V. Sahani, MD - 2016 Honored Educator

PH217-SD-MOA6 First Results of the Quick Project: Accuracy Comparative Evaluation of PET Quantitation Among Multiple PET/CT Systems

Station #6

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PURPOSE

QUICK acronym stands for Quantitation Unified Intercomparison Control Kit (QUICK).The end point of the study is to estimate the global statistical multicenter quantitation accuracy taking into account the discrepancies between PET facilities, using a solid phantom with accurately known activities and volumes.

METHOD AND MATERIALS

This study was based on NEMA NU-2 2012 Image Quality test without any out-of-field activity. Image analysis was performed using the software available on the operating console. The QUICK phantom was designed to meet the IEC61675/NEMA Body IQ phantom in terms of geometry and activity concentrations (spheres vs background ratio = 3.91:1).Tests were performed with the same phantom on different PET scanners. Acquisition time was adjusted to compensate activity decay.5 iterations of acquisitions were made at different dates to test both reproducibility and accuracy. Each set included 5 acquisitions performed without moving the phantom to evaluate repeatability.2 reconstruction algorithms were used: a Block Sequential Regularized Expectation Maximization (BSREM) algorithm and the standard OSEM reconstruction remaining the reference. Recovery coefficients (RC), background variability (BV) and lung error (LE) were reported and statistically analyzed using a single factor variance analysis.

RESULTS

The ß noise constraint factor of the BESRM algorithm was set to 25 to match the OSEM (FWHM=2 mm, 12 subsets, 8 iterations).The equality hypothesis H0 was tested.No statistical difference for the RC was observed concerning both the repeatability and the reproducibility tests (p-value>0.99 - F vs F-criteria ratio<3%), meaning that H0 was true.Same results were observed for both BV and LE.Comparing the OSEM reconstruction to the regularized algorithm, H0 was not always verified. In particular, RC were 11% to 38% higher with BSREM while BV remained statistically the same.At last, no statistical difference was observed comparing the first two PET scanners tested in this study, regardless of any analyzed measurement.

CONCLUSION

These first results of the QUICK project demonstrate that a roaming solid resin phantom may be used to assess quantitation consistency between different PET scanners.

CLINICAL RELEVANCE/APPLICATION

The QUICK test is relevant as a first step in facility accreditation for multicentric clinical trials based on quantitative PET evaluation.

PH218-SD-MOA7 Validation of Two Methods of Measuring Contact Area for Estimation of Applied Compression Pressure in Mammography

Station #7

Participants
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PURPOSE

In mammographic breast compression, the importance of estimating and controlling pressure rather than force is understood to an increasing degree. Recent publications point out the benefits in terms of reproducibility, pain, radiation dose, image quality and even detectability of breast cancer. The average pressure applied by the paddle can be calculated as the applied force divided by the contact area between the breast and the paddle. In this study, we have assessed the accuracy of two methods of estimating the contact area.

METHOD AND MATERIALS

For a set of 300 breast compressions, we measured the contact areas between breast and paddle capacitively using a transparent indium-tin-oxide (ITO) foil attached to the paddle, and retrospectively from the obtained DICOM images using Volpara software (algorithm version 1.5.2). A gold standard was obtained from video images of the compressed breast captured from above using an optical camera. During each compression, the breast was illuminated from the sides in order to create a dark shadow on the video image where the breast was in contact with the compression paddle. We manually segmented the shadows captured at the time of X-ray exposure and measured their areas.

RESULTS

We found a strong correlation between the manual segmentations and the capacitive measurements ($r^2 = 0.979$) and between the manual segmentations and the Volpara measurements ($r^2 = 0.955$). The regression lines were both very close to the line of identity (respectively, $y = 0.046 + 0.965x$ and $y = 0.022 + 0.985x$).

CONCLUSION

The contact area between the paddle and the breast can be measured accurately, both in real-time using the capacitive method, and retrospectively using Volpara software. This finding substantiates many present and future studies that depend on one of these two methods for determining the pressure on the breast during mammographic compression.

CLINICAL RELEVANCE/APPLICATION

Recent evidence suggests that using too high pressure reduces the detectability of breast cancer. An accurate method to determine the contact area is essential to accurately estimate applied pressure.

PH219-SD-MOA8 Backscatter Factors for Computing Skin Dose in Fluoroscopically Guided Interventions (FGIs)

Station #8

Participants
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PURPOSE

Previously, the authors of this work have quantified a rapid in-clinic peak skin dose (PSD) algorithm. The PSD algorithm makes use of the backscatter factors (BSFs) reported in ICRU Report 74. The goal of this study is to update the BSFs and better understand how they differ from the reported literature values when computed at different intervention sites on computational phantoms that better represent the adult and pediatric populations.

METHOD AND MATERIALS

The BSFs were computed as the ratio of the energy deposition in air on the surface of a computational phantom, to the energy deposition in air to the same point in space in absence of the phantom. The energy deposition was computed with a Monte Carlo transport code on underweight, healthy, and overweight phantoms covering the reference height for adult and pediatric populations. The pediatric population was considered at the following ages: newborn, 1, 5, 10, and 15 year old. The BSFs were computed posterior to the following three sites: pubic symphisis, pericardium, and opisthocranion. The field size at the site of the BSF computation ranged from 5 x 5 to 25 x 25 cm^2. The BSFs were computed for monoenergetic beams at 10–120 keV at 10 keV increments to allow for spectral weighting. Polychromatic spectra were also modeled to represent clinical beams with energies ranging from 60-120 kVp with no added filtration and added filtration of 0.1 through 0.9 mm of Cu.

RESULTS

In total, over 10k Monte Carlo runs were performed with a computer time of 2.2×10^3 minutes per run to achieve a relative error less than 1%. The results of this study are in agreement with the values of ICRU 74 for the sites posterior to the pericardium and pubic symphisis. The BSFs at the site posterior to the opisthocranion are not in agreement with previous literature values. The maximum BSFs occurred in the energy range of 60-70 keV. The maximum BSFs also occurred at the largest field size. The BSFs decrease with increasing weight.

CONCLUSION

This work provides a set of BSFs that are energy, field size, and site dependent. Adhering to a BSF computed from a healthy or underweight phantom will provide the most conservative estimate of PSD. Special consideration should be given to neurointerventional procedures when selecting a BSF.

CLINICAL RELEVANCE/APPLICATION

This work will disseminate BSFs for various energies, field sizes, phantoms, and interventional sites to be used in computing PSDs for FGIs.

PH110-ED-MOA9 MRI and Cochlear Implants with Magnets: Strategies for Reducing Artifacts Near Highly Inhomogenous Magnetic Fields

Station #9

Awards
Identified for RadioGraphics

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TEACHING POINTS

MRI of the head and neck near a cochlear implant can be quite challenging due to conductive wire components and local magnetic field inhomogeneities. Several manufacturers now offer cochlear implant devices containing an internal magnet that are FDA-approved as MR-conditional at 1.5T, and at least one device is also MR-conditional for 3T. Artifacts from magnet-in cochlear implants can extend more than 10 cm from the implant using a spin echo sequence, an imaging technique that is typically robust in the presence of magnetic field inhomogeneities. Artifacts from more advanced imaging techniques, such as parallel imaging or long echo train imaging with modulated flip angles, may mimic pathology and appear in unexpected locations displaced from the main artifact.This exhibit will demonstrate: Common artifacts arising from cochlear implants with typical neuro imaging sequences Performance of metal artifact reduction sequences near cochlear implants Strategies to reduce or shift artifacts from a region of interest

TABLE OF CONTENTS/OUTLINE

Introduction to cochlear implants, location of components, interactions with the MRI magnetic fields Common diseases and pathology associated with hearing loss Typical MRI protocols and associated Cochlear Implant artifacts Suggested protocol modifications and trouble-shooting

PHS-MOB

Physics Monday Poster Discussions

Monday, Nov. 28 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
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Sub-Events

PH220-SD-MOB1 Accurate Measurement of Modulation Transfer Function of CT from Extremely Low-contrast Non-zoomed Wire Images

Station #1

Participants
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CONCLUSION

By use of tilted-wires for PSF method, MTF measurement at extremely low-CNR conditions is possible. This should be useful to elucidate the resolution behavior of nonlinear CT images.

Background

Measurement of low contrast modulation transfer function (MTF) is becoming common for non-linear CT images reconstructed by iterative method.Present mainstream is the edge method that observes edge response of plastic rod. But, it still requires some level of contrast-to-noise ratio (CNR) which is not low-enough to represent soft-tissue images.The point-spread function (PSF) method that uses wire image is the basic way of MTF measurement. But it requires very high CNR and zooming reconstruction both of which lose touch with clinical conditions, and can't be applied to non-linear images.We show that the PSF method can be made applicable to non-zoomed extremely low-CNR wire images.

Evaluation

In our method, a wire is not parallel to rotation axis (or z), but tilted with a small angle. By scanning certain range of z, an array of images is obtained. Wire positions, each different for each slice, are detected by multi-dimensional regression. All images are combined, with exact alignment, to form a PSF image that is finely-sampled and noise-tolerant by the aid of many images. For further noise tolerance, we take average of plural wires.Using a variety of thickness and material for tilted wires, we constructed multi-wire multi-contrast phantom to measure MTFs of several CNRs at once.This phantom was immersed in water. Using Toshiba's Aquilion64, z-range of 50mm was scanned helically. A hundred images of 0.5mm pitch were reconstructed by FBP with standard body kernel and 320mm reconstruction FOV.All MTFs obtained from various wires, including the wire of lowest peak-CNR 3.4 (peak height=60HU, SD=17.5) matched well with the ground truth.

Discussion

The concept of tilted-wire method is proven. Zooming reconstruction is unnecessary. Regarding noise, the wire of peak-CNR 3.4, which gave accurate MTF, is obliterated by noise and almost invisible. This CNR is far lower than that has been attainable by any other methods.

PH221-SD-MOB2 Super-hybrid Quantitative MRI using Displacement and Recovery-based Water-lipid Separation Imaging

Station #2

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PURPOSE

Functional information on water and lipid tissues (e.g., diffusion, perfusion, relaxation time, lipid fraction) obtained with magnetic resonance imaging (MRI) is useful to assess the physiological conditions, physical properties, and tissue metabolism. However, it is difficult to obtain all of them at a time. Therefore, to simultaneously acquire those functional information, we developed displacement and recovery-based SeParation of LIpid Tissue (SPLIT) imaging with different inversion time (TI), echo time (TE), and b-values.

METHOD AND MATERIALS

On a 3.0-T MRI, the SPLIT imaging was used with single-shot diffusion echo-planar imaging (SSD-EPI), and optimized scan parameters to eliminate overlap between water and lipid images in the phase-encoding direction, ie., 524 μs echo spacing, 250 kHz receiver bandwidth, 430 mm field of view, 87.7 ms TE, and 0 - 3000 s/mm2 b-values (7 points). Moreover, inversion pulse (292 ms TI) was added to the SSD-EPI to remove olefinic signals. Consecutively, the SSD-EPI (0 s/mm2 b-value) was performed using 31.8 ms TE and 0 ms TI, respectively. We obtained transverse SPLIT images of the lower leg in six healthy subjects, and calculated T1 and T2 from different TE or TI images in muscle, bone marrow, and subcutaneous fat. We also calculated the monoexponential diffusion coefficient (DC), and biexponential perfusion-related and restricted diffusion coefficients (DCp, DCr). Furthermore, we obtained lipid fraction of the muscle after the T1 and T2 corrections.

RESULTS

Water and lipid images of the lower leg were completely separated, and olefinic signals were effectively suppressed. DC of the bone marrow and subcutaneous fat calculated from the lipid images were 0.02±0.02 and 0.04±0.02 ×10-3mm2/s, and DCp, DCr, T1, T2, and lipid fraction of the muscle calculated from the water images were 20.1±10.6 ×10-3mm2/s, 1.60±0.07 ×10-3mm2/s, 837.0±30.8 ms, 27.3±0.7 ms, and 3.3±2.2%, respectively. All values were consistent with previous studies.

CONCLUSION

Our method makes it possible to simultaneously obtain quantitative values concerning diffusion, perfusion, relaxation time, and lipid fraction, thereby increasing the functional information on the water and lipid tissues.

CLINICAL RELEVANCE/APPLICATION

Our method enables one to simultaneously obtain quantitative diffusion, perfusion, relaxation time, and lipid fraction values of the water and lipid tissues without special pulse sequence.

PH223-SD-MOB4 A Framework for Organ-based Dose Monitoring System for Body CT Examinations

Station #4

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PURPOSE

Quantifying and monitoring computed tomography (CT) radiation dose for an individual patient has become an unavoidable requirement to practice medical imaging. Among various dose metrics, organ dose is generally regarded as one of the best metrics for characterizing patient radiation burden. The purpose of this work was to develop a patient-specific radiation dose monitoring system capable of tracking individual patient organ dose for clinical CT exams.

METHOD AND MATERIALS

The dose-monitoring program was developed based on a commercial software (DoseWatch research version, GE Healthcare, Waukesha, WI). The exam CTDIvol, DLP, TCM profiles, scanning parameters, outline of patient contour image, and anatomical landmarks were extracted as bases to estimate organ dose. In the first phase of the study, 30 patients who underwent six unique protocols were selected from the database. A library of 60 adult computational phantoms (age range: 18–70 y.o., weight range: 60–180 kg) were included in the study. Based on the outline of the anatomical landmarks, a clinical patient was optimally matched to a computational phantom to obtain a representation of organ location/distribution. Each of the computational models were previously associated with CTDIvol-normalized-organ dose coefficients as function of size. The organ doses were computed via the h factors, adjusted by size, CTDIvol, and a regional dose convolution factor accommodating the tube current modulation field at the organ location.

RESULTS

Organ doses demonstrated varied distributions across patients and protocols. Across the pilot 30 clinical patients evaluated, the organs that received the highest dose were thyroid for chest CT examinations (average 9.4 mGy), bladder for pelvic CT examinations (average 14.1 mGy), and liver for abdominal examinations (average 21.4 mGy).

CONCLUSION

We extended a dose-monitoring program to include organ dose for individual patients. This tool improves the patient exposure record by incorporating patient-specific information as well as facilitating quality assurance and standardization of CT protocols.

CLINICAL RELEVANCE/APPLICATION

The organ-based dose monitorting system may enable dose tracking pertaining patient-specific information and also aid in the design of individulized CT protocols.

PH224-SD-MOB5 Comprehensive Study of Spectrum Optimization for Split-Filter Dual-Energy CT

Station #5

Participants
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PURPOSE

To investigate multiple parameters for shaping the x-ray spectrum of split-filter dual-energy computed tomography (DE-CT) and determine the optimal spectrum for the iodine quantification (IQ) and virtual-non-contrast (VNC) imaging.

METHOD AND MATERIALS

The spectrum of LE and HE beams is the most important factor affecting the performance of DE-CT. In clinical split-filter DE-CT system, gold and tin prefilters are employed to split the cone beams into low-energy (LE) and high-energy (HE) beams, respectively. A comprehensive study of multiple spectrum shaping parameters, including 16 feasible prefilter materials, the prefilter thickness ranging from 0mm to 0.5mm in step of 0.025mm, and the tube potential ranging from 100kVp to 150kVp in step of 10kVp, were performed through simulation with the HE prefilter being fixed to 0.6mm tin. A cylindrical phantom with multiple iodine inserts and a 3D anthropomorphic phantom with hyperdense hepatic lesion were used in the study. An analytical physics-based CT projection simulation tool was employed to generate the LE and HE noisy projection data with the corresponding prefilter and tube potential settings. Projection data were beam-hardening corrected before filtered backprojection image reconstruction. The IQ and VNC images were obtained by applying image-based two-material decomposition method to the reconstructed DE-CT images. The figure-of-merit (FOM) used for optimization was the normalized inverse of the noise-dose product obtained from the IQ and VNC images and a Monte-Carlo CT simulation tool.

RESULTS

Tungsten, tantalum, and gold LE prefilters, with k-edges of 70 to 80keV, achieved significant higher FOM than other candidate materials (2.08±0.20 vs 1.03±0.07, $p<0.01$). With the optimal gold prefilter thickness, operating tube potential at 120kVp achieved significantly higher FOM than other suboptimal settings (1.88±0.07 vs 1.77±0.05 (110kVp), $p<0.01$).

CONCLUSION

Significant improvement in noise levels of IQ and VNC images under minimal patient dose could be achieved by employing the optimal prefilter material and thickness, and tube potential settings. Practical constraints, such as tube power reserve, and targeted applications might affect the optimal settings.

CLINICAL RELEVANCE/APPLICATION

Operating the clinical split-filter DE-CT system at the optimal spectrum settings would not only reduce noise in the IQ and VNC images but also potentially reduce the radiation dose to patients.

Honored Educators

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Elliot K. Fishman, MD - 2014 Honored Educator
Elliot K. Fishman, MD - 2016 Honored Educator

PH225-SD-MOB6 Revisiting FLT PET Dosing: A Clinical Trial List Mode Based Determination to Guide Dose Reduction

Station #6

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PURPOSE

In order to assess proliferation with PET/CT imaging, 18F-Fluorothymidine (FLT) has been developed as an alternative to 18F-FDG. However, current standard dosing protocols can make such studies costly in addition to having a large radiation burden. We used acquired and archived listmode FLT data to simulate low dose acquisitions in order to assess potential for FLT dose reduction and to evaluate quantitative impacts.

METHOD AND MATERIALS

20 breast cancer patients underwent whole body FLT scans on a Philips Gemini TF 64 PET/CT using a standard dose of 10mCi (370 MBq) with a time of 90 seconds per acquisition volume. Following prior validation of the relationship between decreased acquisition times used for image reconstruction and radiopharmaceutical dose, listmode data were reconstructed using 2/3, 1/2, 1/3 and 1/6 of the original coincident event data, equating to a range of 33 to 83% dose/count reductions. Regions of interest were placed on 53 target tumor lesions as well as a variety of reference background areas. PET images were quantitatively evaluated using the 90s per frame SUVmax as a reference value, calculating SUVmax changes for the dose reduction simulations.

RESULTS

The average SUVmax of all tumor lesions was within 12% of the reference values for even the 5/6 dose reduction. Those images exhibited the greatest noise, yet all but 2 lesions had a SUVmax variability no greater than 15% at 50% dose reduction. Background tissues showed similar quantitative results. Low uptake tissues, such as the muscle and lungs, showed greater variation at larger dose reductions, yet all tissues had SUVmax changes below 20% at a 50% dose reduction. A multi-reader review for image quality is ongoing, however all lesions identified on 90s images were visible at each of the simulated dose reduction levels.

CONCLUSION

FLT dosing can be substantially reduced when using current technology time of flight PET/CT systems. A dose reduction by 50% to 5 mCi (185 MBq) can be achieved even at a 90s acquisition time per bed position, further dose reductions can be achieved by simultaneously increasing the time per bed position making a 2.5 mCi (87 MBq) FLT PET feasible when a 3min bed position acquisition is used.

CLINICAL RELEVANCE/APPLICATION

18F-FLT PET/CT dosing using current generation time of flight PET/CT can be substantially reduced to a 5mCi / 90 s bed acquisition that can be further reduced scans with increasing acquisition time.

PH226-SD-MOB7 Radiation Dose Reduction in Digital Breast Tomosynthesis (DBT) by Means of Patch-based Trainable Nonlinear Regression (PTNR)

Station #7

Participants
Junchi Liu, MS, Chicago, IL (*Presenter*) Nothing to Disclose
Amin Zarshenas, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Laurie L. Fajardo, MD, MBA, Park City, UT (*Abstract Co-Author*) Consultant, Hologic, Inc; Scientific Advisory Board, Hologic, Inc; Consultant, Koninklijke Philips NV; Advisory Board, Koninklijke Philips NV; Consultant, Siemens AG; Consultant, FUJIFILM Holdings Corporation; Advisory Board, Galena Biopharma, Inc
Kenji Suzuki, PhD, Chicago, IL (*Abstract Co-Author*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Stockholder, Alara, Inc; Stockholder, AlgoMedica, Inc.; ; ; ; ; ; ; ;

PURPOSE

To reduce cumulative radiation exposure and lifetime attributable risks for radiation-induced cancer from mammographic and tomographic screening, we developed PTNR for radiation dose reduction.

METHOD AND MATERIALS

Our dose reduction technology based on PTNR was trained with input images and corresponding teaching images to convert the pixel values in patches in a given image to desired pixel values and obtain the entire image by a convolutional operation with the model. PTNR learns the relationship between low-dose (LD) and higher-dose (HD) images to convert new LD images to "virtual" higher-dose (VHD) images. We trained our technology with quarter-dose (25% of standard dose: 12 mAs at 32 kVp) tomosynthesis raw projection (RP) images and corresponding "teaching" HDRP (higher-dose raw projection) images (200% of standard dose: 99 mAs at 32 kVp) of a breast cadaver phantom acquired with a DBT system (Selenia Dimensions, Hologic, CA, U.S.). Once trained, our technique no longer requires HD images. It provides the images that look like HD images; thus term VHD. To determine a dose reduction rate, we acquired 4 sets of RP images of the phantom at 4 different radiation doses (1.35, 2.7, 4.04, and 5.39 mGy entrance dose). Structural SIMilarity (SSIM) index was used to evaluate the image quality. For testing, we collected half-dose (50% of standard dose: 30±10 mAs at 35±5 kVp) and full-dose (standard dose: 70±15 mAs at 35±5 kvp) images of 51 patients with the DBT system at Univ of Iowa Hospitals.

RESULTS

Our PTNR technology was able to convert quarter-dose images (1.35 mGy; SSIM: 0.9911) of the breast cadaver to VHD images with the image quality (SSIM: 0.9972) equivalent to 90% dose images (4.8 mGy); thus, it achieved 72% dose reduction. The image quality of our VHD images of clinical cases was nearly equivalent to full-dose images. Our technology was able to reduce noise in half-dose images, while preserving microcalcifications and breast-tissue structures. The processing time for each breast was 5.1 sec. on a PC (Intel i7-4790K CPU, 4GHz).

CONCLUSION

Our PTNR technology converted LD DBT images to VHD DBT images which were nearly equivalent to full-dose DBT images. Our phantom experiment demonstrated a potential 72% dose reduction.

CLINICAL RELEVANCE/APPLICATION

Substantial radiation dose reduction would benefit patients by reducing the risk of radiation-induced cancer from DBT screening.

PH227-SD-MOB8 Value of Phantom Dosimetry to Estimate Patient Dose in Contrast-Enhanced Spectral Mammography (CESM)

Station #8

Participants
Jordana Phillips, MD, Boston, MA (*Presenter*) Nothing to Disclose
Georgeta Mihai, PhD, Boston , MA (*Abstract Co-Author*) Nothing to Disclose
Alexander Brook, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Toshiba Medical Systems Corporation

PURPOSE

CESM is increasingly being used in clinical practice. As with all mammography systems, a reliable quality control program using phantom dosimetry is vital to successful implementation. However, it is currently unknown how phantom dosimetric measures compare with patient data for CESM. The purpose of this study is to compare average glandular dose (AGD) measured with phantoms with those in patients.

METHOD AND MATERIALS

A phantom study using different simulated breast thicknesses on each of 3 different x-ray systems (GE 2D, GE CESM, and Hologic 2D +3D) was performed to measure the entrance skin exposure (ESE) and compare with reported ESE to calibrate the systems.

Sixteen patients undergoing 4 view mammograms using each of the 3 systems between 2012-2016 were then identified. Reported ESE was recorded for each image. Phantom data was used to calibrate the reported ESE for patient images. As different vendors use different algorithms for AGD reporting, our study used the Dance model for calculating both phantom and patient AGD using the equation AGD = K*g*c*s*t (K is measured ESE [for phantom calculations], calibrated ESE [for patient calculations], and g, c, s and T are conversion factors determined from Monte Carlo simulation). Calibrated patient AGD (cAGD) and phantom measured AGD (pAGD) for CESM were compared to the other systems using a paired t-test.

RESULTS

The mean ratio of differences between cAGD and pAGD for GE 2D and Hologic 2D and 3D are: is 1.01 +/- .15, 1.25 +/- .28, and 1.05 +/- .17 . The mean ratio is not significantly different from recently published data. For CESM, the mean ratio is 0.98 +/- .27 (low energy) and 1.11+/- .23 (high energy). Figure 1 presents the mean ratios for all systems separated by breast thickness. Phantom dosimetry for low energy CESM was comparable to GE 2D but more accurate compared with Hologic 2D and Hologic 3D ($p<.05$). Phantom dosimetry for high energy CESM was comparable to Hologic 3D but was more accurate compared with GE 2D and Hologic 2D ($p<.05$). Phantoms did not correlate well with patient dose in thicknesses >80cm.

CONCLUSION

Phantom dosimetry may be useful for approximating patient dose for CESM as part of a quality control program.

CLINICAL RELEVANCE/APPLICATION

Phantom dosimetry may be useful for approximating patient dose for CESM as part of a quality control program.

PH115-ED-MOB9 How to Perform a Contrast-enhanced Ultrasound in 10 Lessons?

Station #9

Participants
Salma Moalla, MD, Paris, France (*Presenter*) Nothing to Disclose
Benedicte Coiffier, Vilejuif, France (*Abstract Co-Author*) Nothing to Disclose
Samy Ammari, Villejuif, France (*Abstract Co-Author*) Nothing to Disclose
Baya Benatsou, Villejuif, France (*Abstract Co-Author*) Nothing to Disclose
Stephanie Pitre-Champagnat, Villejuif, France (*Abstract Co-Author*) Nothing to Disclose
Nathalie B. Lassau, MD, PhD, Villejuif, France (*Abstract Co-Author*) Speaker, Toshiba Corporation; Speaker, Bracco Group

TEACHING POINTS

Focus on the basics of Contrast-enhanced ultrasound's tehnique and learn how to analyse images and information provided by contrast ultrasound

TABLE OF CONTENTS/OUTLINE

Contrast-enhanced ultrasound (CEUS) consists in performing a "classical" ultrasound associated with the administration of intravenous contrast agents containing microbubbles approuved in Europe, China, Korea for several years and recently in USA in 2016. The intra-vascular bubbles with a diameter around 3 micrometers increase the detection of vascularization as intravenous contrast agents used in CT and MRI.This review describes CEUS techniques, indications, non and contraindications.It summarizes usefulness of CEUS in detection and characterization of lesions but also of dynamic contast-enhanced ultrasound (DCE-US)in quantification of the effect of anti-angiogenic treatments through selected teaching cases. CEUS is a cheap, seducing, alternative technique, that have the advantage over contrast-enhanced MRI and CT in patients with contraindications such as renal failure or contrast allergy. It allows repeated examinations. With DCE-US, new softwares allows the quantification of blood flow and blood volume using the automatic dynamic aquisition during 3 minutes with a high temporal resolution (4 images per second using raw linear data) .

PH010-EC-MOB Machine-Learning-Based Delineation Approach for Gross Tumor Volume Region of Three Types of Lung Tumors using Planning CT and PET/CT Datasets

Custom Application Computer Demonstration

Participants
Koujiro Ikushima, BS, Fukuoka, Japan (*Presenter*) Nothing to Disclose
Hidetaka Arimura, PhD, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Ze Jin, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Hidetake Yabuuchi, MD, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Jyunpei Kuwazuru, BS, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiyuki Shioyama, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Tomonari Sasaki, MD, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroshi Honda, MD, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Masayuki Sasaki, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose

Background

We have developed a computer-assisted delineation system for gross tumor volume (GTV) region of three types of lung tumors with a machine learning classifier based on the planning computed tomography (CT) and positron emission tomography (PET)/CT datasets. Our software consisted of an image registration step, a machine learning step, and the segmentation step for the GTV region. At the image registration step, PET and diagnostic CT images were registered with a planning CT image based on the centroid of lung regions with bronchus. The next machine learning step contained our key idea, which was to feed voxel-based image features around GTV contours determined based on the knowledge of radiation oncologists into a machine learning classifier during the training step, after which the classifier produced the "degree of GTV" for each voxel in the testing step. At the segmentation step, the final GTV regions were estimated using the optimum contour selection (OSC) method that can be used to select global optimum object contours based on multiple active delineations with a level set method around the GTV.

Evaluation

Our proposed framework was applied to fourteen lung cancer patients (age range: 65-86 years, mean: 76, solid: 6, ground glass

opacity (GGO): 4, mixed GGO: 4), who had undergone stereotactic body radiotherapy. Our proposed framework achieved average three-dimensional Dice similarity coefficients (DSCs) of 0.836, 0.763, and 0.701 for solid, GGO, and mixed GGO types, respectively. On the other hand, the conventional approach, in which 80% of the maximum standardized uptake value region was used as initial region for the OCS method, produced average DSCs of 0.776, 0.110, and 0.500 for solid, GGO, and mixed GGO types, respectively.

Discussion

The GTV regions were segmented by our proposed approach even if the tumor type of lung tumor was the GGO. The segmented GTV region can be modified in our software if the segmented GTV region is inadequate.

CONCLUSION

Our results suggested that the software based on our proposed approach may be useful as a tool to assist radiation oncologists for delineation of various types of GTV regions.

FIGURE

http://abstract.rsna.org/uploads/2016/16016920/16016920_mjc4.jpg

SPPH21

AAPM/RSNA Basic Physics Lecture for the RT: Hybrid Imaging: Past, Present, and Future

Monday, Nov. 28 1:30PM - 2:45PM Room: S402AB

CT MR NM PH

AMA PRA Category 1 Credits ™: 1.25
ARRT Category A+ Credits: 1.50

Participants
Scott J. Emerson, MS, Royal Oak, MI, (scott.emerson@beaumont.edu) (*Moderator*) Nothing to Disclose
Osama R. Mawlawi, PhD, Houston, TX, (omawlawi@mdanderson.org) (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Advances in PET/CT imaging. 2) Advances in SPECT/CT imaging. 3) Challenges and opportunities of PET/MR imaging.

ABSTRACT

Nuclear medicine hybrid imaging (PET/CT and SPECT/CT) has undergone several technological advances over the past decade. This lecture will review the evolution of hybrid imaging and describe the technological advances in the field from system design to image generation and data analysis tools. The lecture will cover innovations in detector design, resolution recovery, time of flight imaging, quantitative evaluation, attenuation correction, and reconstruction algorithms. The lecture will also cover PET/MR imaging and its current challenges and opportunities.

URL

SPPH22

Physics Symposium: Best of the SRS/SBRT AAPM Summer School

Monday, Nov. 28 1:30PM - 5:45PM Room: S102C

PH SQ

AMA PRA Category 1 Credits ™: 4.00
ARRT Category A+ Credits: 4.50

Participants
Sonja Dieterich, PhD, Sacramento, CA (*Moderator*) Scientific Advisor, MGS Research, Inc

LEARNING OBJECTIVES

1) Identify critical anatomical features of major SRS/SBRT targets. 2) Learn techniques used in small field dosimetry and the order of magnitude of treatment uncertainties. 3) Learn essential treatment planning techniques, especially with regards to repiratory motion management. 4) Gain knowledge about treatment delivery devices for SRS/SBRT. 5) Understand resources and safety practices for SRS/SBRT.

ABSTRACT

This session summarizes the highlights of the 2014 AAPM Summer School on SRS/SBRT. The first speaker will highlight critical anatomical structures which physicists and treatment planners need to be aware of in SRS/SBRT. Contouring atlases specific to SRS/SBRT are discussed, e.g. the consensus guidelines published by the spine consortium.The second lecture focuses on the physics of small field dosimetry, which is a special skill set within the field of clinical medical physics. The state-of-the art recommendation on detector selection and measurement techniques will be discussed, including current recommendations on the use of detector correction factors.The third speaker will summarize treatment planning approaches specific to classic SRS/SBRT targets in the brain, lung, GI and GU regions. The appropriate use of respiratory management techniques for SBRT in lung, liver and pancreas requires the careful and considerate application of complex technology. Current society recommendations and peer-reviewed literature on accepted approaches to respiratory motion management will be summarized.In the last decade, the selection of treatment machines capable of delivering SRS/SBRT treatments with the required spatial and dosimetric accuracy has increased significantly. The speaker will discuss the major technical components of each delivery device, highlighting strength and weaknesses of each system as they apply to SRS/SBRT.SRS/SBRT delivers a high dose with steep dose gradients in 1-5 fractions, using complex technology with image guidance. Both the risk of error and the impact of errors is amplified under these circumstances. The last speaker of this session will discuss selected case reports of errors, including a root cause analysis. Current safety initiatives and recommendations for improved safety practices will be introduced. Resources to guide safe and effective implementation of an SRS/SBRT program will be discussed and shared with the audience.

Sub-Events

SPPH22A Anatomy for Cranial and Spine SRS/SBRT

Participants
Zachary A. Kohutek, MD, PhD, New York, NY (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the anatomy relevant to CNS radiotherapy of brain and spine tumors. 2) Explain the dose constraints for treatment of brain and spine tumors.

SPPH22B Small Field Dosimetry and Uncertainty

Participants
Sonja Dieterich, PhD, Sacramento, CA, (sdieterich@ucdavis.edu) (*Presenter*) Scientific Advisor, MGS Research, Inc

LEARNING OBJECTIVES

View learning objectives under the main course title.

ABSTRACT

This lecture lecture focuses on the physics of small field dosimetry, which is a special skill set within the field of clinical medical physics. The state-of-the art recommendation on detector selection and measurement techniques will be discussed, including current recommendations on the use of detector correction factors.

Active Handout:Sonja Dieterich

http://abstract.rsna.org/uploads/2016/16001020/ACTIVE SPPH22B.pdf

SPPH22C Treatment Planning and Respiratory Motion Management for SBRT

Participants
Kristi R. Hendrickson, PhD, Seattle, WA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under the main course title.

SPPH22D SRS/SBRT Delivery Devices

Participants
James Gordon, PhD, Birmingham, MI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under the main course title.

SPPH22E Safety and Quality for SRS/SBRT

Participants
Stanley H. Benedict, PhD, Sacramento, CA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under the main course title.

Active Handout:Stanley H Benedict

http://abstract.rsna.org/uploads/2016/16001023/SPPH22E Benedict RSNA2016 SBRTSafetyQA.pdf

SSE21

Physics (CT-Dose II)

Monday, Nov. 28 3:00PM - 4:00PM Room: S403A

CT PH SQ

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
Cynthia H. McCollough, PhD, Rochester, MN (*Moderator*) Research Grant, Siemens AG
Xiujiang J. Rong, PhD, Houston, TX (*Moderator*) Nothing to Disclose

Sub-Events

SSE21-01 Prospective Multicenter Study on DRLs Comparison According to Clinical Indication and Anatomical Region: Preliminary Results

Monday, Nov. 28 3:00PM - 3:10PM Room: S403A

Participants
Hugues G. Brat, MD, Sion, Switzerland (*Presenter*) Nothing to Disclose
Eric Meicher, Sion, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Stephane Montandon, MSc, Saint-Livres, Switzerland (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Dominique Fournier, MD, Sion, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Federica Zanca, PhD, Leuven, Belgium (*Abstract Co-Author*) Employee, General Electric Company

PURPOSE

To compare diagnostic reference levels (DRLs) for CT examinations when using clinical indication versus anatomical region protocols.

METHOD AND MATERIALS

CT dose data from 7 scanners in 5 medical imaging centers of the same institution were collected using a single dose management software (DoseWatch, GE). Prior to data collection, parameters uniformization and protocol Radlex mapping occurred. The institutional DRLs (median CTDIvol) of chest and abdomen CT examinations were estimated based on anatomical region and clinical indication protocols and compared to each other as well as to national DRLs. The one-sample Wilcoxon signed rank and the Mann-Whitney tests were used to assess statistical significant differences among groups, as appropriate.

RESULTS

The institutional DRLs based on anatomical region (175 chest and 499 abdomen CT examinations) were: chest 5.7mGy, abdomen 8mGy and were significantly lower than the national DRLs (10mGy chest, 15mGy abdomen, $p<0.0001$). Per clinical indication, a large variation in dose levels was observed, but the dose was significantly lower than national DRLs in all cases: Chest DRLs: emphysema 4.8mGy, pulmonary embolism 7mGy, pneumonia 5.6mGy ($p<0.0001$ for all). Abdomen DRLs: colonography 4.6mGy, liver 7.5mGy, pancreas 7.6mGy, renal infection 6.5mGy, renal tumor 6.7mGy, diverticulitis 9mGy ($p<0.0001$ for all).When comparing institutional DRLs per clinical indication to anatomical region protocols: For Chest CT examinations, there was no statistical significant difference (p-value range 0.2-0.8). For abdomen CT examinations, there was a statistical significant difference for CT colonography ($p<0.05$), diverticulitis ($p<0.05$), renal infection ($p<0.005$) and renal tumor ($p<0.002$).

CONCLUSION

Dose levels for chest and abdomen CT examination protocols based on specific clinical indications are significantly lower than national DRLs in all cases and significantly lower than institutional anatomical region DRLs for CT colonography, diverticulitis, renal infection and renal tumor. National DRLs are therefore not reflecting clinical practice, where protocols are adapted to clinical indication rather than to anatomical region.

CLINICAL RELEVANCE/APPLICATION

DRL values should be linked to clinical indication, which may require different image quality and therefore a different dose.

SSE21-02 Out-of-Plane Shielding in Pediatric CT: Effect of Lead Apron Location on Radiation Dose Reduction

Monday, Nov. 28 3:10PM - 3:20PM Room: S403A

Participants
Michael R. Bruesewitz, Rochester, MN (*Presenter*) Nothing to Disclose
Lifeng Yu, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Thomas J. Vrieze, RT, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jane S. Matsumoto, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Richard L. Morin, PhD, Jacksonville, FL (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

Use of lead aprons to shield regions outside the CT scan field has been proposed to reduce radiation dose to patients. In practice, aprons need to be placed some distance from the scan range to avoid inclusion in the scan, which can decrease image quality and increase dose when used with tube current modulation. This study aimed to quantify dose reduction as a function of the distance between the apron and the bottom of the scan field for pediatric chest CT.

METHOD AND MATERIALS

Three semi-anthropomorphic head and abdominopelvic (AP) phantoms (CIRS Inc.) were placed adjacent to a chest phantom to mimic the habitus of a 5-year old. A chest CT scan (scan range 20 cm) was performed on a dual-source scanner using both sources operating in a high pitch (Flash) mode, with a reference mAs 10 times the clinical technique to allow measurements of small scattered doses in the AP areas. A point dosimeter (0.3 cc, Radcal Accu-Gold) was used to measure the dose every 5 cm from the start of the scan range (top of the chest) to the end of the AP phantom, which included a 25 cm range beyond the bottom of the scan that received only scattered radiation. A 0.5mm thick lead-equivalent apron was placed 1, 5, and 10 cm away from the bottom of the scan range. The averaged dose (2/3 peripheral + 1/3 center) was calculated both within and outside the scan field for each 5-cm position.

RESULTS

The mean averaged dose within and outside the scan field was 1.7 and 0.067 mGy, respectively. The average dose reduction achieved by the lead apron outside the scan field was 0.018 mGy (27.0%), 0.013 mGy (19.2%), and 0.010 mGy (14.2%) when the apron was 1, 5, and 10 cm away from the bottom of the scan range. The corresponding overall dose reduction (including both scan region and beyond the scan range) was 1.0%, 0.7%, and 0.5%.

CONCLUSION

When the lead apron was placed further away from the scan field, the amount of radiation dose reduction diminishes quickly. The reduction in dose was negligible compared to the overall dose of the exam.

CLINICAL RELEVANCE/APPLICATION

Dose reduction using out-of-plane shielding is extremely small. Potential risks (e.g. artifacts, infection, and discomfort) outweigh the benefit of the small dose reduction gained from the shielding.

SSE21-03 Using a Dedicated CT Metal/Artifact Reduction Algorithm for Arthroplasty Imaging: Can we Reduce the Dose?

Monday, Nov. 28 3:20PM - 3:30PM Room: S403A

Participants
Naveen Subhas, MD, Cleveland, OH (*Presenter*) Research Grant, Siemens AG
Camila P. Purysko, MD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Nancy A. Obuchowski, PhD, Cleveland, OH (*Abstract Co-Author*) Research Consultant, Siemens AG; Research Consultant, QT Ultrasound Labs; Research Consultant, Elucid Bioimaging Inc
Andrew Primak, PhD, Malvern, PA (*Abstract Co-Author*) Employee, Siemens AG
Frank Dong, PhD, Solon, OH (*Abstract Co-Author*) Equipment support, Siemens AG Software support, Siemens AG
Joshua M. Polster, MD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Brian R. Herts, MD, Cleveland, OH (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

To compare readers' ability using iterative metal artifact reduction (iMAR), a new CT reconstruction technique, and standard filtered back projection (FBP) technique to detect lesions near hardware in a CT phantom model at different radiation doses.

METHOD AND MATERIALS

An anthropomorphic CT phantom was manufactured with cobalt chromium spheres attached to titanium rods, simulating an arthroplasty. Spherical lesions of different sizes (10-20mm) and different attenuations from the background (10–60HU) were embedded around the head and stem. Scans were performed using standard clinical technique (140kVp, 0.6mm collimation) at standard-dose (300 rmAs), half-dose (150 rmAs) and double-dose (600 rmAs) on a single CT scanner (Siemens FLASH). iMAR and FBP images were reconstructed with identical parameters and independently and blindly reviewed by 3 radiologists. A confidence score (0 – 100%) was assigned for the presence of a lesion in 8 locations near the head and stem. Accuracy, measured as the area under the ROC curve (AUC), sensitivity and specificity were calculated.

RESULTS

Readers' accuracy (0.946-0.979) and sensitivity (0.818-0.953) using iMAR were significantly higher (p=0.039—0.001) than with FBP (0.856-0.916 and 0.578-0.74, respectively) at all doses. Specificity with iMAR (0.984) and FBP (0.974-0.995) were high at all doses with no significant differences (p=1.0). Accuracy of half-dose iMAR (0.946) was not inferior to standard-dose FBP (0.888,p=0.003) or double-dose FBP(0.916,p=0.038). Accuracy with double-dose iMAR (0.979) and FBP (0.916) were not significantly higher than standard-dose iMAR (0.975, p=0.178-0.880) or standard-dose FBP (0.888, p=0.459). Sensitivity decreased less with iMAR than FBP with decrease in lesion size (p=0.021) and lesions near the head (p<0.001). There were no other significant differences in sensitivity based on lesion characteristics between the techniques.

CONCLUSION

iMAR, at all doses, significantly improved readers' ability to detect lesions near hardware in a CT phantom model, with the accuracy of half-dose iMAR equivalent to standard-dose and double-dose FBP.

CLINICAL RELEVANCE/APPLICATION

Using iMAR reconstructions when evaluating patients with arthroplasties may improve the readers' ability to detect pathology near hardware and allow for significant dose reductions compared to standard FBP reconstructions.

SSE21-04 Dose to the Eye Lens and Skin in CT Perfusion Exams

Monday, Nov. 28 3:30PM - 3:40PM Room: S403A

Participants
Xochitl Lopez-Rendon, MSc, Leuven, Belgium (*Presenter*) Nothing to Disclose
Andreas Stratis, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Walter Coudyzer, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Wim Develter, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose

Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG
Federica Zanca, PhD, Leuven, Belgium (*Abstract Co-Author*) Employee, General Electric Company

PURPOSE

Techniques and tools for CT dosimetry are not generally available for CT perfusion exams. At the same time, CTDIvol cannot be used as a surrogate for organ dose as this metric is expected to overestimate locally absorbed doses in small scanned volumes. The aim was therefore to quantify the eye lens and skin doses due to CT perfusion exams by means of thermoluminescent dosimeters (TLDs) measurements in a cadaver and compare them with reported CTDIvol and Monte Carlo (MC) dose estimations.

METHOD AND MATERIALS

With the help of a pathologist, 35 TLDs were carefully inserted in different organs or tissues (brain, skin, bone surface and eye lens) in a female cadaver head, scanned in a Siemens Definition Flash scanner, using the clinical protocol for brain perfusion (80 kVp, 200 mAs, 32x1.2 mm collimation, 1.5 s scan time, 0.28 s rotation time, 30 scans). A trained CT radiographer positioned the cadaver head as for a typical exam in some of the non-cooperative patients: the eye lenses were in the primary beam (worst-case scenario). From the CT images, a voxel model was created. Doses were calculated with a MC simulation (EGSnrc) and compared to TLD measurements and to the CTDIvol after the exam.

RESULTS

The measured doses were: 216.3 mGy (right eye), 154.4 mGy (left eye), 185.3 mGy (average for eyes) and 107.6 mGy (average) for the skin. Compared to the reported CTDIvol of 260 mGy, the eye lens dose was overestimated by 17% (right) and 41% (left) with an average overestimation of 29%; the skin dose followed the same trend with an overestimation of 59%.MC calculations were: 177.0 mGy and 111.0 mGy for the average eye lenses and skin, respectively, indicating a high accuracy (-4.5% and 3.6% difference respect to TLDs measurements, respectively).

CONCLUSION

CTDIvol stays a conservative metrics for eye lens and skin dose estimation and allows evaluating a safe utilization of such protocols in clinical practice. However, MC framework allows a more accurate dose estimations.

CLINICAL RELEVANCE/APPLICATION

Monte Carlo simulations are easier to perform than TLD measurements if accurate dosimetry is needed, in order to evaluate the applicability of high dose protocols in clinical practice.

SSE21-05 Not all Water Equivalent Diameters Yield the Same Dose: The influence of Patient Ellipticity on AEC Algorithms in CT

Monday, Nov. 28 3:40PM - 3:50PM Room: S403A

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company
Ashley Hermanns, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Annelise Malkus, PhD, Madison, WI (*Abstract Co-Author*) Licensing agreement, General Electric Company
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PURPOSE

Dose monitoring in CT is now common place due to the multitude of commercial and in house dose aggregating tools available. For CT protocols using automatic exposure control (AEC) the dose will increase with patient size. To compare patient doses across patient size, metrics such as SSDE can be used. Other options include plotting a dose surrogate or scanner output as a function of patient size. In any of these methods, one seeks to obtain feedback on how appropriate the dose was for a given patient size. This work explains how on some CT scanners, even for the same water equivalent diameter (WED), the scanner output will change as a function of the ellipticity ratio of the patient. This effect can modulate the scans AEC by large amounts and therefore it should be taken into account.

METHOD AND MATERIALS

Patient dose, size, and scanner output data were acquired under IRB protocol for abdominal pelvis scans. The WED, effective mAs, and ellipticity ratio were calculated for each image slice. The effective mAs for each image slice was plotted against WED for a cohort of patients. The WED and ellipticity ratio were also plotted against effective mAs for individual patients.

RESULTS

The scanner employed an AEC function that produces an exponential increase in effective mAs with WED for uniform cylindrical phantoms. For the patient data analyzed in this study, the effective mAs did not follow the expected exponential relationship with WED. It was observed that when the effective mAs data deviated from the expected relationship, the patient ellipticity changed. In other words, while the patient's cross section remained uniform in anterior to posterior ratio, the AEC behaved as expected. Alternatively, when the ratio deviated, so did the AEC. For example, two patient image slices corresponding to a WED of 370 mm were measured to have effective mAs values of 93 and 136. Their ellipticity ratios were measured to be 1.34 and 1.47 respectively.

CONCLUSION

A new effect of AEC systems was investigated. It was shown that if one desires to obtain a confident estimate of the appropriateness of patient dose for a given patient size, the ellipticity or distribution of the patient's cross section must also be considered.

CLINICAL RELEVANCE/APPLICATION

This work demonstrates an additional patient attribute, the ellipticity of the patient's cross section, which should be considered in addition to overall size for identifying CT dose outliers.

SSE21-06 Comparison of Size-Specific Dose Estimate Conversion Factors for Fixed Tube Current and Tube Current Modulated Computed Tomography

Monday, Nov. 28 3:50PM - 4:00PM Room: S403A

Participants
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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 Research support, Siemens AG

PURPOSE

The purpose of this work is to compare the conversion factors used to calculate size-specific dose estimate (SSDE) as outlined in TG 204 for tube current modulation (TCM) with different modulation strengths to those of fixed tube current (FTC).

METHOD AND MATERIALS

A series of abdominal CT protocols were performed on three cylindrical polymethyl methacrylate (PMMA) phantoms with diameters of 32 cm, 16 cm, and 8 cm on a 64-slice MDCT scanner (Definition AS64, Siemens). The scans were performed using the same kV, collimation, rotation time, and pitch. Several scans were performed using fixed mAs (200) and TCM (CareDose4D, Quality Reference mAs = 200). To examine the effects of different scanner parameters, both Adult and Child options were used as well as three different modulation strengths for TCM: Very Weak, Average, and Very Strong. For each scan, a 0.6-cc ionization chamber was placed in the center hole of each phantom and the air kerma measurement was recorded for each condition. In addition, the scanner reported CTDIvol was recorded and used to normalize the air kerma values in order to produce conversion factors similar to those described in TG 204. Phantom size was described in terms of water equivalent diameter (WED). The conversion factors for all different strengths were plotted against WED. Percent differences were reported between conversion factors from all three strengths and those from FTC scans.

RESULTS

For the child abdomen protocol, differences between FTC and TCM conversion factors were 7%, 7%, and 5% at 32 cm; 6%, 1%, and 4% at 16 cm; and 55%, 13%, and 72% at 8 cm for Average, Very Weak, and Very Strong modulation, respectively. For the adult abdomen protocol, differences between FTC and TCM conversion factors were 21%, 17%, and 23% at 32 cm; 26%, 4%, and 23% at 16 cm; and 46%, 13%, and 63% at 8 cm for Average, Very Weak, and Very Strong modulation, respectively.

CONCLUSION

FTC conversion factors were systematically larger than those of TCM at the three modulation strengths. TCM conversion factors possessed a similar exponential relationship relative size to the FTC factors with the 32 and 16 cm phantoms. At 8 cm, surprisingly, TCM factors deviated from this relationship in a reproducible manner. This deviation is currently being investigated.

CLINICAL RELEVANCE/APPLICATION

FTC conversion factors may not be applicable for TCM protocols depending patient size as they yield an inaccurate estimate of SSDE.

SSE22

Physics (PET/CT and PET/MRI)

Monday, Nov. 28 3:00PM - 4:00PM Room: S403B

CT MR NM PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
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Sub-Events

SSE22-01 Feasibility of 18F-FDG Dose Reduction in Dynamic PET using A Next Generation Digital PET/CT

Monday, Nov. 28 3:00PM - 3:10PM Room: S403B

Participants
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Ajay Siva, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michael V. Knopp, MD, PhD, Columbus, OH (*Presenter*) Nothing to Disclose

PURPOSE

To explore the feasibility of low dose dynamic PET imaging using a next generation digital PET/CT while achieving accurate quantification designed for response assessment studies at multiple time points.

METHOD AND MATERIALS

30min dynamic FDG PET scans were acquired on a digital PET/CT system (Vereos) in continuous list mode. Dynamic PET data were reconstructed (3i15s) using 3 techniques (Time-of-Flight, TOF + Point Spread Function (PSF), and TOF + PSF + Gaussian Filter (GF)), and following a 30-frame (fr) protocol (60s×30fr), a 30s×60fr and 15s×120fr to simulate based on full tracer dose of 450MBq FDG, 1/2 and 1/4 tracer doses. Maximum activity concentrations (Bq/mL) of lesions and arteries were obtained by 3D VOI placement. The average lesion uptake value (L_Ave) and the standard deviation (SD) of lesion uptake (L_SD) were calculated. Kinetic parameters were estimated using in-house developed software with 2-tissue compartment model (2TCM) (k1, k2, k3 and Ki; k4 was set to be 0) and Patlak model (Ki). The 60s×30fr with TOF data were taken as reference. L_Ave values and kinetic parameters generated with different doses and reconstruction techniques were compared to gold standard using Student's t-test with statistical significance being set at $p<0.05$.

RESULTS

High-quality dynamic 18F-FDG PET images could be generated and all lesions were readily identifiable even when FDG dose was decreased by 75%. The addition of PSF alone seemed to slightly increase PET image noise, especially with lower doses. PET with both 50% and 25% doses could still accurately quantify SUVmax values. Kinetic parameters k1, k2 and k3 calculated by 2TCM did not show significant difference with 50% dose regardless of reconstruction technique. PET with 25% dose could generate accurate k3, however, it caused significant differences in k1 and k2 ($p<0.05$). Ki values calculated either by Patlak analysis or 2TCM remained consistent with full as well as lower doses.

CONCLUSION

Even with a 75% FDG dose reduction to the current 13mCi standard, dynamic PET images of high-quality and quantitative accuracy can be obtained using a next generation digital PET system.

CLINICAL RELEVANCE/APPLICATION

This study demonstrates the feasibility of dynamic PET even with very low tracer doses using a next generation digital PET without impacting image quality or quantification.

SSE22-02 Relation of Rb-82 Rest/Regadenoson-Stress PET/CT Measurements to Multi-Vessel Disease as Assessed by X-Ray Coronary Arteriography

Monday, Nov. 28 3:10PM - 3:20PM Room: S403B

Participants
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PURPOSE

X-ray contrast arteriography is the reference standard for confirming coronary artery disease (CAD), but is not always possible due to its invasive nature. Our study was conducted to assess which PET parameter agreed most strongly with a finding of multi-vessel disease (MVD) by arteriography.

METHOD AND MATERIALS

Data were reviewed retrospectively for 70 pts referred for Rb-82 rest/regadenoson-stress PET/CT who also had quantitative x-ray contrast arteriography, with MVD defined as 2 or more left ventricular main arteries with ≥ 70% stenoses. Absolute myocardial

blood flow was calculated from first pass count curves using a 2-compartment model, with coronary vascular resistance (CVR) computed as mean arterial pressure ÷ flow. Gender-specific Rb-82 normal limits for relative perfusion were applied to compute summed stress score (SSS). Emory Cardiac Toolbox algorithms computed ejection fraction (EF) & quantified regional asynchrony as contraction phase histogram bandwidth. ROC analysis determined parameter thresholds of discrimination of MVD by maximizing accuracy, i.e., area under ROC curves.

RESULTS

Of the 70 pts, 14 (20%) had MVD & 56 (80%) did not. For each category of parameter studied, stress values exhibited higher correlation with angiography than either rest values or change values. Highest ROC areas were observed for SSS, EF, bandwidth, & CVR (accuracy = 84%, 79%, 76% & 75%, respectively). For each parameter, stress values were significantly different for pts with & without MVD (SSS = 21±7 versus 10±9, p = 0.0002; EF = 39±19% versus 61±15%, p < 0.0001; bandwidth = 150±69º versus 79±54º, p = 0.0001; CVR = 104±42 versus 68±39 mm Hg/ml/g/min, p = 0.004). Optimal discrimination between pts with & without MVD was the combination of SSS > 12 & stress EF < 50% (accuracy = 87%, sensitivity = 71% & specificity = 91%).

CONCLUSION

Rb-82 rest/regadenoson-stress PET/CT computations agree well with arteriographic findings of multi-vessel disease.

CLINICAL RELEVANCE/APPLICATION

Rb-82 PET is a reasonable alternative in detecting multi-vessel disease when arteriography is not possible.

SSE22-03 Longitudinal Variability of PET SUVs in the NCI Quantitative Imaging Network (QIN)

Monday, Nov. 28 3:20PM - 3:30PM Room: S403B

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Presenter*) Research Grant, General Electric Company; Co-founder, PET/X LLC
Darrin W. Byrd, MS, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Clinical oncology trials that utilize PET measurements to asses change in response to therapy may suffer from reduced study power if biases in the standardized uptake value (SUV) are not consistent between sites or across time. Bias instability due to instrument calibration has not been previously characterized except in studies having limited repeat measurements over short time periods. We evaluated the variability in SUVs over roughly 8 months in a multicenter network.

METHOD AND MATERIALS

We used cross-calibration 'kits' with two long-lived sealed PET sources of 68-Ge in epoxy. The first source is a NIST-traceable dose calibrator reference standard while the second is implicitly NIST-traceable (i.e. made by the same process) 4.5 cm diam. uniform cylinder source for PET scanners. These were distributed to 9 cancer centers that were part of the NCI Quantitative Imaging Network (QIN), with a total of 19 PET/CT scanners and 16 dose calibrators. The number of scans per scanner ranged from 3 to 43 (average of 13) and the duration over which scans were performed ranged from 39 to 412 days (average of 232). A total of 161 dose calibrator measurements were made with an average separation of 24 days between measurements. SUV bias was estimated from the scanner and dose calibrator biases.

RESULTS

Scanner bias was higher than expected, probably due to attenuation and scatter corrections for the epoxy used in the source. However, neither scanner or dose calibrator signal recoveries were stable in time. Scanner bias varied by approximately 10% on average over the course of measurements. Dose calibrator recovery variability was approximately 5%. Fluctuations in recovery of scanners and dose calibrators were uncorrelated, thus SUV variability was not smaller than scanner or dose calibrator variability.

CONCLUSION

Scanner and dose calibrator bias variations are potentially significant contributors to SUV variability both in networks of hospitals and at single sites. Biases from dose calibrators and PET scanners do not cancel out in SUV calculations. Sites conducting clinical trials should employ long-lived sources as part of quality control for PET scanner calibration monitoring.

CLINICAL RELEVANCE/APPLICATION

Sites conducting clinical trials should employ long-lived sources as part of quality control for PET scanner calibration monitoring. Submitted on behalf of the QIN Data Acquisition Working Group.

SSE22-04 A Multi-Method, Multi-Center Study of PET/MRI Brain Attenuation Correction on A Large Cohort of [18F]-FDG Patients: Ready for Clinical Implementation

Monday, Nov. 28 3:30PM - 3:40PM Room: S403B

Participants
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PURPOSE

In order to improve the current vendor-implemented MR attenuation correction (AC) methods for achieving more accurate quantifiable radioactivity concentration measured by PET, a number of AC methods have been proposed in the literature. The aim of this study was to evaluate a selection of novel methods, and identify the ones suitable for clinical use by applying a unified quantitative evaluation with identical metrics, subject cohort, and common CT-based reference.

METHOD AND MATERIALS

In total, eleven MRAC methods were evaluated on 204 [18F]-FDG subjects, and compared to attenuation correction based on CT. Methods were: two vendor-implemented (Dixon (Martinez-Moller et al., 2009) and UTE (Keereman et al., 2010)), five based on template/atlas information (SEGBONE (Koesters et al., 2016), ONTARIO (Anazodo et al., 2014), BOSTON (Izquierdo-Garcia et al., 2014), UCL (Burgos et al., 2014), and LYON (Merida et al., 2015)), one based on simultaneous reconstruction of attenuation and emission (MLAA (Benoit et al., 2015)), and three based on image-segmentation (MUNICH (Cabello et al., 2015), CAR-RiDR (Juttukonda et al., 2015), and RESOLUTE (Ladefoged et al., 2015)). Evaluation was performed both globally and regionally, with a special focus on robustness and outlier analysis (Ladefoged et al., 2015).

RESULTS

The average global performance in PET tracer uptake was for each method (mean ± SD)%: Dixon (-11.3±3.5)%, UTE (-5.7±2.0)%, SEGBONE (-1.7±3.6)%, ONTARIO (-4.3±3.6)%, BOSTON (-0.3±1.8)%, UCL (0.7±1.2)%, LYON (-0.4±1.6)%, MLAA (-1.9±2.6)%, MUNICH (3.7±2.1)%, CAR-RiDR (-0.4±1.9)%, and RESOLUTE (0.3±1.7)%. The best performing methods showed regional average errors within ±3% of PET with CT (BOSTON, UCL, LYON, RESOLUTE). Five methods (BOSTON, UCL, LYON, RESOLUTE, CAR-RiDR) showed that for 95% of the patients, 95% of brain voxels had an uptake that deviated by less than 15% from the reference.

CONCLUSION

All novel methods showed great performance on average. The main difference among the methods has to be found in the robustness, clinical feasibility, and number of outliers. It may be concluded that the problem of MRAC in the brain has been solved to an acceptable degree.

CLINICAL RELEVANCE/APPLICATION

This study compares a selection of novel MR attenuation correction methods, and attempts to identify the ones suitable for clinical use.

SSE22-05 PET/MR Imaging of the ACR Phantom Using Adapted MRAC Techniques

Monday, Nov. 28 3:40PM - 3:50PM Room: S403B

Participants
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Yiqiang Jian, Waukesha, WI (*Abstract Co-Author*) Nothing to Disclose
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Osama R. Mawlawi, PhD, Houston, TX (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

CONCLUSION

The proposed modifications of the MRAC allows accurate PET SUV qunatification in all regions of the ACR phantom with the exception of the Teflon insert. These modifications allow the use/evaluation of the same MRAC pulse sequnece on both patients and phantom studies without resorting to CTAC templates.

Background

The GE SIGNA PET/MR utilizes a LAVA FLEX pulse sequence to separate fat and water to create PseudoCTs(PCT) for attenuation correction(AC) of PET data. This results in large biases in phantom imaging primarily due to lack of fat in PET phantoms and lack of signal from the phantom shell and its solid internal structures when using standard MR pulse sequences. Our objective was to develop novel techniques to generate PCT of the ACR phantom while still using the LAVA FLEX sequence that will result in no bias in the corresponding PET image quantification.

Evaluation

A PET ACR phantom filled with an activity concentration equivalent to 370 MBq of injected activity was scanned on a GE 710 PET/CT and a GE MR 750. Two acquisitions were acquired on each scanner, one with a 300 ml bottle of vegetable oil affixed to the side of the phantom and one without. PET images were reconstructed using CTAC, LAVA FLEX MRAC (PCT_Clin) without oil bottle, and a modified MRAC (PCT_mod) which included: oil bottle to enable fat/water separation, slice to volume normalization, removal of vertebral mask to allow for air pockets, rescaled MRAC Houndsfield Units(HU) from soft tissue(42) to water(0) and fat(-104) to oil(-115), and acrylic shell from HU of -1000 to 120 which was digitally inserted into the phantom. Image analysis was performed according to ACR specifications and compared to CTAC which was considered as the gold standard.

Discussion

There was no appreciable visual difference in uniformity and resolution in the reconstructions. The percent error of the PCT_clin and PCT_mod with respect to CTAC was: Background SUVmean(-31%, -2%), 25mm Hot Cylinder(-30%, -3%), Air SUVmean(174%, -1%), Teflon SUVmean(-67%, -84%), Cold Water SUVmean(-31%, -5%).

SSE22-06 PET/MR Headphone Attenuation Estimation using MLAA

Monday, Nov. 28 3:50PM - 4:00PM Room: S403B

Participants
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PURPOSE

To estimate headphone attenuation in hybrid PET/MR imaging using maximum likelihood reconstruction of attenuation and activity (MLAA).

METHOD AND MATERIALS

Attenuation correction of flexible hardware components such as MR body coils or headphones is still a major challenge in hybrid PET/MR imaging. While stationary components (e.g., patient table and head coils) can be added to the MR-derived patient attenuation map in a straightforward way using CT-derived templates, attenuation of flexible components is neglected in clinical routine. Ignoring headphone attenuation has been shown to result in local brain SUV underestimation values of up to 15%. We propose to employ the MLAA algorithm to simultaneously estimate attenuation and activity distributions outside the patient body outline to obtain an estimate of the headphone attenuation. Due to cross-talk effects, MLAA cannot recover the true attenuation coefficients of the headphones. However, the outline of the headphones can be segmented and pre-defined attenuation coefficients can be applied. The average headphone attenuation coefficients were empirically derived performing phantom measurements and chosen such that the SUV underestimation when ignoring headphone attenuation could be compensated for. For clinical evaluation, we investigated the proposed headphone attenuation estimation for six PET/MR patient data sets acquired with a Siemens Biograph mMR.

RESULTS

For the headphones used in our mMR system it turned out that an average attenuation coefficient of $\mu = 0.007$ 1/mm was required to compensate for the SUV underestimation in the phantom measurements, reducing the average and maximum underestimation from 5.3% to 1.6%, and 12.7% to 2.1%, respectively. Ignoring headphone attenuation resulted in an average SUV underestimation across the six patient data sets of 3.9% evaluated in the full brain and 8.6% evaluated in the cerebellum, compared to compensating for headphone attenuation using the proposed method.

CONCLUSION

We propose a method to estimate PET/MR headphone attenuation making use of the MLAA algorithm. The proposed method was shown to significantly reduce SUV underestimation in both phantom and patient data.

CLINICAL RELEVANCE/APPLICATION

MLAA-based estimation of headphone attenuation has the potential to improve PET quantification in brain PET/MR. The proposed method can, potentially, be readily included into clinical workflow.

SSE23

Physics (Dose in Radiography, Fluoro and Mammography)

Monday, Nov. 28 3:00PM - 4:00PM Room: S404AB

BR PH SQ

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
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Charles E. Willis, PhD, Houston, TX (*Moderator*) Medical Advisory Board, General Electric Company

Sub-Events

SSE23-01 A Five Year Retrospective Review of Radiation Dose from Fluoroscopically Guided Interventional Procedures Performed using Different Imaging Technology - Where We Were, Where We Are and Where Are We Heading?

Monday, Nov. 28 3:00PM - 3:10PM Room: S404AB

Awards
Student Travel Stipend Award

Participants
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Carin F. Gonsalves, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Jaydev K. Dave, PhD, MS, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Transitioning from II to FPD systems was not associated with radiation dose savings, but FPD with newer dedicated image processing software has allowed for substantial dose reduction.

Background

Imaging technology for fluoroscopically guided interventional (FGI) procedures has advanced from image intensifiers (II) to flat panel detectors (FPD) and recently, to FPD systems with dedicated image processing software for radiation dose reduction. The purpose of this work was to evaluate the effect of imaging technology on radiation dose from FGI procedures.

Evaluation

After IRB approval, data from FGI procedures performed in interventional radiology suites was obtained from RIS (years: 2011-2015). Fluoroscopy time, cumulative air kerma (CAK; only for FPD systems) and kerma-area product (KAP) were obtained for all procedures performed either using II, FPD or FPD systems with dose reduction software (ClarityIQ, Philips Healthcare; FPD-CIQ). Data from RIS was cross-verified, and analyzed in aggregate and split by procedure codes (procedures with n > 30 cases with each type of system).

Discussion

Data from 27251 cases was obtained. Error checking and deleting duplicate instances resulted in 22414 cases from 92 unique procedures. Overall, ANOVA revealed a significant effect of imaging technology on fluoroscopy time, CAK and KAP ($p<0.01$). The median fluoroscopy time and KAP were 1.3 minutes and 11.0 Gy*cm² (n=6300), 1.9 minutes and 15.0 Gy*cm² (n=10418), and 2.4 minutes and 6.9 Gy*cm² (n=5696) for II, FPD and FPD-CIQ systems, respectively. The median CAK values for FPD and FPD-CIQ systems were 43.4 mGy and 23.5 mGy, respectively. Trend data showed complex cases increasingly being performed on FPD and FPD-CIQ systems (e.g., 194, 1075 and 699 embolization cases on II, FPD and FPD-CIQ systems, respectively). There were 27 unique procedures with more than 30 cases performed on each type of system; a significant effect of imaging technology on dose values for each of these procedures was noted ($p<0.01$). In this subset, the ratios of median KAP ranged from 0.4 to 1.7 (FPD/II) and from 0.2 to 0.6 (FPD-CIQ/II). For 26 of these procedures, the median CAK with FPD-CIQ systems was less than FPD systems.

SSE23-02 Variability in Target Exposure Index (TEI) and Deviation Index (DI) among Digital Radiography Practices across the United States

Monday, Nov. 28 3:10PM - 3:20PM Room: S404AB

Participants
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Charles E. Willis, PhD, Houston, TX (*Abstract Co-Author*) Medical Advisory Board, General Electric Company

CONCLUSION

Considerable variation was noted in both the TEI and DI from digital radiography practices across the United States. Most of the radiographic images had DI outside the recommended target range. Based on these observations, TEI and DI are potential targets for quality improvement in digital radiography practices.

Background

In digital radiography, target exposure index (TEI) expresses the target image receptor air kerma and the deviation index (DI) quantifies the difference between the air kerma delivered to the image receptor and the target air kerma for a specific body part and view. The current recommended target range for the DI is from -0.5 to 0.5, with DI outside this range identified as under- or over-exposure. The purpose of this work was to quantify the variability in TEI and DI from digital radiography practices across the United States.

Evaluation

Each practice complied with local Institutional Review Board requirements for this retrospective study. TEI and DI values for radiographs of the chest, abdomen, pelvis and extremities corresponding to anteroposterior, posteroanterior, lateral, and decubitus views were collected from 10 practices across the United States between 2012 and 2015. Data were analyzed both in aggregate and stratified by exposure control method, image receptor technology, patient age, and practice site for each body part and view. Descriptive statistics and percentage of cases falling outside the DI target range were computed.

Discussion

Data from 505,930 radiographs were analyzed. The ratio of maximum TEI to minimum TEI for the same body part and view ranged from 2.4 to 4.4 and 3.2 to 16.6 for adult radiographs and from 1.7 to 4.1 and 1.1 to 5.0 for pediatric radiographs acquired with scanned pixel ("CR") and fixed pixel ("DR") image receptor technology, respectively. The standard deviation of the DI stratified by practice site ranged from 1.3 to 3.6 and from 1.3 to 3.0 for adult and pediatric radiographs, respectively. The percentage of cases falling outside the DI target range was 85%, 85%, 80%, and 86% for adult radiographs and 87%, 80%, 78%, and 87% for pediatric radiographs of the abdomen, chest, pelvis, and extremities, respectively.

SSE23-03 Radiation Dose Reduction in X-ray Differential Phase Contrast Breast Imaging using an Energy-resolved Grating Interferometer

Monday, Nov. 28 3:20PM - 3:30PM Room: S404AB

Participants
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Ran Zhang, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ke Li, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

X-ray differential phase contrast (DPC) breast imaging exploits the wave nature of x-rays, generating images with enhanced soft tissue contrast in addition to standard absorption contrast mammographic images. Although DPC imaging has become feasible at clinically acceptable radiation dose levels, additional improvement in its dose efficiency would further expand its potential clinical implementations such as earlier and more frequent screening of women with higher risk of breast cancer. The purpose of this work is to develop a novel image processing method to reduce radiation dose in energy-resolved DPC imaging systems.

METHOD AND MATERIALS

An energy-resolved single photon counting detector (PCD) was incorporated into a DPC breast imaging benchtop system with a hospital-grade x-ray tube. Photons with energies similar to the designed operation energy of the interferometer system were selectively utilized to maximize the detected fringe visibility and the dose efficiency of DPC imaging. On top of this, photons in other energy bins were also utilized by exploiting the rank-one nature of the spatial-spectral DPC image matrix, as DPC information encoded in different energy bins are scalable by an energy square factor. Such intrinsic physical property allows noise to be rejected by only maintaining information in the first rank, meanwhile preserving both DPC signal accuracy and spatial resolution. The proposed rank-one approximation method was experimentally validated using an ACR Mammography Accreditation Phantom.

RESULTS

Compared with images of the ACR phantom acquired at 100% reference dose level and standard DPC image processing method, images acquired with 50% radiation dose and the proposed ran-one approximation method demonstrated equivalent image quality. The measured noise standard deviation for the 50% dose images with the proposed method [(1.98±0.13) ×1E-2] was no greater than that of the 100% dose images [(2.12±0.04) ×1E-2, $p < 0.01$]. Neither spatial resolution loss nor noise texture distortion was observed.

CONCLUSION

A novel energy-resolved grating interferometer system was developed to successfully reduce radiation dose by 50% for DCP imaging.

CLINICAL RELEVANCE/APPLICATION

Radiation dose reduction in DPC imaging would further extend the scope of its potential clinical utilities such as earlier and more frequent screening of women with higher risk of breast cancer.

SSE23-04 Optimization of Patient Dose in Digital Mammography Utilizing a Simplified Method of an FROC Observer Study with a CDMAM Phantom

Monday, Nov. 28 3:30PM - 3:40PM Room: S404AB

Participants
Rie Tanaka, PhD, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Fujiyo Akita, Shizuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Daisuke Fukuoka, PhD, Gifu, Japan (*Abstract Co-Author*) Nothing to Disclose
Yusuke Bamba, Ishikawa, Japan (*Abstract Co-Author*) Employee, EIZO Corporation
Junji Shiraishi, Kumamoto, Japan (*Abstract Co-Author*) Research Grant, FUJIFILM Holdings Corporation; Research Grant, Nihon Medi-Physics Co, Ltd

PURPOSE

Diagnostic accuracy of the radiologic images should be evaluated by taking into account various factors due to human observers as well as the characteristics of the display used in the interpretation. The aim of this study was to propose a simplified method for performing an FROC observer study to optimize patient dose in digital mammography based on the diagnostic accuracies for low-contrast signal detection in a CDMAM phantom.

METHOD AND MATERIALS

The digital images of a CDMAM phantom were obtained by a full-field digital mammography system (Amulet, Fuji Film, Japan) with three levels of patient dose (60, 80, and 100% of the average glandular dose, 30 kV, W/Rh) to compare the diagnostic accuracies for low-contrast signal detection. Case sample images without and with various number of signals (0-3 signals/case) were cropped along the threshold lines predicted by using a CDMAM Analyser (14 regions/image × 3 images× 3 conditions). Case sample images were observed on a high resolution medical LCD by six board-certified breast radiographers using a publically available computer interface (ROC Viewer 2015 ver. 1.0). The figure of merit (FOM) values was calculated and significant differences were statistically tested among the three different imaging conditions with the JAFROC software. Our results obtained with the proposed FROC method were validated by comparison with those obtained from CDMAM Analyser.

RESULTS

Average FOM values and sensitivities of the 6 breast radiographers' performance improved with increasing dose level, whereas no statistically significant difference was found among the three conditions. In addition, there was a high correlation between the average FOM and inverse image quality figure (inv. IQF) in each dose level ($r = 0.98$). Furthermore, the average reading time for 120 case samples was 22 min, which could be considered very short.

CONCLUSION

The effect of dose reduction on the low-contrast signal detection was assessed by a simplified FROC observer study using ROIs of CDMAM phantom images as case sample images. FROC observer studies were conducted in shorter time, with smaller errors and reduced complexity, and the results were well-supported by those obtained by a CDMAM Analyser.

CLINICAL RELEVANCE/APPLICATION

This FROC method can demonstrate changes in diagnostic accuracies of various dose levels and can be utilized for the optimization of patient dose, which is a primary concern in digital mammography.

SSE23-05 Phantom Estimated Dose Comparison between Contrast Enhanced Spectral Mammography (CESM) and Established X-ray Breast Screening Modalities

Monday, Nov. 28 3:40PM - 3:50PM Room: S404AB

Participants
Georgeta Mihai, PhD, Boston , MA (*Presenter*) Nothing to Disclose
Jordana Phillips, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Toshiba Medical Systems Corporation

PURPOSE

As contrast-enhanced spectral mammography (CESM) is considered for breast cancer screening, it is important to understand how its dose compares to other commonly used x-ray modalities. Image reported average glandular dose (AGD) cannot be used to compare between vendors due to the different AGD algorithms employed. Dance et al. have standardized a reproducible method of estimating AGD. Our study used their aproach to compare dosimetry for two x-ray systems (General Electric -GE and Hologic-H) and 5 imaging modes (GE 2D, GE-CESM, H 2D, H Tomo, H Combo).

METHOD AND MATERIALS

Seven breast thicknesses (20-90 mm) were simulated with PMMA slabs and imaged in AEC mode. The reported entrance skin exposure (ESE), AGD, and exposure settings (kVp, mAs, target and filter combination) were recorded. In a separate experiment the exposure settings were then entered in manual mode to measure entrance air kerma (K) and the half value layer (HVL) using a dosimeter. The AGD was estimated using K'*g*c*s*T (where K' is the air kerma corrected to the upper surface of the dosimetry phantom and g, c, s and T are factors determined by Monte Carlo simulations in Dance et al. published work).

RESULTS

The estimated AGD for all 5 imaging modes is shown in Figure 1. GE-2D mode shows the lowest estimated AGD. The GE-CESM (low plus high energy exposures) AGD estimate is slightly above but comparable to the Hologic 2D and Hologic 3D exposures. Hologic Combo mode (2D plus 3D) has the highest AGD estimate at all breast thicknesses.
The range of percent difference in reported and measured ESE, and reported and estimated AGD respectively were: 31.3-56.9% and 22.3-35.4% (GE 2D), 22.0-33.2% and 1.6-22.7% (low energy GE-CESM), 1.4-2% and 2.9-21.4% (high energy GE-CESM), 3-7% and 1.29-18.95% (Hologic 2D), 2.05-4.51% and 3.3-14.65% (Hologic Tomo), 3.35-4.51% and 2.3-17.44% (Hologic Combo Tomo), 6.97-3.18% and 1.1-22.66% (Hologic Combo-2D).

CONCLUSION

Our phantom study demonstrates that GE CESM has an estimated AGD that is comparable to other commonly used x-ray breast cancer screening tools. The differences between the systems' reported and the phantom measured ESE and estimated AGD confirm

that the reported measures should not be used to compare x-ray systems of different vendor .

CLINICAL RELEVANCE/APPLICATION

This study provides phantom validation for AGD appropriateness of GE-CESM for breast cancer screening.

SSE23-06 Automatic Exposure Control using Constant CNR in Digital Radiography

Monday, Nov. 28 3:50PM - 4:00PM Room: S404AB

Participants
Alexander W. Scott II, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Yifang Zhou, PhD, Los Angeles, CA (*Presenter*) Nothing to Disclose
Jessica L. Nute, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Christina M. Lee, BS,ARRT, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To modify the calibration of automatic exposure control in digital radiography from constant exposure index (EI) to constant contrast-to-noise ratio (CNR) and to determine the resulting dose reduction for small or pediatric patients.

METHOD AND MATERIALS

A Philips Optima x-ray unit and Carestream DRX-1C digital detector were used along with phantoms composed of 2-8" of Lucite over an ACR accreditation plate. The plate has targets of decreasing contrast to assess image quality; the third-lowest contrast target (#7) was required to be visualized for ACR radiographic accreditation. The kVp for each Lucite stack was selected based on the detector calibration instructions. Images were acquired for each kVp/Lucite combination using a range of mAs values. The CNR of target #7 was measured using ImageJ by placing an ROI over the target and then drawing an annulus of similar area around the target as background. CNR vs. mAs was fitted using Curve Expert Professional for each kVp/stack combination. For the purpose of making constant CNR exposures, a baseline CNR was determined using the lowest-dose image allowing visualization of target #7 for the 85kVp/5" Lucite combination. The results were then used to back-calculate a mAs and resultant EI for other kVp/sizes to provide an optimal technique.

RESULTS

Baseline CNR was determined to be 0.86 but conservatively set to 1.0 to account for variability in visibility vs. CNR. The back-calculated mAs values corresponding to the baseline CNR at different kVps had uncertainties of 20% - 40%. Compared to the initial phototimer setup for an EI of 1400, the entrance skin exposure (ESE) for the small phantom (2" – 3") would decrease by 60%, the ESE for the medium phantom would be consistent, and the ESE for the large phantom (8") would increase by a factor of 5 – 10.

CONCLUSION

Maintaining constant CNR instead of constant EI when varying patient size would improve image quality for large patients while minimizing dose for small patients (especially important for pediatrics). However, given that the ESE for the 8" and 125 kVp combination would increase from 44 mR to 462 mR, we are currently recommending constant EI for large patients and constant CNR for small patients to save dose.

CLINICAL RELEVANCE/APPLICATION

Recalibration of AEC settings to achieve constant CNR across some patient sizes could be used to reduce unnecessarily high dose in small patients while increasing image quality for large patients.

ED013-TU

Physics Tuesday Case of the Day

Tuesday, Nov. 29 7:00AM - 11:59PM Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants

David M. Gauntt, PhD, Birmingham, AL (*Presenter*) Patent agreement, Radcal Corporation
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Brad Kemp, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) The learner will be able to identify the causes of various imaging effects and artifacts, determine whether the effect is caused by equipment problems, and identify the necessary action to correct the effects or artifacts.

RC321

Advances in CT: Technologies, Applications, Operations-Quantitative CT (QIBA)

Tuesday, Nov. 29 8:30AM - 10:00AM Room: E352

BQ CT PH

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

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

Sub-Events

RC321A Volumetry

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Presenter*) Institutional research agreement, Siemens AG Research support, Siemens AG

Active Handout:Michael F. McNitt-Gray

http://abstract.rsna.org/uploads/2016/16001076/RC321 Volumetry.pdf

RC321B Material Identification

Participants
Daniele Marin, MD, Durham, NC, (daniele.marin@duke.edu) (*Presenter*) Research support, Siemens AG

LEARNING OBJECTIVES

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

ABSTRACT

RC321C Texture Characterization

Participants
Samuel G. Armato III, PhD, Chicago, IL, (s-armato@uchicago.edu) (*Presenter*) Consultant, Aduro Biotech, Inc
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Stockholder, Hologic, Inc; Stockholder, Quantitative Insights, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Toshiba Corporation;

LEARNING OBJECTIVES

1) Understand the concept of texture-based image characterization. 2) Identify radiologic tasks in CT that could benefit from image texture analysis. 3) Describe the limitations of these techniques.

RC322

Imaging for Personalized Medicine: Thorax

Tuesday, Nov. 29 8:30AM - 10:00AM Room: S502AB

CH RO PH

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

Participants
Carri Glide-Hurst, Detroit, MI (*Moderator*) Research Consultant, Koninklijke Philips NV; Research agreement, Koninklijke Philips NV; Research agreement, Modus Medical Devices Inc

Sub-Events

RC322A Managing Anatomical Change and Respiration during Radiotherapy

Participants
Geoffrey Hugo, PhD, Richmond, VA (*Presenter*) Research Grant, Koninklijke Philips NV; Research Grant, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Understand how respiration impacts radiotherapy imaging and delivery and how to implement strategies to mitigate these issues. 2) Understand types and magnitude of geometric changes in thoracic anatomy during radiotherapy, and determine approaches to correct for discrepancies between the planned and delivered dose to the patient.

ABSTRACT

Radiotherapy is in widespread use for both early and advanced stage lung cancer, as a sole modality and also in combination with other modalities such as chemotherapy. Due to the potential for both acute and late toxicities in organs adjacent to treated regions, modern techniques seek to limit the extent of the high dose volume. The purpose of this session is to develop an understanding for how geometric and anatomic changes during radiotherapy can be managed. The focus will be on solutions readily available in the clinic today, particularly with respect to imaging modalities and planning solutions.

RC322B Functional Targeting and Adaptation

Participants
Carri Glide-Hurst, Detroit, MI (*Presenter*) Research Consultant, Koninklijke Philips NV; Research agreement, Koninklijke Philips NV; Research agreement, Modus Medical Devices Inc

LEARNING OBJECTIVES

1) Understand the opportunities for targeting and avoidance based on functional imaging in lung. 2) Discuss the technical details of functional targeting for tumor and functional avoidance in normal tissue for lung cancer in the pre-treatment and adaptive settings.

ABSTRACT

Radiation therapy continues to play an important role in the treatment of lung cancer although many opportunities remain to improve local control and survival as well as reduce toxicity, especially in advanced stage lung cancer. The use of functional imaging and biomarkers to predict tumor burden and response as well as measure and predict normal tissue toxicity has begun to increase in the community. This session aims to summarize the different modalities and types of information available to perform functional targeting or avoidance of tumor and normal tissue in lung cancer, including imaging (such as PET and SPECT) and other data (such as blood-based biomarkers). The session will also highlight the technical details associated with the use of functional data for treatment planning, treatment response, and adaptation.

RC323

Molecular Imaging Mini-Course: Basics of Molecular Imaging

Tuesday, Nov. 29 8:30AM - 10:00AM Room: S403B

CT MI NM PH

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

Participants

Sub-Events

RC323A Developing Molecular Imaging Agents

Participants
Julie L. Sutcliffe, PhD, Sacramento, CA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the ideal properties of a molecular imaging agent and molecular target. 2) Describe the in vitro and in vivo validation of the molecular imaging agent. 3) Describe specific examples of successful molecular imaging agents.

ABSTRACT

RC323B Instrumentation (PET and CT) and Image Reconstruction

Participants
John Sunderland, PhD, Iowa City, IA, (john-sunderland@uiowa.edu) (*Presenter*) Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Identify the primary design components of a modern PET/CT system. 2) Design and implement a PET/CT quality control program to assure high quality and quantitatively accurate clinical imaging. 3) Describe commonly used PET reconstruction algorithms and the practical impact of reconstruction parameters upon image quality and quantitation.

ABSTRACT

RC323C Basic Clinical Applications

Participants
Hubert J. Vesselle, MD, PhD, Seattle, WA (*Presenter*) Consultant, MIM Software Inc

ABSTRACT

RC325

Medical Physics 3.0: Re-envisioning Medical Physics in the Era of Value-based and Precision Healthcare

Tuesday, Nov. 29 8:30AM - 10:00AM Room: N229

PH

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

Participants

Todd Pawlicki, PhD, La Jolla, CA (*Presenter*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC, (samei@duke.edu) (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Understand the broad trajectory of advances in the contribution of medical physics to human health. 2) Understand the attributes of excellent in clinical physics. 3) Outline processes to position physicists to have the competence and the confidence to fulfill their unique calling as scientific agents of precision and innovation in healthcare.

SSG12

Physics (CT Photon Counting)

Tuesday, Nov. 29 10:30AM - 12:00PM Room: S403B

CT PH

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

Participants
Willi A. Kalender, PhD, Erlangen, Germany (*Moderator*) Founder, CT Imaging GmbH; CEO, CT Imaging GmbH
Katsuyuki Taguchi, PhD, Baltimore, MD (*Moderator*) Research Grant, Siemens AG

Sub-Events

SSG12-01 Renal Imaging with Complimentary Contrast Materials Using A Whole Body Photon-Counting CT Scanner

Tuesday, Nov. 29 10:30AM - 10:40AM Room: S403B

Participants
Amir Pourmorteza, PhD, Bethesda, MD (*Presenter*) Researcher, Siemens AG
Rolf Symons, MD, Washington, DC (*Abstract Co-Author*) Nothing to Disclose
Manu N. Lakshmanan, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG;
Tyler E. Cork, BS , Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Kelly A. Rice, DVM, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Cynthia Davies-Venn, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Veit Sandfort, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG

PURPOSE

To demonstrate the feasibility of using spectral photon-counting CT (PCCT) to differentiate the in vivo wash-in and wash-out dynamics of two contrast agents in the kidney for simultaneous visualization of different renal enhancement phases.

METHOD AND MATERIALS

This Institutional Animal Care and Use Committee-approved study used a canine model of chronic myocardial infarction. PCCT was performed during intravenous administration of 4.6 grams of gadolinium (Dotarem, Guerbet) followed after 3.5 minutes by 7.4 grams of iodine (Isovue 370, Bracco). PCCT images were acquired every 4 seconds for a total duration of 6 minutes at the level of the right renal pelvis to visualize the time course of contrast enhancement and excretion in the kidney for both contrast agents. After 1.5 minutes there was a 1 min pause in imaging to avoid system overheating. Scan parameters were 140 kVp tube voltage, 300 mAs tube current, 0.5 second rotation time and energy thresholds of 25, 50, 75, and 90 keV. Images were reconstructed with a quantitative soft tissue kernel (D30f), slice thickness of 1 mm, and increment of 1 mm. Least mean squares linear material decomposition—calibrated to gadolinium and iodine vials of known concentrations in the field-of-view—was used to calculate the concentrations of the contrast agents in the aorta, renal cortex, and renal pelvis.

RESULTS

Time-attenuation curves for gadolinium and iodine in the regions-of-interest (ROIs) were significantly different making contrast agent separation possible. Peak contrast concentration in the aorta and renal cortex were observed ~16 and 24 seconds after each injection. Contrast agent excretion in the renal pelvis started 60 seconds after injection and reached a plateau after ~2.5 minutes for both gadolinium and iodine. Co-registered arterial and equilibrium phase renal images can be reconstructed from a single PCCT scan.

CONCLUSION

PCCT can differentiate contrast agents in vivo. Therefore, multiple inherently co-registered phases of tissue enhancement can be acquired from a single PCCT scan, potentially obviating the need for multi-phase CT scans and reducing radiation dose.

CLINICAL RELEVANCE/APPLICATION

By differentiating contrast materials, PCCT can acquire multiple perfectly co-registered phases of tissue enhancement from a single PCCT scan, potentially obviating the need for multi-phase CT scans and reducing radiation dose.

SSG12-02 A Multi-Channel Block-Matching Denoising Algorithm for Spectral Photon-Counting CT Images

Tuesday, Nov. 29 10:40AM - 10:50AM Room: S403B

Awards
Trainee Research Prize - Fellow

Participants
Adam P. Harrison, PhD, Bethesda, MD (*Presenter*) Nothing to Disclose
Ziyue Xu, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Amir Pourmorteza, PhD, Bethesda, MD (*Abstract Co-Author*) Researcher, Siemens AG
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG
Daniel J. Mollura, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

We present a denoising algorithm designed for a new whole-body prototype photon-counting computed tomography (PCCT) scanner with up to 4 energy thresholds and associated energy-binned images.

METHOD AND MATERIALS

Spectral PCCT images can exhibit low signal to noise ratios (SNRs) due to the limited photon counts in each simultaneously-acquired energy bin. To correct this, denoising algorithms should exploit the correlation and exact alignment between energy bins. Our method follows this approach, modifying the highly-effective block-matching (BM3D) denoising algorithm for PCCT. The original single-channel BM3D algorithm operates patch-by-patch. For each small patch in the image, a grouping action (GA) collects similar patches from the rest of the image, which are then collaboratively filtered together. The resulting performance hinges on accurate GAs. Our improved multi-channel version, called BM3D_PCCT, calculates a shared GA based on the image reconstructed from photons detected in all 4 energy bins. As this image has higher SNR, its GA is more accurate. This shared and improved GA is then used to denoise each individual energy bin.

RESULTS

Preliminary results compare BM3D_PCCT against BM3D_Naive, which denoises each energy bin independently. Experiments used a three-contrast PCCT image of a canine abdomen. Within five regions of interest, selected from paraspinal muscle, liver, and visceral fat, BM3D_PCCT reduced the noise standard deviation by 73.4%, compared to 68.0% for BM3D_Naive. Attenuation values of the contrast agents in calibration vials also clustered much tighter to their respective lines of best fit. Mean angular differences (in degrees) from the line of fit for the original, BM3D_Naive, and BM3D_PCCT images, respectively, were 16.40, 5.98, and 5.11 (iodine); 13.09, 4.05, and 3.27 (galodinium); and 17.81, 5.14, and 4.48 (bismuth).

CONCLUSION

We outlined a multi-channel denoising algorithm tailored for spectral PCCT images, demonstrating improved performance over an independent single-channel approach. Further advancement of this work in progress will include phantom and animal studies to determine the lowest possible mAs required for effective denoising.

CLINICAL RELEVANCE/APPLICATION

This algorithm can denoise PCCT images prior to tissue decomposition in order to produce a more detailed map of contrast-agent concentration.

SSG12-03 Dual-Contrast Spectral Photon-Counting CT: Feasibility for Myocardial Imaging

Tuesday, Nov. 29 10:50AM - 11:00AM Room: S403B

Participants
Amir Pourmorteza, PhD, Bethesda, MD (*Presenter*) Researcher, Siemens AG
Rolf Symons, MD, Washington, DC (*Abstract Co-Author*) Nothing to Disclose
Manu N. Lakshmanan, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG;
Tyler E. Cork, BS , Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Kelly A. Rice, DVM, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Cynthia Davies-Venn, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Mark A. Ahlman, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Veit Sandfort, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research support, Siemens AG

PURPOSE

To demonstrate the feasibility of using two contrast agents (CA) to enhance the myocardial scar and coronary vessels in a single scan using spectral photon-counting CT (PCCT). The first CA (gadolinium) may be injected 10-15 mins prior to scan to create delayed-enhanced images of the scar; the second CA (iodine) is injected at the time of scan to enhance the coronary arteries.

METHOD AND MATERIALS

This study was performed with the approval of ACUC. A canine model of chronic myocardial infarct was used. The animal received intravenous injections of gadoteric acid (60 mL, Dotarem, Guerbet). After 12 minutes, the animal was euthanized by an injection of KCL mixed with iodinated CA (20 mL, Isovue 370, Bracco). We acquired spiral spectral CT scans on a whole-body photon-counting CT scanner at tube voltage/current of 140 kVp, 300 mAs. The energy thresholds were set to 25/50/75/90 keV in order to create 4 spectral bins. Since the current prototype does not support ECG-gating, all cardiac scans were performed immediately after euthanasia. We calculated gadolinium and iodine concentration maps using a linear material decomposition technique calibrated to vials with known concentrations placed in the scan field-of-view. Ex-vivo magnetic resonance imaging was used as gold standard for scar characterization.

RESULTS

The concentration maps were compared in three regions selected based on the ex-vivo MRI: left ventricle (LV) blood pool, scar, and remote myocardium. Iodine concentration was significantly higher in the LV blood pool than in the scar or remote myocardium. In comparison, gadolinium concentrations in the LV blood pool and scar were significantly higher than those in the remote myocardium. By combining the iodine and gadolinium concentration maps, differentiation of blood pool, scar and remote myocardium was possible.

CONCLUSION

Dual contrast agent photon-counting CT may allow for combined assessment of coronary perfusion and delayed enhancement in one acquisition.

CLINICAL RELEVANCE/APPLICATION

Photon-counting CT has the potential for combined first-pass and delayed enhancement CT images, thereby potentially reducing radiation dose by half while providing registered images.

SSG12-04 Initial Experience in Improving Stent Analysis and Intra Stent Lumen Assessment using Spectral Photon Counting CT and K-edge Imaging

Tuesday, Nov. 29 11:00AM - 11:10AM Room: S403B

Participants
Monica Sigovan, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Daniel Bar-Ness, Bron, France (*Presenter*) Nothing to Disclose
Salim Si-Mohamed, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Julia Mitchell, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Jean-Baptiste Langlois, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Philippe Coulon, PhD, Suresnes, France (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Matthias Bartels, PhD,DIPLPHYS, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Bernhard Brendel, Hamburg, Germany (*Abstract Co-Author*) Researcher, Koninklijke Philips NV
Heiner Daerr, DIPLPHYS, Hambrg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Axel Thran, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Ewald Roessl, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Ira Blevis, Haifa, Israel (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Michal Rokni, PhD, Haifa, Israel (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Philippe C. Douek, MD, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Loic Boussel, MD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Coronary stent analysis is still limited using standard CT. We assessed the capability of a spectral photon counting CT (SPCCT) to improve stent analysis and intra stent lumen assessment in comparison with standard CT

METHOD AND MATERIALS

In vitro and in vivo imaging using SPCCT (Philips, Haifa, Israel) and Brilliance 64 CT (B64, Philips, Cleveland, USA) were performed on a phantom consisting of plastic tubes (3.5 mm lumen diameter) and on the abdominal aorta of a NZW rabbit, using 3 types of stents: 1-Platinum (Pt)-Chromium, 2-Cobalt-Chromium, and 3-Stainless steel (true width of metallic struts between 60 to 80 µm depending on the stent). Gadolinium (Gd) contrast agent was used both in vitro (~0.05M) and in vivo (5mL of 0.5M injected for each stent imaging), all at 120 kV and 100 mAs. In plane pixel size of 0.2x0.2mm2 was used for all image reconstructions: conventional HU images for B64, and conventional HU, and Gd and Pt K-edge specific images for SPCCT. Apparent width of the metallic struts was compared between the two systems using a Wilcoxon sign rank test to evaluate stent-related blooming artifact.

RESULTS

SPCCT HU images showed better visualization of the intra-stent lumen with Gd contrast agent due to improved spatial resolution and reduced blooming of the stent compared to B64. The apparent width of the metallic struts was significantly smaller on SPCCT than on B64 for all stents (mean values in mm: 0.68±0.01 vs 1.01±0.02 for Stent1, 0.71±0.01 vs 1.01±0.02 for Stent2, and 0.69±0.03 vs 1.00±0.09 for Stent3, $p<0.05$). Gd specific K-edge imaging enabled visualization of the aortic lumen itself. Finally, Pt specific K-edge imaging enabled exclusive visualization of the Pt only containing stent and removal of other backgrounds and contrast media.

CONCLUSION

SPCCT can allow significant reduction of stent blooming and better lumen assessment due to improved spatial resolution combined with sufficient energy resolution compared to conventional CT. K-edge specific images should allow precise validation of correct deployment of Pt containing stents.

CLINICAL RELEVANCE/APPLICATION

Reduction in blooming artifacts and improved visualization on the lumen of a stented vessel is expected to improve diagnosis of restenosis and stent malapposition.

SSG12-05 Advanced Spectral Analysis of Whole-Body Photon-Counting-Detector Computed Tomography Data

Tuesday, Nov. 29 11:10AM - 11:20AM Room: S403B

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PURPOSE

To investigate advanced spectral analysis of whole-body photon-counting-detector (PCD) CT data and compare it to 2nd generation dual-source (DS) dual energy (DE) imaging.

METHOD AND MATERIALS

A research, whole-body PCD CT scanner (Somatom CounT, Siemens Healthcare) was utilized to acquire head/neck (H&N) and chest CTA data using 140kV at clinically equivalent doses, following iodine injections (Iohexol 350 @ 3cc/sec: Chest – 45 cc, H&N – 60 cc | Saline chaser – 30 cc) in a swine model. The PCD-CT scanner is based on the footprint of a 2nd generation DSCT scanner (Siemens Healthcare), where the "A" detector/source sub-system uses a conventional energy integrating detector (EID) and the

"B" detector/source sub-system uses a cadmium telluride PCD. PCD-CT acquisitions were performed using a 2-bin (Macro) and a 4-bin (Chess) mode, with energy thresholds set at 25/65 keV and 20/25/57/77 keV for the Macro and Chess modes, respectively. Dose matched DECT acquisitions were performed on a 2nd generation DSCT scanner using 80/Sn140 kV, with the same contrast injection protocol. Spectral post processing algorithms were calibrated for water and iodine and the energy thresholds set for each acquisition. The generated calibration tables were then utilized for the optimization of the PCD-CT analysis. Chess mode data was combined to generate 2 spectrally different datasets for input into the post processing algorithms.

RESULTS

Advanced spectral analysis of the PCD-CT data resulted in the generation of virtual non-contrast and iodine only maps, with qualitatively similar material separation as seen in clinically available techniques. Virtual monoenergetic images further improved upon the already-reported increased contrast-to-noise ratio achievable with PCD-CT. Other spectral analyses optimized for PCD-CT included, optimum contrast, pulmonary perfused blood volume and bone removal. Head and body bone removal algorithms demonstrated similar results as their clinically implemented counterparts.

CONCLUSION

The advanced spectral analysis of whole-body PCD-CT data provided qualitatively similar results to those attainable utilizing clinically available dual energy technologies, with improved image quality.

CLINICAL RELEVANCE/APPLICATION

Advanced spectral analysis of whole body PCD-CT allows the extraction of the quantitative spectral information needed to fully assess PCD-CT's capabilities and clinical potential.

SSG12-06 Spectral Performance of a Whole-Body Research Photon Counting Detector CT: Accuracy of Iodine Quantification

Tuesday, Nov. 29 11:20AM - 11:30AM Room: S403B

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PURPOSE

To assess the spectral performance of a research photon counting detector (PCD) CT scanner in terms of iodine quantification accuracy, and to compare the performance with that of dual-source (DS), dual-energy (DE) CT scanners with energy integrating detectors (EID).

METHOD AND MATERIALS

Vials containing iodine solutions at 5 concentrations (2, 5, 10, 15, and 20 mgI/cc) were placed in torso-shaped water phantoms (lateral widths 25 to 45 cm). Phantoms were scanned on the PCD-CT scanner using 140 kV, energy thresholds of 25 and 65 keV, 0.5 sec rotation time, and 0.6 helical pitch. Tube current was adjusted for each phantom size so that the CTDIvol matched that of clinical abdomen scans. For comparison, the same phantoms were also scanned on 2nd and 3rd generation DSDE scanners with matched CTDIvol. Material decomposition was performed using a 'virtual unenhanced' application on commercial software, and iodine concentration was measured in the 5 vials and the background water. Measurements were compared to known concentrations and the root-mean-square-errors (RMSE) were calculated for each phantom size, scanner and DE mode.

RESULTS

A linear relationship was observed between measured and true concentrations for PCD-CT and all DE modes on the EID scanners ($R2>0.98$). For PCD-CT, iodine concentration errors ranged from -2.4 to +0.5 mgI/cc, with overall RMSE of 0.93 mgI/cc. Iodine quantification was more accurate for phantoms 35 cm and below (RMSE<0.38 mgI/cc); accuracy decreased for 40 and 45 cm phantoms (RMSE of 1.21 and 1.59 mgI/cc, respectively). RMSE was 1.17 mgI/cc for the 80/Sn140 mode of the 2nd generation DSDE scanner, and 1.30 mgI/cc for the 70/Sn150 mode of the 3rd generation DSDE scanner. As the tube potential increased for the low energy beam, RMSE decreased substantially for EID scanners, with RMSE from 0.44 to 0.68 mgI/cc.

CONCLUSION

Phantom studies demonstrated high accuracy for iodine quantification using PCD-CT (RMSE of 0.93 mgI/cc), with slight degradation for larger size phantoms. The performance of iodine quantification is comparable to that of EID-based DSDE scanners.

CLINICAL RELEVANCE/APPLICATION

The spectral performance of a research PCD-CT scanner was comparable to that of EID-CT scanners, each of which provided accurate quantification of iodine concentrations, with RMSE of about 1 mgI/cc.

SSG12-07 Spectral Photon-counting CT for Imaging of Contrast Agents Based on lanthanides

Tuesday, Nov. 29 11:30AM - 11:40AM Room: S403B

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PURPOSE

There are multiple techniques for dual-energy CT including fast-kV switching, dual-source, and dual-layer detectors. Here we demonstrate that photon-counting CT (PCCT) offers flexible threshold settings that can be tuned to optimize the differentiability of various contrast agents (CA) with high x-ray absorption k-edge.

METHOD AND MATERIALS

We used a hybrid (dual-source) whole-body prototype CT system (Siemens Healthcare, Germany), which consists of an energy integrating detector and a photon-counting detector. We imaged test tubes with soft tissue equivalent material, iodine (Isovue 300, Bracco), and known concentrations of salts of pentetic acid (DTPA) and 5 lanthanides: Samarium (Sm), Europium (Eu) Gadolinium (Gd), Terbium (Tb), and Lutetium (Lu) with k-edges ranging from 47 to 63 keV. Multiple PCCT scans were acquired with a tube voltage/current of 120kVp/300mA and 2 energy thresholds; one threshold was fixed at 22 keV and the second was swept from 47 to 65 keV, creating two energy bins. The angle between the attenuation coefficient vectors of the CAs and tissue equivalent sample was used as a metric for the spectral differentiability.

RESULTS

We could find a threshold setting that would yield a separation of at least 10° between the CA and tissue equivalent sample. Using different thresholds, for all lanthanide CAs angular separation of 10°-13° (CA vs tissue) and 8-20° (CA vs iodine) was achieved. As a reference, maximum iodine-soft tissue separation was 16°. Lanthanides with higher atomic number had higher angular separation; the highest angular separation was between lutetium and iodine at 65 keV threshold setting with tube voltage of 140 kVp.

CONCLUSION

We demonstrated the feasibility of tuning PCCT energy thresholds to differentiate CAs with various atomic numbers from soft tissue and iodinated contrast. Future work will include a wider and more detailed sweep of threshold settings, quantification of CA concentration mixed in tissue, and finding a 4-energy threshold setting that can differentiate three CA simultaneously.

CLINICAL RELEVANCE/APPLICATION

The improved ability to image contrast materials in PCCT allows for novel multi-contrast clinical protocols and for improved differentiation of contrast materials in existing protocols.

SSG12-08 Ultra-High-Resolution Imaging using a Photon-Counting-Detector CT System: Spatial Resolution, Image Quality and Dose Efficiency

Tuesday, Nov. 29 11:40AM - 11:50AM Room: S403B

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PURPOSE

To evaluate ultra-high-resolution (UHR) imaging techniques on a photon counting detector (PCD) CT system by quantitatively and qualitatively assessing image quality and dose efficiency and by demonstrating the mode's clinical potential using phantoms and cadaveric specimens.

METHOD AND MATERIALS

A UHR data collection mode was enabled on a whole-body, research PCD-CT system that used 0.45 mm x 0.45 mm detector pixels, which corresponded to a pixel size of 0.25 mm x 0.25 mm at iso-center. There were z-axis two collimations: 32x0.25 or 48x0.25 mm, and two energy thresholds. Spatial resolution and image noise were quantitatively assessed for the PCD UHR scan mode, as well as for a commercially available UHR scan mode that uses an energy integrating detector (EID) and a set of comb filters to decrease the effective detector size. Spatial resolution was quantified by measuring the MTF from a scan of a 50-micron wire phantom and noise was quantified as the standard deviation of pixel values in a uniform region of interest. Images of an anthropomorphic lung phantom, cadaveric swine lung, swine heart specimen and cadaveric human temporal bone were assessed qualitatively by two experienced radiologists.

RESULTS

Nearly equivalent spatial resolution was demonstrated by the MTF measurements: 15.3 lp/cm and 20.3 lp/cm spatial frequencies were achieved at 10% and 2% modulation, respectively, for the PCD system, and 14.2 lp/cm and 18.6 lp/cm at 10% and 2% modulation, respectively, for the EID system. Noise was 29% lower in the PCD UHR images compared to the EID UHR images, representing a potential dose savings of 50% for equivalent image noise. PCD UHR images from the anthropomorphic phantom and cadaveric specimens showed clear delineation of small structures, such as lung vessels, lung nodules, temporal bone structures, and coronary arteries, with improvements in spatial resolution apparent in the PCD images.

CONCLUSION

Spatial resolution up to 20 lp/cm was achieved using the PCD UHR technique. This was achieved without the use of a dedicated comb attenuator, enabling 50% dose reduction. Phantom and cadaveric studies demonstrated the potential impact of this imaging mode in lung, temporal bone, and vascular imaging.

CLINICAL RELEVANCE/APPLICATION

The dose efficient PCD UHR mode enables the ultra-high spatial resolution that is needed to delineate fine anatomical structure and pathology in multiple clinical applications and has no dose penalty.

SSG12-09 Multi-Contrast Agent Quantitative Separation via K-Edge Imaging Using Spectral Photon-Counting Computed Tomography

Tuesday, Nov. 29 11:50AM - 12:00PM Room: S403B

Participants
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PURPOSE

Conventional CT cannot discriminate between different contrast materials with similar attenuation using Hounsfield values. We herein report on the capability of spectral photon-counting computed tomography (SPCCT) to differentiate between multiple contrast materials in the same spatial location within a single scan.

METHOD AND MATERIALS

Two phantoms of 11 tubes (1 cm in diameter) were prepared with mixed dilution of two contrast agents (CA) in varying proportions. The CA used was either pegylated gold (Au-nano) nanoparticles (65mg/mL, size 18nm, synthesized in house) mixed with iodine (Iomeron 400 mg/mL, Bracco) or the same Au-nano mixed with gadolinium(Gd) (Multihance 0.5mmol/mL, Bracco). The proportions of CAs were adjusted so that the attenuation of each tube was about 280 HU for conventional CT images; with gd, Au-nano, iodine concentrations between 0 and 7.45 mg/mL, 0 and 10.4 mg/mL and 0 and 10 mg/mL respectively. Axial (1 second rotation time) scans were acquired at 120 kVp and 100 mAs with SPCCT (Philips, Haifa, Israel). Reconstructions were performed at a voxel size of 0.4x0.4x2mm and consisted of conventional HU images, Iodine material decomposition (MD), and Gd and Au K-edge specific images. Each CA was scanned on its own for calibration purposes. Linear regression was used to assess correlation between measured and expected concentrations.

RESULTS

As designed, different solutions of mixed contrast agents could not be differentiated on HU images as all showing the same attenuation of 279 ± 8 HU. Clear separations of the CAs were observed in the MD and K-edge images within the same tubes. The concentration measurements on K-edge images and MD images were in good correlation with the expected concentrations. For the Au-nano and iodine mixture, the Au image correlation had a slope of 1.02, offset -1.1 mg/mL and R^2=0.98; iodine correlation had a slope of 0.99, offset -0.1 mg/mL and R^2=0.98. Similar results were observed for the Au-nano and Gd mixture.

CONCLUSION

Multi-contrast agent quantitative separation via K-edge imaging is achievable using SPCCT as demonstrated by the accurate differentiation between multiple contrast materials within the same voxel using their spectral characteristics.

CLINICAL RELEVANCE/APPLICATION

SPCCT has the potential to provide a new form of functional imaging, opening the door for the use of two or more contrast agents with different pharmacokinetics.

SSG13

Physics (CT-Image Quality)

Tuesday, Nov. 29 10:30AM - 12:00PM Room: S404AB

CT PH SQ

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

FDA Discussions may include off-label uses.

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Sub-Events

SSG13-01 Cloverleaf NPS in Clinical MDCT Systems: Physical Origin and Impact on Diagnostic Performance

Tuesday, Nov. 29 10:30AM - 10:40AM Room: S404AB

Awards
Trainee Research Prize - Resident

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PURPOSE

The noise power spectrum (NPS) is one of the most commonly used imaging performance metrics of CT. Aside from its rotational symmetry found in conventional QA routines, NPS with a peculiar cloverleaf or dumbbell shape was observed in clinical multi-detector CT (MDCT) systems. The purpose of this work is to study the physical origin of those peculiar NPS and the corresponding impact on diagnostic performance.

METHOD AND MATERIALS

A novel theoretical model for the NPS of real MDCT systems was developed to incorporate the impact of the bowtie filter, attenuation properties and position of the image object, and location of the region-of-interest (ROI) on the local NPS. Based on this model, the rotational symmetry of the NPS was found to depend greatly on all these factors. Numerical simulations and physical experiments were therefore performed under a wide variety of conditions to validate the theoretical predictions. The corresponding impact on detection performance was assessed via a human observer study using two CT imaging tasks and a visual grading characteristic (VGC) analysis.

RESULTS

The NPS predicted by the theoretical model matched closely those from simulations and physical experiments. The RMSE between theory and phantom experiments was < 0.12 in all cases. For a peripheral ROI inside a centered object with a small bowtie, a cloverleaf shaped NPS was observed; while, for a central ROI in an off-centered object, a dumbbell shaped NPS was obtained independently of the bowtie size. These peculiar cloverleaf or dumbbell shaped NPSs correspond to a highly oriented noise texture which can significantly influence image perception: depending on the orientation of the imaging task and noise texture, the sensitivity differed by up to 38% while specificity by 4%; the area under the curve (AUC) for VGC ranged between 0.61-0.89.

CONCLUSION

NPS with a peculiar cloverleaf or dumbbell shape was experimentally observed in clinical MDCT. The corresponding physical origin was successfully explained in terms of the bowtie filter and properties of the image object; the potential impact on diagnostic performance was also demonstrated. For certain CT applications, these nonconventional NPS properties need to be taken into account.

CLINICAL RELEVANCE/APPLICATION

The quality of CT images acquired under certain clinical scenarios (e.g. elbow CT scans), that lead to anisotropic NPS, should not be represented by conventional quality assurance procedures.

SSG13-02 Effect of Radiation Dose and Reconstruction Algorithm on Detectability of Subtle Hypo-Attenuating Liver Lesions in CT

Tuesday, Nov. 29 10:40AM - 10:50AM Room: S404AB

Participants
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PURPOSE

To investigate the effect of radiation dose and reconstruction algorithm on noise, contrast, and observer-based detectability of subtle hypo-attenuating liver lesions.

METHOD AND MATERIALS

With IRB approval, a dual source CT system (Siemens SOMATOM Flash) enabling a partitioning of radiation dose from the two x-ray tubes was used to acquire raw CT projection data of a given patient (21 total patients in study) corresponding to six radiation dose levels (12.5, 25, 37.5, 50, 75, and 100%) using only two separate CT acquisitions. A series of anthropomorphic liver lesion models (5 per patient, 105 total) having an inherent (i.e., pre-reconstruction) contrast (lesion-to-liver-attenuation-difference) of -15 HU and average diameter of approximately 12 mm were virtually inserted into the raw CT projection data and images were reconstructed using FBP (filtered-backprojection, B31f) and SAFIRE (Sinogram-affirmed iterative reconstruction, I31f-5). Physical image properties of noise (pixel STD), lesion contrast (post-reconstruction), lesion edge blur (assessed visually), and contrast-to-noise ratio (CNR) were compared. Next, a two alternative forced choice (2AFC) perception experiment was performed (9 readers– 3 radiologists, 6 medical physicists) to estimate detection accuracy as a function of radiation dose and reconstruction algorithm. The results between FBP and SAFIRE were statistically compared using a McNemar binary outcomes test. The dose reduction potential of SAFIRE was estimated by fitting analytical functions of detection accuracy vs dose for FBP and SAFIRE and computing the reduced dose at which SAFIRE had equivalent performance compared to FBP at 100% reference dose.

RESULTS

Compared to FBP, SAFIRE reduced noise by 52% but due to a visually perceivable decrease in spatial resolution, the lesion contrast was also reduced by 12%. The net effect however was an increase in CNR by 87%. From the 2AFC experiment, detection accuracy was 3±1% higher on average in SAFIRE images compared to FBP ($P < .0001$). This increase in detection accuracy translated into a dose reduction potential of 23% for the SAFIRE algorithm.

CONCLUSION

The SAFIRE algorithm enables imaging at 23% reduced radiation dose while low-contrast detectability of very subtle liver lesions is preserved.

CLINICAL RELEVANCE/APPLICATION

The SAFIRE algorithm allows for reducing radiation dose without penalizing low-contrast detectability in body CT imaging.

SSG13-03 Objective and Subjective Image Quality Assessment of an Advanced Iterative Reconstruction Technique in Post Mortem CT Scans

Tuesday, Nov. 29 10:50AM - 11:00AM Room: S404AB

Participants
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PURPOSE

First, to quantify the noise reduction of an iterative reconstruction (IR) technique compared with a conventional filtered back projection (FBP) technique in images with anatomical textured backgrounds. Second, to assess whether or not IR is preferred over FBP by radiologists.

METHOD AND MATERIALS

Cadavers were scanned (SOMATOM Force, Siemens) at various anatomical positions (brain, abdomen, and thorax). Each axial scan was performed 20 times without table motion in between the scans. Images were reconstructed with both FBP and an Advanced Modeled IR technique (ADMIRE) at two strength settings. Slice thicknesses of 5 mm, 3 mm, and 1 mm, were used for the brain, abdomen, and thorax, respectively. Typical reconstruction kernels for the tissues scanned were used. Image noise for each individual pixel was defined as the standard deviation of the CT numbers in the 20 scans. The amount of noise reduction was defined as the median value of the noise reduction for pixels with a CT number > -800 HU. Two radiologists scored 192 image pairs on overall image quality. They were blinded for dose and reconstruction technique used. A 5-point scale (range, -2 to 2) was used to score the preferences. Half of the image pairs showed FBP and IR images at equal dose. The other half showed images at equal noise. Noise in the FBP images was reduced by averaging multiple scans.

RESULTS

Noise reduction at IR strength 3 was 9%, 25%, and 40% for the brain, abdomen, and thorax, respectively. At strength 5, the reduction was 14%, 43%, and 66% for the brain, abdomen, and thorax, respectively. In the observer study, virtually all mean scores were negative, i.e. showed a preference for the FBP technique. An exception was the mean score of 0 for the abdominal images at equal noise with IR strength 3. This allows for a dose reduction by a factor 2 when applying the IR technique. Interobserver agreement was excellent.

CONCLUSION

Mainly due to differences in anatomical texture and slice thickness, amount of noise reduction by ADMIRE varies widely (range 9-66%). For moderate levels of noise reduction only, IR can be fully applied to reduce the dose accordingly without affecting the radiologist's impression of the image quality.

CLINICAL RELEVANCE/APPLICATION

Scanning patients twice is unethical. Phantoms, however, lack realistic tissues. This cadaver study shows to what extent the dose can be reduced by applying IR techniques without affecting clinical image impression.

SSG13-04 Impact of Channel Filter Choices on Channelized Hotelling Observer Performance for a Low-contrast Detection Task in CT

Tuesday, Nov. 29 11:00AM - 11:10AM Room: S404AB

Participants
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PURPOSE

Channelized Hotelling observers (CHO) with Gabor filters are popular for task-based CT image quality assessment. However, channel filter selection for a given clinical task remains unclear, despite being a critical component that affects correlation with human observer performance and image acquisition burden. This study aims to investigate reducing the number of channels without compromising the CHO's performance in a signal-known-exactly low-contrast detection task.

METHOD AND MATERIALS

A cylindrical phantom (Helical CT Phantom, CIRS Inc.) containing 21 low-contrast objects (3 contrast: -5, -10, and -20 HU, and 7 sizes: 10, 9.5, 6.3, 4.8, 4, 3.2, and 2.4 mm) was scanned on a 128-slice CT scanner (Definition Flash, Siemens) at 3 dose levels (CTDIvol of 16, 8, and 4 mGy). Scans at each dose level were repeated 100 times. A validated CHO model with 40 channels (4 frequency passbands, 5 orientations and 2 phases) was used to calculate the area under the receiver operating characteristic curve (Az) for each object and dose level. The Az values were also calculated for all objects with reduced number of channels by varying the number of frequency passbands, orientations, and phases. Correlation between the Az values obtained from images with reduced number of channels and the original 40 channel-images were determined.

RESULTS

When images were channelized with reduced number of filters— phases reduced from 2 to 1 or the number of orientations from 5 to 3, the CHO performance remained highly correlated with that with the original 40 channel-images (goodness-of-fit r2=0.99 and 0.99). When the number of frequency passbands was reduced from 4 to 2, performance was well-correlated for the 2 smallest objects (r2=0.99), less correlated for the 2 middle sizes (r2=0.96), and poorly correlated for the three largest objects (r2=0.01). Using as few as 12 filters (4 passbands x 3 orientations x 1 phase) to channelize the images demonstrated sufficient CHO performance correlation (r2=0.99) for this low-contrast object detection task in the study.

CONCLUSION

The number of Gabor filters used to channelize image for a CHO can be empirically reduced based on performance correlation with a validated model.

CLINICAL RELEVANCE/APPLICATION

Channel reduction in a CHO can be achieved without sacrificing performance, thus improving statistical performance, reducing image acquisition burden, and facilitating practical implementation.

SSG13-05 Use of a Channelized Hotelling Observer Model to Guide Dose Reduction in Size-specific Acquisition Protocols with Iterative Reconstruction

Tuesday, Nov. 29 11:10AM - 11:20AM Room: S404AB

Participants
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PURPOSE

Image quality improvements resulting from iterative reconstruction (IR) have been leveraged to lower patient dose in CT. However, overly aggressive dose reduction may lead to reduced low-contrast object conspicuity that cannot be restored by IR. Here, we apply an observer model to determine appropriate dose reduction for size-specific acquisition protocols that utilize IR.

METHOD AND MATERIALS

A validated channelized Hotelling observer (CHO) model was used to assess the detectability of a 4.8 mm diameter circular object possessing -25 HU contrast relative to background. A Toshiba Aquilion Prime 160 scanner was used to image the phantom (Spiral/Helical CT Phantom, CIRS) containing the object. The phantom was scanned 100 times at 8 different fixed tube current settings: 20, 30, 45, 60, 70, 90, 140, and 180 mA. Filtered back-projection (FBP) images acquired at 60, 90, and 180 mA were used as reference "full dose" FBP images for small, medium and large patient sizes, respectively. These settings yielded image noise values consistent with size-specific target values at our institution. Images were reconstructed with both FBP and IR (AIDR 3D) methods. Area under the receiver operator characteristic curve (AUC) was determined for each tube current setting using 100 signal present images and 100 signal absent images obtained at the same location in the phantom.

RESULTS

AUC measurements demonstrated that IR improves object detectability as compared to FBP for images acquired at the same dose level. This improvement enables moderate dose reduction without loss of low contrast object detectability. Specifically, IR images acquired with 22, 22, and 25% less dose yielded AUC values within measurement error of full dose FBP images for small, medium, and large patient sizes, respectively.

CONCLUSION

CHO-based image quality assessment can be used to guide dose reduction for size-specific acquisition protocols when using IR

CHO based image quality assessment can be used to guide dose reduction for size specific acquisition protocols when using IR without compromising low contrast object detectability.

CLINICAL RELEVANCE/APPLICATION

Objective assessment of CT image quality with a CHO can help determine appropriate amounts of dose reduction for size specific acquisition protocols without loss of low contrast object detectability.

SSG13-06 CT X-Ray Spectrum Reconstruction with High Frequency Components

Tuesday, Nov. 29 11:20AM - 11:30AM Room: S404AB

Participants
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PURPOSE

To provide an x-ray spectrum estimation method that is capable of reproducing high frequency components like characteristic radiation.

METHOD AND MATERIALS

The accurate knowledge of the x-ray spectrum is of importance for many CT applications and artifact correction methods (e.g. organ dose estimation, beam hardening correction, dual energy decomposition). To estimate the x-ray spectrum transmission measurements of different attenuators with known dimension and material decomposition are performed. The inverse problem of reconstructing the x-ray spectrum is solved in two steps. First a low frequency solution is calculated using truncated singular value decomposition (TSVD). In the second step a solution from nullspace is added to the TSVD solution to incorporate prior information of high frequency components. In this work information about the energy distribution of the characteristic peaks of the anode is used. The nullspace solution is found by minimizing a cost function that penalizes deviations from physical assumptions like non-negativity of the total spectrum and flatness of the bremsstrahlung fraction. The algorithm is applied to noise-free and noisy simulated as well as to measured CT data for tube voltages ranging from 80 kV to 150 kV. The resulting spectra are validated using attenuation measurements that are not included in the reconstruction process. We compare our method with the expectation-maximization (EM) approach widely used in literature.

RESULTS

Reconstructed spectra from simulated data show a high fidelity to the ground truth. In comparison to the EM method we found a reduction of the mean square error to a simulated spectrum by one order of magnitude. The proposed algorithm is less dependent on input parameters like the number of iterations or the incident peak height than the EM method. The estimated spectra from the measured data are capable of reproducing the incident attenuation curves as well as attenuation measurements from materials that are not involved in the reconstruction process while providing a physically reliable shape.

CONCLUSION

Our approach that uses minimal prior information accurately reconstructs x-ray spectra from transmission measurements. The method has been validated with help of simulated and measured data.

CLINICAL RELEVANCE/APPLICATION

Detailed x-ray spectra are required for accurate dose calculations in x-ray computed tomography and radiation therapy.

SSG13-07 Comparison on Image Quality and Radiation Dosage of Helical 4cm, Helical 8cm and Axial 16cm Scan Mode on Revolution CT for Whole Abdominal CT Scan

Tuesday, Nov. 29 11:30AM - 11:40AM Room: S404AB

Participants
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PURPOSE

To compare three different scan mode on revolution CT: helical 4cm, helical 8cm and axial 16cm for whole abdominal CT scan and evaluate image quality and radiation dosage to provide the evidence to choose the reasonable abdominal CT scan mode.

METHOD AND MATERIALS

Totally 33 patients in our hospital referred to abdominal contrast-enhanced CT scans on GE Revolution CT were selected in this study. Plain CT scans were used helical 4cm helical mode, artery phase scans were used helical 8cm mode and portal phase scans were used axial 16cm mode. All scans were applied automatic mA modulation from 10-500mA and fixed tube voltage of 120kV, with noise index (NI) of 10. The SD value of fat as image noise in three different slices of the abdomen was measured in three locations: right branch of portal vein, left renal artery and navel. CT dose index volumes (CTDI vol), dose length product (DLP) were recorded from dose report, and effective dose (ED) was calculated. The image quality was evaluated by two experienced abdominal radiologists blindly and independently with a five-point scale (1 for poor and 5 for excellent). CTDI vol, ED, average image noise and average image score were compared with ANOVA.

RESULTS

There was no significant difference in terms of image noise (SD value, $F=0.31$, $P=0.73>0.05$) and subjective image quality (average image score, $F=0.47$, $P=0.63>0.05$) of the three scan modes during abdominal CT scans. 16cm axial scan produced highest radiation dosage (CTDI=11.74±3.81mGy, $F=5.04$, $P=0.01<0.05$; ED=8.45±3.03, $F=3.71$, $P=0.03<0.05$)than the helical 4cm and 8 cm scans,

while there was no statistically different between two helical scans.

CONCLUSION

The comparison of the three different scan modes showed that there was no statistical difference in objective and subjective image quality (SD value and average image score) during abdominal CT scans on Revolution CT. 16cm axial scan yielded higher radiation dosage than the other two helical scans because of wider coverage and mA modulation decreased less. The two helical scans had the similar image quality and radiation dosage.

CLINICAL RELEVANCE/APPLICATION

Helical 8cm scan mode on revolution CT is recommended to be a relatively optimal scan mode for whole abdominal CT scan because of short scan time and good image quality.

SSG13-08 CT Image Quality Assessment Using a 3D Model Observer for Lung Nodule Localization in the Presence of Anatomical Background

Tuesday, Nov. 29 11:40AM - 11:50AM Room: S404AB

Participants
Lifeng Yu, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
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David L. Levin, MD, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
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Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

Objective assessment of nodule detection performance in chest CT using model observers is challenging since both a phantom with lung-mimicking anatomical background and the placement of the same set of nodules at numerous randomized locations are needed. The purpose of this work was to develop a 3D model that mimics the clinical task, without requiring randomized nodule placements, and to use this model to evaluate low-dose chest CT.

METHOD AND MATERIALS

The 3D nodule localization task was mimicked with an 8 cm segment of an anthropomorphic chest phantom (Lungman, Kyoto). Twelve spherical nodules at 3 brightness levels (100, -630, -800 HU) and 4 sizes (10, 8, 5, 3 mm) were attached to the pulmonary trees within the lower 4-cm segment. The phantom was scanned on a 192-slice scanner (Force, Siemens) at 5 low-dose settings (CTDIvol of 0.1, 0.2, 0.4, 0.8, 2.0 mGy) using 100 kV with a tin filter. Scans were repeated 100 times at each dose with each nodule at a fixed location. A 3D spatial-domain observer model, non-prewhitening matched filter with an eye filter (NPWE), was used to calculate a 3D map of test statistics for each scan. The test statistics at each location in the upper 4-cm segment, where nodules were actually absent, were compared to the test statistics at the true nodule locations (lower segment) in each scan to determine if a correct localization was achieved. This was repeated for all 100 scans to determine the localization accuracy for each nodule and dose level.

RESULTS

Localization accuracy improved as the dose level, nodule size, and nodule brightness increased. Using 90% accuracy as the acceptability criterion, dose could be reduced to 0.1, 0.1, 0.1, and 0.4 mGy for the 10, 8, 5, and 3 mm nodules, respectively, for the 100 HU solid nodules. For the -630 HU sub-solid nodules, the corresponding doses were 0.1, 0.1, 0.4, and 2.0 mGy. For the -800 HU nodules, dose could be dropped to 0.1, 0.2, and 0.4 mGy for the 10, 8, and 5 mm nodules, respectively.

CONCLUSION

The proposed phantom-based 3D model observer can be used for task-based image quality evaluation of chest CT without the need for nodule placements in random positions, which is typically needed to mimic a localization task.

CLINICAL RELEVANCE/APPLICATION

Objective assessment of CT image quality for 3D nodule localization in lung anatomical background has been a challenge. The proposed method may resolve this problem.

SSG14

Physics (MR Applications)

Tuesday, Nov. 29 10:30AM - 12:00PM Room: S405AB

MR PH

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

FDA Discussions may include off-label uses.

Participants
Timothy J. Carroll, PhD, Chicago, IL (*Moderator*) Nothing to Disclose
Seth A. Smith, PhD, Nashville, TN (*Moderator*) Nothing to Disclose

Sub-Events

SSG14-01 Using 1H Spectrum as well as High Spectral and Spatial Resolution MRI to Characterize Water and Fat Variations in SV40 Mouse Mammary Gland Under Different Diet

Tuesday, Nov. 29 10:30AM - 10:40AM Room: S405AB

Participants
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Matthew J Brady, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Jeffrey Mueller, MD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The influence of dietary animal fat on breast cancer risk is not well understood. In this study, we used MRI to investigate the effect of diet on the water – fat ratio in the mammary glands of SV40 mice.

METHOD AND MATERIALS

Female C3(1) SV40 Tag transgenic mice (n=12) were studied and divided into three different diet groups: control, high animal fat, and high fructose. Each diet was started when mice were 8 weeks old.MRI was performed on a 9.4T scanner when mice were 12 weeks old. After axial high resolution T2-weighted anatomic images, a 1H spectrum was acquired at two 1 mm3 point resolved spectroscopy (PRESS) boxes on each side of inguinal mammary gland. The boxes were placed to avoid cancer, lymph nodes, and lymph ducts. High spectral and spatial resolution (HiSS) images were acquired from nine 1 mm slices (2 mm gap).The PRESS spectra were analyzed by fitting with a combination of Gaussian and Lorentzian functions. The ratio of the integrals of the water and fat spectra (W/F) was calculated. Water and fat peak height images were generated from HiSS data.Then the percentage of fat in the mammary gland was calculated from fat peak height images. One-way ANOVA and Tukey's HSD tests were performed to determine whether there was a difference between the calculated parameters in the three groups of mice. A p-value less than 0.05 was considered significant.

RESULTS

On average the water-to-fat ratio (W/F) was 11.3±4.2, 5.8±3.8, and 7.7±2.3 for control, high animal fat and high fructose diet mice, respectively. W/F was significantly lower in mice on the high animal fat diet ($p<0.05$). The fat resonances at 1.3, 2.04, 2.77 and 5.31 ppm were significantly narrower ($p<0.01$) in mice on the high animal fat diet than in mice on the control diet. The fat peak height images showed that the fat occupied more than 90% of the mammary gland in mice on the high fat diet, which was significantly more than in control mice. All the calculated parameters for the high fructose diet mouse were in between control and fat diet mouse.

CONCLUSION

Although the mice on high animal fat diets did not gain significant weight compared to control diet mice, the water and fat composition in the mammary glands were dramatically changed by the high fat diet.

CLINICAL RELEVANCE/APPLICATION

The spectrum and HiSS MRI could be used to identify water and fat composition changes in the mammary gland or human breast due to diet.

SSG14-02 Quantifying Intracellular pH Changes in Breast Tumors during Administration of pH Modulating Agents using Chemical Exchange Saturation Transfer (CEST) Magnetic Resonance Imaging

Tuesday, Nov. 29 10:40AM - 10:50AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
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PURPOSE

Tumors are dependent on proton transporters to remove excess protons derived from glycolysis, making them an attractive potential target for new adjunct agents that could be co-administered with traditional chemotherapy or immune therapies. Evaluation of the effectiveness of proton transport inhibitors in tumors has been limited by the lack of a non-invasive method of monitoring changes in pH. We investigated the ability of Chemical Exchange Saturation Transfer (CEST) MR, a quantitative imaging method, to non-invasively measure intracellular pH in vivo to characterize tumor response to pH modulating therapy.

METHOD AND MATERIALS

Experiments were performed using a well-established mouse model of BRCA1-related triple negative breast cancer. CEST MR imaging was performed at 9.4T using a 20mm RF surface coil placed over the tumor, before and after intraperitoneal injection of esomeprazole (40mg/kg) plus amiloride (5mg/kg) in 80uL DMSO or 80uL DMSO only as a control. Imaging acquisitions were performed at baseline and repeated at 15 minute intervals over 1 hour after injection. CEST spectra were analyzed using the previously described Amine/Amide Concentration Independent Detection (AACID) technique to calculate intracellular pH.

RESULTS

We imaged a total of 10 breast tumor-bearing mice. Eight mice were injected with esomeprazole and amiloride in DMSO and two mice were injected with DMSO only. There was a subtle shift in the relative amide and amine peak heights in tumors after drug administration but not with carrier only, corresponding to an approximate 0.2 pH unit decrease in intracellular pH. This effect on tumor pH appeared to peak during the first 15 minutes after injection before tapering back to baseline.

CONCLUSION

This early in vivo data suggests that our CEST imaging protocol may be able to detect a subtle shift in the intracellular pH in breast tumors after administration of esomeprazole and amiloride. Future studies will focus on using more potent proton modulating drugs with larger pH effects to further optimize our CEST imaging protocol. Further analysis of the CEST spectra already obtained will also be performed to identify any other peak changes that may reflect changes in pH.

CLINICAL RELEVANCE/APPLICATION

CEST MR imaging may be able to detect a subtle shift in intracellular pH in breast tumors after administration of esomeprazole and amiloride.

SSG14-03 Assessment of Interplatform Variability of T1 Quantification Methods Used for DCE-MRI in a Multicenter Phantom Study

Tuesday, Nov. 29 10:50AM - 11:00AM Room: S405AB

Participants
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PURPOSE

The precision of pharmacokinetic parameters estimated from DCE-MRI contrast uptake curves is highly dependent on the conversion of T1-weighted signal to Gd concentration, and thus on the baseline T1 value. The objective of this study was to measure interplatform variability in T1 quantification in a multicenter study by testing common inversion-recovery spin-echo (IR-SE) and variable flip angle (VFA) protocols using a dedicated T1 phantom.

METHOD AND MATERIALS

A T1 phantom, produced by NIST, was scanned at 7 different sites on different platforms (eight 3.0T systems, one 1.5 T system) in duplicate (test-retest). The phantom consists of 14 spherical vials doped with varying concentration of $NiCl_2$. The T1 mapping protocols were standardized and consisted of an IR-SE and VFA sequence. T1 fitting was done on signal curves from ROIs drawn by a single observer in each vials. Test-retest and interplatform coefficients of variation (CV) were computed for each platform. The standardized VFA protocol was compared with the reference standard IR-SE protocol using Bland-Altman statistics.

RESULTS

T1 measurements in the 14 spheres ranged between 20 and 2000 ms at 3T, as expected, with greater spread in the distribution of T1 values observed between sites with the VFA sequence (CV range across platforms 18.7-45.6% vs 1.0-14.6% for IR-SE). The IR-SE protocol had high repeatability at both field strengths, with mean test-retest CV of 0.3% at 1.5T and <7% at 3T. The common VFA protocol had poorer repeatability, with test-retest CV <2% at 1.5T, and as high as 18% at 3T. The comparison of the common VFA protocol to the IR-SE reference standard protocol across eight 3T magnets showed absolute % difference bias in the range of 2%-36%.

CONCLUSION

Preliminary results show high interplatform variability in T1 values in test-retest scans and between different protocols. Future work will analyze accuracy of each T1 measurement method with respect to gold standard T1 values determined by NMR spectroscopy at NIST. The complete dataset will be analyzed with a generalized linear mixed statistical model, to compare accuracy of T1

measurements across field strength, scanner models, and sequences.

CLINICAL RELEVANCE/APPLICATION

Standardization of T1 mapping used for DCE-MRI quantification likely improves reliability of pharmacokinetic parameters and thereby potentially enhances the accuracy of e.g. treatment planning and monitoring based on these parameters.

SSG14-04 Classification of MRI Patterns of Multiple Myeloma (MM) Infiltration and Its Prognostic Value for Treatment Response Assessment

Tuesday, Nov. 29 11:00AM - 11:10AM Room: S405AB

Participants
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Jun Wei, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

Studies indicated that the patterns of MM infiltration manifested on MRI are associated with tumor burden and correlated with prognosis in patients with MM. This study investigated the feasibility of classifying the MRI patterns of MM infiltration and assessed the value of our developed pattern biomarker as a prognostic factor in MM patients after bone marrow transplant (BMT).

METHOD AND MATERIALS

With IRB approval, 63 pairs of spinal MRI scans performed pre- and post-BMT were collected retrospectively from 63 MM patients. An experienced musculoskeletal radiologist visually examined each vertebra and provided the descriptor of its pattern (normal, focal, variegated (salt-pepper), and diffuse) as reference standard. Thirty-seven texture features were extracted from each manually outlined vertebral body. Using leave-one-case out cross validation and ROC analysis, a logistic regression model (LRM) was built with stepwise feature selection for classifying the vertebrae into two groups: variegated and diffuse patterns (group 1) that tend to have higher tumor burden vs normal and focal patterns (group 2). Five effective features (1 gray level histogram feature, 3 run-length statistics, 1 gray tone spatial dependence feature) were selected. The percentage of analyzed vertebrae (pV) that were classified into group 1 by LRM for each patient was used as pattern biomarker to estimate progression-free survival. The prognosis was analyzed with the Cox proportional hazards regression model, with respect to the time to progression (TTP) censored at 3 years.

RESULTS

Of the 1244 vertebras, 619 and 625 vertebras were classified as group 1 and 2, respectively, by radiologist. The LRM achieved a test AUC of 0.81±0.01. The Cox model showed that, with an optimal cutoff point of pV<10% determined by the maximally selected rank statistics, the patients had significantly longer TTP ($P<0.001$; hazard ratio 5.7) compared to patients having pV>10%.

CONCLUSION

Our radiomic method classified MRI patterns between the high-grade diffuse or variegated patterns and the normal or focal patterns with high accuracy. The study demonstrated the feasibility of using the pattern biomarker (pV) as prognostic predictor for MM patients.

CLINICAL RELEVANCE/APPLICATION

MR-based radiomic biomarker with prognostic significance may improve the accuracy for staging and assessing treatment response for MM, allowing clinicians to optimize therapy for individual patients.

SSG14-06 Electrical Impedance Spectroscopy for Prompt Intracranial Hemorrhage Diagnosis

Tuesday, Nov. 29 11:20AM - 11:30AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
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PURPOSE

Emergent detection of intracranial haemorrhage (ICH) is crucial for the appropriate management to decrease the risk of permanent neurologic deficits or ensuring infarction. Typically, the diagnosis of ICH is made on CT or MR imaging, but these images only represent the brain at a single point in time. To date, there remains no clinical equipment for continuous monitoring expressly for the purpose of detecting ICH The purpose of this study was to design and construct an Electrical Impedance Spectroscopy (EIS) platform to see if ICH could be detected.

METHOD AND MATERIALS

An in-house developed EIS platform was constructed to non-invasively detect the electrical properties of brain tissue. A conductive head phantom made of agarose gel was constructed to model the anatomic/geometric features of the human head with agarose simulating the native impedance of brain tissue. Stimulation electrodes were placed on scalp of the phantom in a montage

configuration similar to that for EEG recordings. Electrodes pairs were placed at F7, F8, C4, C3, P7 and P8 positions to detect changes in the electrical potential when exposed to Gaussian white noise stimulation pulse (range of 0-50 kHz). Baseline electrical potential recordings were obtained and normalized.A solution of 1 ml of saturated sodium chloride (NaCl) solution, simulating hemorrhage, was injected below the C4 electrode. Post-injection electrical potential measurements were obtained at each electrode position.

RESULTS

After the injection of saturated NaCl solution immediately deep to the C4 electrode an isolated decrease in the normalized C4 voltage of -0.33 volts was observed. Electrodes located anterior and posterior to the C4 electrode maintained their baseline voltage, prior to the injection of saline at the C4 electrode yielding an accurate localization of changes in electrical potential correlating with the site of simulated hemorrhage. Repeat simulation testing using this convention achieved similar results.

CONCLUSION

This study demonstrates proof of concept of using an EIS platform to detect changes in electrical potential within the brain parenchyma using an NaCl solution to simulate intracranial hemorrhage

CLINICAL RELEVANCE/APPLICATION

This study provides proof of concept in the development of a continuous electrical impedance recording device for the detection of intracranial hemorrhage.

SSG14-07 Arterial Input Functions Derived from Ultra-fast DCE MRI and Dynamic Contrast Computed Tomography in Prostate Cancer Patients

Tuesday, Nov. 29 11:30AM - 11:40AM Room: S405AB

Participants
Shiyang Wang, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
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Ambereen Yousuf, MBBS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Gregory S. Karczmar, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The aim of this study is to evaluate the accuracy of arterial input functions (AIF) derived from ultra-high temporal resolution (Ufast) dynamic contrast enhanced (DCE) MRI following a low dose of Gadolinium (Gd) contrast media, using dynamic contrast enhanced (DCE) computed tomography (CT) as gold standard.

METHOD AND MATERIALS

Twenty-three men (46–72yo) who were scheduled for prostatectomy after MRI were enrolled in this IRB approved study. In all patients, DCE-CT scans (with 120mL Omnipaque350 injected at 4mL/s) were performed with 29 dynamics, a temporal resolution of 5s for the first 25 dynamics followed by 2 dynamic scans 1 min apart and 2 dynamic scans 2 min apart. Ufast DCE-MRI was performed ~3 hours after CT scans, 90 dynamic scans with 1.5s temporal,1.5x2.8x3.5 mm^3 in-plane resolution and a low dose injection (15% of conventional dose) Gd-based contrast agent (~3mL injected at 2mL/s). AIFs were extracted from an illiac artery on both Ufast DCE-MRI and DCE-CT images and were interpolated using empirical mathematical models (EMM) to match the temporal resolution. AIFs from Ufast DCE-MRI were convoluted with a rectangular function to adjust for differences in DCE-CT and MRI protocols. The resulting adjusted AIFs from MRI were compared to AIFs from DCE-CT. Goodness of fit R2 was calculated between convoluted AIF from DCE-MRI and the AIF from DCE-CT.

RESULTS

The EMMs accurately fit both MRI and CT data. There was no significant difference ($p>0.05$) between the maximum peak amplitude of AIFs from DCE-CT (mean=21.9kg/L) and convoluted AIFs from Ufast DCE-MRI (mean=25.5kg/L). The shapes of the AIFs from Ufast DCE-MRI and DCE-CT were very similar (mean R2=0.74).

CONCLUSION

AIFs derived from Ufast DCE-MRI correlated strongly with gold standard AIFs derived from DCE-CT. Contrast enhancement was measured in one of the illiac arteries in each patient. The low dose of contrast media in Ufast DCE-MRI minimized water exchange and T2* artifacts that cause underestimation of AIF peak magnitude when the conventional dose is used. The results demonstrate that the AIF directly measured by MRI following a low contrast media dose can be used to calculate accurate values of K[trans] and other pharmacokinetic parameters.

CLINICAL RELEVANCE/APPLICATION

A direct comparison of gold standard DCE-CT measurement with low dose Ufast DCE-MRI demonstrates that Ufast DCE-MRI can provide an accurate and reliable measure of the AIF for pharmacokinetic studies.

Honored Educators

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

Aytekin Oto, MD - 2013 Honored Educator

SSG14-09 Cardiac MR-based 2D Strain Analysis as an Early Marker of Diastolic Dysfunction in the General

Population: A Reproducibility Study

Tuesday, Nov. 29 11:50AM - 12:00PM Room: S405AB

Participants
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PURPOSE

Initial data suggest that subtle alterations in LV function can also be assed using SSFP MRI sequences, which may represent an early biomarker of increased risk in metabolic diseases of the general population, including pre-diabetes. However, the reproducibility of these measurements is unknown but critical for larger implementation.

METHOD AND MATERIALS

We included 30 random subjects from a larger prospective cohort study from the general population without prior cardiovascular disease or symptoms (KORA FF4 cohort) who underwent a 3T whole body MRI scan including Cine SSFP imaging (TR: 29.97ms, TE: 1.46ms, Flip Angle: 62°, Slice-Thickness: 8mm, Field of view: 297x360mm, Matrix: 240x160, Voxel size: 1.5x1.5mm², Segments: 25). Two independent observers determined image quality (5-point Likert scale) and measured radial, longitudinal and circumferential strain by using a semiautomatic segmentation algorithm (CVI42, Circle, Canada). Inter-reader and intra-reader variabilities were assessed using Bland-Altman plot analyses and intra-class-correlation coefficients (ICC) after one-way random-effects ANOVA.

RESULTS

Among all subjects (mean age: 56.3±9 years, 57.8% males) image quality was high (4.5±2) and all images were included in the analysis. Inter-reader reproducibility was excellent for longitudinal strain (relative difference: 0.2%±7.5%, ICC 0.50) whereas radial strain and circumferential strain showed a good inter-reader reproducibility (relative difference: 12.9%±9.7%, ICC 0.67 and 6.7%±6.1%, ICC 0.74; respectively). Intra-reader reproducibility was excellent for all strain directions (relative difference range: -0.6 to 1.4%, ICC from 0.67 to 0.84). All agreement was independent of image quality ($p>0.05$).

CONCLUSION

Cardiac MR-based 2D strain analysis is highly reproducible and may therefore be implemented in larger cohort studies to determine its value as a precursor of diastolic dysfunction in subjects at risk.

CLINICAL RELEVANCE/APPLICATION

Left ventricular 2D strain analysis may represent a reproducible marker for identifying subjects at risk for subclinical left ventricular dysfunction in the general population.

SSG16

Vascular Interventional (Percutaneous Ablation: Basic Science)

Tuesday, Nov. 29 10:30AM - 12:00PM Room: E351

CT IR PH

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

FDA Discussions may include off-label uses.

Participants
Gordon McLennan, MD, Chagrin Falls, OH (*Moderator*) Research Grant, Sirtex Medical Ltd; Research Grant, C. R. Bard, Inc; Consultant, Medtronic plc; Advisory Board, Siemens AG; Advisory Board, Surefire Medical, Inc; Stock Holder, Surefire Medical, Inc; Advisory Board, Medtronic plc; Advisory Board, Stealth Medical; Advisory Board, Rene Medical;
Himanshu Shah, MD, Zionsville, IN (*Moderator*) Consultant, IMARC Research Inc

Sub-Events

SSG16-01 Performance Evaluation of a Robotic Assistance Device Compared to Manual Fluoroscopy Procedure in Computed Tomography Guided Minimally Invasive Ablation Procedures and Diagnostic Punctures

Tuesday, Nov. 29 10:30AM - 10:40AM Room: E351

Participants
Arman Smakic, MD, Mannheim, Germany (*Presenter*) Nothing to Disclose
Nils Rathmann, MD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Michael Kostrzewa, MD, Mannheim, Germany (*Abstract Co-Author*) Institutional research agreement, Siemens AG
Stefan O. Schoenberg, MD, PhD, Mannheim , Germany (*Abstract Co-Author*) Institutional research agreement, Siemens AG
Steffen J. Diehl, MD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate a novel commercially available robotic assistance device for computed tomography guided interventions compared to standard manually performed CT-scan guided interventions in terms of precision, radiation exposure and intervention time.

METHOD AND MATERIALS

Within 16 months 55 patients were treated using robotic assistance (group A) and compared to a control group of 102 patients previously treated with a standard CT-scan guided, manually performed, approach (group B). Evaluated parameters were precision (deviation from planned target and number of needle replacements), radiation exposure and intervention time. Evaluations were performed with regard to complexity (in plane vs. out of plane interventions) and anesthesia type (general vs. local anesthesia).

RESULTS

Parameters related to precision were in general significantly better in the robotic assistance group ($p<0.01$) with a mean deviation of only 1.2mm (±1.6 mm) compared to 2.6mm (±1.1 mm) in the control group. Regarding the sub-groups, differences in deviation in both groups were smaller in procedures performed under general anesthesia compared to local anesthesia (Group A: 0.5mm (±0.9mm) vs. 2.1mm (±1,9mm) group B: 1.9mm (±1.3 mm) vs. 3.4mm (±1.1 mm) (both $p<0.001$). Mean number of needle replacements necessary to reach the target was 0.3 (±0.4) in the robotic assistance group compared to 1.8 (±0.7) in the comparison group ($p<0.001$). Compared to standard procedure mean intervention time was 15 minutes (± 5.4min) shorter in complex out of plane punctures in the robotic group. There was no increase of radiation exposure to the patient while radiation exposure for the physician was reduced to zero when the navigation system was used.

CONCLUSION

Compared to manual placement the use of a robotic assistance device in complex out of plane CT guided interventions under general anesthesia allows probe placement with high precision, reduces intervention time with no increase of exposure to radiation to the patient and zero radiation for the physician. In less complex in plane punctures no advantages concerning intervention time and radiation dose were seen while precision analysis showed small advantages.

CLINICAL RELEVANCE/APPLICATION

Use of a robotic navigation system can improve the workflow of complex CT guided minimally invasive ablation procedures and diagnostic punctures in terms of precision, intervention time and eliminates radiation to the performing physician.

SSG16-02 Effect of Concentration of Perfusate and Power-Setting on Coagulated Size of Hydrochloric Acid-Infused Radiofrequency Ablation

Tuesday, Nov. 29 10:40AM - 10:50AM Room: E351

Awards
Trainee Research Prize - Resident

Participants
Tianqi Zhang, Guangzhou, China (*Presenter*) Nothing to Disclose
Kaiwen Huang, Taipei City, Taiwan (R.O.C.), Taiwan (*Abstract Co-Author*) Nothing to Disclose
Leyi Xu, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Yangkui Gu, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Rongqian Yang, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Ruhai Zou, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Jinhua Huang, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To determine the optimal concentration of hydrochloric acid (HCl) applied in HCl-infused radiofrequency ablation (H-RFA) by investigating the H-RFA lesion sizes and the conductivities in different concentrations of HCl under different ablation powers.

METHOD AND MATERIALS

H-RFA procedure was conducted in 60 ex vivo porcine livers at 103oC within 30 minutes. To test four different concentrations of HCl (5%, 10%, 15%, 20%) as experimental groups and two control groups including distilled water and normal saline under two setting ablative powers (30 w, 60w), 12 subgroups were created, each with five specimens. For each ablation procedure, the power output was recorded every 2.5 minutes, the longitudinal and transverse diameters were measured, and ablation volumes were calculated. The average impedance, actual power output, longitudinal and transverse diameters, and volumes of the lesions in all eight groups were compared with analysis of variance. Alpha was set at 0.05.

RESULTS

The ablation zones of H-RFA were significantly larger than controls ($P<0.001$). The largest mean lesion volume of H-RFA was 179.22 ± 24.79 cm3, with 10% HCl concentration at 60 w; the smallest was 93.97 ± 15.09 cm3, with 5% HCl at 30 w. The average power outputs at concentrations of 5% and 10% were significantly greater than those at 15% and 20% in the 30 w and 60 w groups, respectively ($P<0.05$). In the 60 w groups, the longitudinal and transverse diameters and volume at 10% were significantly greater than those of the other three concentration groups ($P<0.05$). Although the average power output of the 15% and 20% groups was smaller than that at 5% ($P>0.05$), the lesion sizes were similar in 60 watt groups than those of the 5% group and were even larger in 30 watt groups.

CONCLUSION

An HCl concentration of 10% produced the largest lesion and is thus the optimal concentration for HRFA under the conditions tested.

CLINICAL RELEVANCE/APPLICATION

An HCl concentration of 10% is evaluated as the optimal concentration for hydrochloric acid infused radiofrequency ablation (HRFA). By applied 10% HCl, it could create large ablation zone by HRFA.

SSG16-03 Single Exponential Decay Voltage Profile for Non-thermal Tissue Ablation

Tuesday, Nov. 29 10:50AM - 11:00AM Room: E351

Participants
Michael K. Stehling, MD, PhD, Offenbach, Germany (*Presenter*) Investor, InterScience GmbH
Enric Guenther, Dipl Phys, Frankfurt, Germany (*Abstract Co-Author*) Investor, InterScience GmbH
Paul Mikus, DPhil, Coto De Caza, CA (*Abstract Co-Author*) Consultant, Interscience
Nina Klein, MSc, Offenbach am Main, Germany (*Abstract Co-Author*) Nothing to Disclose
Boris Rubinsky, PhD, Berkeley, CA (*Abstract Co-Author*) Consultant, InterScience GmbH

PURPOSE

Non-thermal irreversible electroporation (NTIRE) protocols are designed to maximize tissue ablation by irreversible electroporation while minimizing Joule heating; to spare vital structures such as blood vessels in the treated lesion. Due to muscle contractions, muscle relaxants are necessary. We designed a new technology for non-thermal tissue ablation, which employs a synergistic combination of electroporation and electrolysis (SEE) inducing electrical parameters. The voltage profile, delivered as a millisecond long exponential decay, generates products of electrolysis, which ablate cells by penetrating the interior of electroporation permeabilized cells.

METHOD AND MATERIALS

The liver of three pigs was exposed and treated with two custom-made, electrolysis promoting Ti based electrodes under ultrasound monitoring. We utilized a generator designed to simultaneously deliver electrolysis and electroporation. The initial voltage, the time constants of the exponential voltage profile and the number of pulses delivered were parameters of this study. Animals were sacrificed at 24 hours. For microscopic analysis, the liver samples were fixed in a 10% formalin solution, processed to wax blocks and stained with Masson’s trichromatic stain for histologic examination.

RESULTS

Single SEE electric fields which decayed exponentially within milliseconds from field strengths of 750 and 1000 V/cm produced continuous ablation between electrodes with comparable ablation dimensions to that achieved with 70 typical NTIRE pulses, without the necessity of muscle relaxants. Animals tolerated the procedure without significant adverse events.

CONCLUSION

The SEE technology can reliably ablate liver tissue on a cellular level with single exponential decay voltage profiles. At the same time it reduces the muscle contraction to the extent that no muscle relaxants are needed. While other shapes of voltage potentials for SEE exist, an advantage of the exponential decay voltage shape is its technological simplicity. This non-thermal technology is therefore faster than comparable ablation modalities, with lower toxicity and lower requirements for anesthesia and muscle relaxation.

CLINICAL RELEVANCE/APPLICATION

SEE is a novel technology for non-thermal tissue ablation, which utilizes a synergistic combination of electroporation and electrolysis parameters, delivered as a single exponential decay voltage.

SSG16-04 Evaluation of A Novel Thermal Accelerant Agent to Augment Tissue Heating During Image-Guided Microwave Ablation

Tuesday, Nov. 29 11:00AM - 11:10AM Room: E351

Participants

William C. Park, PhD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Damian E. Dupuy, MD, Providence, RI (*Presenter*) Research Grant, NeuWave Medical Inc Board of Directors, BSD Medical Corporation Stockholder, BSD Medical Corporation Speaker, Educational Symposia
Aaron W. Maxwell, MD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Shaolei Lu, MD,PhD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Grayson L. Baird, PhD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Edward G. Walsh, PhD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Victoria Frank, Fall River, MA (*Abstract Co-Author*) Nothing to Disclose
Michael P. Primmer, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Kara A. Lombardo, BS, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Scott Collins, RT, Providence, RI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The effectiveness of thermal ablation in solid tumors decreases with distance from the applicator tip (thermal diffusion) and with increased adjacent blood flow ("heat sink" effect). In this study, we describe our initial experience with a novel thermal accelerant (TA) agent designed to mitigate these factors and augment ablation zone volume.

METHOD AND MATERIALS

TA performance was evaluated with a commercially available microwave ablation system using *in vitro* agarose phantom, *ex vivo* bovine liver, and *in vivo* porcine liver, kidney, and muscle models. Microwave power, TA dose, and TA-to-tip distance were varied, and temperature readings compared with and without TA. Gross pathologic analysis was performed on *in vivo* specimens using triphenyl tetrazolium chloride (TTC) staining to calculate ablation zone volumes. Imaging characteristics were determined using ultrasound and CT.

RESULTS

Using the *in vitro* model, both the rate and magnitude of increase in ablation zone temperature were significantly greater with TA under all tested conditions ($p<0.0001$). *Ex vivo*, the intrahepatic ablation zone temperature increase was directly proportional to dose, with 60°C reached in 180 second using 250 mg/mL at 60W. *In vivo*, liver, muscle, and kidney ablation zone volumes as determined by TTC staining were significantly increased with TA use ($p<0.01$ for all). The compound exhibited biphasic gel properties, existing as a clear liquid at 25°C and an opaque gel at 37°C. On ultrasound imaging, the TA appeared hypoechoic when liquid and mildly echogenic as gel. On CT, TA density was proportional to dose, with average values ranging from 329 HU to 3071 HU at 10 mg/mL and 1,000mg/mL, respectively.

CONCLUSION

Our novel TA agent improved the performance of a commercially-available microwave ablation system and increased ablation zone volume in multiple tissue types. The agent is readily visible under both CT and ultrasound, and can be reliably placed within biologic tissues owing to its biphasic gel properties. Future studies evaluating optimal TA-to-target geometry and other organ-specific parameters are planned.

CLINICAL RELEVANCE/APPLICATION

Ablation volume is significantly augmented through the use of a novel thermal accelerant agent designed to mitigate thermal diffusion and heat sink effects.

Honored Educators

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

Damian E. Dupuy, MD - 2012 Honored Educator

SSG16-05 Imaging-guided Spinal Radiofrequency, Microwave, and Cryoablation in a Sheep Model

Tuesday, Nov. 29 11:10AM - 11:20AM Room: E351

Participants
Adam N. Wallace, MD, Saint Louis, MO (*Abstract Co-Author*) In-kind support, DFINE, Inc ; In-kind support, Galil Medical Ltd; In-kind support, Medtronic plc
Travis J. Hillen, MD, Saint Louis, MO (*Abstract Co-Author*) Consultant, Biomedical Systems; Instructor, DFine, Inc
Michael V. Friedman, MD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Zohny S. Zohny, MD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Bradley H. Stephens, MD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Suellen C. Greco, DVM, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Michael R. Talcott, DVM, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Jack W. Jennings, MD, Saint Louis, MO (*Presenter*) Speakers Bureau, DFINE, Inc Consultant, DFINE, Inc

PURPOSE

In this study, in vivo RFA, cryoablation, and MWA of healthy sheep vertebrae were performed to accomplish three objectives. First, the technical parameters of each modality were correlated with the diameter of the necrotic ablation zone on gross pathology. Second, ablations were performed that exceeded the dimensions of the vertebral bodies to determine whether the posterior vertebral body cortex acts as a protective barrier for the spinal cord. Third, post-ablation MRI and histologic findings were evaluated and correlated.

METHOD AND MATERIALS

Ten healthy sheep vertebrae were treated with radiofrequency ablation (n = 3), cryoablation (n = 4), or microwave ablation (n = 3).. In the first sheep, the parameters of each ablation were chosen to produce an ablation volume with a 20-mm diameter orthogonal to the ablation probe based on preclinical data provided by the manufacturers. MRI was performed 48 hours (sheep 1) or 7 days (sheep 2, 3) after the ablation procedure. The vertebral bodies were then harvested for gross pathologic and histologic

evaluation.

RESULTS

Radiofrequency ablation zones on gross pathology were 5.9±0.7 mm smaller than those expected based on previously derived correlations with technical parameters. Cryoablation and microwave ablation zones were within 2 and 1 mm, respectively, of those expected. Cryoablation and microwave ablation zones larger than the target vertebral bodies caused histologically confirmed spinal cord injury, but this was not observed with radiofrequency ablation. On MRI, all ablation modalities produced a non-enhancing ablation zone delineated by a thin rim of enhancement, which corresponded histologically to marrow necrosis and hemorrhagic congestion, respectively. Gross pathology ablation zones were larger than those measured on MRI by 0.6±0.2 mm for radiofrequency ablation, 0.9±0.3 mm for cryoablation, and 1.4±0.8 mm for microwave ablation.

CONCLUSION

Estimations of ablation zone dimensions and the risk of ablation-induced spinal cord injury vary among modalities. Ablation zones are slightly larger on pathology than on MRI.

CLINICAL RELEVANCE/APPLICATION

Accurate estimation of spinal ablation zone dimensions derived from an in vivo sheep model, coupled with the knowledge of whether the cortex protects against ablation-induced spinal cord injury, will facilitate the adequate and safe ablation of spinal tumors.

SSG16-06 Use of CT Densitometry to Differentiate between Recurrence and Ablation Scar

Tuesday, Nov. 29 11:20AM - 11:30AM Room: E351

Awards
Student Travel Stipend Award

Participants
Lillian Xiong, MD, Providence, RI (*Presenter*) Nothing to Disclose
Erica S. Alexander, MD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Grayson L. Baird, PhD, Providence, RI (*Abstract Co-Author*) Nothing to Disclose
Damian E. Dupuy, MD, Providence, RI (*Abstract Co-Author*) Research Grant, NeuWave Medical Inc Board of Directors, BSD Medical Corporation Stockholder, BSD Medical Corporation Speaker, Educational Symposia

PURPOSE

This study evaluates CT densitometry's ability to differentiate tumor from scar after radiofrequency ablation.

METHOD AND MATERIALS

Data used from a prospective, multicenter group trial approved by each institutional review board. 54 patients from 16 US sites were enrolled, of these, 50 patients (23 Men, 27 Women; mean age 75.3±7.5 years) met eligibility requirements. Data from patients' pretreatment and multiple post treatment follow up multiphase CT scans (CT densitometry) at 3, 6, 9, and 12 months to evaluate recurrent tumor and scar enhancement at 0, 45, 90, 180, and 300 seconds.

RESULTS

Evaluation of the CT densitometry at times of recurrence showed kinetics that mimic the pretreatment densitometry. The average change in Housfield units (HU) from 0 to 45 seconds at time of recurrence was 48 HU CI 95% (29-67) and pretreatment, biopsy proven tumor, has an average change of 56 HU CI 95% (40-72) with a near identical slopes. After this initial increased uptake, the recurrences and biopsy proven tumor curves show plateau to slight washout of contrast. Conversely, the CT densitometry without recurrence showed kinetics that mimic the 3 month ablation scar densitometry curve with near identical slope. The average change in HU from 0 to 45 seconds with no recurrence was 13 HU CI 95% (1.2-24) and 28 HU CI 95% (14-41) in the 3 month ablation scar. At the 90 and 180 time points, these both show persistent uptake of contrast, consistent with the imaging findings of scar and fibrosis.

CONCLUSION

CT densitometry shows different kinetic curves in recurrent and primary tumor compared to scar. This may be a useful imaging biomarker of neovascularity in patients undergoing ablative therapies.

CLINICAL RELEVANCE/APPLICATION

Similar to the kinetic curves used in breast MRI to evaluate lesion physiology, CT densitometry's ability to differentiate tumor from scar makes it a viable alternative imaging method or adjunct method to evaluate post ablation patients.

Honored Educators

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

Damian E. Dupuy, MD - 2012 Honored Educator

SSG16-07 Novel Needle-Attached Orientation Sensor to Correct for Respiratory Motion during Percutaneous Interventions: Accuracy of Lesion Position Estimation in the Liver

Tuesday, Nov. 29 11:30AM - 11:40AM Room: E351

Participants
Momen Abayazid, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Takahisa Kato, Boston, MA (*Abstract Co-Author*) Employee, Canon Inc
Stuart G. Silverman, MD, Brookline, MA (*Abstract Co-Author*) Author, Wolters Kluwer nv
Olutayo I. Olubiyi, MD , BOSTON, MA (*Abstract Co-Author*) Nothing to Disclose

Nobuhiko Hata, PhD, Boston, MA (*Presenter*) Research Grant, Canon USA Inc; Research Grant, Koh Young Technology Inc; Research Consultant, AZE, Ltd ; Research Consultant, Harmonus, Ltd ; Stockholder, Harmonus, Ltd

PURPOSE

Respiratory motion is the single-most important obstacle in targeting small lesions in the lung, liver and kidney. We assessed if the motion of an initially placed 'reference' needle coupled with an attached sensor could be used to accurately estimate the position of a simulated liver lesion motion in real-time at different proximities of the needle to the lesion.

METHOD AND MATERIALS

An experimental platform was developed to mimic liver motion during breathing using a 2-degrees-of-freedom (DOF) motorized stage. The motorized stage simulated the lesion motion; 10mm in the superior-inferior and 6mm in the anterior-posterior directions; during shallow breathing that includes inhalation (2s), exhalation (2s) and then a pause (2s). A custom made 9DOF inertial measurement unit (IMU) was attached to the hub of an 18-gauge standard 'reference' biopsy needle. Following 21 needle placements into the phantom, IMU collected the surrogate signals including 3D orientation, linear acceleration and angular velocity of the needle during synthetic motions of the phantom. A supervised learning algorithm based on Random k-Labelsets method was trained to create a correspondence model that correlated the surrogate signals to the lesion position over 20 seconds. The actual lesion position was measured using an electro-magnetic (EM) sensor at the lesion site and used as a gold standard. The IMU and EM sensor data were synchronized and split; 66% of the data was used for training and 34% was used for testing. The needle was placed with varying proximity to the lesion.

RESULTS

The errors to estimate lesion motion were 0.0, 1.0 and 0.0 mm in median value, and 0.63±0.87, 0.74±0.79, and 0.53±0.81 mm in average value (p=0.003 by Kruskal-Wallis), for needle-to-lesion proximity range of 0-1cm, 1-2cm and 2-3cm respectively. The processing time for training and testing was 4-12 ms, which is sufficient for real-time lesion motion estimation using the proposed surrogate signal.

CONCLUSION

Motion of an initially placed 'reference' needle can be used as a surrogate signal to accurately estimate a lesion's position in real-time during percutaneous interventions. The needle proximity to lesion significantly affected the lesion position estimation error.

CLINICAL RELEVANCE/APPLICATION

As initially placed 'reference' needle with an attached sensor can be used to compensate for respiratory motion and improve targeting of small tumors in organs that move with respiration.

SSG16-08 In Vitro Artifact Assessment of a New MR-compatible Microwave Antenna Device for Tumor Ablation with Near-Realtime Fluoroscopic MRI-Sequences

Tuesday, Nov. 29 11:40AM - 11:50AM Room: E351

Participants
David-Emanuel Kessler, MD, Tubingen, Germany (*Presenter*) Nothing to Disclose
Jakob Weis, MD, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Stephan Clasen, MD, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Konstantin Nikolaou, MD, Tuebingen, Germany (*Abstract Co-Author*) Speakers Bureau, Siemens AG; Speakers Bureau, Bracco Group; Speakers Bureau, Bayer AG
Rudiger Hoffmann, Tubingen, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate artifact configuration and diameters of a new magnetic resonance (MR) compatible microwave (MW) applicator for percutaneous tumor ablation using two different near-realtime MR fluoroscopic sequences.

METHOD AND MATERIALS

Two new MW applicators (14 and 16 Gauge) were tested in a phantom study at 1.5T with two dedicated sequences optimized for MR fluoroscopic imaging: T1 weighted spoiled Gradient Echo (GRE) sequence and T1/T2 weighted Steady State Free Precession (SSFP) sequence. Applicator orientation to main magnetic field (B0), slice orientation and phase encoding direction (PED) were varied in a systematic fashion. Needle tip location error (TLE) was assessed and artifact diameters were calculated for each needle, sequence, and position. Influence of imaging parameters on artifacts were assessed with ANOVA and post hoc testing.

RESULTS

The artifact was homogenous along the whole length of both antennas with all tested parameters. The tip artifact measured 7.7+/-1.2mm for the 14 G antenna and 6.9 +/-1.0mm for the 16 G antenna, respectively. The shaft artifact diameter measured 9.6+/-1.5 mm and 8.6+/-1.2mm, respectively. TLE was -1.6+/-1.2mm and -1.5+/-1.2mm, respectively. Orientation to B0 had no statistically significant influence on the tip artifact diameter (p=0.07 and p=0.55, respectively) or the TLE (p=0.26 and p=0.93, respectively). GRE sequence produced statistically significant greater TLE (p<0.0001). Slice orientation had no statistically significant influence on the size of the tip artifact (p=0.31 and p=0.93, respectively) and on the TLE (p=0.97 and p=0.35, respectively). PED had no statistically significant influence on the TLE (p=0.15 and p=0.68, respectively)

CONCLUSION

The new MR-compatible MW applicator's artifact is adequately small and TLE seems small enough for safe applicator positioning during near-realtime fluoroscopic MR-guidance for percutaneous ablation procedures.

CLINICAL RELEVANCE/APPLICATION

The results of this study may help implementing MR-guided microwave ablation in clinical practice.

SSG16-09 Cardiac Safety of Irreversible Electroporation Evaluated by Biomarkers and Electrocardiographic Monitoring

Tuesday, Nov. 29 11:50AM - 12:00PM Room: E351

Participants
Michael Kostrzewa, MD, Mannheim, Germany (*Presenter*) Institutional research agreement, Siemens AG
Erol Tueluemen, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Volker Liebe, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Nils Rathmann, MD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Thomas Henzler, MD, Mannheim, Germany (*Abstract Co-Author*) Research support, Siemens AG; Speaker, Siemens AG
Stefan O. Schoenberg, MD, PhD, Mannheim , Germany (*Abstract Co-Author*) Institutional research agreement, Siemens AG
Martin Borggrefe, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Steffen J. Diehl, MD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To systematically evaluate the safety of irreversible electroporation (IRE) in respect to cardiac safety, using cardiac biomarkers and electrocardiographic (ECG) monitoring.

METHOD AND MATERIALS

Computed tomography (CT) guided IRE ablation was conducted with intention to treat. All patients underwent 12-lead ECG and 24h Holter ECG recording on the day of the IRE procedure to detect procedure related conduction disturbances/arrhythmias. Venous blood samples (BNP, high sensitive Troponin I) were obtained before the procedure as baseline, and 4h and 16h after the procedure to detect cardiac injury. Findings were divided into normal, procedure related minor, procedure related major, procedure unrelated minor and procedure unrelated major.

RESULTS

In 25 patients (10 female, 15 male, mean age 63 years) IRE ablation was conducted in order to treat different malignancies at varying locations (liver: 9, kidney: 8, lung: 4, adrenal gland: 3, soft tissue: 1). A standard ablation protocol was used applying voltages from 2000 to 3000 Volts and currents from 20 to 30 Amperes. After ablation Troponin I elevation was found in 9 (36%), BNP elevation in 19 patients (76%). All patients except one with an elevation in Troponin I, also had a BNP elevation. The ECG and Holter results showed normal findings in 9 (36%) patients, procedure unrelated minor abnormalities in 5 (20%), procedure related minor abnormalities in 9 (36%) and procedure related major abnormalities in 2 (8%) patients (3rd grade AV block and non-sustained ventricular tachycardias). On follow up after three months patients had no residual arrhythmias, or signs of cardiac damage.

CONCLUSION

Our findings suggest that IRE might result in temporary cardiac injury. Thus we strongly recommend the implementation of a cardiac safety protocol consisting of ECG, biomarkers and cardiologic surveillance.

CLINICAL RELEVANCE/APPLICATION

Treatment of patients with IRE requires close collaboration between cardiology and radiology in order to assure patient’s safety.

PHS-TUA

Physics Tuesday Poster Discussions

Tuesday, Nov. 29 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Zheng Feng Lu, PhD, Chicago, IL (*Moderator*) Nothing to Disclose
Chen Lin, PhD, Indianapolis, IN (*Moderator*) Nothing to Disclose

Sub-Events

PH229-SD-TUA2 Comparison of Virtual Monochromatic Energy Images of Dual Energy CT and Images of Conventional 120kVp CT in Reducing Beam Hardening Artifact among Different Venders: A Phantom Study

Station #2

Participants
Rongli Wu, MD, Osaka, Japan (*Presenter*) Nothing to Disclose
Yoshiyuki Watanabe, MD, PhD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuhiko Satoh, MBBS, Osaka, Japan (*Abstract Co-Author*) Nothing to Disclose
Yen-Peng Liao, MSc, Kyoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroto Takahashi, MD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Hisashi Tanaka, MD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriyuki Tomiyama, MD, PhD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The purpose of this study is to compare the beam hardening artifact (BHA) reduction ability of virtual monochromatic energy (VME) imaging obtained with different dual energy computed tomography (DECT) systems with that obtained with conventional 120-kVp CT imaging through a phantom that had a given radiation dose.

METHOD AND MATERIALS

Five pairs of syringes were filled with diluted iodine concentration. Each pair of syringes contained different iodine concentration. The iodine concentration values that were used were: 5, 10, 20, 40 and 80 mg of iodine per milliliter. Each pair of syringes was placed parallel to each other in a torso phantom. Dual energy and the conventional (120 kVp) mode CT images were obtained with three vendors: 1) GE (Discovery CT750 HD), 2) Siemens (Definition Flash) and 3) Toshiba (Aquilion Prime), using approximately identical radiation dose (CDTI =15 mGy). Ten VME (40-130 keV at 10-keV intervals) images were collected calculated from each DECT system. One 25 cm2 of Row-of-Interest (ROI) was placed in the phantom background. The other 2 cm2 ROI was placed between the two syringes, where the darkest beam hardening shadow was generated. The CT number (Hounsfield unit (HU)) difference (Δ HU = HUmiddle - HUbackground) between the 2 ROIs was calculated with each VME and 120kVp image of different iodine concentrations. A comparison was then made with VME and 120kVp CT images

RESULTS

The results of this study find that the magnitude of BHA increased as monochromatic image energy decreased and iodine concentration increased. VME imaging of 40mg and 80mg iodine concentrations was compared with120-kVp CT imaging. The Δ HU of GE DECT system is decreased when monochromatic energy are higher than 50keV ($p = 0.003$), and higher than 60keV ($p < 0.001$), respectively; higher than 80keV ($p < 0.001$), and higher than 70keV ($p = 0.002$), respectively for Siemens DECT system; higher than 40keV ($p < 0.001$), and higher than 60keV ($p < 0.001$), respectively for Toshiba DECT system.

CONCLUSION

The monochromatic images of DECT system scan can help to decrease BHA and provide improved image quality in comparison with conventional 120-kVp mode. The effect of BHA reduction is not consistent with different DECT systems.

CLINICAL RELEVANCE/APPLICATION

DECT may decrease beam hardening artifact (BHA) based on different methods. This research would like to compare commercial vendors and their effects in dealing with BHA of different density materials

PH230-SD-TUA3 Reduction of Coronary Motion Artifact in Monochromatic Imaging at Various Energy Levels using a Motion Correction Algorithm in Electrocardiography-gated Single-source Dual-energy Coronary CT with Fast kVp Switching: Phantom Experiment

Station #3

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PURPOSE

To assess in a phantom the reduction in coronary motion artifact in monochromatic imaging (MI) at various energy levels using a motion correction algorithm (MCA) in ECG-gated single-source dual-energy coronary computed tomography with fast kVp switching (DECCT)

METHOD AND MATERIALS

We performed DECCT scan with and without the MCA (SnapShot Freeze; GE Healthcare) of a phantom model of coronary artery branching (PFCP-1; FUYO Corporation) filled with iodine contrast medium and pulsating at 40 to 100 bpm at 10-bpm intervals, reconstructed MI at 50 to 90 keV at 10-keV intervals using an algorithm blending 40% adaptive statistical iterative reconstruction with 60% filtered back projection. Three readers independently graded coronary motion artifact in 9 segments of the coronary models from one (poor) to 5 (excellent) (3 to 5, interpretable), and we compared grades obtained with and without the MCA using Wilcoxon signed-rank test.

RESULTS

Grades of coronary motion artifact at 70 bpm were 3.4 ± 1.4 without the MCA (and 4.1 ± 0.9 with the MCA) at 50 keV, 3.4 ± 1.4 (4.0 ± 0.9) at 60 keV, 3.4 ± 1.5 (4.0 ± 0.9) at 70 keV, 3.2 ± 1.5 (3.1 ± 1.2) at 80 keV, and 3.0 ± 1.3 (2.8 ± 1.3) at 90 keV. At 50 to 70 keV, the grades were significantly better with the MCA ($P < 0.05$ for all); its use significantly reduced the artifact in MI at 50 to 70 keV and at 40 to 60 and 80 to 100 bpm ($P < 0.05$ for all). At 70 bpm, 67% (6 segments) of segments were interpretable at 50 to 90 keV without the MCA, and 100% (9) at 50 to 70 keV and 67% (6) at 80 to 90 keV were interpretable with the MCA.

CONCLUSION

MI at lower energy levels is useful for reducing coronary motion artifact using the MCA in DECCT.

CLINICAL RELEVANCE/APPLICATION

Use of MI at lower energy levels can reduce coronary motion artifacts with the MCA in DECCT even with low image contrast from reduced contrast medium dose or cardiac function.

PH231-SD-TUA4 Four New Microbubble Formulations and their Subharmonic Response Compared to Three Commercially Available Ultrasound Contrast Agents

Station #4

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PURPOSE

Characterizing the subharmonic response of contrast microbubbles is useful for subharmonic imaging (SHI), especially because lack of subharmonic signal generation in tissues leads to increased contrast to tissue ratio. The purpose of this work was to evaluate the subharmonic response of four new microbubble formulations relative to three commercially available ultrasound contrast agents.

METHOD AND MATERIALS

The 3 commercial ultrasound contrast agents used in this study were Definity (Lantheus Medical Imaging, MA, USA), Sonazoid (GE Healthcare, Oslo, Norway) and SonoVue (Bracco, Milan, Italy). The 4 new microbubble formulations consisted of different configurations of the phospholipid shells (comprised of polyethylene glycol 4000) with different solid weights per vial (25 and 50 mg), different gas compositions (perfluoropropane or a mixture of perfluoropropane and nitrogen) and different microbubble concentration (1.4 to 3.4 billion microbubbles/ml). Equal concentrations of each contrast agent were tested in vitro using a SonixTablet (Analogic Ultrasound, MA, USA) ultrasound scanner and an SA4-2 transducer at four acoustic pressure levels (25-100%) for four transmit frequencies (2.5-4.0 MHz) and four pulse inversion configurations. The pulse repetition frequency was set at 1000 Hz. Acquisitions were repeated ($n = 3$; each iteration for 5 s). Subharmonic amplitudes were extracted as the mean signal amplitude in a 0.5 MHz bandwidth around the theoretical subharmonic frequency and averaged over the acquired pulses. Subharmonic enhancement over baseline (no contrast) conditions and the effect of different parameters were compared.

RESULTS

The subharmonic enhancement for Sonazoid, Definity and SonoVue was 10.8 ± 3.2 dB, 4.8 ± 3.3 dB and 9.7 ± 3.5 dB, respectively whereas it ranged from 8.9 ± 3.7 dB to 11.5 ± 6.5 dB for the 4 new microbubble formulations. ANOVA revealed a significant effect of the 3 transmit parameters as well as the interaction terms on the subharmonic amplitude of the agents used in this study ($p < 0.05$); this effect was dominated by the acoustic pressure parameter.

CONCLUSION

Subharmonic response of the 4 new microbubbles formulations was similar to the commercial ultrasound contrast agents.

CLINICAL RELEVANCE/APPLICATION

Contrast enhanced ultrasound (CEUS) imaging is expanding and amongst the CEUS modes, subharmonic imaging provides a relatively high contrast to tissue ratio and exclusive view of the vasculature.

PH232-SD- Participants

TUA5 Effective Radiation Dose of Perfusion CT Exams of Ovarian Cancer Patients: A Multi-center Study

Station #5

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CONCLUSION

Perfusion CT is a feasible clinical technique in terms of radiation dose for monitoring chemotherapy outcome in ovarian cancer.

Background

ACRIN-6695/GOG-262 demonstrated that perfusion CT could serve as a quantitative biomarker of patient outcome in ovarian cancer chemotherapy. This study aims to determine the effective dose (ED) of radiation from the perfusion CT examinations on the patient cohort.

Evaluation

Materials and MethodsFIGO stage III or IV epithelial ovarian cancer patients underwent perfusion CT exams before (T0) and at 3-(T1) and 4-weeks (T2) after chemotherapy initiation. Scanning protocol involved a noncontrast scan for target lesion localization followed by a two-phased dynamic contrast enhanced scan through the target lesion (i.e. 24 images at 2.8 s intervals, then a 8 images at 15 s intervals acquired at 120 kV and 50 mAs). Scanner accreditation required central review of water phantom images. ED estimates were derived from the DLP (dose length product) using a conversion coefficient for an adult abdominopelvic scan at 120kV. Result228 perfusion CT exams were performed on 76 patients at 19 centers on six different scanner types. Dose data was submitted on 225 exams. 174, 36 and 15 exams from vendors 1, 2 and 3 were represented. Average ED (range) and axial coverage (range) for localizer and dynamic contrast were 6.5 (0.9-28.2) mSv and 316 (110-520) mm and 14.5 (4.9-29.9) mSv and 62 (24-120) mm respectively. The average CTDIvol±standard deviation of the dynamic phase were 129.1±11.8 mGy, 108.0±7.0 mGy and 255.3±120.0 mGy for vendors 1, 2 and 3 respectively ($p<0.001$).

Discussion

ED from perfusion CT exams was below the 50mSv recommended but demonstrated seven-fold variability. Most of this is attributable to axial coverage differences. Average ED of the dynamic contrast scan normalized to axial target lesion coverage ±standard deviation were 2.2±0.6 mSv/cm, 1.9±0.3 mSv/cm and 3.6±1.8 mSv/cm for vendors 1, 2 and 3 respectively ($p<0.001$).

Honored Educators

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Susanna I. Lee, MD, PhD - 2013 Honored Educator

PH233-SD-TUA6 Application of 80kV Combined with Adaptive Statistical Iterative Reconstruction Technique in Low Doselumber CT Examination

Station #6

Participants
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PURPOSE

To assess radiation dose reduction and image quality for lumber CT examination with 80kV combined with adaptive statistical iterative reconstruction (ASiR) technique, compared to a standard 120 kV protocol.

METHOD AND MATERIALS

60 patients who underwent lumber CT scan were randomly separated into two groups: conventional 120 kV group with tube current of 230mA (n=30) and 80kV low dose group with tube current of 230mA (n=30), 80kV group was reconstructed with FBP and 40%ASiR. Image noise and CT value of the L3 vertebral body center level and erector apinae were measured. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) for vertebral body were calculated, according the formulas: SNR=CTver/SD and CNR= (CTver-CTmus)/SD. The volumetric CT dose index (CTDIvol) was recorded for each group. Subjective image quality was evaluated by two radiologists with a 5-point scale.

RESULTS

Compared with the conventional 120 kV protocol, 80kV allowed for an overall average decrease of 72 % in CTDIvol (15.75±0.08 mGy vs 4.40±0.49 mGy, $p<0.05$). The CNR and SNR showed statistical difference between 120kV group, 80kV+FBP group and 80kV+ASiR group (CNR, 1.83±0.58 vs 1.28±0.37 vs 2.04±0.84; SNR, 2.57±0.58 vs 2.00±0.46 vs 2.86±0.90, both $p<0.05$), respectively. The image quality was rated higher in 80kV+ASiR group than other groups (3.57±0.85 vs 3.07±0.83 vs 4.14±0.66, $p<0.05$).

CONCLUSION

80kV combination with 40%ASiR reduced radiation dose nearly by 72% than standard 120 kV protocol and provide better image quality in lumber CT examination.

CLINICAL RELEVANCE/APPLICATION

80kV combination with 40%ASiR can reduced radiation dose significantly and provide better image quality, recommended in lumber CT examination.

PH234-SD-TUA7 Quantitative Assessment of Lean Skeletal Muscle Hydration Using Water-Fat MRI

Station #7

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PURPOSE

To investigate if the hydration of lean muscle tissue can be measured using water-fat MRI.

METHOD AND MATERIALS

Water-fat MRI tissue composition can be described by a three compartment model, i.e. water, fat and MR-invisible tissue. The water intensity (*W*) is proportional to the water proton density (PD) and fat (*F*) to the lipid PD. If a compartment's fat content is known and invisible volume is constant, then W and lean tissue volume should be proportional to the hydration. It should thus be possible to determine the hydration level of a lean tissue based on *W*.11 hemodialysis patients were recruited, whole-body T2* and lipid spectra compensated water-fat MRI images were collected pre/post dialysis. The net fluid drawn (NFD), i.e. machine setting compensated for tubular dead space and ingestion, was logged. Images were acquired on a Philips Ingenia 3T with 10 axial 3D Spoiled GRE stack with alpha=10, TE=1.15, 2.3, 3.35, 4.6 ms, TR 5.8 ms, FOV 340x560 mm2, voxel size 2.5x2.5x4 mm3.Leg and abdominal muscles were segmented automatically (Karlsson, jMRI 2015). *W* and *F* were calibrated using adipose tissue (AT) as an intensity reference (Romu, ISBI 2011), so *F* becomes the AT concentration and *W* is related to the PD of lipids in AT. Based on the average *W* of muscle tissue a hydration ratio $H = W/(t*g)$ was computed; $t=1+(f-fn)$ compensates for the hydration of AT, *f* is the AT fat fractions ($F/(F+W)$) of the patient and fn the normal value; $g=k*F+m$ compensates for fat infiltration, *F* is the average muscle AT concentration, *m* and *k* are set such that $g=H$ in normally hydrated tissue. Thus, $H=1$ in normally hydrated tissue. Determining fn, m and k is beyond the scope of this study, $fn=0.95$, $k=-0.6$ and $m=0.65$ was used. The lean muscle volume (V) and muscle *H* differences was measured pre/post, and tested by paired T-tests.

RESULTS

Mean delta-V was -0.38 L ($p<0.001$), delta-*H* -0.015 ($p=0.015$) and NFD was -1.87 L. The correlation delta-V vs NFD was 0.84, and delta-*H* vs NFD was 0.85.

CONCLUSION

As hypothesized, both V and H decreased when the hydration was lowered through dialysis. To infer over/under hydration further work is needed. However, *H* strongly correlates with hydration.

CLINICAL RELEVANCE/APPLICATION

Potentially regional tissue hydration can be of interest in, 1) treatment of renal disease and congestive heart failure, 2) measuring functional muscle volume by eliminating the effect of swelling.

PH235-SD-TUA8 Development and Clinical Translation of the "Level Check" Algorithm for Decision Support in Spine Surgery

Station #8

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PURPOSE

A 3D2D image registration framework for automatic labelling of vertebrae on intraoperative radiographs ("LevelCheck") is under development for translation to clinical use for decision support in spine surgery. This work describes key advances that improve robustness, accommodate deformation, and allow CT-to-radiograph or MR-to-radiograph registration.

METHOD AND MATERIALS

The registration transforms vertebral labels defined in preoperative CT or MR to intraoperative radiographs via gradient-orientation (GO) similarity and CMA-ES optimization. Robustness of GO was evaluated in clinical images with strong content mismatch. For cases involving preoperative MRI, forward projection involves a simple automatic vertebrae segmentation and the performance for both 3D modalities was evaluated in images from 51 patients. To improve accuracy in the presence of spinal deformation, a multi-stage, locally-rigid, globally-deformable process was implemented in which the registration narrows from N levels to single-level about each vertebrae in parallel. Finally, the clinical utility of the LevelCheck algorithm was evaluated by 3 spine surgeons using a

large retrospective study of 398 radiographs from 198 patients.

RESULTS

GO similarity was shown to outperform other gradient-based metrics, achieving geometric accuracy of 5.5 ± 2.6 mm (median ± iqr). Registration based on preoperative MRI also demonstrated robust performance with accuracy = 4.0 ± 1.9 mm and with 100% success rate. In cases demonstrating strong changes in spinal curvature, the multi-stage framework improved accuracy to 3.0 ± 3.8 mm. Assessment of utility in retrospective review by spine surgeons showed that LevelCheck was "helpful" to the decision process in 42.2% of cases (168/398), and improved confidence in 30.6% of cases (122/398). In no case did the algorithm diminish performance (0/398), supporting its potential as a means of independent check for decision support.

CONCLUSION

The LevelCheck framework has been extended to include more robust similarity metric, operate on preoperative CT or MR, and accommodate spinal deformation. These findings support translation to prospective clinical studies to further evaluate benefits to surgical workflow.

CLINICAL RELEVANCE/APPLICATION

An algorithm for automatic vertebrae labelling in radiographs could provide valuable decision support in target localization and present a potentially useful means against wrong-level spine surgery.

PH009-EB-TUA Characteristic CT Value Changes in Postmortem Brain Analyzed by Statistical Parametric Mapping

Hardcopy Backboard

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Background

Understanding the characteristics of postmortem changes is necessary in the forensic investigation using imaging modalities. Measurement of CT value in manually defined regions of interest is a standard method to examine postmortem changes on brain CT image. However, it requires great effort and time for the entire brain assessment of the CT value changes. The aim of this study was to investigate postmortem changes in the entire brain by voxel-based image analysis with statistical parametric mapping (SPM) technique.

Evaluation

A total of 2073 cases of unenhanced postmortem CT were performed from Jun 2011 to March 2016 at our hospital. This retrospective study included 128 deceased patients (male/female ratio: 72/53, mean age: 72.4 years old) without cerebral abnormality for assessing postmortem changes in the brain. They received postmortem CT within 450 min after death. Their antemortem and postmortem brain CT images were spatially normalized using the CT template image that was constructed from 130 unenhanced brain CT images from living patients (male/female ratio: 67/63, mean age: 69.1 years old). Voxel values of the postmortem CT images were then compared with those of the antemortem CT images using a SPM8 software (Wellcome Trust Centre for Neuroimaging, University College London, UK).

Discussion

Cortical gray matter (GM) showed a rapid decrease of CT values within 70 min after death, indicating cytotoxic edema of GM cells. White matter (WM), basal ganglia, and thalamus showed a delayed increase of CT values in later than 120 min after death, which was different from general findings in acute cerebral infarction. The increased CT value in WM may depend on hypoxic circulation in agonal stage. Accumulation of metal substances may partly explain the increased CT value in basal ganglia and thalamus.

CONCLUSION

SPM technique demonstrated that unclear GM-WM interface on early postmortem brain CT was caused by the rapid decrease of CT value in cortical GM and the delayed increase of CT value in WM. There may be different change between postmortem brain and brain infarction in less than 7 hours.

FIGURE

PHS-TUB

Physics Tuesday Poster Discussions

Tuesday, Nov. 29 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
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Sub-Events

PH237-SD-TUB1 Influences of Pitch Factors and Rotation Times on Response Characteristics of a Tube Current in Chest CT for Infants under a CT-Auto Exposure Control: Phantom Study

Station #1

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CONCLUSION

In considering response characteristic of a tube current under CT-AEC, we strongly suggest that scanning speed of CT should be determined according to a rotation time with the pitch factor of 0.656 or 0.844 in chest CT for infants.

Background

ICRP publication 87 has reported that CT- Auto Exposure Control (AEC) is the most effective to dose reduction of CT examination, in especially pediatric CT. We know from experience that the effect of dose reduction of CT-AEC may change with scan parameters.We investigated the response characteristics of a tube current by phantoms under the examination that high performance AEC is required such as the infant chest CT and analyzed the influence of scan parameters on the response characteristics.

Evaluation

Fig. a shows the location of two acrylics phantoms and an interval. The intervals of 5 - 30 cm were employed. The helical scan protocol was used under the CT-AEC system (Aquilion ONE; Toshiba). Fixed the scan parameters were 32 × 1.0 mm beam collimation, 120 kV x-ray tube voltage, 10 - 500 mA of x-ray tube current and setting AEC parameters were slice thickness 3 mm, standard deviation 12.0 HU with CT-AEC system (SureExposure; Toshiba). We changed the rotation time and pitch factor were 1.0/0.75/0.5/0.35 and 0.656/0.844/1.406, respectively. We evaluated the response characteristic of a tube current of the z-axis direction.

Discussion

CT-AEC system modulated the tube currents from 10 to 500 mA at the 20 cm-interval (Fig. a). In using the pitch factor of 1.406 CT-AEC system was not able to modulate the tube currents at the rotation time of 0.5 sec/rot (Fig. b). At the pitch factor of 0.844, as rotation time becomes longer the response of a tube currents becomes better (Fig. c). From above results the best combination of the pitch factor/ the rotation time, was 0.844/0.5 (Fig. d). The table speed was 49.6 mm/sec in this combination. If faster table speed was required, a shorter rotation time should be chosen. If the pitch factor of 1.406 is chosen, the patent dose reduction can't be expected.

PH238-SD-TUB2 Organ Dose Evaluations Based on Monte Carlo Simulation and In-phantom Dosimetry for Interventional Radiology

Station #2

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PURPOSE

The aims of this study were to evaluate organ doses determined using Monte Carlo (MC) simulations for X-ray fluoroscopy and digital subtraction angiography in transcatheter arterial chemoembolization (TACE) procedure for hepatocellular carcinoma (HCC) and to validate the values through comparisons with the doses measured using in-phantom dosimetry.

METHOD AND MATERIALS

Fluoroscopy and angiography were performed with tube voltage of 70 and 80 kVp, added filtration of 0.5 mm copper and 1.8 mm aluminum, tube current of 47 and 160 mA, exposure time of 10.3 and 3.3 seconds, respectively. X-ray projection angles were posteroanterior (PA) for fluoroscopy, and PA and 30-degree right anterior oblique (RAO 30°) for angiography. The entrance skin doses (ESD) and organ doses were measured using 200 radio-photoluminescence glass dosimeters located at various organ positions on and within an adult anthropomorphic phantom. Dose-area products (DAPs) for fluoroscopy and angiography were also measured. For dose simulations, dose distribution images were obtained by inputting the geometry of a digital angiography system (Infinix; Toshiba Medical Systems, Japan), fluoroscopic and angiographic parameters and CT images of the phantom into MC

simulation software (ImpactMC; CT Imaging, Germany). Organ doses for each organ were determined from dose values at the corresponding dose measurement positions on the dose distribution images.

RESULTS

Measured ESD and DAP were 8.1 mGy and 3.1 Gy cm2 for fluoroscopy, 71.2 mGy and 28.9 Gy cm2 for PA angiography and 68.4 mGy and 30.0 Gy cm2 for RAO 30° angiography. Relative differences between the simulated and measured doses were 5.1% for fluoroscopy, 4.3% for PA angiography and 1.7% for RAO 30° angiography. The relative differences were 9.2% to 11.3%, 5.1% to 11.0% and 8.9% to 14.0% for liver, stomach and colon within x-ray irradiated region in fluoroscopy, PA and RAO 30° angiography, respectively.

CONCLUSION

This study showed that the simulated and measured organ doses agreed well. The doses determined using MC simulation will be useful for the evaluation of organ doses and the estimation of radiation risks for individual patients in TACE procedures for HCC.

CLINICAL RELEVANCE/APPLICATION

MC dose simulation will be useful for the real-time dose estimation for individual patients in fluoroscopy and angiography for interventional radiology.

PH239-SD-TUB3 Comparative Evaluation of Super-Resolution Methods Using Sparse Coding and Deep Convolutional Neural Network for Improving Image Quality of Extended Images in Chest Radiography

Station #3

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PURPOSE

Radiologists detect small diagnostic signals such as lung nodule with zooming on a detail, however simple image magnification methods tend to generate over-smoothed images with jagged artifact. The purpose of this study was to improve the image quality of extended images in chest radiography using learning-based Super-Resolution (SR) techniques.

METHOD AND MATERIALS

One hundred fifty four radiographs (matrix size: 2048x2048, pixel size: 0.175 mm, and 12 bits) with nodules (average diameter±std: 17.24±7.50 mm, diameter range: 5-60 mm) from Japanese Society of Radiological Technology dataset were used for this study. We applied two SR methods, Sparse Coding Super-Resolution (ScSR) and Super-Resolution Convolutional Neural Network (SRCNN). ScSR constructs extended images by embedding optimal patches selected from a dictionary, coupled high and low resolution images represented as downscaled images of high resolution ones. SRCNN constructs using directly learned end-to-end mapping, represented as a deep convolutional neural network that takes the low resolution image as input and outputs as the high resolution one. In our study, we magnified cropped images focused on nodules (matrix size: 320x320) up to 2 times (x2.0) and 4 times (x4.0). We compared the image quality of SR schemes and the traditional enlarging schemes, Nearest Neighbor (NN) and Bilinear (BL) interpolations. Image noise was evaluated quantitatively by measuring peak signal-to-noise ratio (PSNR) and image perceived quality was also evaluated by computing structural similarity (SSIM).

RESULTS

In SR schemes (x2.0), the mean±std of PSNR for ScSR and SRCNN were 41.47 ± 2.34 dB and 41.82 ± 2.49 dB respectively, which were higher than those of NN (39.87 ± 2.24 dB, $p<.001$ and $p<.001$ respectively), and BL (40.39 ± 2.32, $p<.001$ and $p<.001$ respectively) and those of SSIM for ScSR and SRCNN were 0.944 ± 0.028 and 0.947 ± 0.029 respectively, which were higher than those of NN (0.924 ± 0.033, $p<.001$ and $p<.001$ respectively), and BL (0.928 ± 0.035, $p<.001$ and $p<.001$ respectively), followed the same trend for 4 times (x4.0).

CONCLUSION

SR methods significantly outperformed traditional interpolation methods in observing small lung structures in chest radiographs.

CLINICAL RELEVANCE/APPLICATION

SR methods can provide substantial high image quality of enlarged images on chest X-rays, leading to more accurate diagnosis of small lung diseases.

PH240-SD-TUB4 XACT:A Novel Imaging Modality for Breast in 3D

Station #4

Participants
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PURPOSE

Exposure to radiation increases the lifetime risk of cancer. We have proposed a new imaging paradigm, X-ray induced acoustic computed tomography (XACT). Applying this innovative technology to breast imaging, an X-ray exposure can generate a 3D acoustic image with high spatial resolution, which dramatically reduces the radiation dose, while still maintaining the imaging

performance.

METHOD AND MATERIALS

Theoretical calculations are done to determine the X-ray energy and ultrasound frequency in breast XACT. Taking the unique advantages of XACT, a low energy X-ray(20 Kev) and a high frequency ultrasound (5.5 MHz) can be employed in breast imaging, which offers better imaging contrast for soft tissues and spatial resolution for breast calcification detection. A series of breast CT image along the coronal plane with calcifications in the breast tissue are used as the source image. The skin, adipose tissue, glandular tissue, breast calcification, and chest bone are segmented from each image. X-ray dose deposition in each pixel is calculated based on the tissue type by using GEANT4 Monte Carlo toolkits. The initial pressure rise caused by X-ray energy deposition is calculated and the propagation of XA waves are simulated by MATLAB K-Wave toolkit. Breast XACT images are reconstructed from the recorded time-dependent XA waves by a filtered back-projection algorithm.

RESULTS

For a breast with 16cm diameter at the chest wall, the effective energy of pulsed X-ray source and the center frequency of ultrasound detector are determined as 20KeV and 5.5MHz. High contrast between the calcification and the background glandular tissue can be acquired from XACT. The spatial resolution for breast calcification detection reaches ~100μm. The location and shape of the calcification can be clearly identified from the XACT image of 3D breast volume.

CONCLUSION

XACT technique takes the advantages of high X-ray absorption contrast and high ultrasonic resolution. With the proposed innovative technique, one can potentially reduce the radiation dose to patient in 3D breast imaging as compared with current X-ray modalities, while still maintaining the high imaging contrast and spatial resolution.

CLINICAL RELEVANCE/APPLICATION

This technique has the potential for breast cancer screening and imaging with high contrast and spatial resolution.

PH241-SD-TUB5 Initial Study of Dose Reduction and Image Quality in Abdominal CT using Prospective Adaptive Statistical Iterative Reconstruction-V Technique

Station #5

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PURPOSE

To evaluate the dose reduction and image quality with the application of prospective adaptive statistical iterative reconstruction-V (ASiR-V) in the abdominal CT scan on GE Revolution CT.

METHOD AND MATERIALS

Totally 132 patients with BMI above 20 in our hospital underwent abdominal contrast-enhanced CT scan on GE Revolution CT were randomly divided into four groups using prospective ASiR-V technique (0%, 20%, 40%, 60%). All the scans were used the same parameters as tube voltage of 120kV, automatic mA modulation of 10-500mA and noise index (NI) of 10. To measure the SD value of fat as image noise in three different locations of the abdomen: right branch of portal vein, left renal artery and navel. CT dose index volumes (CTDI vol), dose length product (DLP) were recorded from dose report, and effective dose (ED) was calculated. The image quality was evaluated by two experienced abdominal radiologists blindly and independently with a five-point scale (1 for poor and 5 for excellent). CTDI vol, ED, average image noise and average image score were compared with ANOVA.

RESULTS

There was statistical difference of CTDI vol and ED between each group. Images of the 60% ASiR-V yielded relatively lowest objective image noise (SD=7.57±0.71, P=0.02<0.05), significantly lowestCTDI (3.48±1.08mGy, P=0.00<0.05) and ED(2.72±0.93mSv, P=0.00<0.05), compared with other groups. However, the subjective image quality of the 60% ASIR-V scores was poorest (2.33±0.60, P=0.000<0.05) and could not meet the diagnostic requirement while images of other three groups(0%, 20%, 40%ASiR-V) were qualified to make the diagnosis. There was no significantly difference in image noise and subjective image quality between 0% , 20% and 40% ASiR-V, SD values were 8.13±0.93 VS 8.05±0.91 vs 7.70±0.74 (P=0.69>0.05) and image quality scores were 4.79±0.42 VS 4.67±0.48 vs 4.27±0.67 (P=0.37>0.05).

CONCLUSION

Images of prospective 60% ASiR-V provided the lowest SD values, CTDI vol and ED in all the groups, but the poorest image quality and could not meet the diagnostic requirement. Images obtained from 40% ASiR-V had the similar objective image noise and subjective image quality with 0%,20% ASiR-V, produced lower radiation dose. 40% ASiR could be recommended on the abdominal CT scan.

CLINICAL RELEVANCE/APPLICATION

Prospective ASiR-V technique is a promising method to reduce radiation dose and maintain relatively good image quality during abdominal CT scan and may represent a new clinical option.

PH242-SD-TUB6 Creation of Realistic Structured Backgrounds using Adipose Compartment Models in a Test Object for Breast Imaging Performance Analysis

Station #6

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PURPOSE

To create a realistic, structured background for a breast imaging test object based on 3D printed volumes representing adipose compartments.

METHOD AND MATERIALS

In previous work, models of manually segmented breast adipose compartments were generated and characterized from CT images of a mastectomy specimen. Based on this work, a collection of segmented compartments (of average size 12-29 mm) was printed with a stereolithographic 3D printer (FORM 1+, formlabs, Somerville, MA) using formlabs Clear Resin. The printed models were placed in a semi-cylindrical container, 48 mm thick, filled with water. Mammographic and tomosynthesis images were acquired under automatic exposure control. The resulting images were evaluated in terms of power spectra (PS) and other quantitative and qualitative means. The results were compared to PS from 80 patient images, and a previous structured background phantom with various sized acrylic spheres in water.

RESULTS

Visual inspection shows that the phantom images demonstrate a strong resemblance to breast structure. Power spectra for mammographic images of the phantom are close to the average patient PS at very low spatial frequencies (<0.2mm-1); the phantom PS is lower than the patient PS at higher spatial frequencies (0.2-0.7mm-1). The power law exponent (β), a quantitative descriptor of the parenchymal texture, was superior for the compartment-based phantoms vs. sphere-based phantoms; β = 3.8 for the compartments, and 2.8 for the spheres, versus 3.4 for patient mammograms. Modifications of the compartment model aimed at improving the agreement with the patient data may include the use of less dense print material to increase the contrast of the compartments, inclusion of smaller compartments by downscaling the existing models, and refining the compartment segmentation method.

CONCLUSION

A mixture of printed adipose compartments was developed as a concept for the creation of an anthropomorphic 3D structured background in a test object for breast imaging performance analysis.

CLINICAL RELEVANCE/APPLICATION

We present a new means of creating 3D structured backgrounds aimed at improving the realism of test objects for breast imaging, based on 3D printed adipose compartments segmented from clinical images.

PH243-SD-TUB7 An Interaction-free Second Pass Cardiac Motion Compensation Method

Station #7

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PURPOSE

A user interaction-free approach is introduced for motion compensated CT coronary angiography reconstruction. This second pass correction method can be switched on whenever motion artefacts due to strong motion or sub-optimal cardiac phase selection show up in cardiac CT scans. Its fully automatic processing can be applied to prospectively-triggered (Step-and-Shoot) as well as retrospectively gated helical cardiac CT scans to improve the assessment of coronary arteries.

METHOD AND MATERIALS

A time series of cardiac CT volume images is first reconstructed at different phase points in the cardiac cycle. For helical scans a temporal distance of 5% cardiac cycle has been chosen for the time series. When using Step-and-Shoot data sets partial scan reconstruction is used to generate a sequence of images from an angular range of 360°. Vessel features are enhanced in the reconstructed images by a ray-casting vessel filter. Using elastic image registration, dense motion vector fields are calculated for the different cardiac phases for the whole heart. The resulting motion vector fields are included in the motion compensated reconstruction and interpolated in the time domain to cover the temporal projection range required for reconstruction. The method is applied to clinical datasets with high heart rate (> 70 bpm) acquired with a 256-slice CT scanner (iCT, Philips Healthcare, Cleveland, USA) using both helical and Step-and-Shoot data acquisitions.

RESULTS

The method achieves motion artifact reduction for both helical and Step-and-Shoot cardiac CT data sets. Improved delineation and segmentation of the coronary arteries is feasible from motion compensated cardiac CT volumes compared to gated reconstructions. The method does not require user interaction.

CONCLUSION

User interaction-free motion compensated reconstruction is feasible using vessel filtering and image based registration for motion estimation. Improved image quality can be achieved in CT coronary angiography.

CLINICAL RELEVANCE/APPLICATION

Motion compensated reconstruction yields reduced artefact levels in helical and step and shoot coronary CT angiography.

PH244-SD-TUB8 Adaptive Optimization of the Number of OSEM Subsets improves Image Quality and Lesion Detectability in Time-of-Flight FDG PET

Station #8

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PURPOSE

While OESM iterative reconstruction has been widely utilized as the standard for clinical time-of-flight (TOF) PET image quality and lesion detectability may vary with changing patient size, dose administration, voxel size, and scanner type. In order to harmonize the approach to determine this important recon parameter, we developed an optimization strategy for the number of subsets (#S) to consistently improve image quality and lesion detectability in FDG PET.

METHOD AND MATERIALS

With the introduction of next generation digital PET, we started with previous default setting of #S=29 despite the fact that the TOF timing resolution improved from 550ps to 325ps. We used 30 wholebody FDG PET cases having a total of 109 lesions for analysis. PET imaging was reconstructed using different voxel volumes 64mm3 (SD), 8mm3 (HD) and 1mm3 (UHD) and with varying #S from 1 to the default 29. Quantitatively, ROIs on liver and lesions were placed with SUV and STDEV measured together with penalty scores being assigned for images based on noise levels. Visually, blinded image reviews were performed with 5-level scores (1-worst to 5-best) determined by professional readers. All results were evaluated and compared including consideration for patient size.

RESULTS

Using the default 29 subsets let to inadequate image quality when imaging was performed using 325ps TOF (dPET) compared to the previous 550ps TOF cPET. Apparently, the iterative convergence is different which leads to increased apparent noise on images, particular in the liver, decreased image quality and deteriorated lesion detectability. We found, that lower #S substantially resolved these issues and let to improved image quality. The most favorable #S was found to be dependent on several aspects such as BMI and relative count density indicating that an adaptive reconstruction approach should be considered with variable #S. Overall, 15 subsets was found to be most preferable for SD, 13 for HD and 9 for UHD recon.

CONCLUSION

Adaptive optimization of iteration subsets is essential to capitalize on TOF image quality improvements as the recon remains dependent on relative county density factors (Dose, BMI etc.).

CLINICAL RELEVANCE/APPLICATION

Contrary to current standards, adaptive subset reconstruction approaches are essential to leverage advanced TOF technology to achieve best image quality and quantitative accuracy.

PH245-SD-TUB9 Assessment of Anal Fistulas with T2 Weighted BLADE Sequence

Station #9

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CONCLUSION

Fat sat T2 weighted BLADE and contrast enhanced FSE T1weight sequences' diagnostic quality were equal to each other for the diagnosis of perianal fistule. BLADE was significantly superior to TSE regarding motion artifacts, vasculary flow phenomena, and other artifacts.

Background

The aim of the present study was to prospectively compare overall image quality, contrast, and diagnostic information of the recently implemented T2-weighted BLADE TSE sequence with fat saturation and contrast enhanced T1-weighted TSE sequence and T2-weighted TSE with fat saturation sequence for perianal fistulas.

Evaluation

Twenty three consecutive patientswith the clinical diagnosis of anal fistul.MRI was performed in supine position on a 1.5-T wholebody scanner (Magnetom Avanto; Siemens Healthcare, Erlangen, Germany) using a six-channel phased array body coil. MR images were evaluated separately by two radiologists, and all images were presented in random order to each of the readers and were evaluated on a three-point scale for various criteria defining image quality. Statistical evaluations were performed by using the Wilcoxon and the 2 test; differences with P .05 were regarded as statistically significant. Finally, readers were asked to indicate their preferred sequence (T2weighted BLADE TSE or T2-weighted TSE or contrast enhanced T1-weighted TSE sequence) and the view (sagittal or coronal or axial) taking into account the diagnostic performance and overall contrast. If no difference

was visible equal ranking was allowed.

Discussion

Using the Fat sat T2 weighted BLADE sequence for pelvic imaging proved to be advantageous to reduce various kinds of artifacts. To use Diffusion-weighted imaging as an adjunct to T2-weighted imaging in the diagnosis of anal fistulae , especially for patients who have risk factors for IV contrast agents, increase the radiologist's level of confidence and to add value imaging.

PH121-ED-TUB10 Easy Understanding of the Technical Aspects of Computed Diffusion-weighted Image (cDWI) for Radiologists

Station #10

Awards
Identified for RadioGraphics

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TEACHING POINTS

Computed diffusion-weighted images (cDWIs) are virtual DWIs calculated from actual DWIs using two arbitrarily selected low b-values. cDWI is advantageous because images can begenerated on MR scanners that do not allow the acquisition of high b-value DWIs. cDWI can also reduce the scan time and lower the image noise when DWIs are acquired with routinely-used b-values. We easily demonstrate the technical aspects and applications relating to the cDWIs.

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Basic knowledge about diffusion weighted image Principle of computed diffusion weighted image Advantages and limitations of computed diffusion weighted image Clinical applications of computed diffusion weighted image

SSJ21

Physics (Ultrasound)

Tuesday, Nov. 29 3:00PM - 4:00PM Room: S403A

US PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

FDA Discussions may include off-label uses.

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Sub-Events

SSJ21-01 Monitoring Neoadjuvant Chemotherapy Response of Breast Cancer using 4D Subharmonic Aided Pressure Estimation and Imaging with Ultrasound Contrast Agents

Tuesday, Nov. 29 3:00PM - 3:10PM Room: S403A

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PURPOSE

To determine if 4D subharmonic aided pressure estimation (SHAPE) and imaging (SHI) can predict the response of breast cancer to neoadjuvant chemotherapy based on changes in interstitial fluid pressures and breast tumor vascularity.

METHOD AND MATERIALS

Seventeen patients scheduled for neoadjuvant therapy of a localized breast cancer underwent 4 ultrasound exams: immediately prior to therapy, at 10%, 60%, and 100% completion of chemotherapy. The exams were performed using a modified Logiq 9 scanner with a 4D10L probe (GE Healthcare, Milwaukee, WI). Modified software enabled RF data collection from 4D subharmonic imaging (transmitting pulses at 5.8 MHz and receiving at 2.9 MHz) before and during infusion of the contrast agent Definity (Lantheus Medical Imaging, N Billerica, MA) at acoustic settings optimized for SHAPE and SHI separately. The maximum subharmonic frequency magnitude and mean subharmonic intensity were calculated from the RF data of SHAPE and SHI, respectively, for all 4 exams. The relative signal differences in the tumor relatively to the surrounding area were then compared according to the final tumor treatment response.

RESULTS

Four patients left the study and 2 patients' data were discarded due to technical problems. Patients' clinical outcomes consisted of 6 complete responders (final tumor size < 10% of the original) and 5 partial/non responders. The results from 10% completion of the therapy showed the subharmonic signal increased more in the tumor than in the surrounding area for complete responders compared to partial/non responders (3.23 ± 1.41 dB vs. -0.88 ± 1.46 dB; p = 0.001 from SHAPE and 1.32 ± 0.73 dB vs. -0.82 ± 0.88 dB; p = 0.002 from SHI). Also the relative subharmonic signal in the tumor increased for complete responders, but decreased for partial/non responders after 10% completion of the therapy relatively to that before the therapy. Moreover, 3 patients whose tumor size increased after 10% completion of the therapy were predicted by SHAPE and SHI to be complete responders.

CONCLUSION

4D SHAPE and SHI have the potential to predict neoadjuvant chemotherapy response of breast cancer as early as at 10% completion of the therapy; albeit based on a small sample size.

CLINICAL RELEVANCE/APPLICATION

It may be possible to predict neoadjuvant chemotherapy treatment response of breast cancers prior to changes in tumor size using contrast-enhanced SHI or SHAPE.

SSJ21-02 Shear Wave Speed Measurement with Point Shear-Wave Elastography and MR Elastography: A Phantom Study Compared with Rheometer Measurement

Tuesday, Nov. 29 3:10PM - 3:20PM Room: S403A

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PURPOSE

To compare shear-wave speed (SWS) measured by US-based point shear-wave elastography (pSWE) using acoustic radiation force impulse (ARFI) technology and magnetic resonance elastography (MRE) on phantoms with known shear modulus, and to assess the method validity and variability.

METHOD AND MATERIALS

Five homogeneous phantoms of different stiffness were made for this study. Their shear modulus was physically measured by rheometer, and this value used as standard. Ten SWS measurements were obtained with 1.0 – 4.5 MHz convex (4C1) and 4.0 – 9.0 MHz linear (9L4) transducers using pSWE, at four different depths each (2, 4, 6, 8cm for 4C1 transducer and 1, 2, 3, 4 cm for 9L4). Spin-echo echo planar imaging (SE-EPI) MRE was carried out once per phantom, and SWS at five different depths (2, 3, 4, 5, 6 cm) was obtained. These SWS were then compared with those obtained by rheometer using linear regression analyses. Repeatability of the 10-repeat pSWE measurement was assessed with single–measure intraclass correlation coefficient (ICC).

RESULTS

From rheometer measurement, the SWS of each phantom was 1.41, 2.23, 3.01, 3.56, and 4.86 m/s. In pSWE, measurement error occurred more than 50% at a depth of 1 cm with the 9L4 and at 2 cm with the 4C1 transducer. Therefore, the data at these depths were abandoned. SWS' obtained with both pSWE as well as MRE had strong correlation with these obtained using a rheometer ($R2 > 0.97$). ICC of SWS measurement with pSWE was more than 0.93 for all measurements with the 9L4 and 4C1 transducers. The relative difference in SWS between those procedures was from -25.2% to 25.6% for all phantoms, and from -8.1 to 6.9% when the softest and hardest phantoms were excluded. Depth-dependent bias was found in the 9L4 transducer of pSWE and MRE.

CONCLUSION

SWS' from pSWE and MRE showed a strong correlation with rheometer-determined SWS. Although based on phantom studies SWS' obtained with these methods are not always equivalent, the measurement can be thought of as reliable and these SWS' were reasonably close to each other for the middle range of stiffness within the measurable range.

CLINICAL RELEVANCE/APPLICATION

pSWE and MRE gave similar SWS for the middle range of stiffness within the measurable range, on the other hand, SWS' obtained with these modalities were not equivalent for the extremes of the total measurement range.

SSJ21-03 Improved Measurement of Portal Pressures Using Subharmonic Contrast Imaging and Pulse Shaping

Tuesday, Nov. 29 3:20PM - 3:30PM Room: S403A

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PURPOSE

To analyze the effect of pulse shape on the sensitivity of subharmonic aided pressure estimation (SHAPE) *in vitro* and *in vivo*, and using SHAPE to estimate portal pressures in patients undergoing a transjugular liver biopsy compared to the hepatic venous pressure gradient (HVPG).

METHOD AND MATERIALS

A Logiq 9 ultrasound scanner with a 4C curvi-linear probe (GE, Milwaukee, WI) was used to acquire radio frequency data. The SHAPE mode was set to transmit 4 cycle pulses at 2.5 MHz and receive subharmonic signals at 1.25 MHz. The contrast agent Sonazoid (GE, Oslo, Norway) was infused at a rate of 0.024 µL/kg/min. Eight different pulse waveforms (3 narrowband and 5 broadband) were implemented and tested *in vitro* and *in vivo* in 3 canines. Sensitivity of the pulses for SHAPE was based on the decrease in the subharmonic signal amplitude with increasing ambient pressure and correlation coefficients. Next, 43 transjugular liver biopsy subjects were enrolled as part of an ongoing IRB approved protocol. Post biopsy, patients received an infusion of Sonazoid. An ROI within the portal vein was selected and an automated power control algorithm was initiated to determine the optimal acoustic output power for maximum SHAPE sensitivity. Cine loops were collected in triplicate, averaged and compared to the HVPG.

RESULTS

A linear decrease in subharmonic amplitude with increased pressure was observed for all waveforms (r from -0.77 to -0.93; $p<0.001$) *in vitro*. Data from 1 of the 3 canines was eliminated for technical reasons, while the other 2 produced similar results to

those obtained *in vitro* (r from -0.72 to -0.98; p<0.01). Overall, the broadband pulses performed better (p<0.05). Within the broadband group, the Gaussian windowed binomial filtered square wave was the most sensitive. The linear relationship between the SHAPE gradient (obtained with the new pulse) and HVPG over the patient dataset showed a good correlation (r = 0.72).

CONCLUSION

Pulse shaping can greatly improve the sensitivity of SHAPE. A Gaussian windowed binomial filtered square wave gives the highest correlation between changes in subharmonic amplitude of the microbubbles and ambient pressure changes. Results in patients indicate SHAPE may be useful for estimation of portal pressures.

CLINICAL RELEVANCE/APPLICATION

It may be possible to noninvasively quantify portal vein pressures and accurately diagnose portal hypertension using SHAPE.

SSJ21-04 A Novel Wearable Fluorescence Surgical Navigation System for Segmentectomy

Tuesday, Nov. 29 3:30PM - 3:40PM Room: S403A

Participants
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PURPOSE

Recently, segmentectomy has become a secure and effective treatment for certain small, early-stage lung cancer, especially in patients with emphysema. To achieve complete segmentectomy, it is critical to precisely identify adjacent lung segments, which is difficult for surgeons without suitable interventions. Thus, a novel technique by transbronchial or intravenous injection of indocyanine green (ICG) has been developed, which can efficiently avert needless resection, lower the costs and reduce complications. However, lack of intraoperative fluorescence imaging systems has seriously impeded the further development of this method. So, we developed a novel wireless wearable fluorescence surgical navigation system (WFNS).

METHOD AND MATERIALS

WFNS is composed of a laptop, Google glass, light source and handle, which consists of a filter, C mount lens and CCD camera. Firstly, NIR light excited by the light source transmitted through the filter, illuminated the target and then was collected by the NIR camera installed in the handle. An application was written to capture real-time images. Finally, the result was displayed simultaneously on the Google glass in real-time mode at video-rate capacity of 20 frames per second, which was achieved by synchronizing the Google glass with the laptop.

RESULTS

Twelve swine were equally divided into two groups. Group A was injected with 0.2mg/kg ICG into the marginal ear vein and Group B was injected with 0.6mg/kg ICG. Five seconds later after injection, the black-and-white transition borders among the targeted segment and the non-targeted segments were easily recognized visually in all swine. Real-time videos were displayed on the prism screen of the Google glass during the surgery. Using ImageJ (Image Processing and Analysis Application in Java), the corresponding SBR of the two groups (Group A and Group B) were 9.00±0.70 and 8.96±1.23 respectively. The NIR fluorescent images of Group A lasted ten minutes and those of Group B lasted up to fourteen minutes until the SBR was 1. Besides, the surgical field was 200 mm×200mm.

CONCLUSION

This study demonstrates our system has major advantages in identifying intersegmental planes and potentials in determining the margin of tumors.

CLINICAL RELEVANCE/APPLICATION

(dealing with segmentectomy)"A novel wearable fluorescence surgical navigation system can be used to conduct segmentectomy for certain small, early-stage lung cancer, especially in patients with emphysema."

SSJ21-05 Clinical Evaluation of Real-Time Optical Tracking to Provide Feedback During Blinded Contrast-Enhanced Ultrasound Imaging

Tuesday, Nov. 29 3:40PM - 3:50PM Room: S403A

Participants
Ahmed El Kaffas, PhD, Palo Alto, CA (*Presenter*) Co-founder, Oncoustics
Renhui Gong, Palo Alto, CA (*Abstract Co-Author*) Nothing to Disclose
Rosa Maria Silveira Sigrist, MD, Palo Alto, CA (*Abstract Co-Author*) Nothing to Disclose
Juergen K. Willmann, MD, Stanford, CA (*Abstract Co-Author*) Research Consultant, Bracco Group; Research Grant, Siemens AG; Research Grant, Bracco Group; Research Grant, Koninklijke Philips NV; Research Grant, General Electric Company; Advisory Board, Lantheus Medical Imaging, Inc; Advisory Board, Bracco Group
Dimitre Hristov, PhD, Stanford, CA (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV Partner, SoniTrack Systems, Inc

CONCLUSION

To the best of our knowledge, this study is the first to demonstrate the feasibility of tracking for 3D DCE-US to provide feedback during lengthy scan sessions.

Background

Current commercial matrix transducers for 3D Dynamic Contrast-Enhanced Ultrasound (3D DCE-US) do not display side-by-side B-mode and contrast-mode images, thus leaving the operator with no position feedback during lengthy acquisitions. The purpose of this study was to demonstrate the feasibility of using tracking to provide positioning feedback and to assess resulting improvements

in maintaining imaging position.

Evaluation

A tracking system was developed in house using infrared camera (Polaris, NDI, Canada) and a 3D-printed tracking target attached to a X6-1 matrix transducer. Cameras were connected to a PC, enabling real-time streaming of transducer coordinates and display of virtual probe on a separate screen. The tracking system captures a reference position to provide operators positioning feedback when no B-mode image is available. To test this set-up, five experienced operators were asked to locate an image landmark within a healthy volunteer liver in B-mode images using the X6-1 connected to an EPIQ7 system (Philips, Bothell, WA). Operators were then asked to maintain the transducer position for 4 min under three feedback methods: i) B-mode, ii) display of real-time virtual transducer, iii) blind. The magnitude of displacement of a voxel over the cine was computed relative to the reference position as an estimate of the imaging position error.

Discussion

Results suggest that tracking can assist operators maintain a position during a lengthy acquisition. An average displacement of 3.75 mm with standard deviation (S.D.) of 3.31 mm and displacement histogram skewness of -0.18 was noted when using B-mode feedback. When blinded, an average displacement of 4.58 mm (S.D. 2.65 mm; skewness 6.19) was noted. In contrast, the average displacement for tracking-feedback was comparable to that from B-mode at 3.48 mm (S.D. 0.8 mm; skewness 0.09). One operator performed better with tracking than B-mode; one operator performed better blinded than with tracking and B-Mode.

SSJ21-06 An Experimental Study for the Evaluation of the Photoacoustic Effect of Pectin-melanin Admixture in the Subcutaneous Muscle Layer and Liver of Rat as a Long-retaining Inoculating Photoacoustic Contrast Agent

Tuesday, Nov. 29 3:50PM - 4:00PM Room: S403A

Participants
Won Jae Lee, MD, Seoul, Korea, Republic Of (*Presenter*) Research Grant, Samsung Electronics Co, Ltd
Hyo Keun Lim, MD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate the feasibility of biocompatible pectin-melanin admixture to be used as a long-retaining, inoculating photoacoustic (PA) contrast agent by comparing the sustainability for the PA effect of melanin alone and pectin-melanin admixture in the subcutaneous muscle layer and liver of rat.

METHOD AND MATERIALS

Two types of biocompatible PA contrast agents, i.e., the 'melanin alone' (3% melanin) and 'pectin-melanin admixture' (2% pectin and 3% melanin) were inoculated into two organs, i.e., the subcutaneous muscle (hypovascular) and liver (hypervascular) of 40 rats so that each contrast agent was inoculated into ten of each organ. PA imaging was obtained every week after the contrast inoculation for four weeks, and analyzed qualitatively (the presence of PA signal) and quantitatively (the measurement of relative PA signal intensity). PA imaging was performed with a L5-13 linear array transducer (Accuvix A30, Samsung Medison, Seoul, Korea) combined with a Nd:YAG laser (Phocusmobile, Optek, USA).

RESULTS

Both 'melanin alone' and 'pectin-melanin admixture' groups showed persistent PA signals during four weeks when inoculated into the subcutaneous layer, while only 'pectin-melanin admixture' group showed persistent PA signals during four weeks when inoculated into the liver.

CONCLUSION

The biocompatible 'pectin-melanin admixture' can be used as a long-retaining, inoculating PA contrast agent, regardless of the organ vascularity.

CLINICAL RELEVANCE/APPLICATION

If this biocompatible PA contrast agent becomes available clinically, PA imaging combined with this contrast agent can be used for pre- or intra-operative localization of various cancers such as breast cancer and liver metastasis after chemotherapy.

SSJ22

Physics (Nuclear Medicine, SPECT and PET)

Tuesday, Nov. 29 3:00PM - 4:00PM Room: S403B

NM PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Moderator*) Research Grant, General Electric Company; Co-founder, PET/X LLC
Chien-Min Kao, PhD, Chicago, IL (*Moderator*) Stockholder, Walgreens Boots Alliance, Inc

Sub-Events

SSJ22-01 Coincidence Imaging of In-111: A Monte Carlo Simulation

Tuesday, Nov. 29 3:00PM - 3:10PM Room: S403B

Participants
Raymond B. Pahlka, PhD, Houston, TX (*Presenter*) Nothing to Disclose
Srinivas C. Kappadath, PhD, Houston, TX (*Abstract Co-Author*) Research Grant, General Electric Company
Osama R. Mawlawi, PhD, Houston, TX (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG

CONCLUSION

This work demonstrates that coincident imaging of In-111 using a clinical gamma camera is possible. Further work to determine optimal clinical applications and conducting measurements on a physical scanner is ongoing.

Background

The decay of In-111 results in a gamma-ray cascade of two photons. Because the gamma-rays are emitted in succession, we consider the concept of employing the gamma-ray coincidence to provide additional information about the decay and its environment. Gamma cameras operated in coincidence mode have been used successfully to image PET tracers, however the concept of producing images from gamma cameras using cascaded gamma-rays in coincidence from In-111 has not been previously explored. Coincidence images can provide three-dimensional (3D) information in planar gamma camera studies, and can complement information obtained in tomographic acquisitions. This work provides the foundation for exploring coincidence imaging with In-111 by producing some simple images and evaluating some important basic considerations including the source activity and timing window resolution, for future studies.

Evaluation

GEANT4 was used to model a gamma camera and to simulate the decay of the In-111 nucleus. A point source of In-111 was simulated to evaluate the true coincidence efficiency. We use a simple reconstruction algorithm to produce images when the detector heads are positioned at 90°. The decay vertex is computed by projecting a ray from each interaction point, normal to each detector face, then finding the point of minimum separation. To test the algorithm, images are produced from reconstructed coincident events from point sources positioned at the camera isocenter at several source-to-detector distances. To determine the optimal timing window and activity concentration, we compute the noise equivalent count rate as a function of timing window resolution for different activities.

Discussion

We found the coincidence detection efficiency to be around 5 events/mCi-s, independent of source-to-detector distance. We found that point source activities ranging from 10 uCi to 5 mCi could be imaged with spatial resolutions of ~1 cm. Optimal time window resolutions ranged between 200 and 500 ns.

SSJ22-02 Initial Evaluation of a Novel General Purpose CZT based Digital SPECT Camera: Significant Improvement of Resolution and Contrast Compared to Standard Analog SPECT

Tuesday, Nov. 29 3:10PM - 3:20PM Room: S403B

Participants
Simona Ben-Haim, MD, DSc, Ramat Gan, Israel (*Presenter*) Consultant, Spectrum Dynamics Ltd; Consultant, Molecular Dynamics; Spouse, Stockholder, Molecular Dynamics
Elinor Goshen, MD, Ramat Gan, Israel (*Abstract Co-Author*) Nothing to Disclose
Ronen Goldkorn, MD, Ramat Gan, Israel (*Abstract Co-Author*) Research support, Molecular Dynamics
Leonid Beilin, PhD, Caesarea, Israel (*Abstract Co-Author*) Employee, Molecular Dynamics Ltd

PURPOSE

We have assessed the performance of a novel digital SPECT camera with multiple pixelated cadmium zinc telluride (CZT) detectors and high sensitivity collimators (Digital SPECT; Valiance X12 prototype, Molecular Dynamics). The system's architecture enables gantry rotation, as well as radial and swivel detector motion, providing multiple degrees of freedom for the scanning pattern. These features are used to minimize the patient-detector distance, providing patient-tailored imaging.

METHOD AND MATERIALS

Images of Tc-99m filled Jaszczak phantom with cold rod and solid sphere inserts (rod diameter 4.8-12.7 mm, spheres 9.5-31.8 mm) were compared to images acquired on a standard NaI based analog (Anger) SPECT system with high resolution collimators (Discovery NM/CT 670, GE). All images (analog and digital SPECT) were iteratively reconstructed and evaluated visually for resolution. Contrast was calculated using standard methodology.

RESULTS

Digital SPECT demonstrated cold rods in reconstructed transaxial slices of 5 segments with rod diameters of 12.7, 11.1, 9.5, 7.9, 6.4 mm, and in five external rows in the sixth segment (diameter 4.8 mm). Analog SPECT demonstrated rods in 4 segments and in part of the 5th (down to 6.4mm). Spheres were resolved on digital SPECT with contrast of 92.9%, 87.8%, 82.7%, 68.2%, 66.3% and 51.7% (for sphere diameters measuring 31.8, 25.4, 19.1, 15.9, 12.7 and 9.5 mm, respectively). These results are a significant improvement compared to analog SPECT, with 63.5%, 52.8%, 44.4%, 39.3%, 26.4%, and 18.6% for the same spheres respectively.See figure: Transaxial slices of Jaszczak phantom cold rods section: Left - Valiance X12 prototype; Right – NaI based analog SPECT system.

CONCLUSION

Contrast and resolution of digital SPECT consistently surpassed standard analog SPECT performance in the phantom studies reported.

CLINICAL RELEVANCE/APPLICATION

The superior image quality will likely prove useful in clinical settings.

SSJ22-03 Best in Class Time of Flight PET Performance - What is the Clinical Benefit?

Tuesday, Nov. 29 3:20PM - 3:30PM Room: S403B

Participants
Jun Zhang, PhD, Columbus, OH (*Presenter*) Nothing to Disclose
Ajay Siva, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Prayna Bhatia, BS, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Katherine Binzel, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Chadwick L. Wright, MD, PhD, Lewis Center, OH (*Abstract Co-Author*) Nothing to Disclose
Michael V. Knopp, MD, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Chuanyong Bai, Cleveland, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV;

PURPOSE

As the benefits of time-of-flight (TOF) in PET has been increasing recognized, we wanted to assess if there are clinical benefits by using best in class TOF timing resolution, which is enabled by next generation, solid state digital photon counting PET detectors.

METHOD AND MATERIALS

30 patients receiving a whole body oncologic FDG PET participated in an intra-individual comparison study to detect and assess potential differences due to different timing resolution of TOF. Patients were sequentially imaged using a 325 ps TOF next generation digital dPET (Vereos) and a conventional 550 ps TOF cPET (Gemini). A dose of 13mCi FDG and 90s/bed were used. Listmode data sets were reconstructed with and without TOF using optimized 3D OSEM algorithms. ROI's of liver background and lesions were placed with SUV and SNR compared between all data sets. Blinded image reviews were performed comparing the 4 image data sets. Additionally, phantoms with hot spheres and cold rods of varying sizes were acquired and assessed.

RESULTS

109 assessable lesions were identified and analyzed. The 325ps TOF dPET images were ranked best in all categories with best signal-to-noise, contrast, recovery coefficient, visual quality and lesion delineation. Comparing the two generation systems, 325ps TOF dPET presented SNR of ~2x vs non TOF, 550ps TOF cPET a SNR of ~1.6x vs non TOF. On SUV analysis, 325ps presented with 20%±27% higher SUV vs non TOF, 550ps with 15%±18% vs non TOF. No significant SUV differences in the liver background ROI were found ($p>0.05$). 10% of the lesions confidentially classifiable on 325ps TOF were not assessable on 550 ps TOF, while 25% were non assessable on non-TOF.

CONCLUSION

325ps TOF PET was found to consistently present with the best performance in all categories, especially SNR. The clinical benefit appears to come from the more precise localization of metabolic activity which translates to higher SUV peak value, sharper lesion delineation and overall better visualization with an improved lesion detection of 10% compared to current generation TOF timing resolution.

CLINICAL RELEVANCE/APPLICATION

SNR, lesion uptake and visual quality all benefit from improved timing resolution with the more precise event localization that appears to be able to improve clinically relevant lesion detectability.

SSJ22-04 System Physics Characteristics and Stability of Next Generation Digital Photon Counting PET

Tuesday, Nov. 29 3:30PM - 3:40PM Room: S403B

Participants
Jun Zhang, PhD, Columbus, OH (*Presenter*) Nothing to Disclose
Michael Miller, Highland Heights, OH (*Abstract Co-Author*) Nothing to Disclose
Katherine Binzel, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michael V. Knopp, MD, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To measure and assess the system physics characteristics and stability of a next generation solid state, digital PET and its potential to advance clinical PET.

METHOD AND MATERIALS

Physical characteristics of timing resolution and energy resolution as well as NEMA 2012 based spatial resolution, sensitivity, count loss and image quality of the next generation digital photon counting (DPC) PET/CT system (Vereos) was performed. System stability in timing and energy were monitored over a year, and complete NEMA testing was done at the beginning and the end of the 1-yr window since system installation. CQIE PET uniformity was measured in a quarterly manner. The observed system

characteristics were compared to current technology systems and its potentials impact for clinical oncologic PET imaging assessed.

RESULTS

The DPC PET/CT system demonstrated robust system physics characteristics with <2% variability in timing resolution, ±0.4% change in energy resolution, <2% change in spatial resolution, <10% variations in detector temperature and humidity as well as <5% change of SUV/uniformity profile through a > one year monitoring period. NEMA 2012 testing found a spatial resolution (in mm FWHM) from 4.10 / 3.96 at 1 cm to 5.79 / 6.20 at 20 cm in the transverse and axial plane. 325 ps timing resolution and 11.1 % energy resolution were consistently obtained. We measured a 5.7 kcps/MBq system sensitivity and 24.1 kcps/MBq effective sensitivity with TOF gain. For count loss testing, ~171 kcps peak NECR and > 680 kcps peak true rate were obtained at 50 kBq/mL, and the scatter fraction is about 30%. NEMA IQ demonstrated hot sphere contrast ranging from ~62%±2% (10 mm) to ~88%±2% (22 mm), cold sphere contrasts of ~86%±2% (28 mm) and ~89%±3% (37 mm) and excellent image uniformity. These characteristics led to excellent image quality of clinical oncologic PET imaging.

CONCLUSION

The system physics performance characteristics were found to be robust over an one year period and of excellent specifications, overall considerably more preferential than current conventional benchmark systems.

CLINICAL RELEVANCE/APPLICATION

The next generation solid state, high TOF temporal resolution PET technology is robust and with excellent imaging physics characteristics promising substantial improvements for clinical PET imaging.

SSJ22-05 Are Camera Measurements Alone Sufficient in Determining I-131 Thyroid Cancer Therapy Maximum Permissible Blood Dose?

Tuesday, Nov. 29 3:40PM - 3:50PM Room: S403B

Participants
Kenneth Nichols, PhD, New Hyde Park, NY (*Presenter*) Royalties, Syntermed, Inc;
Fritzgerald Leveque, New Hyde Park, NY (*Abstract Co-Author*) Nothing to Disclose
Miyuki Yoshida-Hay, BS, New Hyde Park, NY (*Abstract Co-Author*) Nothing to Disclose
William Robeson, MSC, New Hyde Park, NY (*Abstract Co-Author*) Nothing to Disclose
Christopher J. Palestro, MD, New Hyde Park, NY (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Our study was undertaken to determine the validity of recent suggestions that I-131 thyroid cancer therapy dose to blood can be estimated by camera measurements alone (Health Phys 2015;108:53-58eHH), rather than the conventional approach of combining camera count measurements with blood assays (Am J Roetgenol Radium Ther Nucl Med 1962;87:171-182).

METHOD AND MATERIALS

Data were examined retrospectively for 74 pts undergoing I-131 therapy for thyroid cancer ablation, divided into first & second half groups of 37 pts each (Groups 1&2). Following the conventional approach, anterior & posterior pt counts were obtained by an uncollimated gamma camera, & blood withdrawn & assayed in vitro by a well counter 1, 4, 24, 48, 72-96, & 96-144 hrs after ingestion of I-131 to compute the whole body γ & in vivo β dose contributions to blood. Linear regression for Group1 established predictions of total blood dose by in vitro-only and by camera-only measurements. Predictions were compared to conventional total blood dose for Group1, Group2 & for all pts by the paired t-test and by Pearson correlation.

RESULTS

Mean doses were similar for total blood dose by conventional, in vitro-only & camera-only methods ($p > 0.40$) for Group1 (0.75±0.50, 0.76±0.50 & 0.74 ±0.47 rad/mCi, respectively), Group2 (0.77±0.56, 0.76±0.54 & 0.80 ±0.55 rad/mCi, respectively), & all pts (0.76±0.52, 0.77±0.51 & 0.76 ±0.51 rad/mCi, respectively). However, correlation was significantly stronger between conventional & in vitro-only than between conventional & camera-only estimates for Group1 ($r = 0.98$ versus $r = 0.94$, $p = 0.02$), Group2 ($r = 0.98$ versus $r = 0.94$, $p = 0.02$) & for all pts ($r = 0.98$ versus $r = 0.94$, $p = 0.0004$).

CONCLUSION

While it is possible to simplify I-131 dose estimation using camera measurements alone, estimating blood dose by blood work alone is the more statistically robust approach.

CLINICAL RELEVANCE/APPLICATION

For cases in which camera measurements are compromised by technical errors, it is justifiable to rely on blood measurements alone in estimating I-131 thyroid cancer therapy maximum permissible blood dose.

SSJ22-06 Evaluation of Different Strategies to Improve CT-based PeT Attenuation Correction Close to Metal Impants: A Phantom Study

Tuesday, Nov. 29 3:50PM - 4:00PM Room: S403B

Participants
Christoph Schabel, MD, Tubingen, Germany (*Presenter*) Nothing to Disclose
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Malte N. Bongers, MD, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Juergen Kupferschlaeger, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Georg Bier, MD, Tubingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Fabian Bamberg, MD, MPH, Tuebingen, Germany (*Abstract Co-Author*) Speakers Bureau, Bayer AG; Speakers Bureau, Siemens AG; Research Grant, Bayer AG; Research Grant, Siemens AG;
Christian la Fougere, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Konstantin Nikolaou, MD, Tuebingen, Germany (*Abstract Co-Author*) Speakers Bureau, Siemens AG; Speakers Bureau, Bracco Group; Speakers Bureau, Bayer AG
Christina Pfannenberg, MD, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To compare different strategies of metal artifact (MA) reduction in CT for the improvement of CT-based PET attenuation correction close to metal implants.

METHOD AND MATERIALS

A phantom was studied consisting of a cylindrical tube filled with [18-F]FDG solution containing two artificial jaws with metal containing dental work.CT datasets were acquired using a 3rd generation dual-source CT (Somatom Definition Flash, Siemens Healthcare, Germany). Two datasets were obtained with a CTDI of 15mGy using single energy (SE) mode at 120kV and dual energy mode at 100/Sn140kV. Single energy datasets were reconstructed using filtered back projection without (NOMAR) and with iterative MA reduction (IMAR, Siemens Healthcare, Germany). Dual energy datasets were reconstructed using linear blending (Mix) and mono energetic extrapolation (ME) at 150 and 190 keV without IMAR.PET measurements of the phantom were performed on a state-of-art PET/CT scanner. Afterwards PET/CT datasets were co-registered with the CT only datasets and PET data were reconstructed with the previously reconstructed CT only data sets.Relative PET quantification errors were quantified by 16 regions of interest (ROI).

RESULTS

MA were present in all CT datasets. MA reduction strategies were able to reduce these artifacts to different extend, with IMAR showing best capabilities followed by ME190keV and ME150keV. SE and Mix images depicted strongest artifacts. In general, activity concentrations were overestimated / underestimated in areas of high/low-density metal, artifacts respectively.Relative errors in PET quantification ranged between -71 and 70% for Mix, -63 and 49% for SE, -67 and 42% for ME150keV, -66 and 39% for ME190keV and -37 and 13% for IMAR images. Averaged absolute values were 34±22%, 29±17%, 24±18%, 23±18%, 8±9%, respectively ($p<0.001$).

CONCLUSION

CT-based PET-attenuation correction was improved significantly using dual energy based metal artifact reduction strategies; nevertheless iterative metal artifact reduction strategy was superior. Further clinical studies are necessary in order to assess the clinical performance of this algorithm in patients.

CLINICAL RELEVANCE/APPLICATION

CT-based PET attenuation is susceptible for errors in regions with CT artifacts. Metal artifact reduction is essential to optimize attenuation correction. This study compares different and novel strategies.

SSJ23

Physics (Diagnostic X-Rays II)

Tuesday, Nov. 29 3:00PM - 4:00PM Room: S404AB

PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

FDA Discussions may include off-label uses.

Participants
Stephen Rudin, PhD, Buffalo, NY (*Moderator*) Research Grant, Toshiba Corporation
Ioannis Sechopoulos, PhD, Atlanta, GA (*Moderator*) Research agreement, Siemens AG; Research agreement, Toshiba Medical Systems Corporation; Speaking agreement, Siemens AG

Sub-Events

SSJ23-01 Validation of Model Observers: Required Number of Radiologists and Cases

Tuesday, Nov. 29 3:00PM - 3:10PM Room: S404AB

Participants
Robert M. Nishikawa, PhD, Pittsburgh, PA (*Presenter*) Royalties, Hologic, Inc; Research Consultant, iCAD, Inc;

PURPOSE

It has been well established that inter-reader variability is high amongst radiologists. The purpose of this study was to determine the minimum of radiologists and cases required to validate a model observer for screening mammography.

METHOD AND MATERIALS

We examined the performance of 208 radiologists who attended one of five American College of Radiology Breast Imaging Boot Camps, which are three-day intensive courses designed to provide practicing radiologists with an intensive hands-on experience in breast imaging. Each radiologist read up to 240 cases under direct supervision from the course instructors. We examined data from 108 radiologists who read the same 102 digital screening mammograms. We randomly selected a predetermined number of radiologists and cases and computed the overall sensitivity. This was repeated 1000 times. From this resampling, we computed the 95% confidence intervals (CI) for the measured sensitivity as a function of number of cases and the number of radiologists. Calculations were done per view and the radiologist needed to specify the correct location of the cancer to be considered correct.

RESULTS

The average sensitivity for all 108 readers reading 102 cases was 0.643. There was a strong dependence of the 95%CI range on the number of readers. Estimating sensitivity based on 10 radiologists gave a 95% CI range of 0.109. This decreased to 0.015 with 90 readers. We found a weaker dependence on the number of cases. For 30 radiologists, the 95% CI range decreased from 0.080 to 0.055, as the number of cases increased from 10 to 102 cases. For a +/-5% error in sensitivity based on the 95% CI (i.e., a 95% CI range of 0.064) required at least 30 radiologists and 30 cancer cases. Thirty radiologists far exceed the typical number of radiologists participating in an observer study and will present a challenge when validating model observers.

CONCLUSION

To perform an observer study to validate a model of observer for screening mammography can be done with a relatively small number of cases, but requires a large number of radiologists to reduce the inter-reader variability.

CLINICAL RELEVANCE/APPLICATION

Proper validation of observer models is needed to ensure that predictions based on model observers will be clinically relevant and correct. Our study indicates that a large number of radiologists is needed for proper validation.

SSJ23-02 Optimizing Neonatal Techniques After Replacing a Computed Radiography with a Digital Radiography Portable

Tuesday, Nov. 29 3:10PM - 3:20PM Room: S404AB

Participants
Loretta Johnson, PhD, Birmingham, AL (*Presenter*) Nothing to Disclose

CONCLUSION

Our newly-programmed techniques have made it easier for technologists to achieve good neonate image quality at a low and appropriate dose every time.

Background

Our neonatal ward recently replaced their portable computed radiography (CR) unit with a Carestream Revolution DRX digital radiography (DR) portable. Since DR can achieve comparable image quality with less radiation, we took this opportunity to optimize techniques for the DRX. Data from two types of phantoms (Lucite and Cornish hen) as well as neonates was used. The DICOM headers of the DRX provide the deviation index (DI) and relative x-ray exposure, which were used to determine whether sufficient radiation reached the detector. As a quantitative measure of image quality (IQ), a region of interest was drawn over a uniform area (e.g. neonate liver), and the standard deviation (SD) was recorded. Radiologist reports were checked for references to IQ problems.

Evaluation

180 neonate exams were reviewed and 138 had acceptable IQ and dose metrics. Recent survey data was used to estimate the

180 neonate exams were reviewed and 138 had acceptable IQ and dose metrics. Recent survey data was used to estimate the patient entrance exposure for the neonates and phantoms. For each 500 g increment in neonate weight, the lowest dose technique with acceptable IQ was determined from phantom images. These techniques were then compared to the techniques recently used for neonates; half the new techniques were consistent with (though on the low-dose side) the neonate exams that had acceptable image quality and appropriate DI, while 1/6 were higher-dose and 1/3 were lower-dose techniques.

Discussion

Since our new portable arrived, technologists have had to dial in the technique for each neonate, and as a result, the techniques used have varied widely. Having each technologist think about patient size for each neonate and dial in the kVp and mAs is both wasteful of the technologists' time and opens doors to potential errors. Neonate radiography is already challenging for plenty of patient-related reasons that cannot be easily addressed. Developing an optimal technique chart and programming in the techniques by neonate weight is an achievable and useful goal for a medical physicist.

SSJ23-03 Can Solid-State Meters Reliably Measure Fluoroscopic Air-Kerma Rates?

Tuesday, Nov. 29 3:20PM - 3:30PM Room: S404AB

Participants
Janet Ching-Mei Feng, PhD,MSc, Houston, TX (*Presenter*) Nothing to Disclose
Bahadir Ozus, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Luong Thai, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Louis K. Wagner, PhD, Houston, TX (*Abstract Co-Author*) Partner, Partners in Radiation Management Ltd Company

CONCLUSION

Air-kerma rates can be measured favorably well using solid-state devices, but users must be aware of the possibility that readings can be grossly in error with no discernible indication for the deviation.

Background

Ionization chambers remain the standard for calibration of air-kerma rate measuring devices. Despite their strong energy-dependent response, solid state radiation detectors are increasingly used, primarily due to their efficiency in making standardized measurements. To test the reliability of these devices in measuring air-kerma rates, we compared ion chambers measurements with solid-state measurements for various mobile fluoroscopes operated at different beam qualities and air-kerma rates.

Evaluation

Six mobile fluoroscopes (GE OEC models 9800 and 9900) were used to generate test beams. Using various field sizes and dose rate controls, copper attenuators and a lead attenuator were placed at the image receptor in varying combinations to generate a range of air-kerma rates. Air-kerma rates at 30 centimeters from the image receptors were measured using two 6-cm3 ion chambers with monitors (Radcal, models 1015 and 9015) and two with solid state detectors (Unfors Xi and Raysafe X2). No error messages occurred during measurements. However, about two months later, one solid-state device stopped working and was replaced by the manufacturer. Two out of six mobile fluoroscopic units were retested with the replacement unit.

Discussion

Generally, solid state and ionization chambers agreed favorably well, with two exceptions. Before replacement of the detector, the Xi meter when set in the "RF High" mode deviated from ion chamber readings by factors of 2 and 10 with no message indicating error in measurement. When set in the "RF Low" mode, readings were within -4% to +3%. The replacement Xi detector displayed messages alerting the user when settings were not compatible with air-kerma rates.

SSJ23-04 Tomosynthesis Reconstruction Based on Principal Component Analysis (PCA)

Tuesday, Nov. 29 3:30PM - 3:40PM Room: S404AB

Participants
Lucas R. Borges, Philadelphia, PA (*Presenter*) Nothing to Disclose
Eileen Hwuang, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Raymond Acciavatti, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Marcelo A. Vieira, PhD, Sao Carlos, Brazil (*Abstract Co-Author*) Nothing to Disclose
Andrew D. Maidment, PhD, Philadelphia, PA (*Abstract Co-Author*) Research support, Hologic, Inc; Research support, Barco nv; Research support, Analogic Corporation; Spouse, Employee, Real-Time Tomography, LLC; Spouse, Stockholder, Real-Time Tomography, LLC; Scientific Advisory Board, Real-Time Tomography, LLC; Scientific Advisory Board, Gamma Medica, Inc

PURPOSE

To explore whether digital breast tomosynthesis reconstruction can be recast as a denoising problem to be addressed with principal component analysis (PCA).

METHOD AND MATERIALS

Tomosynthesis projection images were acquired on an anthropomorphic phantom and a geometry phantom. Commercial reconstruction software (Real Time Tomography, Villanova, PA) was used to compute backprojections. Conventionally, the backprojections are averaged in filtered backprojection reconstructions; in this work, PCA was investigated as an alternative to redistribute the backprojection data into independent components ranked by variance. PCA was performed treating the image as a whole and in patches. Three PCA algorithms were investigated. Images were evaluated qualitatively to look at the impact on artifacts and quantitatively to assess noise and artifact spread function.

RESULTS

Our hypothesis was confirmed that the first principal component (PC1 map) is the reconstructed image, and the remaining higher order components predominantly contain artifacts and noise. When PCA was performed on the image as a whole, the PC1 map demonstrated reduced artifacts compared to conventional reconstruction; the PC1 map corresponds to >99.97% of variance. Successively higher order components contain banded features at locations of out-of-plane artifacts. The artifact spread function showed no significant difference between the commercial reconstruction and PCA reconstruction. When PCA was performed in

patches, smaller kernel sizes produced PC1 maps with fewer discernible structures, increased noise, and discontinuities that we attribute to variations in the order of principal components; larger kernel sizes yielded superior PC1 maps. Singular value decomposition and eigenvalue decomposition produce similar results.

CONCLUSION

PCA produces tomosynthesis reconstructions that are comparable to current methods and may have the advantage of removing out-of-plane artifacts. Further work needs to be performed to understand the mechanism of PCA in reconstruction and develop an appropriate mathematical framework.

CLINICAL RELEVANCE/APPLICATION

Digital breast tomosynthesis is still in its infancy. As such, there is a need for reconstruction methods that more effectively remove artifacts and noise than current methods.

SSJ23-05 Characterizing Noise Sources for Image Receptors of Digital Radiography Systems using the Pixel Variance Technique

Tuesday, Nov. 29 3:40PM - 3:50PM Room: S404AB

Participants
Caitlin Finley, Wynnewood, PA (*Presenter*) Nothing to Disclose
Prakruti Talreja, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Jaydev K. Dave, PhD, MS, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Pixel variance technique characterizes noise sources which may affect image quality. This technique may be integrated during periodic quality assessments of digital image receptors.

Background

Images acquired using digital radiography systems may be affected by structured, quantum or electronic noise. For an optimal performing clinical system, quantum noise is the dominant noise source. Characterizing the noise sources for image receptors of digital radiography systems is therefore useful. The purpose of this work was to evaluate the use of pixel variance technique to characterize the noise sources for image receptors of digital radiography systems.

Evaluation

Nine portable digital radiography systems (Carestream Health, Inc., Rochester, NY) equipped with 11 calibrated image receptors (9: 35x43 cm; 2: 25x30 cm) were used to acquire noise only images. Thirteen images per image receptor using RQA5 beam conditions and with input detector air kerma ranging from 0 to 110 mGy were acquired. Linearized 'For Processing' images were extracted for analysis. Square ROIs with varying dimensions (2.5 to 20 mm) were used to obtain mean pixel value (MPV), standard deviation (SD), and relative noise (SD/MPV) from each image. Variance (SD^2) and relative noise were fitted as a function of input detector air kerma, using least-squares approach, to determine structured, quantum, and electronic noise coefficients and the overall contribution of quantum noise.

Discussion

There was no effect of the ROI size on the analysis (coefficient of variation < 1%). All fitting functions showed correlation values above 0.9. The structured, quantum, and electronic noise coefficients were 0.6±0.3, 5.6±3.7, and 3.4±1.4 (mean ± standard deviation). One image receptor showed electronic noise to be dominant, but for all other image receptors quantum noise was the dominant noise source. The noise coefficients with 35x43 cm sized image receptor (0.4±0.1, 4.0±3.7, and 2.9±0.7) were lower relative to 25x30 cm sized image receptor (1.2±0.3, 13.1±0.3, and 5.9±0.5). The power parameter from the relative noise fitting equation was 0.47±0.02 indicating minor contributions from other noise sources (a value of 0.50 indicates purely quantum noise).

SSJ23-06 Comparison of 3 Performance Metrics for the Assessment of Microcalcification Detection in 2D Digital Mammography

Tuesday, Nov. 29 3:50PM - 4:00PM Room: S404AB

Participants
Kristina Wigati, Leuven, Belgium (*Presenter*) Nothing to Disclose
Lesley Cockmartin, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Joke Binst, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Nelis Van Peteghem, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Liesbeth Vancoillie, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Nicholas Marshall, Leuven, Belgium (*Abstract Co-Author*) Research Grant, Siemens AG
Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG

PURPOSE

To compare 3 different types of performance metrics for microcalcification detection in 2D mammography.

METHOD AND MATERIALS

The 3 metrics tested were: (1) Contrast-detail analysis with CDMAM phantom and automatic read-out with cdcom software (www.euref.org). Threshold gold thickness (T) for the 0.1 mm diameter disk was obtained. (2) A detectability index d' for a 0.1 mm diameter disk was calculated from modulation transfer function, noise power spectrum, contrast and visual transfer function. (3) Detectability was tested with a 3D structured phantom including different size groups of calcifications on a background of beads in water. The percent correct (PC) response for the 0.119 mm calcification group was assessed based on a four-alternative forced-choice task performed by 5 readers. The 3 metrics were tested on 24 2D digital mammography (DM) systems, including recently introduced systems such as Siemens PRIME, GE PRISTINA and Giotto CLASS, and all types of digital detectors (flat panel, computed radiography and photon counting), under automatic exposure control (AEC) settings. Four systems were also tested at a dose of half and double the AEC level.

RESULTS

A logarithmic relation between d' and T was found with R^2 equal to 0.65. Detectability indices of 1.6 and 0.95 were found equivalent to the achievable and acceptable European limits of T (1.10 µm and 1.68 µm resp.). These limits for d' were close to previously published limiting values i.e. 1.7 and 1.05 resp. Detection results of the structured phantom correlated with T (Spearman correlation r=-0.64) and with d' (r=0.70). The achievable and acceptable threshold of d'=1.6 and d'=0.95 resulted in PC limits of 85% and 56% for the 0.119 mm microcalcifications.

CONCLUSION

Performance results of the three investigated metrics correlated well. Next to this, the phantoms are intrinsically complementary, with method (1) a detection task performed on for processing data and homogenous background, (2) a Fourier-based approach that allows analysis of the impact of the different system components, (3) detection task for a group of microcalcifications within a 3D structured background.

CLINICAL RELEVANCE/APPLICATION

Calcification detection remains a critical task in DM. The correlation between 3 different test metrics shows the validity of each of them for system benchmarking.

RC421

Advances in CT: Technologies, Applications, Operations-CT Operation

Tuesday, Nov. 29 4:30PM - 6:00PM Room: S103AB

CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

Sub-Events

RC421A Statistical and Iterative Reconstruction and Image Domain Denoising

Participants
Norbert J. Pelc, ScD, Stanford, CA (*Presenter*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

RC421B Protocol Optimization and Management

Participants
Mannudeep K. Kalra, MD, Boston, MA, (mkalra@mgh.harvard.edu) (*Presenter*) Technical support, Siemens AG; Technical support, Medical Vision

LEARNING OBJECTIVES

1.) CT protocol optimization begins with justification of clinical indication and proceeds to tailoring of scan parameters according to clinical region of interest, clinical indication, and patient size. Taking a nuanced and stratified approach to protocol stratification helps in the optimization process. 2) CT protocol management is a team effort involving attention to CT image quality and associated radiation doses. Medical physicists, radiologists, and CT technologists have a common responsibility in CT protocol optimization and management.

ABSTRACT

Optimization and management of CT protocols are joint responsibilities of medical physicists, radiologists and CT technologists. Attributes of optimized CT protocols include adaptation of image quality and radiation dose through suitable choice of scan parameters based on body area of interest, clinical indication, presence of prior imaging, patient size, and need for contrast enhancement. In an ideal practice, scan protocols must be divided according to the area of interest, and then clinical indication for which CT has been requested. Management of CT protocols must include frequent audits of image quality and radiation dose monitoring to ensure that good practices are maintained.

RC421C Dose Monitoring and Analytics

Participants
Joshua Wilson, PhD, Durham, NC, (joshua.wilson@duke.edu) (*Presenter*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Describe conventional radiation dose monitoring workflows and analytics. 2) Critique the current shortcomings and future potential value of dose monitoring solutions. 3) Identify opportunities improving clinical operations and consistency with dose monitoring.

ABSTRACT

Recent legislative and accreditation requirements have driven rapid development and implementation of radiation dose monitoring platforms. Multiple solutions are available that require financial commitments and oversight. Once requirements are met, how can institutions derive added-value from their monitoring program by improving the quality of their clinical performance? Global alert thresholds, the standard in commercial products, naïve to system model and patient size have limited value. Setting a threshold presupposes a clinically-relevant level is known. For an arbitrary level, appropriately-dosed obese patients triggered false alerts, but over-dosed small patients were missed. Numerous study parameters must be retained because chronologic trends, the industry standard, are rarely useful without controlling for other moderators. Dashboards must be interactive enabling dynamic drill-down into cohorts. Dose databases require curation tools and maintenance, largely absent from all solutions, because wrong information will be inadvertently entered, and the utility of the analytics is entirely dependent on the data quality. Dose monitoring can satisfy requirements with global alert thresholds and patient dose records, but a program's real value is in optimizing patient-specific protocols, balancing image quality trade-offs that dose-reduction strategies promise, and improving the performance and consistency of a clinical operation.

RC422

Imaging for Personalized Medicine: Abdomen

Tuesday, Nov. 29 4:30PM - 6:00PM Room: S102C

GI RO PH

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

Participants
Kristy K. Brock, PhD, Houston, TX (*Moderator*) License agreement, RaySearch Laboratories AB; Development agreement, Varian Medical Systems, Inc;

ABSTRACT

The use of imaging and other biomarkers to increase the efficacy of treatment and decrease the risk of toxicity increased in the abdomen. Functional imaging and serum-based biomarkers can enable a more detailed understanding of the tumor, its characteristics, and early indications of its response to therapy. In addition, they can also be utilized to assess an individual patients risk for toxicity, enabling a personalize approach to radiotherapy. These advanced imaging techniques can be combined with anatomical information to generate high precision treatment plans which can be adapted over the course of treatment to account for identified uncertainties, changes, and deviations which may compromise the delivery of the intended treatment or identify the ability to re-optimize treatment to improve the therapeutic ration. In this session, technical and clinical concepts will be described to design and deliver personalized radiotherapy in the abdomen. Technical concepts will include incorporation of multi-modality imaging for treatment planning, image guidance at treatment, and functional and anatomical adaption. Clinical concepts will include functional targeting, clinical goals, and toxicity risks.

Sub-Events

RC422A IGRT and Anatomical Adaptation

Participants
Kristy K. Brock, PhD, Houston, TX (*Presenter*) License agreement, RaySearch Laboratories AB; Development agreement, Varian Medical Systems, Inc;

LEARNING OBJECTIVES

1) Describe the processes necessary for the safe and accurate integration of multi-modality imaging for treatment planning. 2) Understand the role of image guidance for abdominal radiotherapy. 3) Illustrate methods to perform functional and anatomical adaptation in the abdomen.

ABSTRACT

The use of imaging and other biomarkers to increase the efficacy of treatment and decrease the risk of toxicity increased in the abdomen. Functional imaging and serum-based biomarkers can enable a more detailed understanding of the tumor, its characteristics, and early indications of its response to therapy. In addition, they can also be utilized to assess an individual patients risk for toxicity, enabling a personalize approach to radiotherapy. These advanced imaging techniques can be combined with anatomical information to generate high precision treatment plans which can be adapted over the course of treatment to account for identified uncertainties, changes, and deviations which may compromise the delivery of the intended treatment or identify the ability to re-optimize treatment to improve the therapeutic ration. In this session, technical and clinical concepts will be described to design and deliver personalized radiotherapy in the abdomen. Technical concepts will include incorporation of multi-modality imaging for treatment planning, image guidance at treatment, and functional and anatomical adaption. Clinical concepts will include functional targeting, clinical goals, and toxicity risks.

RC422B Functional Targeting, Clinical Goals, and Toxicity Risks

Participants
Cullen M. Taniguchi, MD, PhD, Houston, TX (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Review methods to obtain, process and analyze tissue and serum based biomarkers for abdominal tumors. 2) Describe current dose/fractionation regimens as well as normal tissue constraints utilized in treating abdominal tumors. 3) Explain potential advantages of assessing treatment response with MRI and quantitative PET/SPECT (PERCIST) imaging over CT based response (RECIST) in abdominal tumors.

ABSTRACT

In order to deliver personalized radiation therapy in abdominal tumors, it is important to understand the methods used to obtain, analyze, and interpret serum and tissue based biomarkers. Most research to date has focused on identifying specific biomarkers used to personalize systemic or targeted therapies. Radiation-specific biomarkers are emerging and may eventually be used to determine whether radiation is indicated or identify specific radiation sensitizers for use in abdominal tumors. Radiation therapy planning has historically used computed tomography (CT)-based imaging. Molecular imaging using hybrid positron emission tomography (PET)/CT scanning or single-photon emission computed tomography (SPECT) imaging and functional magnetic resonance imaging (MRI) has provided new insights into the precise identification of gross tumor volume (GTV) and clinical tumor volume (CTV) and has provided response information during and after therapy. The effective use of PET/SPECT and MRI in clinical practice, however, requires an appreciation of the unique challenges inherent to these modalities. Fundamental physical issues of limited spatial resolution relative to the biological process, partial volume effects, image misregistration, motion management, and edge delineation must be carefully considered and can differ by agent or the method applied. Integration of PET/SPECT and MRI imaging into multicenter clinical trials and clinical practice can be particularly challenging due to differences in imaging protocols, machines, and anatomy. Imaging protocols that clearly outline scan and fusion parameters are crucial. Further,

interpretation of tumor response should be standardized, and scans should be obtained at consistent time intervals. In addition, it is important to consider novel tracers of tumor biology (e.g. hypoxia, proliferation, apoptosis) beyond the commonly used radiotracers. In this session, we will discuss these applications and challenges as well as provide guidance on how to integrate PET/SPECT/MRI into radiation treatment planning and assessing treatment response. Finally, we will evaluate common dose and fractionation regimens as well as established dose constraints used in treating abdominal tumors with conventional and stereotactic body radiation therapy.

RC423

MR Safety

Tuesday, Nov. 29 4:30PM - 6:00PM Room: S402AB

MR PH SQ

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

FDA Discussions may include off-label uses.

Participants
Matthew A. Bernstein, PhD, Rochester, MN (*Director*) Research collaboration, General Electric Company;
Yunhong Shu, PhD, Rochester, MN (*Director*) Nothing to Disclose

LEARNING OBJECTIVES

1) List several MR Safety incidents and describe their root causes. 2) List a variety of commonly implanted Neurostimulators and MR Conditional Pacemakers. 3) Identify potential risks associated with scanning patients implanted with these devices using MRI in the clinical environment. 4) Describe special MR Safety hazards present in the MR interventional environment, and identify countermeasures to reduce the associated risks. 5) Describe MR Safety guidelines and recommendations to prevent accidents and injuries.

Handout:Yunhong Shu

http://abstract.rsna.org/uploads/2016/16001093/MR safety - neurostimulator -handouts.docx

Sub-Events

RC423A Case Review of Real MR Safety Incidents

Participants
Armen Kocharian, PhD, Houston, TX, (akocharian@houstonmethodist.org) (*Presenter*) Research collaboration, General Electric Company

LEARNING OBJECTIVES

1) Identify main safety risk factors from incident reviews at MR Imaging sites. 2) Assess and address the MRI safety potential risks. 3) Implement preventive measures in clinical practice for improved standard of care.

Active Handout:Armen Kocharian

http://abstract.rsna.org/uploads/2016/16001094/RC423A Case Review of Real MR Safety Incidents.pdf

RC423B MRI Safety of Deep Brain and Other Simulators

Participants
Yunhong Shu, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) List a variety of commonly implanted neurostimulators. 2) Understand the importance of MRI as a diagnostic imaging tool for patient with implanted neurostimulator. 3) Identify the potential risks associated with scanning patient with implanted neurostimulator using MRI. 4) Describe MR safety guidelines and recommendations to prevent accidents and injuries.

ABSTRACT

A neurostimulator is a surgically placed programmable device. It delivers mild electrical signals to the targeted area through thin wires. The purpose is usually for pain relief or improving patient's ability to perform daily activities. There are a variety of commonly used neurostimulators include deep brain stimulator, spinal cord stimulator, vagus nerve stimulator and sacral nerve stimulator. MRI is clinically important for post-implantation evaluation. It is very likely that a patient will require an MRI scan after the neurostimulator is implanted. The risks of performing MRI on patients with neurostimulators are related to static magnetic field, gradient magnetic field and the RF field. The talk will provide an imaging physics overview on the potential risks and make recommendations for MR imaging safety procedure.

Handout:Yunhong Shu

http://abstract.rsna.org/uploads/2016/16001095/MR safety - neurostimulator -handouts.docx

RC423C MRI Conditional Pacemakers, What to Do?

Participants
Anshuman Panda, PhD, Scottsdale, AZ (*Presenter*) Nothing to Disclose

Active Handout:Anshuman Panda

http://abstract.rsna.org/uploads/2016/16001096/RC423C Panda RSNA 2016 MR Conditional Pacemakers.pdf

RC423D MRI Safety in the MR-Guided Interventional Environment

Participants
Krzysztof Gorny, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

Presentation will include overview of interventional MRI practice within context of generally accepted principles of MRI safety. Description of the practice will be provided including example protocol for safety testing of previously unlabeled equipment considered for potential use inside Zone 4.

ABSTRACT

Handout:Krzysztof Gorny

http://abstract.rsna.org/uploads/2016/16001097/Safety in the MRI hand out.pdf

RC425

What's Up with the New Requirements for Diagnostic Imaging Services? The Joint Commission, Medicare and Beyond

Tuesday, Nov. 29 4:30PM - 6:00PM Room: N229

HP PH

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

Participants
Tyler S. Fisher, Gardena, CA, (tyler@therapyphysics.com) (*Presenter*) Nothing to Disclose
Andrea D. Browne, PhD, Oakbrook Terrace, IL (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Identify new requirements applying to medical imaging. 2) Assess the degree to which their current policies and procedures will meet the new requirements. 3) Develop and implement new policies and procedures that will satisfy the new requirements.

Active Handout:Tyler S. Fisher

http://abstract.rsna.org/uploads/2016/16001116/RC425 RSNA 2016 Presentation Fisher.pdf

Active Handout:Andrea D. Browne

http://abstract.rsna.org/uploads/2016/16001116/rc425 11-2016 Handout.pdf

ED013-WE

Physics Wednesday Case of the Day

Wednesday, Nov. 30 7:00AM - 11:59PM Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants

David M. Gauntt, PhD, Birmingham, AL (*Presenter*) Patent agreement, Radcal Corporation
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Brad Kemp, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) The learner will be able to identify the causes of various imaging effects and artifacts, determine whether the effect is caused by equipment problems, and identify the necessary action to correct the effects or artifacts.

MSSR41

RSNA/ESR Hybrid Imaging Symposium: The ABCs of Hybrid Imaging (An Interactive Session)

Wednesday, Nov. 30 8:30AM - 10:00AM Room: S402AB

MR NM PH

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

FDA Discussions may include off-label uses.

Participants
Alexander Drzezga, MD, Cologne, Germany (*Moderator*) Consultant, Siemens AG; Consultant, Bayer AG; Consultant, General Electric Company; Consultant, Eli Lilly and Company; Consultant, The Piramal Group; Speakers Bureau, Siemens AG; Speakers Bureau, Bayer AG; Speakers Bureau, General Electric Company; Speakers Bureau, Eli Lilly and Company; Speakers Bureau, The Piramal Group
Katrine Riklund, MD,PhD, Umea, Sweden, (katrine.ahlstrom.riklund@umu.se) (*Moderator*) Nothing to Disclose

LEARNING OBJECTIVES

Sub-Events

MSSR41A What You Need to Know about PET-Physics

Participants
Jan Axelsson, Umea, Sweden, (Jan.E.Axelsson@vll.se) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the basics of physics in PET imaging. 2) To learn about the different approaches of PET attenuation correction. 3) To learn about potential artefacts in hybrid imaging.

MSSR41B How MR Physics Influence Image Quality in Hybrid Imaging

Participants
Ciprian Catana, MD, PhD, Charlestown, MA, (ccatana@nmr.mgh.harvard.edu) (*Presenter*) Research Consultant, Cubresa Inc

LEARNING OBJECTIVES

1) Learn about MR for attenuation and motion correction. 2) Learn about MR artefacts influencing PET-quality. 3) Understand the complexity of physics in MR/PET.

ABSTRACT

MSSR41C Interactive Case Discussion

Participants
Jan Axelsson, Umea, Sweden, (Jan.E.Axelsson@vll.se) (*Presenter*) Nothing to Disclose
Ciprian Catana, MD, PhD, Charlestown, MA (*Presenter*) Research Consultant, Cubresa Inc

LEARNING OBJECTIVES

1) Learn how to identify common MR artefacts. 2) Learn how to identify common PET artefacts. 3) Learn how to identify common CT artefacts.

RC521

Advances in CT: Technologies, Applications, Operations-CT Performance

Wednesday, Nov. 30 8:30AM - 10:00AM Room: S105AB

CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

LEARNING OBJECTIVES

1) Understand the basic components of CT performance evaluation. 2) Understand the difference between basic and operational performance of CT. 3) Understand the methods to characterize iterative reconstruction, tube current modulation, and task specific noise and resolution.

ABSTRACT

Handout:Ehsan Samei

http://abstract.rsna.org/uploads/2016/16001056/RSNA Presentation - Bolch - 30Nov16.pdf

Sub-Events

RC521A Dose and Risk Characterization

Participants
Wesley E. Bolch, PhD, Gainesville, FL (*Presenter*) Nothing to Disclose

RC521B Image Quality Estimation

Participants
Guang-Hong Chen, PhD, Madison, WI, (gchen7@wisc.edu) (*Presenter*) Research funded, General Electric Company Research funded, Siemens AG

LEARNING OBJECTIVES

1) To understand the potential consequences of the nonlinear model based image reconstruction on image quality assessment in terms of (i) spatial resolution assessment, (ii) noise power spectra, (iii) task-based CT protocol optimization.

ABSTRACT

RC521C Performance Evaluation, TG233

Participants
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Understand the basic components of CT performance evaluation in terms of basic as well as operational performance. 2) Understand the methods to characterize task based performance of CT. 3) Understand methods to characterize tube current modulation.

ABSTRACT

RC522

Imaging for Personalized Medicine: Head and Neck

Wednesday, Nov. 30 8:30AM - 10:00AM Room: S102D

HN NR RO PH

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

Participants
Robert Jeraj, Madison, WI (*Moderator*) Founder, AIQ Services

LEARNING OBJECTIVES

ABSTRACT

Sub-Events

RC522A IGRT and Anatomical Adaptation

Participants
Marija Popovic, PhD, Montreal, QC, (marija.popovic@mcgill.ca) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the evolution of adaptive radiotherapy and relevant technological advances as they pertain to head and neck radiotherapy. 2) Understand the clinical rationale for plan adaptation in head and neck patient population. 3) Describe possible routes to clinical implementation. 4) Discuss risks associated with adaptive planning workflows and appropriate quality assurance.

ABSTRACT

This session will focus on the practical implementation of adaptive radiotherapy for head and neck cancer. Although the concept of adaptive radiation therapy (ART) has been around for more than two decades, routine plan adaptation has not become standard practice in the management of head and neck cancer despite huge technological advances in imaging, image registration software, and dose calculation speed. The remaining challenges in implementing ART for head and neck cancer in 2016 as well as an update of the demonstrated clinical need will be discussed. Features of successful adaptive radiotherapy implementations will be highlighted as well as a summary of useful clinical tools and required quality assurance.

RC522B Functional Targeting and Adaptation

Participants
Robert Jeraj, Madison, WI (*Presenter*) Founder, AIQ Services

LEARNING OBJECTIVES

1) To learn about appropriate anatomical and imaging modalities for selection and delineation of target volumes in HN. 2) To learn about biologically conformal approaches (dose painting) in HN. 3) To learn about quantitative imaging requirements for RT in HN.

ABSTRACT

Anatomical and molecular imaging is used to tailor radiation treatment by enabling proper selection and delineation of target volumes and organs, which in turn lead to dose prescriptions that take into account the underlying tumor biology. Dose modulation to different parts of target volume may also be used to match variable tumor radiosensitivity (so-called biologically conformal radiotherapy or dose-painting). For accurate implementation of targeted and adaptive IMRT, tools and procedures, such as accurate image acquisition and reconstruction, automatic segmentation of target volumes and organs at risk, non-rigid image and dose registration, and dose summation methods, need to be developed and properly validated.

RC523

Molecular Imaging Mini-Course: Clinical Applications of Molecular Imaging-Oncology

Wednesday, Nov. 30 8:30AM - 10:00AM Room: S403A

MI OI PH

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

FDA Discussions may include off-label uses.

Participants

Sub-Events

RC523A Diagnosis

Participants
Terence Z. Wong, MD, PhD, Chapel Hill, NC, (tzwong@med.unc.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Discuss the value of combined FDG-PET and CT for diagnosing malignant disease.2) Discuss selection of PET radiotracers the potential role of non-FDG PET tracers in managing patients with cancer.

RC523B Staging

Participants
Dominique Delbeke, MD, PhD, Nashville, TN, (dominique.delbeke@vanderbilt.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) The potential clinical indications of PET and PET/CT in the evaluation of patients with malignancies. 2) The impact on patient care. 3) Recommendations for PET/CT in the NCCN guidelines.

Active Handout:Dominique Delbeke

http://abstract.rsna.org/uploads/2016/15002834/Handout NCCN.pdf

RC523C Evaluation of Treatment

Participants
David A. Mankoff, MD, PhD, Philadelphia, PA, (david.mankoff@uphs.upenn.edu) (*Presenter*) Speaker, Koninklijke Philips NV; Consultant, General Electric Company; Advisory Board, RefleXion Medical Inc

LEARNING OBJECTIVES

1) List applications of quantitative imaigng for clinical trials. 2) Describe the approach to the design of cancer imaging trials. 3) Discuss biomarkers applicationf forf cancer imaging.

Honored Educators

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

David A. Mankoff, MD, PhD - 2013 Honored Educator

RC525

Mini-course: Image Interpretation Science: Understanding What and How Radiologist See and Think-Clinical Foundations of Medical Image Perception-Why Study Radiologists

Wednesday, Nov. 30 8:30AM - 10:00AM Room: S103AB

PH RS

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

Participants

Sub-Events

RC525A Clinical Relevance of Perceptual Issues in Radiology

Participants
Francine L. Jacobson, MD, MPH, Boston, MA, (fjacobson@partners.org) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Define the perception factors and considerations in interpreting a medical image. 2) Delineate how perception considerations impact the radiologist's practice in terms of increasing sensitivity and reducing errors. 3) Describe perceptual factors while interpreting medical images including cognitive overload, satisfaction of search, CAD influence, color presentation, image processing, and graphical user interface.

ABSTRACT

In the 21st Century, technology has led to increased workloads for radiologists with advanced modalities and image processing dramatically increasing the volume of images to be studied by the Radiologist. Information overload is not limited to visual data as we enter the era of the electronic medical record. Increasingly, radiologists are being asked to perform the physical examination of the patient without the opportunity to interact with the patient directly. Such interaction provides important inputs including localization of pain and the opportunity to acquire additional history about prior ilnesses and surgical treatments. Set against a background of changing diagnostic criteria and individualization of treatment, critical decisions are increasingly made by radiologists using a variety of diagnostic and non-diagnostic quality image displays. Perception science provides keys to evolving the human visual processes in evaluating medical images. It is through perception science that we can move with technology to newer image presentation paradigms and maintain the efficacy of radiology.

RC525B A Short History of Image Perception in Radiology

Participants
Elizabeth A. Krupinski, PhD, Atlanta, GA, (ekrupin@emory.edu ekrupin@emory.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the origins of the inter and intra-observer variability issue. 2) Trace the roots of visual search studies in radiology. 3) Show when Receiver Operating Characteristic (ROC) analysis comes into the picture. 4) Delineate why vision models are important for image perception research.

ABSTRACT

Research in medical image perception began in radiology soon after World War II when investigators observed that there was more variation in interpretation than expected. Since then we have developed a wide variety of tools and techniques to improve our understanding of how images are perceived, abnormalities detected and diagnostic decisions made. This understanding is critical in order to improve our understanding of why errors are made, what swe can do to reduce them, and how we can better train residents to become expert radiologists and improve patient care and outcomes.

Active Handout:Elizabeth Anne Krupinski

http://abstract.rsna.org/uploads/2016/16001180/ACTIVE RC525B.pdf

SSK16

Physics (Cone Beam CT)

Wednesday, Nov. 30 10:30AM - 12:00PM Room: S403B

BR CT PH

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

FDA Discussions may include off-label uses.

Participants
Sabee Y. Molloi, PhD, Irvine, CA (*Moderator*) Research Grant, Toshiba Corporation
Guang-Hong Chen, PhD, Madison, WI (*Moderator*) Research funded, General Electric Company Research funded, Siemens AG

Sub-Events

SSK16-01 Mask-Free Intravenous 3D Digital Subtraction Angiography (IV 3D-DSA) from a Single Sweep C-arm CBCT Acquisition

Awards
Student Travel Stipend Award

Participants
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Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

The current technology of intravenous 3D digital subtraction angiography (IV 3D-DSA) requires a pre-contrast mask scan and a contrast-enhanced (i.e. filled) scan, which prolongs the total data acquisition time, making the images more sensitive to involuntary patient motion and potentially increasing radiation dose. In this work, a new technique was developed to generate high quality IV 3D-DSA images from a single sweep C-arm cone beam CT (CBCT) data acquisition without the mask scan.

METHOD AND MATERIALS

A newly developed image reconstruction technique, Synchronized Multi-Artifact Reduction with Tomographic Reconstruction (SMART-RECON), enables four sub-image volumes to be generated from a single 200 degree filled scan. Each sub-image volume corresponds to a super short segment of the projection data, but without suffering from limited view angle artifacts. The first virtual nonenhanced sub-image volume is subtracted from the sub-image volume corresponding to peak contrast enhancement, generating the desired IV 3D-DSA images without the mask scan. The proposed method was applied retrospectively to filled standard-of-care (SOC) IV-DSA datasets of 15 human subjects with various neurovascular pathologies such as aneurysms; SOC images generated with both mask and filled scans were used to benchmark imaging performance.

RESULTS

Mask-free IV 3D-DSA images of the 15 human subjects were successfully generated with no noticeable limited view angle artifacts. Requiring just half the radiation dose, these images demonstrated arguably better image quality, as they were less prone to artifacts arising from inter-scan involuntary patient motions and mis-registration. The noise standard deviations measured in the mask-free SMART-RECON images are 3±1 HU, compared with 13±5 HU of SOC images. The CNR values of SMART-RECON and SOC images are 38±10 and 9±3, respectively. The subjective conspicuity of neurovascular abnormalities such as aneurysms was improved in the SMART-RECON images.

CONCLUSION

High quality IV 3D-DSA can be generated from a single C-arm CBCT data acquisition to reduce overall image acquisition time, reduce artifacts associated with inadvertent patient motion, and reduce radiation dose by a factor of two.

CLINICAL RELEVANCE/APPLICATION

Intraoperative IV 3D DSA plays an important role in neurointerventions. The proposed method relaxed the need for two separate (mask+fill) scans, therefore reducing motion artifacts and radiation dose.

SSK16-02 Organ Dose and Radiation Risk Assessment for Orthognathic Patients in Large FOV Dental CBCT and Head MSCT Imaging

Wednesday, Nov. 30 10:40AM - 10:50AM Room: S403B

Participants
Andreas Stratis, Leuven, Belgium (*Presenter*) Nothing to Disclose
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PURPOSE

to estimate organ doses and the associated radiation-induced risks for a cohort of orthognathic patients, referred for a head CT either in a multi slice CT scanner (MSCT) or in a dental cone beam CT (CBCT) scanner for surgery planning purposes

METHOD AND MATERIALS

An EGSnrc-based-Monte-Carlo (MC) framework was used to calculate organ doses in the ICRP-female voxel phantom for a dedicated maxillofacial protocol in a MSCT (Somatom Definition Flash, Siemens, DE) and for full skull protocols in dental CBCT systems (Promax-3D-Max, Planmeca, FI and VGi-evo, Newtom, IT). The maxillofacial MSCT protocol is carried out at 120 kV, with a collimation of 64x0.6mm, a pitch of 0.8 and 3D tube-current-modulation (TCM) mode with a quality reference 125mAs (CareDose4D). Promax-3D-Max employs a 230x260 mm² FOV (diameter x height) along with a stitching technique and fixed current during rotation at 96 kV whereas VGi-evo (Newtom, IT) employs a 240x190 mm² FOV and rotational TCM at 110kV. An adult anthropomorphic phantom (SK 150, The Phantom Laboratory) was scanned to extract the TCM curves in Somatom Definition Flash and in Vgi-Evo. TCM was implemented in the MC-framework via dose-integral weighting factors. Doses were calculated for the aforementioned quality reference mAs in MSCT, for the entire range of available modes (mAs levels) of the specific protocol in Promax-3D-Max and for the Normal /regular dose mode in Vgi-evo.

RESULTS

The effective dose (ED) in Somatom Definition Flash was 1.13mSv. The dose to thyroid (245µSv), salivary glands (183µSv) and oral mucosa (181µSv) contributed most to the total risk. In Promax-3D-Max the ED ranges from 85µSv to 1.09 mSv depending on the operation mode (mAs-settings), whereas for VGI-evo the ED was 265µSv. Compared to MSCT, the dose delivered to most radiosensitive organs in dental CBCT, for normal dose operation modes, was three times lower. The absorbed dose to eye lenses was 13.5 mGy in MSCT, 1.85 to 24 mGy in Promax-3D-Max and 5.05 mGy in Vgi-evo.

CONCLUSION

Full-head dental CBCT scans deliver lower organ doses and are associated with lower EDs compared to MSCT scanners.

CLINICAL RELEVANCE/APPLICATION

For orthognathic surgery planning purposes, switching from MSCT imaging to CBCT imaging is justified, since head CBCT exams deliver lower radiation doses and are associated with lower risks.

SSK16-03 Comparative Assessment of High- and Low-Contrast Detectability Performance in Digital Mammography, Breast Tomosynthesis, and Dedicated Photon-Counting Breast Computed Tomography: A Phantom Study

Wednesday, Nov. 30 10:50AM - 11:00AM Room: S403B

Participants
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Ann-Christin Roessler, MSc, Erlangen, Germany (*Abstract Co-Author*) Nothing to Disclose
Willi A. Kalender, PhD, Erlangen, Germany (*Abstract Co-Author*) Founder, CT Imaging GmbH; CEO, CT Imaging GmbH

PURPOSE

Projection imaging such as digital mammography (DM) suffers from superimpositions, especially in dense breasts. Breast tomosynthesis (BT) and dedicated breast computed tomography (BCT) try to overcome this disadvantage. The study compared the performance of DM, BT, and BCT in detecting high- and low-contrast objects with and without superimposing structures as a function of average glandular dose (AGD).

METHOD AND MATERIALS

The performance of DM and BT using standard clinical systems and protocols was compared to a novel photon-counting BCT (pcBCT). Two breast-equivalent phantoms mimicking a compressed breast (for DM/BT) and a pendant breast (for pcBCT) were used. Both phantoms offer cubical (4 cm)³ cavities to be filled with up to 64 cubical (1 cm)³ breast equivalent inserts. Structures of varying size (130–530 µm calcifications (µCa), 1–8 mm lesions) and shape (spheres and fibrils) were embedded in 16 inserts. These 16 test structures were arranged randomly in one or two transverse planes of interest (POI). The positions of the POIs were varied in different distances to the phantom border and to each other. Superimpositions were simulated by placing organic structures above and below the POIs. Images were acquired with and without superimpositions using AGD levels from 1 to 10 mGy. Receiver operating characteristics were determined for five observers with respect to the detectability of the test structures.

RESULTS

The detection rates for test structures without superimpositions were similar in DM, BT and pcBCT for AGD below 5mGy: detection of 2 mm lesions in BT and pcBCT, 4 mm in DM; detection of 160 µm µCa pcBCT, 250 µm in DM and BT. When superimposing structures were present the detection rates remained constant in pcBCT. They were superior compared to DM and BT especially regarding low contrast objects: detection of 2 mm lesions in pcBCT, no lesion detection in DM and BT; detection of 160 µm µCa in pcBCT, 250 µm in BT, and 530 µm in DM.

CONCLUSION

BT showed higher performance than DM. pcBCT outperformed DM and BT due to superior detectability performance for calcifications and low-contrast objects owing to higher image contrast and the absence of superimpositions.

CLINICAL RELEVANCE/APPLICATION

pcBCT offers the opportunity to increase sensitivity and specificity in early detection of breast cancer and thus the potential to improve the diagnostic accuracy compared to DM and BT.

SSK16-04 Dosimetry Approaches and Results for Photon-Counting Spiral Breast CT

Participants

Wednesday, Nov. 30 11:00AM - 11:10AM Room: S403B

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PURPOSE

To evaluate technical and patient dose indicators and to provide dosimetry approaches for high-resolution photon-counting spiral breast CT (pcBCT).

METHOD AND MATERIALS

Measurements were performed on a pcBCT (CT Imaging GmbH, Erlangen, Germany), using 60 kV, 3 mm Al filtration, 30 mm axial collimation and spiral scan mode offering 100 µm spatial resolution.As technical dose indicator, the weighted computed tomography dose index (CTDIw) was measured according to IEC 60601-2-44 using a PMMA phantom 160 mm in diameter and 150 mm in length and a calibrated 100 mm long pencil ionization chamber (type 30009, PTW, Freiburg, Germany). From this, volume CTDI (CTDIvol) and dose length product (DLP) were calculated. Additionally the CTDI free in air (CTDIair) and air kerma in the isocenter were assessed.As patient dose indicators, the average glandular dose (AGD) and the effective dose (E) according to ICRP publication 103 were determined. For this, conversion factors of AGD per air kerma and E per air kerma were calculated for different breast phantoms using Monte Carlo software (ImpactMC, CT Imaging GmbH, Erlangen, Germany) taking the system geometry, xray spectrum, scan trajectory, breast size and patient body size into account. Using measured air kerma values, AGD and E for the scan protocol in question were calculated for the individual breast examined.

RESULTS

Measurements of technical dose indicators: CTDIw was 10.6 mGy per 100 mAs, and CTDIair was 20.5 mGy per 100 mAs. Simulations of patient dose indicators: AGD was 0.29 to 0.48 mGy and E was 0.039 to 0.059 mSv per 1 mGy air kerma, respectively, depending on breast size and composition. E.g., for a breast of 140 mm in diameter, 105 mm in length and 20% glandular tissue the investigation revealed: CTDIvol of 6.8 mGy, DLP of 71.4 mGy * cm, AGD of 4.8 mGy and E of 0.61 mSv for our protocols.

CONCLUSION

Technical concepts established in clinical CT are suitable for dose assessment in pcBCT. Patient-specific dose can be estimated based on Monte Carlo simulations. AGD of about 5 mGy and E less than 1 mSv for bilateral examinations in pcBCT are low, acceptable and confirm photon-counting technology. Dose to all other organs not directly exposed appears negligible.

CLINICAL RELEVANCE/APPLICATION

Dedicated high-resolution photon-counting spiral breast CT potentially offers higher sensitivity and specificity for breast cancer detection without increasing dose levels significantly.

SSK16-05 Cone Beam Breast CT for Breast Cancer Detection Comparing with Ultrasound, and Digital Mammography: A Prospective Study with 120 Asian Patients with Dense Breasts

Wednesday, Nov. 30 11:10AM - 11:20AM Room: S403B

Participants
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CONCLUSION

In this preliminary study, BCBCT was found to accurately identify malignant breast masses and calcifications in a diagnostic setting. CE-BCBCT provided additional information and improved cancer diagnosis in dense breasts compared to the use of BCBCT, US, or MG alone.

Background

Breast cone-beam computed tomography (BCBCT) is a flat-panel detector (FPD)-based X-ray imaging system that provides high-quality images of the breast. The purpose of this study was to investigate the ability to detect breast abnormalities using non-contrast BCBCT and contrast-enhanced BCBCT (BCBCT and CE-BCBCT) compared to ultrasound (US) and digital mammography (MG).

Evaluation

A prospective study was performed from May 2012 to August 2014. 120 patients with dense breast (270 lesions) underwent BCBCT and CE-BCBCT, all the patients underwent US and MG.

Discussion

Cancer diagnosis was confirmed pathologically in 102 patients (110 lesions). BCBCT identified 97 of 110 malignant lesions, whereas 93 malignant lesions were identified using MG and US. The areas under the receiver operating curves (AUCs) for breast cancer diagnosis were 0.861 (BCBCT), 0.856 (US), and 0.829 (MG). CE-BCBCT improved cancer diagnostic sensitivity by 20.3% (78.4-98.7%). The AUC values were 0.869 (CE-BCBCT), 0.846 (BCBCT), 0.834 (US), and 0.782 (MG).

SSK16-06 High-resolution Low-dose Breast CT Performance Tests on Surgical Specimens in Comparison with Digital Mammography and Breast Tomosynthesis

Wednesday, Nov. 30 11:20AM - 11:30AM Room: S403B

Participants
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Willi A. Kalender, PhD, Erlangen, Germany (*Abstract Co-Author*) Founder, CT Imaging GmbH; CEO, CT Imaging GmbH

PURPOSE

Using dedicated breast computed tomography (bCT) for detection and diagnosis of breast cancer is a novel approach in breast imaging. Existing bCT systems showed comparable performance to digital mammography (DM) and breast tomosynthesis (BT) in detection of lesions especially if contrast media were applied but do not have sufficient resolution to detect microcalcifications (µCa) smaller than 300 µm. The purpose of the study was to compare a novel high-resolution low-dose bCT system to clinical DM and BT.

METHOD AND MATERIALS

30 surgical specimens were evaluated for this study. 14 of the specimens were lumpectomies, 16 total mastectomies. All women had a pre-operatively diagnosed breast cancer or DCIS. Specimens were investigated directly after surgery with DM, BT, bCT and pathology examination (ground truth). DM and BT were used with standard clinical settings, bCT with a tube voltage of 60 kV. Dose was kept below 5 mGy for bCT. 3 breast imaging experts examined the randomized data sets. Time for image viewing was recorded. Sensitivity and specificity for detection of lesions and calcifications were calculated.

RESULTS

Histology revealed 17 invasive cancers and 10 DCIS in the specimens (27 lesions in total). 16 of the specimens contained calcifications. 73 % of the specimens were rated as heterogeneously or extremely dense in DM. Mean time for image viewing was 77 s for DM, 122 s for BT and 131 s for BCT. Sensitivity for lesions was 41 % for DM, 52 % for BT and 70 % for bCT. Sensitivity for calcifications was 75 % for DM, 69 % for BT and 94 % for bCT. Specificity for lesions was 71 % for DM, 29 % for BT and 71 % for bCT. Specificity for calcifications was 67 % for all modalities.

CONCLUSION

For detection of lesions as well as calcifications, bCT showed superior sensitivity compared to DM and BT. Radiologists are not used to inspect bCT images in clinical routine, viewing times nevertheless were still comparable to those of BT. Sensitivity and specificity for lesion detection could potentially be increased further using contrast media.

CLINICAL RELEVANCE/APPLICATION

Dedicated high-resolution low-dose bCT proved to be superior to DM and BT especially for detection of calcifications and lesions in dense breasts.

SSK16-07 A Point-of-Care Cone-Beam CT System for Imaging of Intracranial Hemorrhage: Performance Characterization for Translation to Clinical Studies

Wednesday, Nov. 30 11:30AM - 11:40AM Room: S403B

Participants
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Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Elekta AB; ; ;

PURPOSE

To assess the imaging performance and suitability to clinical studies of a newly developed prototype cone-beam CT system for imaging intracranial hemorrhage (ICH) at the point of care.

METHOD AND MATERIALS

The prototype was designed for reliable detection of acute ICH (~2 mm diameter, 40-80 HU) in the ICU or other points of care for patients with brain injury. System design was guided by a task-based image quality model, yielding a mobile U-arm with 550 mm source-axis distance, 1000 mm source-detector distance, a 15 kW / 0.6 FS x-ray tube (IMD Monobloc), and a 0.14 mm pixel pitch / 43 x 43 cm2 detector (Varian PaxScan 4343CB). Nominal imaging technique involved 720 projections over 360º in 28 s at 100 kVp and 216 mAs with 3x3 pixel binning and dual-gain detector readout. Artifact correction included a fast, GPU-based Monte Carlo scatter correction, Joseph-Spital beam hardening correction, and deconvolution of detector glare and lag effects. Image reconstruction was based on a penalized weighted least squares (PWLS) method with modified weights for artifact corrections.

RESULTS

The prototype has been deployed at our institution in preparation for clinical studies. Dose measured for the nominal scan protocol

(Farmer chamber in 16 cm CTDI phantom) yielded central D0 = 21 mGy, peripheral DP = 24 mGy, and CTDIW = 23 mGy (c.f., head scan protocols for a multi-detector CT CTDIvol = 45-55 mGy). Measurements in head phantoms presenting a spectrum of simulated ICH lesions demonstrated clear visualization down to 2 mm diameter at 50 HU contrast. Field of view was sufficient to cover the head without truncation from crown to mid-cervical spine. The assessment quantified the performance gains associated with detector readout (~10% increase in CNR at matched resolution for dual-gain readout), artifact correction (image uniformity improved by ~300 HU), and image reconstruction methods (contrast to noise > 6.9 at point spread function width ~1.2 mm).

CONCLUSION

The technical assessment indicates imaging performance and dose characteristics suitable to detection / monitoring of ICH at the point of care and provides important preclinical evidence in support of translation to clinical studies.

CLINICAL RELEVANCE/APPLICATION

A cone-beam CT system with image quality characteristics beyond that of existing mobile systems will enable detection and monitoring of acute ICH in applications such as the ICU, urgent care, concussion clinics, and field hospitals.

SSK16-08 Mobile C-Arm Cone-Beam CT: A New Prototype Incorporating Model-Based Image Reconstruction and Soft-Tissue Contrast Resolution

Wednesday, Nov. 30 11:40AM - 11:50AM Room: S403B

Participants
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PURPOSE

Mobile C-arms are often limited to high-contrast visualization suitable to bone applications. This work reports the cone-beam CT (CBCT) imaging performance of a new mobile platform incorporating model-based image reconstruction to improve contrast resolution suitable to soft-tissue visualization.

METHOD AND MATERIALS

The system is based on a fluoroscopic C-arm (Cios Alpha, Siemens) with an external controller providing motorized gantry movement (orbital, angular, and linear) synchronized with x-ray exposure and detector readout. Nominal scan protocol involved a 300°, 452-view propeller orbit rotation. Image quality and dose were measured in phantoms presenting tissue-equivalent simulated lesions as a function of dose (80 kV, CTDIW = 2.25-11 mGy). CBCT volumes were reconstructed using FDK and Huber Penalized Likelihood (PL). The FDK filter and PL regularization strength were set to match the ESF width (0.75 mm) in the brain-equivalent insert. The PL algorithm used 20 iterations of the OS-SQS algorithm with 10 subsets. Noise was derived from the standard deviation in ROIs in soft-tissue regions of interest. Contrast and ESF widths were measured by fitting a Gaussian error function to radial samples of the low-contrast inserts.

RESULTS

For FDK reconstructions, the CNR in brain (to polyethylene background) was 1.8-3.0 over the dose range tested, whereas PL yielded CNR of 2.9-4.0 over the same dose range at matched spatial resolution. Recontructions of an anthropomorphic head phantom demonstrated clear visualization of low-contrast inserts and bony anatomy throughout the cranial vault, including the skull base. Residual ring and streak artifacts were evident from residual errors in gain correction and geometric calibration.

CONCLUSION

The mobile C-arm offers increased x-ray power and the potential to overcome traditional limitations in soft-tissue visibility via model-based reconstruction. Contrast resolution appears sufficient for visualization of 80 HU lesions, with further gains via improved artifact correction. Realizing such capability in a manner consistent with surgical workflow (<2 min) leverages accelerated reconstruction methods.

CLINICAL RELEVANCE/APPLICATION

Mobile C-arms with image quality suitable to soft-tissue visualization could advance 3D imaging in neurosurgical, thoracic, and abdominal surgery for improved evaluation of the surgical product and detection of complications.

SSK16-09 Does Rotational Tube Current Modulation have Significant Impact on Organ Doses in Dental CBCT to Impose its Implementation in Dose Calculating Software Tools?

Wednesday, Nov. 30 11:50AM - 12:00PM Room: S403B

Participants
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Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG

PURPOSE

to compare organ doses and the associated radiation-induced risk for dental CBCT scanning with and without tube-current-modulation (TCM) with identical average tube loading (mAs).

METHOD AND MATERIALS

An EGSnrc-Monte-Carlo (MC) modelling system was used to simulate a VGi-evo (Newtom, Verona, IT) dental-CBCT-scanner with TCM. The scanner employs rotational TCM based on one anterio-posterior and one lateral mA value defined from two scout exposures before the scan. Patient data and exposure parameters were retrieved from PACS for four cases; a 7 years old female undergoing a sinus jaw 8x5cm² Normal-resolution protocol; an 8 years old male undergoing an upper-jaw 5x5cm² Normal-resolution protocol; a 12 years old female undergoing a lower jaw 8x5cm² High-resolution and a full-jaw12x8cm² normal-resolution-protocol. Age and gender-specific voxel models, based on head/neck CT image datasets, were designed (manually segmented) and were used in the simulations. TCM was simulated by applying projection-specific-weighting-factors when calculating the dose integral. The weighting-factors corresponded to the mA modulation at each projection. The constant-current scanning was modelled with a fixed weighting factor=1.

RESULTS

For the upper jaw protocol, TCM reduced the dose to oral mucosa (1.9mGy vs 2.1mGy), yet increased the dose to esophagus (80µGy vs 70µGy), to extra thoracic tissues (ET) (470µGy vs 400µGy) and to thyroid (70µGy vs 60µGy). In the lower jaw protocol TCM resulted in a lower dose to ET (1.5mGy vs 1.65mGy), to oral mucosa (2.9mGy vs 3.2mGy) and salivary glands (1mGy vs 1.1mGy), though the dose to the thyroid (710µGy vs 640µGy) and esophagus (1.1mGy vs 0.95mGy) increased. In full-jaw, except for the dose to RBM, all major radiosensitive organs received lower doses with TCM. In sinus protocols, there was a dose reduction to salivary glands with TCM (330µGy vs 400µGy), yet an increased dose to the brain (100µGy vs 80µGy). Organ dose differences didn't lead to significant changes in effective dose. All the above dose differences were beyond the overall statistical uncertainty (5%).

CONCLUSION

TCM results in different organ dose distributions and should be taken into account in software dosimetry tools.

CLINICAL RELEVANCE/APPLICATION

Accurate organ dose estimations for paediatric patients in dental CBCT imaging requires the implementation of TCM schemes in software tools and MC simulation frameworks

SSK17

Physics (CAD)

Wednesday, Nov. 30 10:30AM - 12:00PM Room: S404AB

CT IN PH

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

Participants
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Heang-Ping Chan, PhD, Ann Arbor, MI (*Moderator*) Institutional research collaboration, General Electric Company

Sub-Events

SSK17-01 Automatic Lymph Node Cluster Segmentation Using Holistically-Nested Deep Convolutional Neural Networks and Structured Optimization in CT Images

Participants
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PURPOSE

To perform lymph node cluster (LNC) segmentation and volume measurement in thoracoabdominal (TA) CT images. To overcome complexity of TA LNC segmentation caused by poor intensity and texture contrast between agglomerated lymph nodes and surrounding tissues.

METHOD AND MATERIALS

This study presents a novel approach to TA LNC segmentation that combines holistically-nested neural networks (HNNs) and structured optimization (SO). Two HNNs, built upon fully convolutional neural networks and deeply supervised networks, are trained to learn LNC appearance (HNN-A) or contour (HNN-C) probabilistic output maps from TA CT images. HNN first produces class label maps with the same resolution as the given input image. Next, HNN-A and HNN-C predictions are formulated into the unary and pairwise terms of conditional random fields (CRFs), which are subsequently solved using three SO methods: dense CRF (dCRF), graph cuts (GC), and the recently developed boundary neural fields (BNF). LNC volumes are then computed from the segmentation predictions.The method was evaluated on a (publicly available) dataset containing 84 abdominal (with 395 LNs) and 87 mediastinal (with 295 LNs) CT scans. 16,268 axial slices were extracted in the portal venous phase with slice thickness 1-1.25 mm. All enlarged LNs (those with short axis diameter >=10 mm, volume range 0.24–31.74 cc, with mean 11.75 +/- 25.05 cc) were segmented by an expert radiologist.

RESULTS

BNF yields the highest quantitative results. Its mean Dice coefficient (DC) between segmented and ground truth LN volumes is 82.1+/-9.6%, compared to 73.0+/-17.6% for HNN-A alone, 69.0+/-22.0% for dCRF, and 67.3+/-16.8% for GC.BNF's LNC relative volume difference (RVD) is 13.7+/-13.1%, compared to 32.2+/-46.3% for HNN-A, 29.6+/-45.4% for dCRF, and 86.5+/-107.6% for GC.The p-values from a paired t-test comparing ground truth to segmented lymph node volumes are p=0.87 for BNF, p=0.37 for HNN-A alone, p=0.10 for dCRF, and p<<0.01 for GC.

CONCLUSION

BNF yields a state-of-the-art RVD result, which thus is promising for the development of LN imaging biomarkers based on volumetric measurements.

CLINICAL RELEVANCE/APPLICATION

Improved TA LNC segmentation and a more robust LN volume measurement will yield more accurate assessment of lymphadenopathy in oncology patients, and may lay the groundwork for improved RECIST measurements of LNs.

SSK17-02 Ensemble Deep Learning for the Improvement of the Performance of Computer-aided Detection of Polyps in CT Colonography

Wednesday, Nov. 30 10:40AM - 10:50AM Room: S404AB

Participants
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PURPOSE

To develop and evaluate an ensemble deep learning (EDL) in the improvement of the detection performance of computer-aided detection (CADe) of polyps in CT colonography.

METHOD AND MATERIALS

A total of 154 CT colonography (CTC) cases were sampled from a large multi-center CTC screening trial. A deep convolutional neural network (DCNN) that had been pre-trained with millions of natural non-medical images was re-trained to identify polyps by use of virtual endoluminal (VE) images of the polyp candidates that were obtained by application of our existing CADe system to these CTC cases. Seven different types of rendering were generated for each of the VE images. An EDL was developed by first re-training seven DCNNs on the seven types of rendered VE images, and then combine them by a super-learner algorithm using a random forest classifier as the meta-classifier. The resulting EDL was reviewed the VE images of the polyp candidates to determine the final detected polyps. For evaluation, the 154 CTC cases were divided randomly into a training and a test dataset. The test set contained 107 biopsy-confirmed adenomas and carcinomas ≥6mm in size: 69 were ≥10 mm and 38 were 6–9 mm in size. The performance of the EDL on the test dataset was evaluated by sensitivity analysis compared with that of the baseline CADe and a single DCNN with McNemar test.

RESULTS

At 4.3 FPs per patient, the per-polyp sensitives of CADe, DL, and EDL were 84.1%, 91.6%, and 93.5%, respectively, for polyps ≥6 mm; and 84.1%, 97.1%, and 97.1%, respectively, for polyps ≥10 mm. The sensitivity difference between CADe and EDL was statistically significant (for polyps ≥6 mm, p=0.002; for polyps ≥10 mm, p=0.03). The CADe scheme yielded 93.5% of the polyps at 12.7 FP detections per patient on average. With the application of EDL, the number of FP detections was reduced to 4.3 per patient (66% reduction) at the same sensitivity.

CONCLUSION

EDL can significantly improve the performance of CADe of polyps in CTC.

CLINICAL RELEVANCE/APPLICATION

The EDL-based CAD could be used to provide a high detection accuracy of polyps in screening population.

SSK17-03 Detectability of Simulated Low-Contrast, Low-Attenuation (LCLA) Liver Lesions on CT: A Comparison of Two Alternate Forced Choice (2AFC) Human Observer Results with Channelized Hotelling Observer and Contrast-to-Noise Ratio for both FBP and ADMIRE

Wednesday, Nov. 30 10:50AM - 11:00AM Room: S404AB

Participants
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PURPOSE

To compare the LCLA lesion detectability accuracy of Channelized Hotelling Model Observer (CHO), Contrast-to-Noise Ratio (CNR) and area-weighted CNR (CNRa) against Human Observer detection accuracy (2AFC), for both filtered back-projection (FBP) and Advanced Modeled Iterative Reconstruction (ADMIRE).

METHOD AND MATERIALS

A custom designed abdominal phantom with liver insert (90 HU density) containing 3 copies each of 4 unique low-attenuation spherical lesions (15 mm x 6 HU, 10 mm x 12 HU, 10 mm x 18 HU, and 5 mm x 24 HU lesion contrasts) was scanned on a Siemens Somatom Force CT scanner at 6 exposure settings: 200, 160, 120, 80, 40 and 20 effective mAs without automated exposure control. A total of 100 repeat scans were done at each exposure level and images were reconstructed with both FBP and ADMIRE (strength A3). A 19 reader Naïve Human Observer (NHO) study in the form of a 2AFC experiment was performed on 577 pairs of lesion-present and lesion-absent images that were selected from one set of the four unique lesions, and the accuracy (AUC) values were computed for both reconstruction modes. A CHO (with internal noise) with 40 Gabor channels was used to evaluate pairs of 100 images, and the accuracy values (Area Under the Curve (AUC)) were computed. The internal noise for CHO was calibrated using the AUC result from data corresponding to FBP at 160 mAs from the NHO analysis. CNR and CNRa and the corresponding scaled accuracy values were also computed for the select lesions. The NHO 2AFC results were compared with the accuracy from CHO, CNR and CNRa and linear regression coefficients (R^2) were calculated.

RESULTS

CNR showed poor correlation with human observer results, with R^2 values of 0.28 and 0.39 for FBP and ADMIRE respectively, and 0.48 and 0.44 respectively for CNRa. CHO showed strong correlation with humans with a R^2 value of 0.88 and 0.92 for FBP and ADMIRE respectively.

CONCLUSION

Our analysis showed good overall detectability correlation of CHO with human results for both ADMIRE and FBP at all exposure levels and for all lesions.

CLINICAL RELEVANCE/APPLICATION

Objective assessment of detectability performance in a controlled environment is important in order to determine the dose reduction

Objective assessment of detectability performance in a controlled environment is important in order to determine the dose reduction potential of novel iterative reconstruction methods. Validation of good correlation between CHO and human observers demonstrate that rigorous human observer studies can be replaced with simpler CHO studies.

SSK17-04 3D Computer-Aided Detection System for Lung Nodule: Comparison of Detection Performance between Filtered-Back Projection and Iterative Reconstruction Methods at Standard-, Reduced and Ultra-Low-Dose CT Levels

Wednesday, Nov. 30 11:00AM - 11:10AM Room: S404AB

Participants
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PURPOSE

To determine the utility of iterative reconstruction (IR) method on a 3D computer-aided detection (CAD) system for pulmonary nodule at standard-, reduced- and ultra-low-dose CTs (SDCT, RDCT and ULDCT) as compared with filtered-back projection method.

METHOD AND MATERIALS

Forty patients prospectively underwent chest CT examinations at MDCT scanners with SDCT (250mA), RDCT (50mA) and ULDCT (10mA) protocols, and CT data were reconstructed into 1-mm-thick images with and without commercially available IR method (i.e. adaptive iterative dose reduction using 3D processing: AIDR 3D). Therefore, the following CT data set in each patient was reconstructed: SDCT with and without AIDR 3D, RDCT with and without AIDR 3D, and ULDCT with and without AIDR 3D. Then, nodule detections were automatically performed by our proprietary CAD software. To determine the utility of IR method for improving nodule detection capability, sensitivity and false positive rate (/case) of the CAD system were also compared among all protocols by means of McNemar's test or signed rank test.

RESULTS

The gold standard consisted of 101 (48 solid and 53 sub-solid) nodules. Although there were no significant difference of false-positive rate among all protocols, sensitivities of RDCT and ULDCT with AIDR 3D (RDCT: 72.3% , ULDCT: 66.3% <2.9/case>) were significantly higher than that without AIDR 3D (RDCT: 56.4% <2.9/case>, $p<0.0001$; ULDCT: 35.6% <2.9/case>, $p<0.0001$). Sensitivity of SDCT with and without AIDR 3D (with AIDR 3D: 73.3% <2.8/case>, without AIDR: 76.2% <2.6/case>) were significantly higher than that of RDCT without AIDR 3D ($p<0.0001$) and ULDCT with and without AIDR 3D ($p<0.0001$), although there were no significant differences of sensitivity between SDCT with and without AIDR 3D and RDCT with AIDR 3D ($p>0.05$).

CONCLUSION

Iterative reconstruction method is useful for improving nodule detection performance on a 3D CAD system at reduced- and ultra-low-dose CTs as compared with filtered-back projection method. When applied AIDR 3D, 75% radiation dose can be reduced without decreasing detection performance on 3D CAD system.

CLINICAL RELEVANCE/APPLICATION

Iterative reconstruction method (i.e. AIDR 3D) is useful for improving nodule detection performance on a 3D CAD system at reduced- and ultra-low-dose CTs as compared with filtered-back projection method. In addition, when applied AIDR 3D, tube current would be better to be set equal to or more than 50mA in this setting.

SSK17-05 CAD Performance on a Large Cohort of National Lung Screening Trial Patients at Screening and Sub-screening Doses

Wednesday, Nov. 30 11:10AM - 11:20AM Room: S404AB

Participants
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PURPOSE

Lung cancer screening is designed to be low-dose and high-throughput. CAD tools promise to assist radiologists in analyzing the

influx of screening exams. However, the effects of dose on CAD performance are not fully understood. In this work, we investigated the impact of reducing the dose further than the National Lung Screening Trial (NLST) dose protocols.

METHOD AND MATERIALS

The raw CT data files from 481 NLST patients were collected and input to a reduced-dose simulation software. The original NLST protocols called for 25 mAs for standard-size patients and 40 mAs for larger patients. We simulated reduced-dose scans corresponding to 50% and 25% of the original protocols. All cases were reconstructed at the scanner (Sensation 64, Siemens Healthcare) with 1 mm slice thickness and B50 kernel. The lungs were segmented in MeVisLab software, and then all images and segmentations were input to an in-house CAD algorithm. CAD results were compared to a reference standard generated by an experienced reader as part of the NLST. We computed subject-level sensitivities, false-positive rates, and analyzed the relative change in those metrics with dose. LungRADS categories were also assigned to each nodule based on nodule size and solidity, and a sub-analysis was peformed by LungRADS category.

RESULTS

For larger category 4 nodules, median sensitivities were 100% at all three dose levels, and mean sensitivities were 72%, 63%, and 63% at original, 50%, and 25% dose respectively. Overall mean subject-level sensitivities were 38%, 37%, and 38% at original, 50%, and 25% dose due to the prevalence of smaller category 2 nodules. The mean false-positive rates were 3, 5, and 13 per case.

CONCLUSION

The results suggest some loss of CAD sensitivity with dose for larger nodules, although overall sensitivity appeared unaffected by dose. The false-positive rate increased substantially at 25% dose, illustrating the difficulty of adapting CAD to very challenging, high-noise screening exams.

CLINICAL RELEVANCE/APPLICATION

Care should be taken to adapt CAD algorithms for very challenging, high-noise lung screening exams.

SSK17-06 Computational Detection, Analysis, and Classification of Lytic, Sclerotic, and Mixed Spinal Metastases on PET/CT Imaging

Wednesday, Nov. 30 11:20AM - 11:30AM Room: S404AB

Participants
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PURPOSE

To develop a fully-automated system to detect, analyze, and classify spinal metastases on 18F-FDG PET/CT, integrating CT and PET features into lesion segmentation algorithms and classifiers

METHOD AND MATERIALS

The most common locale for spinal metastases, thoracic and lumbar vertebral bodies, is targeted. Modeling clinical evaluation, fused images are created. To utilize the higher dimensional operation capability of computers, two image sets are produced for each study by weighted integration of PET with CT data, with one set for lytic and one for sclerotic loci, for density amplification by PET activity. Spine segmentation/partitioning is performed, and watershed, graph cut, and level set algorithms are used to obtain initial detections. If a preliminary lytic and a sclerotic detection are spatially overlapping, they are merged and sent to a mixed lesion SVM classifier; otherwise, they are routed to lytic and sclerotic lesion classifiers, respectively. 10-fold cross validation was employed to evaluate classifier performance The system was tested on PET/CTs of 53 patients (average age 53 (range 21-68), 28 F, 25 M). 35 patients had reported spinal metastases. 266 of 901 vertebrae demonstrated metastases. The numbers of lytic, sclerotic and mixed lesions were 205, 286, and 120, respectively

RESULTS

The sensitivities for detecting lytic, sclerotic and mixed lesions were 79.4% (95% CI [75.6%, 82.3%]), 80.8% (95% CI [76.7, 84.4]), and 80.2% (95% CI [74.2, 84.3]), respectively, with a false-positive (FP) rate of 2.1, 1.7 and 0.9 per patient. With only CT data used, performance sensitivity was 64.3%, 70.5%, and 48.6%, for lytic, sclerotic and mixed lesions respectively at a FP rate of 1.9, 1.9 and 1.0 per patient. Performance improvement with PET/CT fusion is statistically significant ($p<0.01$). There were 32 FP in 18 control cases. Lesions ranged from 4 to 37 mm size, and were most common from T9 to T12. FP detections were most often due to bone islands. False negatives occurred with small lesions/insufficient activity on PET

CONCLUSION

A multi-classifier quantitative analysis system was created to detect, classify, and generate metrics for metastatic lesions of the vertebral bodies in the thoracic and lumbar spine on 18F-FDG PET/CT

CLINICAL RELEVANCE/APPLICATION

Quantitative characterization of metastatic lesions to the spine can assist ongoing efforts to develop new clinically relevant response criteria to guide patient therapy.

SSK17-07 Dynamic Texture Feature Analysis Using Dynamic Contrast-Enhanced CT Applied to Malignant Pleural Mesothelioma

Wednesday, Nov. 30 11:30AM - 11:40AM Room: S404AB

Participants
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PURPOSE

The purpose of this work was to investigate the utility of texture analysis of dynamic contrast-enhanced computed tomography (DCE-CT) scans in the assessment of tumor response for malignant pleural mesothelioma (MPM).

METHOD AND MATERIALS

Two DCE-CT scans were acquired at approximately 3-month intervals from a total of 16 MPM patients, of whom eight were on treatment and eight were on observation. The dynamic component of the scans involved the imaging of a 55-mm thick slice of thoracic anatomy at 25 time points immediately following the start of contrast injection. Visible tumor within the dynamically imaged anatomy of each patient was manually contoured. These contours were projected to other time points of the scan using deformable image registration and eroded by one voxel to limit the effect of misregistration and inadvertent inclusion of non-tumorous tissue. Twelve first-order texture features were calculated from the tumor voxels at each time point. The relative change in texture feature values from the start of contrast injection was calculated for all time points of each scan, as was the difference in these relative changes between the first and second scans. A Wilcoxon rank-sum test was used to test whether the median relative change in texture feature value and the median difference in relative change between the two scans were significantly different between the two patient cohorts.

RESULTS

The texture features interquartile range, mean HU value, median HU value, energy, and entropy each showed significant differences ($p < 0.05$) between the two patient cohorts at ten or more time points for the second DCE-CT scan. Differences in relative change between the two scans were statistically significant between patients on treatment and patients on observation at seven time points across all texture features.

CONCLUSION

Observed differences in median texture feature values between patients on treatment and patients on observation for the second scan of this study suggest that dynamic texture analysis is sensitive to MPM tumor response. This finding should be validated in future studies using a larger patient cohort and a more unified treatment regimen.

CLINICAL RELEVANCE/APPLICATION

Ultimately, this work could lead to more sophisticated methods to assess tumor response in MPM patients.

SSK17-08 Performance Evaluation of Machine-Learning-based Electronic Cleansing Schemes for Ultra-Low-Dose Dual-energy CT Colonography

Wednesday, Nov. 30 11:40AM - 11:50AM Room: S404AB

Participants
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PURPOSE

To develop and evaluate accuracy of machine-learning electronic cleansing (ML-EC) schemes for non-cathartic ultra-low-dose dual-energy CT colonography (DE-CTC).

METHOD AND MATERIALS

Thirty-two patients were prepared for non-cathartic colorectal examinations by oral ingestion of 50 ml of iodinated contrast on the day before and two hours prior to DE-CT (SOMATOM Definition Flash) scans. The DE-CTC images were acquired at a current/voltage of 15 mAs/140 kVp and 40 mAs/80 kVp and reconstructed with sinogram-affirmed iterative image reconstruction. Our ML-EC performed a water-iodine material decomposition of the DE-CTC images and calculated virtual-monochromatic (VM) images at multiple energies for preparing radiomic image set, after which a machine-learning method [k-nearest neighbors (kNN), random forest (RF) and deep learning (DL)] was used to label the images into regions of lumen air, soft tissue, fecal tagging, and two types of partial-volume boundaries based on the features of these images. The EC was performed by removing materials other than soft tissues from the original CTC images. For pilot evaluation, 384 volumes of interest (VOIs) where current EC schemes generate typical EC artifacts (Type I: air-tagging boundary; Type II: three-material layer; Type III: three-material mixture) were extracted and labeled into a reference standard. The EC accuracy was evaluated by means of the mean overlap ratio (OR) between the reference standard labels and the labels generated by the ML-EC schemes.

RESULTS

In the DL-based ML-EC scheme, the mean±std of ORs for Types I, II, and III artifacts were 0.984±0.029, 0.932±0.046, and 0.958±0.021, respectively, which were higher than those of kNN-based ML-EC (0.975±0.035 [p<.001], 0.895±0.058 [p<.001], and 0.938±0.027 [p<.001], respectively), and RF-based ML-EC (0.982±0.032 [p=.11], 0.913±0.064 [p<.001], and 0.953±0.025 [p<.001], respectively). Visual assessment confirmed that the DL-based ML-EC generates less EC artifacts than do kNN- and RF-based ML-EC.

CONCLUSION

Our DL-based ML-EC scheme yields superior performance over kNN- and RF-based ML-EC schemes in identifying and minimizing subtraction artifacts on non-cathartic ultra-low-dose DE-CTC images.

CLINICAL RELEVANCE/APPLICATION

Current electronic cleansing methods for visualization of the colonic surface in CTC produce subtraction artifacts. The proposed method shows potential to minimize these artifacts and to facilitate non-cathartic examinations.

SSK17-09 Multivariate Modeling of Nodule Recognition in 3-D Chest CT using Gaze Tracking

Wednesday, Nov. 30 11:50AM - 12:00PM Room: S404AB

Participants
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PURPOSE

Nodule detection in CT scans requires a large volume to be visually scanned for small objects. Recognition of potential nodules is a critical step towards detection. However the process of recognition is unknown, involving potential factors such as search strategy, size of the nodule and visible cross sectional area of the lung. Using gaze tracking data from chest CT reads, we developed a multivariate probabilistic model to elucidate the importance of these factors in the recognition process and the variation across readers with various levels of training.

METHOD AND MATERIALS

Gaze data was collected from 13 readers, ranging from 1st year residents to attending radiologists. Each reader examined 40 chest CTs, each embedded with 3-6 simulated nodules. Nodule recognition is modelled as a spatio-temporal Poisson process. The instantaneous probability of nodule recognition (IPR) was modelled as a linear combination of i) gaze distance from the nodule center at the moment of recognition (DG); ii) the visible cross-sectional (CS) size of the embedded nodules (nodule CS); iii) visible CS area of the lung (lung CS) using generalized Poisson regression. The linearity assumption was validated by considering a smooth (potentially non-linear) additive function of the variables.

RESULTS

The mean (SD) of 25th and 75th percentiles of DG were 1.71 (0.49) and 5.35 (1.30) cm respectively across readers. The IPR decreased approximately exponentially with increasing DG for all 13 readers ($P<0.00001$), with a mean (SD) rate of decrease of 27.6% (8.8%) /cm across readers. The nodule CS effect was significant in 11/13 readers ($P<0.005$) with a mean (SD) rate of increase in IPR of 8.6% (4.2%) /mm2. The IPR decreased at a mean rate of 0.6% (0.2%)/cm2 with increasing lung CS, with significant effects for 12/13 readers ($P<0.001$).

CONCLUSION

Nodule recognition often occurs when the gaze is far from the target; the probability of recognition increases approximately exponentially with proximity. Factors like nodule size and lung cross section size also significantly impact recognition. Despite the variation in experience, the recognition process appears to be similar across readers.

CLINICAL RELEVANCE/APPLICATION

We have quantitatively characterized the process of nodule recognition during free search of 3-d chest CT scans. The insights from this characterization may lead to the development of CAD algorithms which work complementarily to the human recognition process.

PHS-WEA

Physics Wednesday Poster Discussions

Wednesday, Nov. 30 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
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Sub-Events

PH246-SD-WEA1 Radiation Dose, Contrast Medium Dose, and Image Quality at Low Tube Voltage CT for Right Adrenal Vein Imaging

Station #1

Participants
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PURPOSE

Right adrenal vein (RAV) imaging prior to adrenal venous sampling with less radiation and iodine contrast dose is preferred. We aimed to compare radiation dose, contrast medium dose, and image quality for CT imaging of the RAV among conventional, low kV, and low kV with reduced contrast protocols.

METHOD AND MATERIALS

This institutional-review-board approved prospective study included 90 consecutive patients with primary aldosteronism. Written informed consent was obtained from all patients. Patients were randomized into three groups: contrast dose of 600 mg/kg body weight at conventional 120 kV tube voltage setting (600-120 group), 600 mg/kg at 80 kV (600-80 group), and 360 mg/kg at 80 kV (360-80 group). All patients were imaged with a second generation dual-source MDCT scanner. Images at 120 kV were reconstructed with filtered back projection and those at 80 kV with iterative reconstruction (SAFIRE, strength 3). Slice thickness was 1mm with 1mm interval. RAV visualization was evaluated using a 5-point scale (0-4). A score of ≥ 2 was defined as detectable. Estimated effective radiation dose (ED), background noise, signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) were calculated. Analysis of variance with Tukey's test for post hoc comparisons was used for continuous variables, and Kruskal Wallis test was used for categorical variables. $P < .05$ indicated statistical significance.

RESULTS

RAV detectabilities were 96% (26/27), 97% (30/31) and 97% (31/32) for 600-120 group, 600-80 group, and 360-80 group, respectively ($P = .99$). No significant differences in the visualization scores were found among the three groups (3.5 ± 0.8, 3.6 ± 0.8 and 3.3 ± 0.9, respectively ($P = .20$). EDs were 1.9 ± 0.8, 1.6 ± 0.6 and 1.3 ± 0.6, respectively. The 360-80 group showed significantly lower ED than 600-120 group ($P = .004$). Both 80kV groups showed significantly lower background noise than 120kV group. The 600-80 group showed significantly higher SNR and CNR than 600-120 group.

CONCLUSION

RAV detectability was comparable among the three groups. Low tube voltage CT can reduce radiation and contrast medium dose while keeping image quality and RAV detectability.

CLINICAL RELEVANCE/APPLICATION

Low tube voltage CT can precisely identify the RAV while reducing radiation dose and contrast medium dose in patients with primary aldosteronism.

PH247-SD-WEA2 A New Automatic Registration Technique for Temporal Subtraction in Successive Hand CR Images

Station #2

Participants
Seiichi Murakami, Kitakyusyu, Japan (*Presenter*) Nothing to Disclose
Shota Kajiwara, Kitakyusyu, Japan (*Abstract Co-Author*) Nothing to Disclose
Hyoungseop Kim, PhD, Kitakyushu, Japan (*Abstract Co-Author*) Nothing to Disclose
Takatoshi Aoki, MD, PhD, Kitakyushu, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Although the radiographic assessment of joint damage is essential in characterizing disease progression and prognosis in rheumatoid arthritis (RA) patients, it is often difficult even for trained radiologists because interval changes are often subtle. The purpose of this study is to develop an automatic registration technique for temporal subtraction images in order to assist radiologists in the detection of interval changes on phalange radiographs.

METHOD AND MATERIALS

We developed an automatic registration technique with scale-invariant salient region features. First, we performed a segmentation

technique for extracting the detailed phalangeal regions using the multiscale gradient vector flow snakes method. Next, the salient regions were detected based on entropy from the image of the phalangeal regions. Then, the optimum deformation value was determined from the relationship between the previous salient region features and current ones. Finally, the interval changes are detected by registration of phalangeal regions based on rigid registration technique. We applied our developed method to 84 bone pairs (current and previous images) of hand CR images. For quantitative assessments, we employed the Jaccard similarity coefficient in the registration area between the previous and the current segmented region. For qualitative assessments, the temporal subtraction images was reviewed by two radiologists using a four-point scale (1=poor: most of outline not registered; 4=excellent: all of outline perfectly registered).

RESULTS

The Jaccard similarity coefficient of our registration technique was 94% at average. Overall image quality was good to excellent in the observers' qualitative assessment.

CONCLUSION

We have developed a new computerized scheme to enhance the temporal change based on image registration technique. The novel automatic registration technique for temporal subtraction images has high registration accuracy.

CLINICAL RELEVANCE/APPLICATION

We have been developing a new temporal subtraction method using the salient region featured image registration technique. This registration technique can reduce computational time and can potentially be used for detection of subtle interval changes caused by arthritis.

PH248-SD-WEA3 Change in ADC during Cardiac Cycle in Idiopathic Normal Pressure Hydrocephalus Decreases with Shunt Surgery

Station #3

Participants
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Tomoshi Osawa, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Shota Ishida, BS, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Harumasa Kasai, MSc, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuta Shibamoto, MD, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

We have reported that the apparent diffusion coefficient (ADC) in brain significantly changed during the cardiac cycle, and this change (ΔADC) in the frontal white matter in patients with idiopathic normal pressure hydrocephalus (iNPH) characterized by low intracranial compliance was significantly higher than those in patients with atrophic ventricular dilatation and control subjects. Shunt surgery by which the reduced intracranial compliance can be improved is the most common treatment for iNPH. In this study, we assessed the ΔADC of the white matter in iNPH before and after shunt surgery.

METHOD AND MATERIALS

With a 1.5-T MR imaging unit (Gyroscan Intera; Philips Medical Systems, Best, The Netherlands), ECG-triggered single-shot diffusion echo-planar imaging (b = 0 and 1000 s/mm2) was used with sensitivity encoding and half-scan techniques to minimize the bulk motion. The imaging parameters were set at TR, two R-R intervals; TE, 70 msec; flip angle, 90 degrees; section thickness, 4 mm; imaging matrix, 64x64; field of view, 256 mm; number of signals averaged, two; the number of cardiac phases, 20; duration and respective times between leading edges of the diffusion gradients, 28.6 and 48.7 msec. Then, we determined the maximum change in ADC (ΔADC) during the cardiac cycle and compared those values of the white matter in patients with iNPH before and after shunt surgery (n = 7, all patients improved symptoms after the shunt procedure, ie., definite iNPH). This study was approved by the institutional review board.

RESULTS

ΔADC in the frontal white matter in iNPH after the shunt surgery was significantly lower than that before shunt surgery, indicating that fluctuation of water molecules in the white matter caused by the arterial inflow, ie., volume loading of the brain as the driving force was reduced by increase in the intracranial compliance after the shunt. However, there was no significant difference in ADC values in iNPH before and after shunt surgery.

CONCLUSION

ΔADC in the frontal white matter in iNPH decreases with the shunt surgery. Determination of ΔADC makes it possible to obtain more detailed information on change in the intracranial condition in iNPH than standard ADC measurement before and after shunt surgery.

CLINICAL RELEVANCE/APPLICATION

ΔADC analysis makes it possible to noninvasively provide detailed information on change in the intracranial condition due to the shunt surgery.

PH249-SD-WEA4 Framework for Objective and Fully Automated Image Quality Control of Dedicated Breast CT Systems

Station #4

Participants
Christian Steiding, PhD, Erlangen, Germany (*Presenter*) Employee, CT Imaging GmbH
Daniel Kolditz, PhD, Erlangen, Germany (*Abstract Co-Author*) Employee, CT Imaging GmbH
Veikko Ruth, MSc, Erlangen, Germany (*Abstract Co-Author*) Nothing to Disclose
Ferdinand Lueck, DIPLPHYS,PhD, Erlangen, Germany (*Abstract Co-Author*) Employee, CT Imaging GmbH
Willi A. Kalender, PhD, Erlangen, Germany (*Abstract Co-Author*) Founder, CT Imaging GmbH; CEO, CT Imaging GmbH

PURPOSE

Dedicated breast CT (BCT) represents an emerging 3D imaging modality that has significant potential for breast cancer detection and diagnosis; the first BCT system has recently been granted FDA approval. As for all new tomographic imaging devices, the conformance of system characteristics with specifications needs to be checked on a regular basis, but to date there is no consensus on acceptance and constancy testing for image quality (IQ) in BCT. The aim of this work was to introduce and validate a quality assurance (QA) framework for objective and easy-to-use IQ control of BCT scanners.

METHOD AND MATERIALS

A cylindrical QA phantom, with a diameter of 14 cm, a height of 10 cm, made of water-equivalent plastic, was chosen. Various test inserts are embedded in this phantom to determine the desired IQ parameters. Noise by means of the standard deviation and the noise power spectrum as well as uniformity are determined in homogeneous phantom compartments located at different axial positions. Special inserts providing defined CT values allow for assessing image contrast and CT value accuracy. For fully volumetric evaluation of high-contrast spatial resolution, the 3D modulation transfer function of a 12 mm PTFE sphere can be calculated. We implemented an automated detection algorithm for the proposed QA phantom to make automatic and easy-to-use tracking of imaging characteristics feasible. Measurement series were carried out on a photon-counting BCT prototype equipped with a tiled cadmium telluride detector with 0.1 mm pixel size.

RESULTS

Only one scan is required to determine all essential IQ parameters routinely when using the novel QA framework. The interscan variation of repeated measurements was neglectable for all the assessed IQ metrics. Less than 10 s were required for the phantom detection and IQ analysis. The robustness of the proposed QA framework was validated successfully over a period of several months.

CONCLUSION

The proposed QA framework provides quantitative, robust, and fully automated 3D IQ control and is applicable for arbitrary scan protocols. Our study indicates that the concept is suitable for any acceptance and constancy testing in BCT to come.

CLINICAL RELEVANCE/APPLICATION

The proposed framework ensures accurate and reproducible assessment of the stability of objective IQ aspects in BCT and may thereby help to establish QA standards for this emerging imaging modality.

PH251-SD-WEA6 Technical and Clinical Factors Affecting Success Rate of a Novel Holistic Deep Learning Method for Pancreas Segmentation on CT Scans

Station #6

Participants
Mohammad Hadi Bagheri, MD, Bethesda, MD (*Presenter*) Nothing to Disclose
Holger R. Roth, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
William Kovacs, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Le Lu, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Jianhua Yao, PhD, Bethesda, MD (*Abstract Co-Author*) Royalties, iCAD, Inc
Francine Thomas, BS,RT, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Ronald M. Summers, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Royalties, iCAD, Inc; ;

PURPOSE

Pancreas segmentation on CT scans is an extremely difficult problem due to the pancreas's high deformability and complex surroundings. In order to improve the accuracy of pancreas segmentation, it is important to identify the technical and clinical factors that affect it.

METHOD AND MATERIALS

A holistic deep convolutional neural network approach for pancreas segmentation in 82 abdominal CT scans from 53 men and 27 women, combining interior and boundary mid-level cues via spatial aggregation segmentation method for the pancreas was evaluated by the Dice similarity coefficient (DSC). Seventeen patients were healthy kidney donors and the remaining 65 patients had neither major abdominal pathologies nor pancreatic lesions. All scans were in the portal-venous phase (~70 seconds after intravenous contrast injection). Mean slice thickness was 1.2 ±0.7 mm. Using multiple regression analysis (PSPPIRE, Linux Version: 0.7.9), the DSC was compared with CT technical factors (image pixel size, slice thickness, presence or absence of oral contrast), demographic data (age, gender, height, weight, BMI) and CT imaging findings (volume and density of pancreas, visceral and subcutaneous abdominal fat volume and CT attenuation of the structures within 5-mm neighborhood of the pancreas).

RESULTS

The overall DSC was 78.0% ± 8.0. Factors that were statistically significantly correlated with DSC included age ($r=0.25$, $p=0.03$), abdominal fat (visceral ($r=0.4$, $p=0$), subcutaneous ($r=0.25$, $p=0.02$) and total abdominal fat($r=0.38$, $p<0.01$)), standard deviation of CT attenuation within the pancreas ($r=0.28$, $p=0.01$), volume of the pancreas ($r=0.22$, $p=0.05$) and median and average CT attenuation in the immediate neighborhood of the pancreas ($r=-0.41$, $p<0.01$ and $r=-0.40$, $p<0.01$ respectively). We found no significant correlation between the DSC and the height, weight, BMI, gender or mean CT attenuation of the pancreas.

CONCLUSION

Increased abdominal and visceral fat, age and fat within or around the pancreas are major factors associated with better segmentation (higher DSC) of the pancreas. These results provide a clear direction for future research for solutions to this difficult image processing problem.

CLINICAL RELEVANCE/APPLICATION

This pancreatic segmentation method, which achieves the current state-of-the-art performance, is more accurate in elderly patients and those with greater pancreatic and peripancreatic fat.

PHS-WEB

Physics Wednesday Poster Discussions

Wednesday, Nov. 30 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Xinming Liu, PhD, Houston, TX (*Moderator*) Nothing to Disclose
Gregory S. Karczmar, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

PH252-SD-WEB1 Correlation of MRI Derived Parameters and Classical Anthropometry in the Evaluation of Obesity

Station #1

Awards
Student Travel Stipend Award

Participants
Nicolas Linder, Leipzig, Germany (*Presenter*) Nothing to Disclose
Alexander Schaudinn, MD, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Nikita Garnov, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Thomas Karlas, MD, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Matthias Bluher, MD, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Stefanie Lehmann, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Andreas Oberbach, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Rima Chakaroun, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Arne Dietrich, 04103, Germany (*Abstract Co-Author*) Nothing to Disclose
Thomas K. Kahn, MD, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose
Harald F. Busse, PhD, Leipzig, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The purpose of this study was to evaluate the relationship between common anthropometric measures and MRI-derived adipose tissue volumes in the evaluation of obesity.

METHOD AND MATERIALS

Obese patients of a local obesity research center were MRI examined after IRB approval and data were analyzed retrospectively. Anthropometric parameters consisted of patient weight, BMI and WHR (waist-to-hip ratio). Patients were classified into grades of obesity according to the WHO definition (I°: BMI 30-35 kg/m², II°: 35-40, III°: > 40). MRI data included the segmented volumes of the visceral and subcutaneous adipose tissue (V-VAT and V-SAT) as well as segmented adipose tissue areas at an optimum (BMI-dependent) axial reference position (A-VAT and A-SAT). Patients were analyzed according to their class of obesity using a linear regression and calculating the coefficient of determination R^2. V-VAT was set as the gold standard for evaluation of abdominal obesity.

RESULTS

261 patients were included in the analysis. 94, 86 and 81 patients were classified as I°, II° and III° obese, respectively. VAT and SAT could be quantified for 261 and 173 patients, respectively. Average weight, BMI, WHR and V-VAT were 160.5 (range 27.7-172.0) kg, 37.7 (30.0-60.3) kg/m², 0.92 (0.70-1.17) and 4.43 (0.91-12.4) cm³. A-VAT showed a good correlation with V-VAT both overall (R^2 = 0.89) as well as within each obesity class (I°: 0.92, II°: 0.88, III°: 0.84). A-SAT showed good correlation with V-SAT (0.78) with slight variation between individual BMI classes (I°: 0.61, II°: 0.79, III°: 0.60). Correlation of weight, BMI and WHR with volumes of adipose tissue was generally poor, both for V-VAT (0.23, 0.08, 0.35) and for V-SAT (0.20, 0.44 and 0.03).

CONCLUSION

This comparison confirms the poor performance of common anthropometric measures and the good performance of simplified MRI-derived adipose tissue measures for the evaluation of whole-abdominal VAT and SAT volumes.

CLINICAL RELEVANCE/APPLICATION

Simplified, MRI-derived measures of adipose tissue outperform traditional anthropometry in the evaluation of whole-abdominal VAT and SAT volumes and should be evaluated further.

PH253-SD-WEB2 Feasibility of Ultralow Tube Voltage Low Radiation Dose Protocol for Coronary Stent Imaging Using High-definition256-Detector Row Gemstone CT: A Phantom Study

Station #2

Participants
Yi-Luan Huang, MD, Kaohsiung, Taiwan (*Presenter*) Nothing to Disclose
Ming-Ting Wu, MD, Kaohsiung, Taiwan (*Abstract Co-Author*) Nothing to Disclose
Chiung Chen Chuo, Kaohsiung City, Taiwan (*Abstract Co-Author*) Nothing to Disclose
Chen Shying Chen, Kaohsiung, Taiwan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate the feasibility of a low radiation dose protocol at a 256-detector row CT using ultralow tube voltage (70- and 80-kVp) high-definition (HD) imaging to evaluate the in-stent and peri-stent stenosis in a coronary-stent phantom.

METHOD AND MATERIALS

A coronary-stent phantom (3-mm diameter) with in-stent and peri-stent 70% concentric luminal narrowing made of acrylic resin were filled with iodinated contrast agent and fixed in a water-filled tank. The phantom was scanned on a 256-detector row CT (Revolution CT, GE Healthcare) with ECG-triggered axial cardiac mode at 65 bpm. Different tube voltages (70, 80, 100, 120, and 140-kVp) and tube currents (50mA~580mA) adjusted by CTDI values were applied. CTDI had three groups: low (~1.15 mGy), intermediate (~2.70 mGy), and high (~3.95 mGy). High resolution mode was turned on and off during data acquisition for comparison. Iterative reconstruction was not used. Images were reconstructed with different convolution algorithms: standard, HD-standard, and HD-detail. All images were analyzed at appropriate window settings (AW Server 2.0). The visibility of the peri-stent and in-stent lumen were graded by Likert 5 scale: 1 (not evaluable) to 5 (excellent). A high-CTDI protocol (120-kVp/545-mA) served as reference.

RESULTS

With standard convolution algorithm, it is hardly to evaluate the in-stent lumens in all 3 CTDI protocols. In high-CTDI group, HD-standard (score: 3.83±0.72) and HD-detail (score: 3.58±0.9) both improved the evaluation of in-stent stenosis as compared to standard algorithm (scores: 1.42±0.66) (P <0.001, P =0.02, respectively).In intermediate CTDI group, the 80-kVp protocol provided higher quality of in-stent lumen than the high (120-/140-) kVp protocol (score: 5.0±0 vs. 2.34±0.58, P=0.102). In low-CTDI group, ultra-low (70-/80-) kVp HD images (score: 4.34±0.28) were superior to high-kVp HD images (score 2.5) for visualization of in-stent lumen. HD-detail images (score: 3.08±1.16) were not superior to HD-standard images (score: 3.50±0.90). Although with higher blooming artifact of the stent, the 70/80-kVp low-CTDI protocol was not inferior to the reference for in-stent lumen while saving of 80% CTDI.

CONCLUSION

With clinical relevant CTDI, 70/80-kVp CT with HD-standard algorithm is feasible for evaluation of metallic stent.

CLINICAL RELEVANCE/APPLICATION

70/80-kVp CT with HD-standard algorithm is feasible for evaluation of metallic stent.

PH255-SD-WEB4 Cone Beam CT Radiation Exposure Reduction by Reconstructing Undersampled Data with Prior Knowledge and Symmetry Considerations

Station #4

Participants
Khanlian Chung, Mannheim, Germany (*Presenter*) Nothing to Disclose
Lothar R. Schad, PhD, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose
Frank G. Zoellner, Mannheim, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Modern cone beam CT allows for dynamic perfusion imaging however it comes with a high patient dose. We propose an iterative reconstruction (IR) algorithm using undersampling and prior knowledge to reduce dose while keeping image quality.

METHOD AND MATERIALS

IRs typically face the trade-off between fewer projections (equal less information) and higher computational demands, in particular computer memory and reconstruction time.In our algorithm, we implemented cylindrically shaped voxels for image reconstruction, which are ordered in a special pattern. This design takes both, scan trajectory and cone beam geometry symmetries of interventional cone beam CTs, into account. Different projections can be treated as rotations of a reference projection. This reduces the computational demands (computing time and memory capacity) by the magnitude of the number of projections.Furthermore, the algorithm incorporates high quality prior images (e.g. from diagnostic scans) and updates only diverging voxels in the prior image. Typically, only few voxels are updated and therefore, the image quality of the reconstruction is enhanced.To validate the algorithm, a cubic box filled with a sphere was scanned with 397 projections and reconstructed by a commercial cone beam CT. This image was used as reference. Undersampled datasets with 50 projections and size of 240*182 pixels were generated and, afterwards, reconstructed by our algorithm. To provide prior knowledge, the box was scanned a second time without a sphere.

RESULTS

The reconstructed undersampled CTs with cylindrically shaped voxel scheme displayed all structure properly. Using a prior image to enhance the reconstruction, the edges became clearer. For example the perforations of the phantom increased about 40 % in contrast.Our approach allows a dose reduction of more than 85 % because instead of 397 only 50 projections are needed.

CONCLUSION

The presented approach allows reconstructing CT images with a fraction of the number of projections usually needed with only minor quality losses. This was achieved by utilizing prior knowledge and symmetry considerations.

CLINICAL RELEVANCE/APPLICATION

It is intended to use our knowledge- and symmetry- based algorithm in interventional cone beam CT applications (e.g. 3D perfusion imaging) to reduce radiation exposure.

PH256-SD-WEB5 Comparison of Mass Detection for Digital Breast Tomosynthesis (DBT) with and without Transfer Learning of Deep-learning Convolution Neural Network (DLCNN) from Digitized Screen-film Mammography (SFM) and Digital Mammography (DM)

Station #5

Participants
Ravi K. Samala, PhD, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Institutional research collaboration, General Electric Company
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

Jun Wei, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Kenny H. Cha, MSc, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Mark A. Helvie, MD, Ann Arbor, MI (*Abstract Co-Author*) Institutional Grant, General Electric Company

PURPOSE

Transfer learning is expected to be an efficient method for training DLCNN when the available training sample size is small. We compare the performance of DLCNN trained using mass candidates from DBT versus using transfer learning by training first with SFM and DM for false positive (FP) reduction in a mass CADe system for DBT.

METHOD AND MATERIALS

In the CADe system prescreening stage, mass candidates are identified with a combination of first- and second-order features from gradient field convergence map and eigenvalues from Hessian analysis. The candidate regions-of-interest (ROI) are extracted for FP reduction using DLCNN. For training of the DLCNN, heterogeneous mass candidates from SFM, DM and DBT are collected. The training set includes 2200 lesions from 856 SFM and DM cases and 192 lesions from 153 DBT cases. The independent test set consists of 94 views from 47 breasts with 90 lesions, of which 31 are malignant and 59 benign.128x128-pixel ROIs are extracted from the images/slices. To augment the training patterns, each ROI in DM or SFM is rotated and flipped to generate eight patterns. For DBT, five slices are extracted. Over 60,000 SFM, DM and DBT ROIs were available for DLCNN training. The DLCNN structure consists of four convolution layers connected by max-pooling and normalization layers for the first two convolution layers. For transfer learning, the network was first trained with the SFM and DM ROIs, then the first two convolution layers were frozen and the last two convolution layers were allowed to train based on the DBT ROIs (over 18000 ROIs). Without transfer learning, the DLCNN was trained directly using all training DBT ROIs alone. In both approaches, the DLCNN was trained until a stable AUC was achieved.

RESULTS

The AUC with and without transfer learning reached 0.94±0.01 and 0.97±0.01, respectively. For the independent test set, view-based sensitivities of 79% and 86% were achieved at 3.8 and 3.9 FPs/view with and without transfer learning, respectively. Similarly, the case-based sensitivity of 85% was achieved at 2.0 and 1.9 FPs/view, respectively.

CONCLUSION

Training of the DLCNN on DBT ROIs alone without transfer learning resulted in better learning of the mass patterns for DBT.

CLINICAL RELEVANCE/APPLICATION

An effective CADe systems for mass detection in DBT may be a useful second reader or a component of an efficient visualization tool to improve workflow of DBT interpretation.

SSM20

Physics (Radiation Therapy and Cancer Imaging)

Wednesday, Nov. 30 3:00PM - 4:00PM Room: S404CD

CT PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 1.00

FDA Discussions may include off-label uses.

Participants
Lei Xing, PhD, Stanford, CA (*Moderator*) Nothing to Disclose
Bulent Aydogan, PhD, CHICAGO, IL (*Moderator*) Nothing to Disclose

Sub-Events

SSM20-01 High Definition Oncological FDG PET CT: Tomorrow's Imaging Using Yesterday's Technology

Wednesday, Nov. 30 3:00PM - 3:10PM Room: S404CD

Participants
Katherine Binzel, PhD, Columbus, OH (*Presenter*) Nothing to Disclose
Preethi Subramanian, MS, BEng, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michelle I. Knopp, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Jun Zhang, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michael V. Knopp, MD, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

While clinical, time of flight PET imaging is currently typically reconstructed using voxel sizes of 3mm or more and matrix sizes of 200 or less, advances in reconstruction, both hard and software, facilitate smaller voxel and larger reconstruction matrix sizes. We hypothesized that those high definition approaches developed for next generation digital PET could be utilized and improve conventional PET imaging.

METHOD AND MATERIALS

32 FDG oncologic whole body PET scans acquired on a current generation time of flight PET/CT (Gemini 64 TOF, Philips) with a median dose of 13 mCi and 90s/bed acquisition were newly reconstructed using a High Definition (2x2x2 mm3 voxel size, PSF and Gaussian filter approach) (HD) after performing a re-optimization of reconstruction parameters and compared by blinded individual and intra-individual comparison to the default 4x4x4 voxel recon (SD). Reader quality assessment and ROI analysis for lesion uptake was performed.

RESULTS

Initial HD recon results presented with unacceptable noise levels. After recon optimization using separate data sets and reducing the number of subsets from 33 to 15, noise levels were greatly reduced and used for this study. Image quality, lesion conspicuity, lesion delineation and confidence in diagnosis were all found to be significantly higher (at least $p<.05$) for the HD then SD reconstruction. ROI analysis revealed significantly higher SUVmax in smaller or heterogeneous lesions, consistent with improved recovery coefficients found on independent phantom testing. Otherwise, SUVmax was unchanged.

CONCLUSION

Higher definition, smaller voxel volume reconstruction appear readily feasible even on older generation time of flight PET systems, however reconstruction parameters need to be optimized. Blinded, intra-individual assessment led to significant improvements in lesion conspicuity, delineation, perceived image quality and diagnostic confidence. High Definition reconstruction can and should be implemented even on current generation time of flight PET systems and appear lead to reduced partial volume effects during reconstruction and thus improved image quality, both visually and quantitative.

CLINICAL RELEVANCE/APPLICATION

Smaller voxel reconstruction appear readily feasible even on older TOF PET systems after appropriate optimization leading to improved image quality, lesion conspicuity and quantitative accuracy.

SSM20-02 Thermoacoustic Range Verification for Proton Therapy - Overlay of Bragg Peak Location onto Ultrasound Image with Perfect Coregistration

Wednesday, Nov. 30 3:10PM - 3:20PM Room: S404CD

Participants
Sarah K. Patch, PhD, Milwaukee, WI (*Presenter*) Nothing to Disclose
Michel Kireeff Covo, PhD, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Alan Jackson, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Yazeed Qadadha, Milwaukee, WI (*Abstract Co-Author*) Nothing to Disclose
Kerri Campbell, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Ra Albright, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
P Bloemhard, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Ap Donoghue, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
CR Siero, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
TL Gimpel, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
SM Small, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
BF Ninemire, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose

Michael Johnson, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose
Larry Phair, Berkeley, CA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The potential of particle therapy due to focused dose deposition in the Bragg peak has not yet been fully realized due to inaccuracies in range verification. The purpose of this work was to correlate the Bragg peak location with target structure, by overlaying thermoacoustic localization of the Bragg peak onto a standard ultrasound image.

METHOD AND MATERIALS

Pulsed delivery of 50 MeV protons was accomplished by a fast chopper installed between the ion source and the inflector of the 88" cyclotron at Lawrence Berkeley National Lab. 2 Gy were delivered in 2 us by a beam with peak current of 2 uA. Thermoacoustic emissions were detected by a cardiac array and Verasonics V1 ultrasound system, which also generated a grayscale ultrasound image. 1024 thermoacoustic pulses were averaged before filtering and one-way beamforming focused signal onto the Bragg peak location with perfect co-registration to the ultrasound images. Data was collected in a room temperature water bath and gelatin phantom with a cavity designed to mimic the intestine, in which gas pockets can displace the Bragg peak. Experiments were performed with the cavity both empty and filled with olive oil.

RESULTS

In the waterbath overlays of the Bragg peak agreed with Monte Carlo simulations to within 1 mm. Agreement within 1.4 mm was achieved in the gelatin phantom, although relative stopping powers were estimated only to first order from CT scans. Thermoacoustic emissions were detected after travel from the Bragg peak through 29 mm and 65 mm of phantom material when the cavity was empty and full of olive oil, respectively.

CONCLUSION

Thermoacoustic range verification is feasible with a commercial clinical ultrasound array, but at doses exceeding the clinical realm. Further optimization of both transducer array and injection line chopper will be required to enable range verification within a 2 Gy dose limit, which could potentially enable online adaptive treatment.

CLINICAL RELEVANCE/APPLICATION

Thermoacoustic range verification has the potential to localize the Bragg peak with millimeter accuracy in tumors that can be imaged with ultrasound during treatment.

SSM20-03 Detecting Respiratory Signal for Image-Guided Radiation Therapy based on 3D Movements of the Diaphragm from Planning 4D MDCT Images

Wednesday, Nov. 30 3:20PM - 3:30PM Room: S404CD

Participants
Jang-Hwan Choi, Daejeon, Korea, Republic Of (*Presenter*) Nothing to Disclose
Yoonseon Song, Daejeon,, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Seung-Hoon Chae, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Young Nam Kang, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Sooyeul Lee, PhD, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

The proposed method was able to accurately detect the respiratory signal from any angle of the CBCT gantry using the structural information-based 2D/3D registration.

Background

Diaphragm motion is shown to be an effective surrogate for tumor motion estimation. However, extracting diaphragm motion is challenging, especially from lateral cone-beam CT (CBCT) projections where various organs overlap. Moreover, for some tumors exhibiting hysteresis, the diaphragm location may be insufficient to track tumor position. Here, we propose a method to effectively identify respiratory rates in all projection directions based on structural information from the diaphragm for planning 4D multi-detector CT (MDCT) and treatment CBCT for image-guided radiation therapy.

Evaluation

In-vivo respiratory gated MDCTs of the whole chest of two lung cancer patients were acquired. To simulate kV CBCT projections in all directions around the patient, digitally rendered radiographs (DRR, i.e. pseudo projection) were computed at every 10% of the respiratory cycle. Diaphragm tracking based on 2D/3D registration was performed as follows: DRRs of volume in 3D regions of interest were generated from MDCT images at every 20% of the respiratory cycle. Structural SIMilarity (SSIM) index was then computed between DRRs and a pseudo projection in pixel areas influenced by diaphragm motion. Finally, respiratory rate was identified based on SSIM rank. Method accuracy was evaluated on a motion-controlled diaphragm phantom with actual kV projections.

Discussion

The method successfully identified the respiratory rate in *in-vivo* (98.8% accuracy) and phantom studies (100% accuracy). The method performed robustly for projections at every 10% of the respiratory cycle using DRRs at every 20%. Treatment projections with finer respiratory cycles should be identifiable as SSIM was sensitive to slight movements of the diaphragm phantom. SSIM between the x-ray and corresponding DRRs was close to 1 in the phantom study. Thus, our DRRs were a good surrogate for an actual projection. After correctly identifying the respiratory rate, we could localize tumors in 3D based on their positions in the corresponding MDCT images with the same or adjacent rates.

SSM20-04 In Vitro Study of Cerenkov Radiation Enhanced External Beam Radiotherapy

Wednesday, Nov. 30 3:30PM - 3:40PM Room: S404CD

Participants

Zi Ouyang, Lowell, MA (*Presenter*) Nothing to Disclose
Michele Moreau, Lowell, MA (*Abstract Co-Author*) Nothing to Disclose
Sayeda Yasmin-Karim, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Wilfred Ngwa, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

This study investigates the feasibility of exploiting the Čerenkov radiation (CR) present during external beam radiotherapy (EBRT) for significant therapeutic gain, using titanium dioxide (titania) nanoparticles (NPs) as a photosensitizer.

METHOD AND MATERIALS

CR is light emission when charged particles travel faster than the phase velocity of light in a dielectic medium. The hypothesis is that CR existed in EBRT can be used for titania photocatalysis. The products—reactive oxygen species—can inflict increased damage to cancer cells. Furthermore, higher incident radiation energy produces more CR, and hence more cancer cell damage. To test this hypothesis, *in vitro* experiments were performed. 1000 human prostate cancer cells (PC-3) per well were seeded in 48-well plates. Cells were treated with 0 or 1 μg/g titania NPs 18 hours after being seeded. 2 Gy of 6 MV radiation was delivered to the experiment group 8 hours after NP treatment. An MTS assay was done about 72 hours after irradiation. Similar experiment was repeated using 220 kVp radiation.

RESULTS

In the 6 MV experiments, cells treated with NP only or radiation only did not show significant change in viability; cells treated with both 1 μg/g of titania NPs and 2 Gy of radiation had significantly reduced viability—about 75% compared to the control group. Similar results were not observed in the 220 kVp experiments.

CONCLUSION

Using very low concentration of titania NPs in EBRT has the potential to provide therapy enhancement. Lower energy radiation being not able to show the enhancement further confirms the effect is due to the Čerenkov radiation.

CLINICAL RELEVANCE/APPLICATION

By using titania as a photosensitizer, external beam radiotherapy results can be improved at very low costs.

SSM20-05 Quantitative Texture Classification for Differentiating Fat-poor Angiomyolipoma from Renal Cell Carcinoma: Development of Feature Classification in MDCT Images

Wednesday, Nov. 30 3:40PM - 3:50PM Room: S404CD

Participants
Han Sang Lee, MS, Daejeon, Korea, Republic Of (*Presenter*) Nothing to Disclose
Helen Hong, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Dae Chul Jung, MD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Seunghyun Park, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Junmo Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Our method can be applied to the differentiation of various types of RCC, e.g. clear cell-type, papillary, and oncocytomas, and can be used in early diagnosis of small renal masses.

Background

Differentiating benign fat-poor angiomyolipoma (fp-AML) from malignant renal cell carcinoma (RCC) is an important task for early diagnosis of renal cancer. Since fp-AML has similar intensity distribution and heterogeneity with RCC, classifying them is considered to be a challenging problem. In this research, we propose a texture-based classification method for differentiating fp-AML from clear cell-type RCC in contrast-enhanced CT images.

Evaluation

Our method was tested on a dataset consisting of 30 volumetric renal CT scans from thirty patients from ten with AML without gross fat, and twenty with RCC. CT examinations were performed on MDCT scanners at 100s to 120s delay after contrast injection, to acquire axial plane images with a slice thickness of 1.0-3.0 mm, and a resolution between 0.66 x 0.66 mm to 0.77 x 0.77 mm. For each scan, a region of interest (ROI) for a renal mass was marked by a radiologist. From the tumor ROI of training set, 117 features consisting of 22 with gray-level histogram, 14 with gray-level co-occurrence matrix (GLCM), 22 with gray-level run-length matrix (GLRLM), and 59 local binary patterns (LBP), were extracted. Then, feature selection was performed to select useful features with high separability with the ReliefF method. Throughout the feature selection process, 70 features with 16 gray-level histogram, 7 GLCM, 12 GLRLM, and 35 LBP features were selected. Finally, a support vector machine (SVM) was trained with the training features and labels to classify the unseen test features. In evaluation, 5-fold cross validation was performed and our results were quantitatively evaluated by average accuracy rates, sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV) of 84.0%, 55.2%, 98.5%, 95.1%, and 81.5%, respectively.

Discussion

Our feature extraction can provide complementary information for separating fp-AML and RCC in MDCT images. Our feature selection can improve the classification performance by enhancing separability of features. This work was supported by the National Research Foundation of Korea grant funded by the Korean Government (MEST) (NRF-2015R1A2A2A04003460)

SSM20-06 Measurement of Variability in CT Imaging-based Quantification of Tumor Heterogeneity

Wednesday, Nov. 30 3:50PM - 4:00PM Room: S404CD

Participants
Daniele Marin, MD, Durham, NC (*Presenter*) Research support, Siemens AG
Yuese Zheng, MSc, Durham, NC (*Abstract Co-Author*) Nothing to Disclose

Justin B. Solomon, PhD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Jared D. Christensen, MD, Durham, NC (*Abstract Co-Author*) Advisory Board, Riverain Technologies, LLC
Carolyn R. Lowry, BS, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG

PURPOSE

To characterize the impact of technical sources of variability on CT quantification of tumor heterogeneity.

METHOD AND MATERIALS

A digital library of lung nodules with different texture characteristics was created using the Lung Image Database Consortium (LIDC). A broad spectrum of heterogeneity features was extracted from the lung nodules. A 3D clustered lumpy background (3D-CLB) was used to create synthetic nodules of realistic texture. 24 physical phantoms of lung lesions were fabricated using a multi-material 3D printer (Objet Connex3, Stratasys). Lung nodules varied in their shapes (spherical, lobulated, speculated), textures (homogeneous, heterogeneous), and size characteristics. Lesions were embedded into an anthropomorphic chest phantom (Multipurpose Chest Phantom N1, Kyoto Kagaku) and scanned on one clinically-available CT (Definition Flash, Siemens). CT acquisitions were performed at three radiation dose levels (CTDIVol = 0.67, 1.42, 5.80 mGy). Images were reconstructed at 0.6 and 5.0 mm section thickness using FBP and a range of clinically-applicable iterative reconstruction (IR) algorithms and kernels. Segmentation of quantitative imaging features was performed using a semi-automated lesion segmentation program (Seg3D). Heterogeneity features derived from gray level co-occurrence matrix were measured (energy, contrast, correlation, homogeneity, variance, entropy, and dissimilarity). Precision (coefficient of variance) and accuracy (root mean squared error) of image-based measurements of heterogeneity were measured.

RESULTS

Coefficient of variance of all texture features for all lesions varied significantly across different scanning conditions, ranging from 13% to 77%. High variability was also observed for the root mean squared error, which ranged from 0.03 to 1.8. The root mean squared error was significantly lower for the combination of higher radiation dose, thin section thickness, and high IR strengths. Counterintuitively, variability in measurements of texture features was higher for homogeneous compared to heterogeneous lesions.

CONCLUSION

Variability related to CT imaging acquisition and reconstruction techniques is a clinically important source of bias and variance during quantification of tumor heterogeneity.

CLINICAL RELEVANCE/APPLICATION

Technical sources of variability during quantification of tumor heterogeneity may hamper the clinical utility of these imaging-based measurements for patient management.

RCA45

Introduction to Computational Fluid Dynamics from Medical Images: A Step by Step Demonstration (Hands on)

Wednesday, Nov. 30 4:30PM - 6:00PM Room: S401AB

IN PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 0

Participants
Dimitris Mitsouras, PhD, Boston, MA, (dmitsouras@alum.mit.edu) (*Presenter*) Research Grant, Toshiba Corporation;

LEARNING OBJECTIVES

At the end of this course the attendee will be able to: 1) Describe each of the steps involved in performing a computational fluid dynamic (CDF) simulation of blood: a) Segment the blood lumen in a 3D volumetric angiography image dataset (e.g., CT or MRI) starting from DICOM images. b) Produce a finite volume mesh on which to perform the CFD computation starting from the segmented lumen. c) Determine appropriate CFD boundary conditions to set up the problem physics on this mesh. d) Perform the blood flow simulation e) Finally, interrogate the resulting solution for quantities of interest such as pressure, fractional flow reserve (FFR) or endothelial shear stress. 2) Identify the different software components required to perform each of the steps. 3) Use these software components to perform their own computational fluid dynamic analyses in their own field of interest.

ABSTRACT

In this exercise, we will be working with the contrast-enhanced coronary CT angiogram (CTA) of a 48-year-old male patient with hypertension and dyslipidemia who presented with atypical chest pain and that had no personal or family history of CAD. Coronary CTA demonstrated a 59% stenosis of the proximal RCA (AHA segment 1). The patient then underwent elective catheter angiography, which demonstrated a 61% stenosis of the corresponding segment and an FFR measurement of 0.85, indicating no hemodynamic significance of this obstructive (>=50 %) lesion.We will first use a semi-automated coronary segmentation tool in Mimics (Materialise NV) to segment the right coronary artery and its two terminal branches, the posterior descending artery (PDA) and posterior left ventricular branch (PLV) from the CTA and create a 3D model. We will then export the 3D model in the Standard Tessellation Language, or STereo Lithography (STL) file format. The STL file will then be imported into the CFD software (Fluent, ANSYS Inc) and we will generate a finite volume mesh to fill the lumen defined by this STL. We will finally solve the Navier-Stokes equations in this mesh simulating blood flow at hyperemic conditions in the steady state, and we will interrogate the solution for pressure and CT-FFR after setting the coronary pressure at the ostium to that measured in the patient using a sphygmomanometer at the time of CTA.The training guide for this course can be downloaded from here: Click to Download PDF automaticallyor if link doesn't work, copy paste this URL to your web browser:http://www.brighamandwomens.org/Departments_and_Services/radiology/Research/documents/RSNASyllabus-final-online.pdf

Handout:Dimitris Mitsouras

http://abstract.rsna.org/uploads/2016/16005103/RSNASyllabus_final.pdf

ED013-TH

Physics Thursday Case of the Day

Thursday, Dec. 1 7:00AM - 11:59PM Room: Case of Day, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants

David M. Gauntt, PhD, Birmingham, AL (*Presenter*) Patent agreement, Radcal Corporation
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
James M. Kofler JR, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jonathan M. Morris, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Brad Kemp, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1) The learner will be able to identify the causes of various imaging effects and artifacts, determine whether the effect is caused by equipment problems, and identify the necessary action to correct the effects or artifacts.

RC621

Advances in CT: Technologies, Applications, Operations-Spectral CT

Thursday, Dec. 1 8:30AM - 10:00AM Room: S105AB

CT PH

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

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

Sub-Events

RC621A Data Acquisition and Image Formation Methods for Multi-Energy CT

Participants
Cynthia H. McCollough, PhD, Rochester, MN, (mccollough.cynthia@mayo.edu) (*Presenter*) Research Grant, Siemens AG

LEARNING OBJECTIVES

1) Understand the various methods used to acquire multi-energy CT data. 2) Comprehend the different methods used to present the information obtained with multi-energy CT.

ABSTRACT

RC621B Applications

Participants
Sebastian T. Schindera, MD, Basel, Switzerland, (sschindera@aol.com) (*Presenter*) Research Grant, Siemens AG; Research Grant, Ulrich GmbH & Co KG; Research Grant, Bayer AG; Speakers Bureau, Bayer AG

LEARNING OBJECTIVES

1) Describe the various clinical applications of multi-energy CT. 2) Discuss the most important challenges of multi-energy CT in clinical routine. 3) Identify future opportunities of multi-energy CT.

ABSTRACT

RC621C Future Prospects-Photon Counting

Participants
Taly G. Schmidt, PhD, Milwaukee, WI, (tal.gilat-schmidt@marquette.edu) (*Presenter*) Research Grant, General Electric Company

LEARNING OBJECTIVES

1) Understand the potential benefits of photon-counting detection for Spectral CT. 2) Understand the current challenges of photon-counting Spectral CT.

RC622

MRI: Imaging for Radiation Treatment Guidance and Verification

Thursday, Dec. 1 8:30AM - 10:00AM Room: S102D

MR RO PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 0

Participants
Rojano Kashani, Saint Louis, MO (*Moderator*) Investigator, Koninklijke Philips NV; Investigator, ViewRay, Inc

LEARNING OBJECTIVES

1) Understand the main concepts of MRI-guided radiation therapy. 2) Understand the advantages and limitations of MRI-guided radiotherapy systems currently in use or under development. 3) Understand the use of in-room MRI guidance for management of intr- and inter-fraction variations in anatomy.

ABSTRACT

Sub-Events

RC622A In-Room MRI for Treatment Guidance

Participants
Rojano Kashani, Saint Louis, MO (*Presenter*) Investigator, Koninklijke Philips NV; Investigator, ViewRay, Inc

LEARNING OBJECTIVES

1) Understand the main concepts of MRI-guided radiation therapy. 2) Understand the advantages and limitations of MRI-guided radiotherapy systems currently in use or under development. 3) Understand the use of in-room MRI guidance for management of intr- and inter-fraction variations in anatomy.

RC622B Integrating MRI, The Clinician Perspective

Participants
Mary U. Feng, MD, San Francisco, CA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the clinical benefits associated with the integration of MRI into Radiotherapy. 2) Describe the uncertainties and challenges that exist in MR for radiotherapy.

RC623

Molecular Imaging Mini-Course: Advanced Molecular Imaging

Thursday, Dec. 1 8:30AM - 10:00AM Room: S404CD

MI MR NM PH

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

FDA Discussions may include off-label uses.

Participants

Sub-Events

RC623A Novel Tracers

Participants
Timothy R. DeGrado, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Identify the major considerations when developing a novel molecular imaging probe. 2) Compare the strengths and weaknesses of the various imaging modalities with regard to probe development and implementation. 3) Define appropriate experiments for probe validation. 4) Gain an understanding of the process of translation of a probe to clinical practice.

ABSTRACT

Molecular imaging is rapidly advancing as new imaging biomarkers are invented to allow noninvasive assessment of biochemical function. Those who embark on the process of developing novel probes come to know the excitement of imaging biological processes for the first time, but are also well aware of the great effort and many pitfalls that can impede progress. This introductory lecture will provide an overview of the process of molecular imaging probe conception, development, preclinical validation, and translation. Specific examples will be used to illustrate the presenter's experience with meeting these challenges.

RC623B Novel Instrumentation (PET/MR)

Participants
Ciprian Catana, MD, PhD, Charlestown, MA, (ccatana@nmr.mgh.harvard.edu) (*Presenter*) Research Consultant, Cubresa Inc

LEARNING OBJECTIVES

1) Distinguish the technical approaches that have been proposed for integrating PET and MRI for the purpose of simultaneous data acquisition. 2) Evaluate the latest methodological developments in PET/MRI for improving PET data quantification. 3) Incorporate simultaneous PET/MRI techniques into research and clinical projects.

ABSTRACT

RC625

Radiologic Expertise-Incorporating Perception into Training

Thursday, Dec. 1 8:30AM - 10:00AM Room: S103CD

ED PH RS

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 0

Participants

Sub-Events

RC625A On the Development of Expertise in Image Interpretation

Participants
Elizabeth A. Krupinski, PhD, Atlanta, GA, (ekrupin@emory.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Summarize evidence for changes in visual search as a function of expertise. 2) Describe other specialties where similar trends have been documented. 3) Provide an overview of attempts to predict who will make a good radiologist.

ABSTRACT

The nature of expertise is of great interest in many fields including radiology. What does it take to become an expert in one's field? Can e predict who will make a good radiologist? These are just a couple of the questions that guide research on the development of expertise in radiology image interpretation. There have been a number of studies conducted over the years to explore this issue, including those that study the visual search patterns of radiologists. These studies have noted how search patterns change with expertise, becoming more streamlined and more efficient. Through improved understanding of what characterizes the expert, we can develop better and more efficient training methods, thereby reducing error and variation in radiologic interpretation.

Active Handout:Elizabeth Anne Krupinski

http://abstract.rsna.org/uploads/2016/16001182/ACTIVE RC625A.pdf

RC625B Using Expert Interpretation Strategies to Teach Trainees

Participants
William Auffermann, MD, PhD, Atlanta, GA, (wauffer@emory.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Summarize current training paradigms in medical imaging. 2) List the common sources of error in medical image perception. 3) Differentiate focused perceptual training methods from conventional training for image interpretation. 4) Examine areas where focused training may be useful for decreasing perceptual errors.

ABSTRACT

Radiologists learn how to interpret images during a multi year residency, where they work with senior faculty radiologists on a one-to-one basis. The fundamental principles by which we teach medical trainees skills for image interpretation have not changed appreciably over the past several decades. The goal of this presentation is to demonstrate new tools for radiology education based on our knowledge of human image perception, and examine how these tools may change the way we teach skills related to image interpretation.

RC625C Formal Assessment of Practicing Radiologists

Participants
Alastair G. Gale, PhD, Loughborough, United Kingdom, (a.g.gale@lboro.ac.uk) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Review the importance of self & group interpretation assessment. 2) Provide an overview of the PERFORMS project goals & methods. 3) Summarize PERFORMS progress & results to date.

SSQ18

Physics (CT-Quantitative)

Thursday, Dec. 1 10:30AM - 12:00PM Room: S403B

BQ CT PH

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

FDA Discussions may include off-label uses.

Participants
Kenneth R. Hoffmann, PhD, Buffalo, NY (*Moderator*) Vice President, Imagination Software Corporation; Stockholder, Imagination Software Corporation; Officer, Imagination Software Corporation ;
Hiroyuki Yoshida, PhD, Boston, MA (*Moderator*) Patent holder, Hologic, Inc; Patent holder, MEDIAN Technologies;

Sub-Events

SSQ18-01 Deep-Learning Bladder Cancer Treatment Response Assessment in CT Urography

Thursday, Dec. 1 10:30AM - 10:40AM Room: S403B

Participants
Kenny H. Cha, MSc, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Institutional research collaboration, General Electric Company
Ravi K. Samala, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Richard H. Cohan, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Elaine M. Caoili, MD, MS, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Alon Z. Weizer, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Ajjai S. Alva, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To estimate bladder cancer treatment response in CT urography (CTU) by training a Deep-Learning Convolution Neural Network (DL-CNN) to recognize the patterns of bladder lesions indicative of treatment response.

METHOD AND MATERIALS

With IRB approval, pre- and post-neoadjuvant chemotherapy CTU scans of 82 patients (87 lesions) were collected retrospectively. Cystectomy was performed at the end of treatment, and the cancer stage after treatment was used as the reference standard to determine if a patient responded to treatment. 27% of the patients had T0 cancer stage after chemotherapy, which corresponds to a complete response to treatment. Bladder lesions in the CTU scans were segmented using our Auto-Initialized Cascaded Level Sets (AI-CALS) system. Regions of interests (ROIs) were extracted from within the segmented lesions from corresponding pre- and post-treatment scans of a patient and were paired together in multiple combinations to generate pre-post-treatment paired ROIs. A total of 104 temporal lesion pairs were generated from the 87 lesions, resulting in 6,700 pre-post-treatment paired ROIs. We trained a DL-CNN to distinguish between bladder lesions that were diagnosed as stage T0 post-treatment and those that were greater than stage T0. Leave-one-case-out cross-validation was performed for training and testing the DL-CNN. In each partition the trained DL-CNN outputted a likelihood of stage T0 score for the left-out test case. An observer performance study with two experienced radiologists was also performed independently, in which the radiologist estimated the likelihood of stage T0 after viewing each pre-post-treatment CTU pair. Receiver operating characteristic (ROC) analysis was performed and the area under the curve (AUC) was calculated for the DL-CNN and radiologists' estimates.

RESULTS

The AUC for prediction of T0 disease after treatment was 0.75 ± 0.05 for the DL-CNN, and 0.75 ± 0.05 and 0.70 ± 0.06 for the two radiologists. The differences in the AUC values among the DL-CNN and the two radiologists did not reach statistical significance.

CONCLUSION

Our study demonstrated the feasibility of using DL-CNN for the estimation of bladder cancer treatment response in CTU

CLINICAL RELEVANCE/APPLICATION

Deep learning CNN may be useful as decision support for bladder cancer treatment response assessment, vital for identifying non-responders and stopping treatment to preserve their physical condition.

SSQ18-02 K-Means Clustering Guided Bilateral Filter for Dynamic CT Perfusion at Lower Dose Levels

Thursday, Dec. 1 10:40AM - 10:50AM Room: S403B

Participants
Francesco Pisana, Heidelberg, Germany (*Presenter*) Doctoral student, Siemens AG
Thomas Henzler, MD, Mannheim, Germany (*Abstract Co-Author*) Research support, Siemens AG; Speaker, Siemens AG
Stefan O. Schoenberg, MD, PhD, Mannheim , Germany (*Abstract Co-Author*) Institutional research agreement, Siemens AG
Ernst Klotz, DiplPhys, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Marc Kachelriess, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To develop a practical filter for functional maps quality improvement in dynamic CT perfusion (CTP), exploiting the temporal redundancy of data.

METHOD AND MATERIALS

CTP acquisitions are normally performed with low kVp and mAs values, to keep the radiation dose in acceptable levels. Functional maps are derived by non-linear algorithms and normally result in enhanced noise. We developed a new image filter exploiting data redundancy in two ways: first, voxels belonging to vessels and small anatomical structures were automatically segmented from noise using the temporal autocorrelation function of the high spatial frequencies and an optimal guiding image was created (G). In a second step, all voxels were iteratively classified in K clusters, based on their temporal CT values, via k-means clustering (K); this information was used to avoid mixing distinct functional classes. Based on that, we implemented a k-means clustering guided bilateral filter (KG) and compared its performances to the time-intensity profile similarity filter (TIPS) and to the partial temporal non local means filter (PATEN). The study was conducted on an in-house developed phantom and on clinical cases. The dose reduction potential of KG compared to TIPS was also estimated by adding noise to the raw-data.

RESULTS

For a better comparison, all filters were implemented with the same sizes. Blood flow maps obtained from the KG filtered CT images showed the highest contrast-to-noise ratio improvements (6.96), followed by the TIPS (5.81) and the PATEN (2.09) ones. The KG filter was able to better preserve the original spatial resolution of the CT images. Finally, computational times were significantly shorter with the KG filter. Our results suggest that with the KG filter, dose could be reduced potentially by c.ca 40 % at same CNR levels when compared to the TIPS filter.

CONCLUSION

The proposed KG filter seems to provide better results when compared to state-of-the-art filters for quality improvement of CTP functional maps, and in much shorter times. To our knowledge, this is the first approach using the k-means clustering and the temporal autocorrelation function in a denoising strategy for CTP.

CLINICAL RELEVANCE/APPLICATION

We believe the potential of the proposed algorithm can be further exploited and optimized, to allow for lower dose CTP protocols that still provide high diagnostic quality in clinically acceptable times.

SSQ18-03 Building Towards a QIBA Challenge: Establishing Exchangeability between Clinical and Virtual Databases for Quantitative CT Volumetry

Thursday, Dec. 1 10:50AM - 11:00AM Room: S403B

Participants
Marthony Robins, BSc, Durham, NC (*Presenter*) Nothing to Disclose
Justin B. Solomon, PhD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Andrew J. Buckler, MS, Wenham, MA (*Abstract Co-Author*) Stockholder, vascuVis Inc President, vascuVis Inc CEO, vascuVis Inc Stockholder, Elucid Bioimaging Inc President, Elucid Bioimaging Inc CEO, Elucid Bioimaging Inc
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG

PURPOSE

To devise and pilot test a Challenge through Quantitative Imaging Biomarkers Alliance (QIBA) to establish statistical exchangeability between virtually inserted and native lesions.

METHOD AND MATERIALS

Computational lung lesion models (based on pathologically confirmed malignant tumors) were virtually inserted into 16 phantom datasets and 30 chest CT cases using a validated image-domain insertion program. The study is designed as a public challenge to academic researchers and commercial software developers to apply their segmentation and volume estimation algorithms on simulated and corresponding real lung lesions. Initial data were analyzed in terms of bias (in phantom data only), location reproducibility, and algorithm reproducibility (variance between measurements by different algorithms on the same lesion) in volume estimation between the virtual and real lesions to assess non-inferiority of virtually inserted lesions.

RESULTS

Pilot results from three segmentation algorithms (iNtutition, Tera Recon Inc., Syngo.via, Siemens Healthcare, and IntelliSpace, Philips Healthcare) yielded <2% difference in mean bias for real and virtual lesions, respectively for one algorithm, while others yielded 5-6%, and 5-8%, respectively. Lesion complexity and insertion location (juxta-pleura and mediastinum) affected volume estimation for both virtual and real lesions similarly with no statistically significant difference ($p > .05$). Algorithm reproducibility was consistent between virtual and real lesions for all lesion types (solitary or attached), noise levels, pitch, and slice thickness.

CONCLUSION

Patient images provide anatomical detail but often lack ground truth. Standardized databases of virtually inserted lesions can address this obstacle. These pilot results pave the way for a broad QIBA challenge to enable generalization for statistical similarity of hybrid (virtual lesions inserted in clinical patient data) datasets to clinical datasets across a wider set of volumetry algorithms.

CLINICAL RELEVANCE/APPLICATION

Standardized databases of virtually inserted lesions will help to develop and validate better lesion segmentation tools for quantitative CT towards enacting precision medicine.

SSQ18-04 Measuring Head Movement in 3D During CT-Perfusion Analysis - A Pilot Study

Thursday, Dec. 1 11:00AM - 11:10AM Room: S403B

Participants
Mette C. Marklund, MD, PhD, Roskilde, Denmark (*Presenter*) Nothing to Disclose
Anders O. Baandrup, BSC, Roskilde, Denmark (*Abstract Co-Author*) Nothing to Disclose
Troels Wienecke, MD,PhD, Roskilde, Denmark (*Abstract Co-Author*) Nothing to Disclose
Carsten Thomsen, Copenhagen, Denmark (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

A robust, very accurate and low tech marker can be used for measuring head movement in the X-, Y and Z-direction and rotation during a CTP.

Background

The purpose of this pilot study is to test a simple, non-anatomical dependent method to calculate head motion in the X-, Y- and Z-dimensions and rotation. Most CT-scanners have inbuilt options for movement correction based on landmarks. Some of the algorithms operate in 3D others in 2D. Only very few studies have examined, how much the patient actually moves during a CT perfusion (CTP) study since no external, non-anatomic dependent marker for objective measurement in all 3 dimensions exists.

Evaluation

To determine the motion in patients instructed to lying still, we developed a marker designed to be placed on the patients forehead. The marker was drawn in Autocad® and 3D printed. It contains 4 air filled cones in 2 planes pointing in 2 directions in each plane. It was tested in a phantom set-up with a micrometer (Mitutoyo 164-163 Digimatic Micrometer) enabling the marker moving as little as 0.001 mm. Raw data were calculated by an external radiologist with no knowledge on the applied movement parameters. By applying an advanced mathematical algorithm, measuring the size and elliptical deformation of the black holes during the scan, a very accurate value (δ) for movement in the X-, Y- and Z-direction could be calculated. The marker was placed on the forehead of 5 consecutive patients suspected for Ischemic Stroke (IS) undergoing CTP. The patients were all well-cooperating. Movement parameters (fig. 4) are given for our most restless patient nr. 3: δ(X): -3.6 to 4.4 mm, δ(Y): -1.3 to 1.9 mm,δ(Z): -1.4 to 2.0 mm and rotation -2.0 to 3.2 degrees.

Discussion

Movement artifacts lower the signal/noise ratio and increase the risk of diagnostically insufficient images. Even though the movement errors can be reduced by post processing, the S/N-ratio will remain lower than if the patient had not moved at all. Determining the extent of true motion is fundamental for setting up future projects aiming to optimize head stabilization and developing advanced post processing algorithms.

SSQ18-05 Initial Validation of a View-Sharing Acquisition Using a Physical Perfusion Phantom

Thursday, Dec. 1 11:10AM - 11:20AM Room: S403B

Participants
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PURPOSE

Dynamic contrast-enhanced (DCE) MRI is a clinical research tool that can provide quantitative imaging biomarkers (QIBs) of perfusion. As new commercially-available and research MR acquisition strategies utilize view sharing and sparse sampling techniques to achieve high spatial and temporal resolution images, validating the ability of these methods to reproduce QIBs is critically important. We used a perfusion phantom to evaluate the reproducibility of gamma-variate (GV) fits using a commercial view-sharing sequence (DISCO) compared with a conventional fast spoiled gradient echo sequence (FSPGR).

METHOD AND MATERIALS

The phantom (Shelly Medical Imaging Technologies) consists of a peristaltic pump that provides a single input to a custom shell-contained perfusion cylinder. Within the cylinder, the input is coiled and perforated which allows flowing water to traverse the length of the input to the "tube" output or flow into the bulk of the cylinder to the "cylinder" output. Adjustable valves control the flow ratio, r, of the tube/cylinder output. The flow was set to 4mL/s and r was set to 0.5. Images were acquired on a 3.0T GE MR750 scanner using a 32-channel head coil (NOVA) with the FSPGR (FOV=24x12x7.2 cm^3, matrix=256x128x24, 9.7s/volume) and DISCO (FOV=24x12x28.8 cm^3, matrix=256x128x96, 9.6s/volume) sequences. The FSPGR data were acquired twice during two different scanning sessions to assess reproducibility. For each method, a power injector was used to inject 5mL of Gd-DOTA followed by a 10mL saline flush at a rate of 2mL/s after acquiring images for 60s. The GV parameters (alpha and beta) were estimated for all contrast concentration time curves. The mean, 95% confidence intervals (CI), and coefficients of variation (CV) were calculated for each parameter.

RESULTS

For the conventional DCE-MRI acquisition, the mean, 95%CI, and CV for alpha was 2.66, (2.32, 3.00), and 6.53%, respectively, while that of beta was 25.13, (21.60, 28.65), and 7.17%, respectively. The alpha and beta parameters for the DISCO acquisition were 2.98 and 23.13, respectively.

CONCLUSION

For comparable temporal resolutions, DISCO reproduced the GV parameters within the 95% CI of the conventional DCE-MRI acquired parameters.

CLINICAL RELEVANCE/APPLICATION

For a conventional temporal resolution, DCE-MRI GV reproducibility of a commercial view-sharing technique was established. This methodology can be used to validate other research techniques.

SSQ18-06 Quantitative CT Perfusion Imaging of the Liver in Sparse-view Setting

Thursday, Dec. 1 11:20AM - 11:30AM Room: S403B

Participants
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PURPOSE

We investigated the effect of projection undersampling on quantitative CT liver perfusion imaging.

METHOD AND MATERIALS

Dynamic contrast enhanced (DCE) liver images were acquired from a 68 kg patient with hepatocellular carcinoma (HCC) after intravenous contrast injection, with a 64-slice GE HD750 CT scanner at 120 kVp, 70 mA and 0.4 s gantry period using an axial shuttle mode for 42 times, during which the patient was free-breathing throughout. DCE liver images were reconstructed from full projections (984) using filtered backprojection (FBP), and 1/3 (328) and 1/4 (246) of full projections, evenly distributed over 360° with FBP and compressed sensing (CS). Each set of DCE liver images were registered and analyzed with CT Perfusion (GE) to generate hepatic arterial blood flow (HABF) maps. HABF measurements from the sparse-view FBP and CS protocols were compared to those from the full-view FBP method.

RESULTS

Mean HABF measured from full (984) view FBP were comparable to those from 328-view FBP and 328-view CS: 60.6 vs. 63.1 and 62.2 mL/min/100g in liver tumor, and 27.7 vs. 25.6 and 23.4 in normal liver tissue, respectively. In the 246-view setting, FBP failed to minimize streaks in DCE images, leading to a larger discrepancy in HABF measurement from full-view FBP: 37.0 vs. 27.7 mL/min/100g in tumor (-25% difference), and 70.5 vs. 60.6 (16.3% difference) in normal tissue, respectively. By contrast, DCE images generated from the same number of projections (246) with CS was without streaks and the resulting HABF values were in better agreements with those of full-view FBP: 29.8 vs. 27.7 mL/min/100g (-7.6% difference) in tumor, and 55.1 vs. 60.6 (-9.1% difference) in normal tissue, respectively. Projected effective doses of the full and ¼ view DCE acquisition protocols for 8 cm coverage were 11.3 and 3.8 mSv respectively.

CONCLUSION

Only 1/3 of full projections were needed in CT liver perfusion measurement, regardless of the choice of image reconstruction algorithm (FBP or CS). Under extremely sparse condition (< 1/3 of full projections), CS may be more reliable than FBP in preserving image quality and accuracy of liver perfusion measurement.

CLINICAL RELEVANCE/APPLICATION

It is feasible to achieve low dose (<4 mSv) CT perfusion imaging of the whole liver for HCC treatment planning and follow-up by reducing the number of projection measurement in DCE acquisition.

SSQ18-07 Identifying Quantitative Image Features that Correlate with Radiologists' Image Quality Preferences on Breast CT

Thursday, Dec. 1 11:30AM - 11:40AM Room: S403B

Participants
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PURPOSE

To evaluate which quantitative image features on breast computed tomography (CT) images correlate with radiologists' subjective image quality preferences.

METHOD AND MATERIALS

A total of 102 pathology-proven breast lesions in 92 dedicated breast CT images were collected under an IRB-approved protocol. An iterative image reconstruction (IIR) algorithm was used to obtain CT images with 28 different image qualities. Through image feature analysis from breast lesions (developing classifiers on 23 image features extracted from the lesion), three IIRs and one clinical reconstruction with a wide range of image quality (from smooth to sharp quality) were selected for an IRB-approved reader study. A subset of breast lesions was selected (N = 30, 17 malignant) with corresponding trained classifier AUCs of 0.68 – 0.95 for the selected reconstructions. For each lesion, six experienced MQSA radiologists ranked the four image data sets in regards to their impression of best diagnostic information. In addition, each feature value was ranked for the four reconstructions. The correlation between computer feature and radiologists' rankings was evaluated to identify computer features that correlate with radiologists' preferences. The correlation analysis was repeated for benign and malignant lesions separately, as the characteristics of benign and malignant lesions are different.

RESULTS

Five image features were identified. The radiologists' image quality preferences increased as the lesion shape became more spherical (p-value = 0.02), as the lesion surface flattened (p-value = 0.01), and as the lesion texture increased (p-value = 0.02) for benign lesions. Radiologists' preferences increased as more lesion margin was visible (p-value = 0.02) and as lesion contrast at the margin increased (p-value = 0.03) for malignant lesions. For all lesions, radiologists' preferences increased as the lesion texture increased (p-value = 0.02).

CONCLUSION

There exists a set of quantitative image features that correlate with radiologists' image quality preferences, potentially allowing subjective impression to be quantified. More cases and readers are required to generalize these results.

CLINICAL RELEVANCE/APPLICATION

We identified quantitative image features that correlate with radiologists' perceptions of image quality for breast CT images. These features may be useful for optimizing reconstruction algorithms and evaluating dose reduction techniques.

SSQ18-08 Modeling of Human Lungs: An Anatomically Based Prototyping of Airways, Arteries, and Veins from Initially Segmented Branches to the Terminal Branches and Interstitium

Thursday, Dec. 1 11:40AM - 11:50AM Room: S403B

Participants
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PURPOSE

To mathematically model and grow airway, artery, and vein trees toward simulation of comprehensive lung architecture facilitating virtual clinical trials (VCTs).

METHOD AND MATERIALS

Lung lobes and initial branches of airways, arteries, and veins were segmented separately inside each lobe using CT data of 58 adult patients. Airway trees were grown, within the boundary of each lobe, from the endpoints of the segmentations based on a volume-filling method. The growth model for the arteries was spatially constrained to neighboring and corresponding airways according to the anatomical understanding of bronchial arterial units. In contrast, pulmonary veins and venules were grown independently according to the anatomical known interstitial meshwork. At each bifurcation, diameters of the daughter branches were assigned using morphometry equations in the literature. The algorithm was assigned to stop growing if a branch length was less than 1.2 mm. Co-incidental intersections were identified automatically and subsequently avoided. Simulated CT images were obtained from the virtual lung phantoms using an analytical algorithm developed in our lab and reconstructed using filtered backprojection.

RESULTS

A database of 58 adult patient-specific lung phantoms was created. Airways and vessels were generated up to 16 and 15 bifurcations, respectively. For airways and arteries, the diameters in the first branches were on the order of 10, 6, 8, 5, and 8 mm for the upper left lobes, lower left lobes, upper right lobes, middle right lobes, and lower right lobes, respectively. For veins, the first branch diameters were 16, 8, 10, 9, and 12 mm. Terminal generated branches diameters were approximately 0.2, 0.3, and 0.3 mm for airways, arteries, and veins, respectively.

CONCLUSION

We present an algorithm to create anatomically-informed lung phantoms. For the first time, we 1) incorporated airway, artery, and vein tree structures from initially segmented branches to the terminal branches; and 2) simulated CT images based on these models. The outcome will be used to perform VCTs such as patient-based optimization and comparison of imaging techniques that would not be practical using simplistic phantoms or real human datasets.

CLINICAL RELEVANCE/APPLICATION

Modeling anatomically-informed lung airways and vessels to the level of interstitial structures makes the virtual phantoms more representative of clinical realities which lead to more realistic VCTs.

SSQ18-09 Application of Compressed Sensing for Low-intensity Sparse-view CT Myocardial Perfusion Imaging

Thursday, Dec. 1 11:50AM - 12:00PM Room: S403B

Participants
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Aaron So, PhD, London, ON (*Presenter*) Nothing to Disclose

PURPOSE

We investigated the effectiveness of compressed sensing (CS) for reconstructing dynamic contrast-enhanced (DCE) CT heart images from sparsely sampled x-ray projections at different noise levels in CT myocardial perfusion (MP) imaging.

METHOD AND MATERIALS

Prospectively ECG gated CT MP imaging was acquired on three normal pigs (40-60kg) over 22-25 heart beats after contrast injection with a 64-slice GE HD750 CT scanner using 140kV/80mA/350ms. Reference DCE heart images were reconstructed from the full set of beam-hardening (BH) corrected projections (984) with filtered backprojection (FBP). Synthetic noise that incorporated the effects of energy-integrating detector and bowtie beam filtering was added to the BH corrected projections to simulate image noise corresponds to 50, 40, 30 and 20 mA at 140 kV and 350 ms gantry period. From each set of simulated low mA projections, one-third (328) evenly distributed over 360º was used to reconstruct DCE heart images with CS. MP maps generated from each set of FBP and CS DCE images with CT Perfusion (GE) were compared in the lateral, apical and septal wall of the myocardium over 8 consecutive 5 mm slices (144 myocardial segments total).

RESULTS

328-view CS DCE images at all low mA settings were able to resolve the same anatomical features as 80 mA 984-view FBP. MP maps derived from each low mA CS DCE image set were also comparable to those from 80 mA full-view FBP. Bland-Altman analysis revealed subtle mean bias in CT MP measurement for all low mA sparse-view CS protocols compared to 80 mA full-view FBP: 2.67 mL/min/100g (95% CI: 18.37 – 13.04 ml/min/100g), 5.35 (21.51 – 10.81), 6.02 (24.34 – 12.29) and 8.77 (30.15 – 12.62) for 50, 40, 30 and 20 mA respectively. Projected effective dose of the 20 mA 328-view CS protocol for MP imaging was 0.66 mSv and 12 times lower than that of the standard 80 mA full-view FBP protocol (8 mSv) for 8 cm axial coverage.

CONCLUSION

Compared to FBP, CS was effective in reconstructing DCE heart images from 1/3 of full projections at four times reduced mA without affecting the anatomical and functional CT assessment.

CLINICAL RELEVANCE/APPLICATION

Low mA and sparse view dynamic acquisition coupled with CS reconstruction can minimize radiation dose of CT MP imaging, which would facilitate its use for assessing high-risk coronary artery disease.

SSQ19

Physics (CT-Performance and Evaluation)

Thursday, Dec. 1 10:30AM - 12:00PM Room: S404AB

CT PH

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

Participants
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Sub-Events

SSQ19-01 Dual-Energy CT Intra- and Inter-Scanner Variability within One Make & Model

Thursday, Dec. 1 10:30AM - 10:40AM Room: S404AB

Participants
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Dianna D. Cody, PhD, Houston, TX (*Abstract Co-Author*) In-kind support, General Electric Company

PURPOSE

It can be logistically difficult to scan patients on the same exact device for repeat visits in multi-scanner facilities. The reliability between dual-energy (DE) CT scanners' quantitative results is not known, nor is their individual repeatability. Therefore, we evaluated intra- and inter-scanner variability with respect to several quantitative metrics specific to dual-energy CT.

METHOD AND MATERIALS

Eleven identical GE HD-750 CT scanners in a busy clinical environment were used to perform DE CT scans of a large elliptical quality control (QC) phantom (Gammex, Inc.; Middleton, WI) containing many standard insert materials. The protocol contained 6 CTDIvol levels (17.1-33.9mGy) to provide variation in mAs. The DEQC phantom was scanned approximately bi-weekly from July 2015-March 2016; 12 scans were obtained from each scanner. Iodine accuracy for the 2, 5, and 15mg/ml rods (on an Iodine(Water) image set) and soft tissue HU (40HU at 50keV based on NIST constants) from the 50keV data set were used to assess intra- and inter-scanner variability (standard deviation). Additionally, intra- and inter-scanner variability were calculated for 120kVp (CTDIvol=38.3mGy) daily water HU measurements over the same time period.

RESULTS

Intra-scanner variability average for 2mg/ml Iodine was 0.12 mg/ml (range 0.07-0.16 mg/ml), for 5mg/ml Iodine was 0.14 mg/ml (range 0.09-0.20 mg/ml), for 15mg/ml Iodine was 0.28 mg/ml (range 0.24-0.39 mg/ml), for soft tissue inserts was 2.6 HU (range 1.9-3.4 HU) and for daily QC was 0.4 HU. *Inter*-scanner variability average for 2mg/ml Iodine was 0.16 mg/ml (range 0.10-0.21 mg/ml), for 5mg/ml Iodine was 0.19 mg/ml (range 0.13-0.23 mg/ml), for 15mg/ml Iodine was 0.38 mg/ml (range 0.33-0.45 mg/ml), for soft tissue inserts was 4.0 HU (range 3.2-4.5 HU) and for daily QC was 0.7 HU.

CONCLUSION

Intra-scanner variability for the iodine and soft tissue inserts averaged 0.18 mg/ml and 2.6 HU respectively, and inter-scanner variability averaged 0.24 mg/ml and 4.0 HU, respectively. The iodine results may support using multiple scanners for dual-energy scanning over the course of a patient's treatment, but if clinicians rely heavily on 50keV measurement of soft tissue, this may need revisiting.

CLINICAL RELEVANCE/APPLICATION

Scanner-to-scanner quantitative consistency for dual-energy CT may impact scheduling; evaluating patients on the same scanner for repeat exams may be logistically impossible at some sites.

SSQ19-02 Dual-Energy CT Iodine Accuracy Across Vendors and Platforms

Thursday, Dec. 1 10:40AM - 10:50AM Room: S404AB

Participants
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Dianna D. Cody, PhD, Houston, TX (*Abstract Co-Author*) In-kind support, General Electric Company

PURPOSE

Although a major benefit of dual-energy CT is its quantitative capabilities, it is critical to understand how results vary by scanner manufacturer and/or model before making clinical patient management decisions. Each manufacturer utilizes a specific dual-energy CT approach; cross-calibration may be required for facilities with more than one dual-energy CT scanner type.

METHOD AND MATERIALS

A solid dual-energy quality control phantom (Gammex, Inc.; Middleton, WI) representing a large body cross-section containing three Iodine inserts (2mg/ml, 5mg/ml, 15 mg/ml) was scanned on these CT systems: GE HD-750 (80/140kVp), prototype GE Revolution CT with GSI (80/140kVp), Siemens Flash (80/140kVp and 100/140kVp), Siemens AS128 (80/140kVp), Siemens Edge (120kVp) and Philips IQon (120kVp and 140kVp). Iodine content was measured in units of concentration (mg/ml) from a single 5mm-thick central image. Three to five acquisitions were performed on each scanner platform in order to compute standard deviation. Scan

acquisitions were approximately dose-matched (~25mGy CTDIvol) and image parameters were as consistent as possible (thickness, kernel, no noise reduction applied).

RESULTS

Iodine measurement error ranges were -0.24 to 0.16 mg/ml for the 2mg/ml insert, excluding a single outlier (-12.0 to 8.0%), -0.40 to 0.26 mg/ml for the 5mg/ml insert (-8.0 to 5.2%), and -1.46 to 0.99 mg/ml for the 15mg/ml insert (-9.7 to 6.6%). Standard deviations ranged from 0 to 0.31 mg/ml for the repeated acquisitions from each scanner. The average iodine measurement error and standard deviation across all systems and inserts was -0.20 ± 0.57 mg/ml (-0.9 ± 5.1%). The largest absolute measurement error was found in the 15mg/ml iodine insert.

CONCLUSION

There was generally good agreement in Iodine quantification across 3 dual-energy CT manufacturers and 4 scanner models (with one exception). This was unexpected given the widely different underlying dual-energy CT mechanisms employed. Future work will include additional scanner platforms, independent verification of the Iodine insert standard concentrations (especially the 15 mg/ml insert), and how much measurement variability can be clinically tolerated.

CLINICAL RELEVANCE/APPLICATION

Current daily CT quality control programs do not address dual-energy CT. This is particularly important if clinical facilities rely on dual-energy CT data from more than one scanner make and model.

SSQ19-03 Spectral CT "Fingerprinting" On a Pre-Clinical Detection Based Spectral CT Scanner: Tools for Exploration and Examples

Thursday, Dec. 1 10:50AM - 11:00AM Room: S404AB

Participants
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PURPOSE

Spectral CT "Fingerprinting" is the principle of looking for distinct patterns in the statistics of a projection-space spectral decomposition using the classic photoelectric/Compton scatter basis set of Alvarez and Macovski. Compared to conventional CT and dual energy image-space spectral decomposition, the voxels in this decomposition have the potential to be more stable.

METHOD AND MATERIALS

We developed software tools to transfer data from the original Spectral Basis Images (SBIs) from a detection-based spectral CT (IQon, Philips Healthcare) to a format for analysis using the recently published ScatterJn scatterplot analysis package (Zeitvogel and Obst, 2016) in ImageJ (NIH). As described elsewhere, we refer to these scatter plots as material attenuation decomposition (MAD) plots. In current form, this process is limited by the 8-bit dynamic range of ScatterJn, but the SBI soft tissue zone can readily be moved to an 8-bit space in a lossless manner. Using this tool chain, it is possible to go back and forth between the original imaging volume and a scatterplot of the underlying 2D data. We have explored both phantoms and clinical images using this approach.

RESULTS

In a calibration phantom containing vials with differing concentration of zinc salt, different vials can be identified in the scatterplot for all voxels. It is clear however that the vial with the lowest concentration can not be separated from voxels for the water only background. Silicone has a unique signature in the fingerprint, and therefore these tools can be used to rapidly segment breast implants. In the head, CSF is found in an 'L' shaped region, possibility indicating some residual artifacts due to the cranium. Soft tissue outside the cranium can be shown to be distinct from brain tissue in fingerprint analysis.

CONCLUSION

Using a chain of software tools, we were able to correlate the spatial distribution of spectral decomposition coefficients with a per slice or global MAD plot. Blurring artifacts in the MAD plot due to bone were uncovered during exploration with these tools.

CLINICAL RELEVANCE/APPLICATION

Using an approach such as this, it may be possible to differentiate pathology from healthy tissue based on location in the MAD plot.

SSQ19-04 Evaluation of CT Brain Perfusion Quantitation Using A Dynamic Phantom

Thursday, Dec. 1 11:00AM - 11:10AM Room: S404AB

Participants
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Adam E. Flanders, MD, Narberth, PA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To measure the quantitative precision of CT perfusion imaging for a range of procedural variables, including CT scanner model and

hemodynamics, while also validating the ability of a novel dynamic phantom to be useful in this regard.

METHOD AND MATERIALS

Although widely used for the evaluation of acute stroke, vasospasm, and other neurovascular disorders, CT brain perfusion (CTP) has not been well-characterized for quantitative precision and accuracy. It is not possible to perform reproducibility testing on human subjects, and phantoms simulating the hemodynamics have previously not been available. We evaluated a new phantom designed for CTP consisting of tissue-equivalent plastic and moveable rods that simulate arterial and venous contrast enhancement as well as perfused brain tissue. The phantom was scanned on two 64-slice CT scanners made by different manufacturers at 2 simulated flow rates and processed with commercial time density analysis software. Quantitative measures of cerebral blood flow (BF), cerebral blood volume (BV), and mean transit time (MTT) were recorded and analyzed for precision and consistency.

RESULTS

Repeat scanning of the perfusion phantom showed consistent appearance of the artery and vein time-attenuation curves. Reproducibility of BF, BV and MTT on each scanner was in the range of 2-5% for phantom slices that received the simulated contrast bolus in its entirety. A -33% change in the speed of the simulated contrast bolus resulted in a -17 to -25% change in measured blood flow and 16 to 28% increase in mean transit time, while measured blood volume remained effectively unchanged. Comparing results obtained from scanners made by different manufacturers, the arterial and venous contrast curves were similar, whereas large differences were observed in BF, BV and MTT calculated by the post-processing software.

CONCLUSION

The dynamic CT perfusion phantom is a useful tool for evaluating quantitative CT brain perfusion. It has revealed important differences in calculated parametric values between CT scanners, and for different cardiac output conditions. The phantom can be used to optimize scanning protocols and to benchmark postprocessing software.

CLINICAL RELEVANCE/APPLICATION

Improved understanding of the accuracy and precision of CT brain perfusion will increase diagnostic confidence in the technique, and has the potential to validate its clinical value.

SSQ19-05 Design and 3D Printing of an Anthropomorphic Brain CT Phantom Based on Patient Images

Thursday, Dec. 1 11:10AM - 11:20AM Room: S404AB

Participants
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Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

PURPOSE

To construct a realistic brain CT phantom using 3D printing techniques and patient images.

METHOD AND MATERIALS

CT images of a patient with an acute cerebral infarction were chosen, showing hyper-attenuation in the right M1-segment due to an internal clot. Using the images, a voxelized virtual brain phantom was created using segmentation software (Mimic, Materialise, Belgium). The segmentation was performed based on CT number thresholding, with additional morphologic processes (region growing, dilation, and erosion) performed to improve anatomical fidelity by suppressing image noise. The voxelized phantom was processed by computer aided design (CAD) software (3-Matic, Materialise) to generate stereolithography (STL) files. The STL file was sent to a 3D printer (Objet Connex 350, Stratasys, MN) and a physical phantom was printed. Three materials of different radiodensities were used in the printed phantom to reflect the CT number differences between white matter, gray matter, and cerebrospinal fluid. The printed phantom was placed within a skull phantom and scanned on a 192-slice scanner (SOMATOM Force, Siemens Healthcare, Germany) with a routine head protocol. Images of the phantom were then compared to the images of the original patient.

RESULTS

Despite the high degree of anatomical complexity (over 200 CAD shells), the brain CT phantom was successfully printed. The absolute CT numbers for white matter, gray matter, and cerebrospinal fluid were different between the phantom and the original patient images as a result of the limited choice of 3D printing materials. However, the CT number differences between white matter, gray matter, and cerebrospinal fluid were the same for the phantom and patient images. Therefore, when viewed with the same display window width but different window level, the phantom and patient images showed similar ranges of gray scales and contrast levels. When viewed at such setting, the phantom images and patient images also showed great similarity in terms of anatomical structure and texture.

CONCLUSION

An anthropomorphic brain CT phantom was designed and 3D printed. CT images of the phantom showed great similarity to the anatomy of the original patient.

CLINICAL RELEVANCE/APPLICATION

This study demonstrated that the complex heterogeneous anatomy of the brain can be imitated with a 3D printed phantom. The phantom may be useful for evaluation and optimization of neuro CT protocols.

SSQ19-06 Quantitative Performance for ACR CT Accreditation Images Across Different Vendors, Protocols, and Institutions: Initial Report of an ACR-RSNA Collaboration

Thursday, Dec. 1 11:20AM - 11:30AM Room: S404AB

Participants
Yakun Zhang, MS, Durham, NC (*Presenter*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG
Sujith Nair, Reston, VA (*Abstract Co-Author*) Nothing to Disclose
Laura P. Coombs, PhD, Reston, VA (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

To assess the variability in fundamental image quality attributes of operation across a sample of clinical CT systems across the US through a pilot collaboration between the ACR and the RSNA (QIBA).

METHOD AND MATERIALS

To obtain ACR CT accreditation, institutions are required to submit quality assurance images using the 4-module Gammex 464 phantom. Through a pilot collaboration between the RSNA QIBA and ACR, de-identified phantom data was provided. Four inserts in module 1 were used to evaluate HU and task-specific resolution (TTF). The low contrast module was used to assess CNR. The uniform module was used to assess noise property. Two task-based metrics that incorporate all the aforementioned metrics were also computed: detectability index (d') and estimability index (e'). A software package was created to automatically sort and analyze the images, and output results into a database and into summary pages. Statistical analysis was conducted on a pilot set of data from 20 scanners (representing 5 vendors and 67 protocols).

RESULTS

HU values and resolution showed small discrepancies among vendors. For polystyrene HU values, the ranges were -92.6±3.4, -90.5±0.1, -88.8±7.1, -92.4±5.6, and -100.8±5.2 for the 5 vendors. For resolution, the frequencies for 0.5 TTF for air insert were 0.42±0.01, 0.36±0.02, 0.33±0.02, 0.40±0.04, and 0.40±0.04 1/mm, respectively. Noise values were highly dependent on the protocol used: pediatric head (6.5±1.3), pediatric body (9.4±2.5), adult head (4.0±0.8), and adult body (4.8±0.8). Same was also the case for the CNR. The corresponding CNRs were: 1.0±0.2, 0.8±0.2, 1.7±0.4, and 1.3±0.3. Corresponding d' and e' for polystyrene were 115±27 and 0.025±0.014, 87±16 and 0.018±0.007, 166±36 and 0.032±0.011, 132±27 and 0.027±0.09 respectively.

CONCLUSION

While ACR accreditation offers a strong assurance in meeting a minimum quality for clinical CT imaging, clinical data across institutions, vendors, and protocols exhibit significant variability. A systematic analysis of national accreditation data can be used for future performance monitoring, consistency analysis, and programmatic planning.

CLINICAL RELEVANCE/APPLICATION

Analysis of reference phantom data across systems and institutions through the ACR Accreditation process enables extraction of multi-parameter clinical variability across our national healthcare system enabling more meaningful clinical and quantitative planning, accreditation, and integration into precision medicine practices.

SSQ19-07 Comparative Performance of Two Generations of Single-Source, Rapid kV-Switching Dual Energy CT Systems (GE 750HD and GE Revolution CT)

Thursday, Dec. 1 11:30AM - 11:40AM Room: S404AB

Awards
Student Travel Stipend Award

Participants
Yakun Zhang, MS, Durham, NC (*Presenter*) Nothing to Disclose
Wendy L. Ehieli, MD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Bhavik N. Patel, MD,MBA, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Rendon C. Nelson, MD, Durham, NC (*Abstract Co-Author*) Consultant, General Electric Company Consultant, Nemoto Kyorindo Co, Ltd Consultant, VoxelMetrix, LLC Research support, Bracco Group Research support, Becton, Dickinson and Company Speakers Bureau, Siemens AG Royalties, Wolters Kluwer nv
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG

PURPOSE

To evaluate the attenuation (HU) stability and image quality of virtual monoenergetic images (VMI) for two generations of single-source, rapid kV-switching dual energy CT (DECT) systems (GE 750HD and GE Revolution) using a size-varying phantom.

METHOD AND MATERIALS

A size-varying phantom (Mercury 3.0, Duke University) with five tiered sections was used. Images were acquired on the two systems using consistent techniques at matched CTDIvol (around 9.5 mGy). ASIR-V at 50% was used to reconstruct VMI at 70 keV. In each section of the phantom, there are two subsections – one with uniform attenuation for noise assessment (NPS) and one with cylindrical inserts for resolution assessment (MTF) and HU measurement (average HU values). The 5 inserts include 8.5 mg/mL iodine concentration, bone, polystyrene (fat), and water equivalents, as well as an empty rod (air). A task-specific detectability index (DI) was calculated for iodine and water inserts using a 5 mm circular disk as the task.

RESULTS

HU values decreased with increasing diameters for 750HD and remained consistent for Revolution. For large SFOV, the respective HU values for 750HD and Revolution were 185±13.2 and 223±2.2 for iodine, -44±7.3 and -38±0.4 for polystyrene, 862±47 and 1004±6.8 for bone and -1±5.7 and 8±0.6 for water. The medium SFOV had similar HU values.Noise increased proportionally with diameters for both. The NPS curves almost overlapped at all diameters, indicating similar noise magnitude and texture. The MTF curves remained unchanged for small diameters with a small drop when the diameter reached the maximum 37 cm for both. The MTFs for Revolution medium SFOV was slightly higher than for 750HD but nearly identical for the large SFOV. DI decreased with

increasing diameter, where Revolution had slightly higher values. The average increase between 750HD and Revolution of DI across diameters for iodine were 0.17 and 0.53 for large and medium SFOV, respectively; the average increase for water were 0.11 and 0.33 for large and medium SFOV, respectively.

CONCLUSION

For the 70 keV VMI, Revolution showed significant HU stability across different diameters compared to 750HD. The two systems had similar noise performance. Revolution had slightly superior resolution and detectability performance.

CLINICAL RELEVANCE/APPLICATION

Two generations of single-source, rapid kV-switching DECT systems were compared. For VMI, the newer generation GE Revolution showed superior image quality.

SSQ19-08 Evaluation of Two Different Single-Source, Rapid kV-Switching Dual Energy MDCT Platforms: Are There Differences in Contrast Sensitivity, Noise Characteristics and Accuracy of Iodine Quantitation?

Thursday, Dec. 1 11:40AM - 11:50AM Room: S404AB

Awards
Student Travel Stipend Award

Participants
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Bhavik N. Patel, MD,MBA, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Yakun Zhang, MS, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; Research Grant, Siemens AG
Rendon C. Nelson, MD, Durham, NC (*Abstract Co-Author*) Consultant, General Electric Company Consultant, Nemoto Kyorindo Co, Ltd Consultant, VoxelMetrix, LLC Research support, Bracco Group Research support, Becton, Dickinson and Company Speakers Bureau, Siemens AG Royalties, Wolters Kluwer nv

PURPOSE

To compare contrast-to-noise ratios (CNR) and accuracy of iodine quantitation on two different single-source, rapid kV-switching dual energy MDCT platforms in a phantom model.

METHOD AND MATERIALS

A dual-energy phantom with inserts having known iodine concentrations (Gammex, Inc, Middleton, WI) was scanned with two different single-source, rapid kV-switching and gemstone spectral imaging platforms (Revolution CT and 750HD, GE Healthcare, Inc) using tailored parameters to match CTDIs. ROIs were placed on five different iodine-containing rods on a 5 mm thick section. MDCT variables included body size (large/medium SFOV), mode (axial/helical), pitch (0.984/0.992), z-axis collimation (40 mm: 750HD, 40 or 80 mm: Revolution) and gantry rotation time (GRT) (0.5-1 second). CNR (calculated via iodine and water equivalent inserts) was compared between the two platforms. Measured iodine concentrations were compared to known iodine concentrations; t test was performed.

RESULTS

Two matched protocols were evaluated. The first used a medium SFOV, axial mode, 40 mm collimation, GRT of 1 sec (Revolution) or 0.7 sec (750HD) and CTDI of 9.8 and 9.54 mGy, respectively. The Revolution had improved CNR with increasing iodine concentrations at 50 keV compared to the 750HD (mean increase in CNR 30.2%); at 70 keV, CNR were similar (mean increase 5.0%).The Revolution more accurately quantitated the iodine concentration compared to the 750HD [mean difference 0.35±0.3 mg/mL (4.9%) and 1.8±1.4 mg/mL (19.4%), respectively](p=0.011). The second used a large SFOV, helical mode (pitch 0.984), 40 mm collimation, GRT of 0.5 sec (Revolution) or 0.6 sec (750HD) and CTDI of 9.48 and 9.10 mGy, respectively. The Revolution had improved CNR at increasing iodine concentrations at 50 and 70 keV compared to the 750HD (mean increase in CNR: 87.8% and 48.1%, respectively). The Revolution more accurately quantitated the iodine concentration compared to the 750HD [mean difference 0.52±0.44 mg/mL (6.8%) and 1.44±0.84 mg/mL (20.0%), respectively](p=0.005).

CONCLUSION

The hardware changes on Revolution allow for improved CNR at increasing iodine concentrations. Furthermore, the Revolution more accurately measures iodine concentration.

CLINICAL RELEVANCE/APPLICATION

When comparing two generations of dual-energy CT systems on virtual monochromatic images, the newer generation GE Resolution shows improved CNR and more accurate iodine concentration measurements.

SSQ19-09 Dual-Energy CT Monochromatic Image Consistency Across Vendors and Platforms

Thursday, Dec. 1 11:50AM - 12:00PM Room: S404AB

Participants
Megan Jacobsen, Houston, TX (*Presenter*) Nothing to Disclose
Cayla Wood, MS, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Dianna D. Cody, PhD, Houston, TX (*Abstract Co-Author*) In-kind support, General Electric Company

PURPOSE

Although dual-energy CT provides improved sensitivity of HU for certain tissue types at lower simulated energy levels, if these values vary by scanner type they may impact clinical patient management decisions. Each manufacturer has selected a specific dual-energy CT approach (or in one case, three different approaches); understanding HU variability among monochromatic images may be required when more than one dual-energy CT scanner type is available for use.

METHOD AND MATERIALS

A large elliptical dual-energy quality control phantom (Gammex Inc.; Middleton, WI) containing several standard tissue type

materials was scanned at least three times on each of the following systems: GE HD-750 (80/140kVp), prototype GE Revolution CT with GSI (80/140kVp), Siemens Flash (80/140kVp and 100/140kVp), Siemens AS128 (80/140kVp), Siemens Edge (120kVp) and Philips IQon (120kVp and 140kVp). Monochromatic images were generated at 50, 70, and 140 keV. Soft tissue (29 HU at 120kVp) and Iodine (5 mg/ml) HU were measured on a single central 5mm-thick image; NIST constants were used to calculate the ideal HU for each material. Scan acquisitions were approximately dose-matched (~25mGy CTDIvol) and image parameters were held as consistent as possible across scanner types (thickness, kernel, no noise reduction).

RESULTS

Measured soft tissue (29 HU at 120 kVp) varied from 28 HU to 44 HU at 50 keV (excluding one outlier), from 21 HU to 31 HU at 70 keV, and from 19 HU to 32 HU at 140 keV. Measured iodine (5 mg/ml, 106 HU at 120 kVp) varied from 246 HU to 280 HU at 50 keV, from 123 HU to 129 HU at 70 keV, and from 22 HU to 32 HU at 140 keV.

CONCLUSION

Measured HU in standard rods across 3 dual-energy CT manufacturers and 6 scanner models varied directly with monochromatic level, with the most variability observed at 50 keV and least variability at 70keV. Future work will include additional scanner platforms and how measurement variability in monochromatic images impacts radiologists.

CLINICAL RELEVANCE/APPLICATION

Current daily CT quality control programs do not address dual-energy CT. This is particularly important if clinical facilities rely on dual-energy CT data from more than one scanner make and model.

PHS-THA

Physics Thursday Poster Discussions

Thursday, Dec. 1 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Jun Deng, PhD, New Haven, CT (*Moderator*) Nothing to Disclose
Jun Zhang, PhD, Columbus, OH (*Moderator*) Nothing to Disclose

Sub-Events

PH259-SD-THA2 Direct Measurement of Breast Surface Dose during Coronary CT Angiography and Effectiveness of Lower Tube Voltage and Cranial Breast Displacement to Reduce Breast Radiation Exposure

Station #2

Participants
Min Kyoung Lee, MD, Incheon, Korea, Republic Of (*Presenter*) Nothing to Disclose
Yon Mi Sung, MD, Incheon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Yoon Kyung Kim, MD, Incheon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jeong Ho Kim, MD, Incheon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Hye-Young Choi, MD, PhD, Incheon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Special consideration is brought up for women regarding safety issue of radiation exposure to the breasts with coronary CT angiography (CTA). The purpose of this study was to measure the surface radiation dose received by the adult female breast during coronary CTA and to evaluate the effectiveness of lower tube voltage and cranial breast displacement to reduce breast radiation exposure.

METHOD AND MATERIALS

The subjects were 276 women (mean age, 57.8 ± 10.2 years) who underwent coronary CTA between March 2014 and June 2015. Patients were divided into four different protocol groups by tube voltages of 120 or 100 kVp and use of cranial breast displacement; group A with no cranial displacement at 120 kVp (n=69), group B with no cranial displacement at 100 kVp (n=69), group C with cranial displacement at 120 kVp (n=69), group D with cranial displacement at 100 kVp (n=69). Direct measurement of breast surface dose was done on each breast quadrant in all patients with optically-stimulated luminescence dosimeters. The degree of breast displacement was evaluated by volume assessment of fibroglandular tissue in both breasts on reconstructed full field-of-view images.

RESULTS

The breast surface dose was significantly lower in groups B and D (p<0.001; group A, 35.9 ± 16.6 mGy; group B, 22.1 ± 10.0 mGy; group C, 39.2 ± 17.3 mGy, group D, 23.1 ± 8.3 mGy). The greatest dose reduction was observed in the right upper inner quadrant (43.0%) followed by in the left upper inner quadrant (42.6%). No significant difference in the breast surface dose was seen with same tube voltages but different use of cranial breast displacement (p=0.262, group A vs group C; p=0.523, group B vs group D). The total volume of the fibroglandular tissue of the breasts within the scan range was significantly lower in groups C and D (group A, 56.7 ± 37.6 cm3; group B, 51.7 ± 39.0 cm3; group C, 46.6 ± 57.0 cm3; group D, 38.7 ± 30.5 cm3).

CONCLUSION

Lower tube voltage was effective to reduce breast surface dose during coronary CTA. Significant reduction of the fibroglandular tissue of the breasts within the scan range of coronary CTA was obtained using cranial breast displacement with no significant change in breast surface dose.

CLINICAL RELEVANCE/APPLICATION

Both lower tube voltage and cranial displacement of the breasts can be applied during coronary CTA that may have the most benefit from this technique to avoid radiation risk in the radiosensitive female breasts.

PH260-SD-THA3 Factors of Volume Estimation Uncertainty for Low-contrast Liver Lesions in CT: A Phantom Study

Station #3

Participants
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Yongguang Liang, Royal Oak, MI (*Abstract Co-Author*) Nothing to Disclose
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Binsheng Zhao, DSc, New York, NY (*Abstract Co-Author*) License agreement, Varian Medical Systems, Inc; License agreement, Keosys SAS ; License agreement, Hinacom Software and Technology, Ltd; License agreement, ImBio, LLC ; Research funded, ImBio, LLC; License agreement, AG Mednet, Inc
Nicholas Petrick, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

QIBA guidelines for the use of volumetric CT as an imaging biomarker are based primarily on lung nodule assessment; however, lesion-to-background contrast is far lower in liver CT. In this work, we aim to evaluate the performance of liver lesion volumetry with CT using a range of imaging parameters through a phantom study.

METHOD AND MATERIALS

An anthropomorphic abdominal phantom was designed, featuring two substitutable inserts: one modeling the arterial phase (parenchyma 80 HU), and the other modeling the portal-venous phase (parenchyma 110 HU) of contrast enhancement; each includes 19 lesions of various sizes (6-40 mm), shapes, and lesion-to-parenchyma contrasts (10-65 HU, homogenous or mixed-density). The phantom was scanned by 2 commercial CT scanners with multiple imaging protocols (4 slice thicknesses, 3 doses, 2 reconstruction kernels), resulting in 320 datasets. Volume was estimated for all lesions using a model-based algorithm, which incorporated properties of the imaging systems. Statistical analyses were applied to determine the accuracy and precision of the measurements.

RESULTS

The lesions ≤10 mm could not be measured and were excluded from analysis. For the lesions >10 mm, the measurements showed low biases (-2% to 1%) and the variances increased with lower dose. Lesion size, contrast, CT dose, and slice thickness were significant factors based on ANOVA; reconstruction kernel and scanner system were not. Lesions with relatively large size and high contrast (size ≥30mm, contrast ≥20HU; or 20-30mm, ≥35 HU) showed good reproducibility (reproducibility coefficients (RDC) 7%, 12%, 16% for CTDIvol of 19.0, 7.6, 3.8 mGy, respectively). For the other lesions, the RDC corresponding to those three doses were 16%, 22% and 45%.

CONCLUSION

Findings in our study showed that volume estimation for liver lesions was strongly dependent on their size, and contrast, as well as the CT dose. These factors differ from similar analyses of lung nodules, where contrast and dose had less impact.

CLINICAL RELEVANCE/APPLICATION

QIBA guidelines for the CT tumor volume biomarker may benefit from being specifically tailored to different contrasts and/or different estimation tasks (lung vs. liver).

PH262-SD-THA5 Measuring Head Movement in 3D During CT-Perfusion Analysis - A Pilot Study

Station #5

Participants
Mette C. Marklund, MD, PhD, Roskilde, Denmark (*Presenter*) Nothing to Disclose
Anders O. Baandrup, BSC, Roskilde, Denmark (*Abstract Co-Author*) Nothing to Disclose
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Carsten Thomsen, Copenhagen, Denmark (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

A robust, very accurate and low tech marker can be used for measuring head movement in the X-, Y and Z-direction and rotation during a CTP.

Background

The purpose of this pilot study is to test a simple, non-anatomical dependent method to calculate head motion in the X-, Y- and Z-dimensions and rotation. Most CT-scanners have inbuilt options for movement correction based on landmarks. Some of the algorithms operate in 3D others in 2D. Only very few studies have examined, how much the patient actually moves during a CT perfusion (CTP) study since no external, non-anatomic dependent marker for objective measurement in all 3 dimensions exists.

Evaluation

To determine the motion in patients instructed to lying still, we developed a marker designed to be placed on the patients forehead. The marker was drawn in Autocad® and 3D printed. It contains 4 air filled cones in 2 planes pointing in 2 directions in each plane. It was tested in a phantom set-up with a micrometer (Mitutoyo 164-163 Digimatic Micrometer) enabling the marker moving as little as 0.001 mm. Raw data were calculated by an external radiologist with no knowledge on the applied movement parameters. By applying an advanced mathematical algorithm, measuring the size and elliptical deformation of the black holes during the scan, a very accurate value (δ) for movement in the X-, Y- and Z-direction could be calculated. The marker was placed on the forehead of 5 consecutive patients suspected for Ischemic Stroke (IS) undergoing CTP. The patients were all well-cooperating. Movement parameters (fig. 4) are given for our most restless patient nr. 3: δ(X): -3.6 to 4.4 mm, δ(Y): -1.3 to 1.9 mm,δ(Z): -1.4 to 2.0 mm and rotation -2.0 to 3.2 degrees.

Discussion

Movement artifacts lower the signal/noise ratio and increase the risk of diagnostically insufficient images. Even though the movement errors can be reduced by post processing, the S/N-ratio will remain lower than if the patient had not moved at all. Determining the extent of true motion is fundamental for setting up future projects aiming to optimize head stabilization and developing advanced post processing algorithms.

PH263-SD-THA6 Breast Density Estimation from 3D High Spectral and Spatial resolution (HiSS) MRI

Station #6

Participants
Hui Li, MD, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
Milica Medved, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
William Weiss, BS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Hiroyuki Abe, MD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Gregory S. Karczmar, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Maryellen L. Giger, PhD, Chicago, IL (*Abstract Co-Author*) Stockholder, Hologic, Inc; Stockholder, Quantitative Insights, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Toshiba Corporation;

PURPOSE

We aim to investigate a new 3D breast density estimation method using High Spectral and Spatial resolution (HiSS) MR imaging

We aim to investigate a new 3D breast density estimation method using High Spectral and Spatial resolution (HiSS) MR imaging, combined with a novel semi-automated breast density measurement technique, in order to improve measurements of breast density for cancer risk assessment.

METHOD AND MATERIALS

22 patients (ages 23-71 years) were recruited with informed consent under an IRB approved protocol and in compliance with HIPAA for high risk breast cancer screening at our institution. All patients received a standard-of-care digital X-ray mammogram and MR scans on a 1.5T Philips Achieva MR scanner, as well as HiSS scans (2D high resolution EPSI-based sequence, 0.8x0.8x3 mm3 in-plane resolution, 23.9 Hz spectral resolution) during the clinical MR scans. HiSS water signal images were generated by integrating the water resonance obtained from the HiSS dataset in each voxel. There are several steps involved in breast density estimation based on HiSS images, including breast mask generating, breast skin removal, and breast percentage density calculation. The inter- and intra-user variability of HiSS-based density estimation was assessed using correlation analysis and limits of agreement. The correlation analysis was also performed between HiSS-based density estimation and BI-RADS ratings by radiologists.

RESULTS

A correlation coefficient of 0.91 ($p<0.0001$) was obtained between left and right breast percent density estimation based on HiSS images. The interclass correlation coefficient (ICC) of 0.99 ($p<0.0001$) was observed for reliability assessment of inter-user variability of HiSS-based breast percent density estimation. The limits of agreement for HiSS-based percent density were [-0.8 1.4] between two readers, and [-0.2 0.4] for the same reader. The moderate correlation coefficient of 0.55 ($p=0.0076$) was observed between HiSS-based breast density estimation and radiologists' BI-RADS density rating.

CONCLUSION

An objective breast density estimation method using HiSS spectral data was developed. The high reproducibility with low-inter and low-intra user variability suggest that such HiSS-based density metric may be beneficial to breast cancer risk assessment and monitoring response to therapy.

CLINICAL RELEVANCE/APPLICATION

Accurately and objectively measuring breast density using HiSS spectral data may aid clinicians in assessment of breast cancer risk and monitoring of response to therapy in cancer patients.

PHS-THB

Physics Thursday Poster Discussions

Thursday, Dec. 1 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Jun Deng, PhD, New Haven, CT (*Moderator*) Nothing to Disclose
Jun Zhang, PhD, Columbus, OH (*Moderator*) Nothing to Disclose

Sub-Events

PH264-SD-THB1 Computed Diffusion-Weighted Image for Abdominal MRI

Station #1

Participants
Takeshi Yoshikawa, MD, Kobe, Japan (*Presenter*) Research Grant, Toshiba Corporation
Yoshiharu Ohno, MD, PhD, Kobe, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Eisai Co, Ltd; Research Grant, Fuji Pharma Co, Ltd; Research Grant, FUJIFILM RI Pharma Co, Ltd; Research Grant, Guerbet SA;
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Hisanobu Koyama, MD, PhD, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
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Shinichiro Seki, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuro Sugimura, MD, PhD, Kobe, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation Research Grant, Koninklijke Philips NV Research Grant, Bayer AG Research Grant, Eisai Co, Ltd Research Grant, DAIICHI SANKYO Group

PURPOSE

To assess capability of computed diffusion-weighted image (cDWI) in evaluation of abdominal diseases

METHOD AND MATERIALS

102 patients (52 men and 50 women, mean: 67.3years), who were suspected to have hepato-biliary-pancreatic malignancy and underwent 3T-MRI, were retrospectively analyzed. DWIs were obtained with SE-EPI (b: 0 and 1000, DWI0 and DWI1000). cDWI images at b values of 200, 400, 600, 800, 1200, 1400, 1600, 1800, and 2000 were reconstructed (cDWI200-2000). 65 malignant lesions and 68 benign lesions were confirmed. Lesions with a diameter of >10 mm were chosen for quantitative analysis. Signal-to-noise ratio of each organ (SNR=SI*organ*/SD*organ*) and lesion contrasts (*CM*=SI*lesion*-SI*organ*/SI*lesion*+SI*organ*) were compared among the images. Two readers assessed image quality, i.e. organ signal and contour, suppression of vessels and ducts, and signal inhomogeneity and noise on images, and recorded b values with best quality and with complete gallbladder signal suppression for each patient, and assessed lesion conspicuity using a 5-point scale on DWI1000 and cDWIs. Malignant lesion detection for each patient and accuracies of lesion characterization were separately assessed using a 5-point scale on DWI0+1000 and +cDWIs sets. Consensuses were made and compared. ROC analysis was used for detections and accuracies.

RESULTS

SNRs were significantly highest on cDWI800 in the liver and on cDWI600 in the pancreas and spleen (Ps<0.0001). Malignant lesions contrasts were significantly increased (0.026) and benign ones were significantly decreased (<0.0001) in proportion to increase of b value. Image quality was best on cDWI800 followed by DWI1000 (mean: 835 ± 176). Gallbladder signal was completely suppressed on cDWI1200 or higher (mean: 1777 ± 266). Conspicuity of malignant lesion was significantly highest (0.005) and that of benign lesion was significantly lowest (<0.0001) on cDWI2000. Malignant lesion detection was significantly higher (Az: 0.728 vs 0.798, 0.033) and accuracy of lesion characterization was significantly higher (Az: 0.662 vs 0.904, <0.0001) on +cDWIs set.

CONCLUSION

Computed DWI can improve image quality, lesion contrast, detection, and characterization, and is a useful post-processing tool for abdominal MRI.

CLINICAL RELEVANCE/APPLICATION

Computed DWI can improve image quality, lesion contrast, detection, and characterization, and is a useful post-processing tool for abdominal MRI.

PH265-SD-THB2 Importance of US Coupling Gel on Photoacoustic Signal Attenuation

Station #2

Awards
Student Travel Stipend Award

Participants
Caitlin Finley, Wynnewood, PA (*Presenter*) Nothing to Disclose
Maria Stanczak, MS, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Flemming Forsberg, PhD, Philadelphia, PA (*Abstract Co-Author*) Equipment support, Toshiba Corporation; Research Grant, Toshiba Corporation; Equipment support, Siemens AG; In-kind support, General Electric Company; In-kind support, Lantheus Medical Imaging, Inc
Ji-Bin Liu, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Shunxin Zhang, Beijing, China (*Abstract Co-Author*) Nothing to Disclose

Yanhong Wang, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
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John R. Eisenbrey, PhD, Philadelphia, PA (*Abstract Co-Author*) Support, General Electric Company; Support, Lantheus Medical Imaging, Inc

PURPOSE

To determine the attenuating effects of various ultrasound (US) coupling gels on photoacoustic signals using a commercial imaging system.

METHOD AND MATERIALS

Photoacoustic signals from 3 tissue phantoms were acquired using the Vevo LAZR system with a LZ250 probe (Visualsonics, Toronto, Canada). Two agar phantoms were dyed with methylene blue or IR820 dye (Sigma-Aldrich). A third phantom was made with no dye. Phantoms were scanned from 680 to 970 nm at a gain of 45 dB and a depth of 8 mm with four different types of acoustic coupling gel: a clear medium viscosity gel (NEXT Medical Products, Branchburg, NJ, USA), a clear high viscosity gel (NEXT Medical Products, Branchburg, NJ, USA), a blue medium viscosity gel (Owens & Minor, Mechanicsville, VA, USA), and a white, medium viscosity opaque US lotion (Parker Laboratories, Inc., Fairfield, NJ, USA). The clear phantom's spectra were subtracted from the spectra of the methylene blue and IR820 phantoms in order to eliminate any photoacoustic signal from the agar. The photoacoustic signal intensities across different coupling gels and phantoms were compared using ANOVA tests.

RESULTS

The photoacoustic signal from both phantoms showed a dependence on the type of coupling gel used. The average maximum signal intensities in the methylene blue phantom using the white, blue, clear high viscosity, and clear medium viscosity gels were 0.28±0.01, 0.42±0.17, 0.56±0.16, and 0.76±0.20 linear arbitrary units (au), respectively ($p=0.03$). While variations in intensities were observed between clear and blue gels, these differences were not found to be statistically significant ($p=0.12$). For the IR820 phantom, the average maximum intensities of the signal due to the white, blue, clear high viscosity, and clear medium viscosity gels were 0.38±0.04, 2.31±0.22, 2.25±0.43, and 2.30±0.23 au, respectively ($p<0.001$). However, unlike the methylene blue phantom, no differences were observed between clear and blue coupling gels ($p=0.9$). In both phantoms, no significant differences were observed in peak absorbance wavelengths between the blue and either clear coupling gel groups ($p>0.49$).

CONCLUSION

The selection of acoustic coupling gels can lead to the attenuation of photoacoustic signal and should be kept constant during serial imaging studies.

CLINICAL RELEVANCE/APPLICATION

Unlike US imaging, the choice of coupling gel may potentially alter photoacoustic signals and should be kept constant for longitudinal studies.

PH266-SD-THB3 The Vertical Positioning on Abdomen and Thorax CT Studies and the Influence to Dose

Station #3

Participants
Hannele M. Niiniviita, MSc, Turku, Finland (*Presenter*) Nothing to Disclose
Jukka Jarvinen, Turku, Finland (*Abstract Co-Author*) Nothing to Disclose
Heli Maattanen, Turku, Finland (*Abstract Co-Author*) Nothing to Disclose
Jarmo Kulmala, DPhil, Turku, Finland (*Abstract Co-Author*) Nothing to Disclose
Jani Saunavaara, Turku, Finland (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To assess patient positioning in abdomen and thorax studies and its effect on doses.

METHOD AND MATERIALS

DoseWatch (commercial software, GE, Milwauke, USA) was used to collect radiation dose as computed tomography dose index (CTDIvol), body mass index (BMI) and patient positioning as a difference from isocenter on abdomen and thorax studies. The data was collected at six departments from November 2015 to April 2016. The patients were divided by their BMI into four groups (BMI <20, 20-25, 25-30 and >30 kg/m²) and mean doses and mean vertical shifts were calculated. Differences in patient positioning at different BMIs and at different departments were assessed. The doses of each BMI group were also compared to the mean doses of patients scanned in isocenter (vertical shift between -3 and 3 mm). The data of 610 thorax and 1545 abdomen studies were collected.

RESULTS

BMI values ranged from 14.7 to 62.5 kg/m² and delta vertical shifts from -45 to 96 mm and from -64 to 70 mm in thorax and abdomen studies, respectively. Vertical shift was BMI dependent as patients with BMI over 25 were centered lower than patients with lower BMI. Patients with BMI over 25 were centered lower than the isocenter in abdomen scans, but on average patients from all BMI groups were centered higher than the isocenter in thorax scans (figure 1 a). When comparing mean doses of all patients to mean doses of patients positioned at isocenter in abdomen studies, the doses were 15.3 % and 4.9 % lower for BMI groups <20 kg/m² and 20-25 kg/m², respectively. On the other hand, they were 0.8 % and 8.4 % higher for BMI groups 25-30 kg/m² and >30 kg/m² (figure 1 b). However, the doses remained the same despite of vertical shift on thorax scans. At department level, the results were similar to overall results.

CONCLUSION

Vertical shift in both abdomen and thorax CT scans was BMI dependent as smaller patients were positioned higher with respect to the isocenter than larger patients. The miscentering affected patient doses in abdomen imaging.

CLINICAL RELEVANCE/APPLICATION

The patient centering is BMI dependent, where smaller patients are positioned higher.

Participants

Quantitative Evaluation of Coronary Artery Diameter: Effect of CT Scan Modes and Heart Rate

THB5

Station #5

Jeong Hoon Hwang, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
Moon C. Kim, RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Yoon C. Nam, RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jin Seok Park, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jun-Su Kim, RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

In high heart rate patients, it demonstrates that scanning at 45% phase of helical (systole) is the best suitable and using high pitch spiral scan mode is unsuitable. In low heart rate patients, it demonstrates that scanning at 75% phase of helical (diastole) is the best suitable for the measurement of exact coronary artery size. If using proper scan mode by heart rate, it could be helpful to accurate diagnosis for cardiovascular patients.

Background

To evaluate the coronary lumen area and roundness for coronary CT angiography with the change of scan mode and heart rate which are significant factors affecting motion artifact and diagnostic accuracy.

Evaluation

All CT scans were performed on SOMATOM Definition Flash (Siemens, hereafter, S) with a cardiac motion simulating phantom (MOCOMO, Fuyo Corp, JP) attached 400HU solid phantom of 3 and 4mm diameter. The phantom was scanned at 0(static) for reference and heart rate (HR) simulated of 50-100 beat/min with sequence, helical, high pitch scan mode and reconstructed at 45% and 75% phase (sequence, helical) and 60% start phase (high pitch) of the R_R cycle. The mean area and roundness of scanned images were analyzed by using Image J software. Statistical analysis was performed to T-test and ANOVA by using SPSS software (version 18.0, IBM corp).

Discussion

As increased heart rate, the error value of the mean area of 3mm and 4mm phantom were the smallest about 4.9% and 2.9% in helical mode 45 %, and followed sequence mode 45%, helical mode 75%, sequence mode 75%, high pitch mode in ascending order. The error value of the mean roundness of 3mm and 4mm phantom were the smallest about 2.1% and 2.1% in helical mode 45%, and there was no significant difference among the other scan modes. For the comparison of scan modes in 3mm phantom and heart rate 50bpm(suitable phase for high pitch mode), the error value of the mean area was the smallest about 9.2% in helical mode 75% and followed sequence mode 75%, high pitch spiral scan mode. The error value of the mean roundness was the smallest about 3.4% in sequence mode 75% and followed helical mode 75%, high pitch spiral scan mode(P<.05 for all).

PS50

Thursday Plenary Session

Thursday, Dec. 1 1:30PM - 2:45PM Room: E450A

PH

AMA PRA Category 1 Credits ™: 1.25
ARRT Category A+ Credits: 1.50

Participants

Sub-Events

PS50A RSNA/AAPM Symposium: Precision Imaging in Medicine

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Moderator*) Research Grant, General Electric Company; Co-founder, PET/X LLC

LEARNING OBJECTIVES

1) To learn what the Precision Medicine Initiative (PMI) is, and how it is evolving as a national program. 2) To learn the current and potential impacts of the the PMI on radiology through quantitative imaging and a focus on outcomes. 3) To learn how radiology can support the PMI through advances in big data analysis and supporting therapy.

PS50B Precision Medicine: Optimizing Imaging Strategies

Participants
Daniel C. Sullivan, MD, Durham, NC (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

During the past two decades, the molecular characterization of disease has revealed that each patient is likely to have a unique combination of genotypic, epigenetic, and phenotypic profiles for their disease. In other words, no two patients with lung cancer or diabetes will have exactly the same molecular profile for their diseases, despite the fact that we currently give them the same clinical diagnosis. Biomarkers--both specimen and imaging--play an increasingly important role in healthcare as physicians try to determine the most appropriate therapy for any patient's molecularly-unique version of disease. This concept is variously called targeted, personalized or precision medicine. The Federal government recently launched the Precision Medicine Initiative, the goal of which is described as tailoring therapies "to you" instead of treating based on averages. For clinical imaging there are three important implications of Personalized Medicine which will be discussed in this presentation. These are (1) the importance of imaging information (biological, functional or anatomic) that reflects the individual's molecular basis of disease, (2) objective, quantitative information that is reproducible and can be incorporated into decision support algorithms, and (3) a focus on therapeutic implications or options as opposed to primarily focusing on diagnosis. Furthermore, these evolutionary shifts in healthcare will inevitably require radiologists to accept more standardization in imaging acquisition protocols and to use structured reporting systems.

PS50C Quantitative Radiomics, Big Data, and Deep Learning in Precision Medicine

Participants
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Stockholder, Hologic, Inc; Stockholder, Quantitative Insights, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Toshiba Corporation;

Abstract

Adapting the Precision Medicine Initiative into imaging research includes studies in both discovery and translation in order to enable the conversion of current radiological interpretation from that of the "average patient" to the precise interpretation and patient-care management decisions specific to the individual. The goal is to individually detect disease, and then give the right person the right treatment at the right time. Discovery is a multi-disciplinary data mining effort involving researchers such as radiologists, medical physicists, oncologists, computer scientists, engineers, and computational geneticists. Similar to how the genomics community approached the big biology of the Cancer Genome project, the radiological community continues to conduct robust collection, annotation, analysis, and evaluation of images of large populations. Advances in computer power and machine learning algorithms are allowing for computer-extracted features, both from clinically-driven computer-extraction systems (such as those from computer-aided diagnosis) and deep learning methods, to yield "radiomics", i.e., the high throughput conversion of image sets into a multi-dimensional feature space. With quantitative imaging, a patient's tumor can be characterized quantitatively via "virtual digital biopsies". Ultimately translation of the discovered relationships will include applications to the clinical assessments of cancer risk, prognosis, response to therapy, and risk of recurrence.

RC721

Advances in CT: Technologies, Applications, Operations-Special Purpose CT

Thursday, Dec. 1 4:30PM - 6:00PM Room: S103CD

BR MK CT IR PH

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

Participants
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; Research Grant, Siemens AG
Norbert J. Pelc, ScD, Stanford, CA (*Coordinator*) Research support, General Electric Company; Research support, Koninklijke Philips NV; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Medical Advisory Board, OurCrowd, LP ;

Sub-Events

RC721A Breast

Participants
John M. Boone, PhD, Sacramento, CA (*Presenter*) Research Grant, Siemens AG; Royalties, Wolters Kluwer nv;

RC721B MSK

Participants
Wojciech Zbijewski, PhD, Baltimore, MD, (wzbijewski@jhu.edu) (*Presenter*) Research Grant, Carestream Health, Inc

LEARNING OBJECTIVES

1) Describe the special prupose CT systems for musculoskeletal (MSK) imaging. 2) Compare the capabilities of special purpose MSK CT systems to conventional modalities. 3) Identify diagnostic applications enabled by special purpose MSK CT.

ABSTRACT

RC721C Interventional

Participants
Charles M. Strother, MD, Madison, WI (*Presenter*) Research Consultant, Siemens AG Research support, Siemens AG License agreement, Siemens AG

RC722

MRI: Imaging for Radiation Treatment Planning

Thursday, Dec. 1 4:30PM - 6:00PM Room: E351

MR RO PH

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

Participants
Eric Paulson, Milwaukee, WI (*Moderator*) Nothing to Disclose

ABSTRACT

Sub-Events

RC722A MRI for Anatomical Definition

Participants
Eric Paulson, Milwaukee, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the advantages of MRI simulation for anatomical delineation in both external beam radiation therapy and brachytherapy. 2) Understand the differences between images obtained during MRI simulation versus diagnostic MRI. 3) Understand the current solutions to address technical challenges of using MRI for anatomical delineation in Radiation Oncology.

ABSTRACT

MRI is rapidly emerging as a primary imaging modality in Radiation Oncology, fueled by innovations in MRI-guided treatment delivery, MRI simulation systems, and the role of MRI in individualizing and adapting radiation therapy. This course will discuss the advantages and technical challenges of using MRI for anatomical definition in radiation treatment planning. Current solutions to tailor MRI to the unique demands of Radiation Oncology will be explored. Clinical examples illustrating the use of MRI for anatomical delineation in both external beam radiation therapy and brachytherapy will be presented.

Active Handout:Eric Paulson

http://abstract.rsna.org/uploads/2016/15001743/RC722A PaulsonES_MRForAnatomicalDefinition.pdf

RC722B MRI for Functional Definition

Participants
Uulke A. van der Heide, PhD, Amsterdam, Netherlands (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Get an overview of the most relevant functional MRI modalities are available. 2) Understand how they can be used to improve target definition. 3) Understand their limitations and specific concerns for use in radiation oncology.

ABSTRACT

In addition to anatomical imaging, MRI affords a range of functional techniques. Diffusion-weighted MRI images the restriction of water mobility in tissue, thus probing microanatomy. This is used to identify tumors and monitor response to treatment. Dynamic contrast-enhanced MRI shows the tracer kinetics of contrast agents and reflects the characteristics of the microvasculature, such as flow and permeability. These and other techniques can be used to improve target definition, and to characterize tumor tissue for radiotherapy dose painting.

RC723

Molecular Imaging Mini-Course: Clinical Applications of Molecular Imaging-Neuro

Thursday, Dec. 1 4:30PM - 6:00PM Room: S504AB

NR MI OI PH

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

Participants

Sub-Events

RC723A Oncology Applications

Participants
Hyunsuk Shim, PhD, Atlanta, GA, (hshim@emory.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To learn about the potential of combining an advanced spectroscopic MR imaging with standard MR images to reduce the recurrence rate in glioblatomas.

ABSTRACT

Radiation therapy (RT) is as good as the images that guide RT planning. RT based on conventional MRIs may not fully target tumor extent in glioblastomas (GBM), which may, in part, account for high recurrence rates (60-70 percent at 6 months). Magnetic resonance spectroscopy, a molecular imaging modality that quantifies endogenous metabolite levels without relying on perfusion, leakage and diffusion of injected material, may better define extent of actively proliferating tumor. In addition, advances in this technology now permit acquisition of whole-brain high-resolution 3D spectroscopic MRI (sMRI) in 12-14 minutes. We correlated state-of-the-art sMRI metabolite maps and their ratio maps with tissue histopathology to validate further its use for identifying non-enhancing and infiltrating tumors that may not be fully imaged by conventional MRI sequences and provide support for its adjunctive use in tumor contouring for RT planning. Integration of histologically-verified, whole brain 3D sMRI into RT planning is feasible and may considerably modify target volumes. Thus, RT planning for GBMs may be augmented by sMRI potentially leading to reduced or delayed recurrence rates.

RC723B Functional Applications

Participants
Satoshi Minoshima, MD, PhD, Salt Lake City, UT (*Presenter*) Royalties, General Electric Company; Research Consultant, Hamamatsu Photonics KK; Research Grant, Hitachi, Ltd; Research Grant, Nihon Medi-Physics Co, Ltd;

RC725

Computational Perception

Thursday, Dec. 1 4:30PM - 6:00PM Room: E353B

IN PH

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

Participants

Sub-Events

RC725A Status of CAD in Clinical Radiology

Participants
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Stockholder, Hologic, Inc; Stockholder, Quantitative Insights, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Toshiba Corporation;

LEARNING OBJECTIVES

1) Provide an overview of the types & applications of CAD being developed & used today. 2) Summarize the evidence & controversies regarding clinical impact of CAD. 3) Describe future trends in CAD research.

RC725B Intersection of Imaging Informatics and Perception

Participants
Katherine P. Andriole, PhD, Dedham, MA (*Presenter*) Advisory Board, McKinsey & Company, Inc;

LEARNING OBJECTIVES

1) Provide a basic overview of imaging informatics. 2) Describe the importance of data visualization for practitioners. 3) Assess ways imaging informatics can impact image interpretation.

RC725C Review the Effects on Radiologist Interpretation of Reading Paradigms and Visualization Methods in CT Colonography CAD

Participants
Ronald M. Summers, MD, PhD, Bethesda, MD, (rms@nih.gov) (*Presenter*) Royalties, iCAD, Inc; ;

LEARNING OBJECTIVES

1) Review the time & resource constraints radiologists face clinically. 2) Discuss the role of non-radiologists interpreting radiographic images. 3) Describe crowd-sourcing & how it can apply to radiology.

ABSTRACT

RC825

Perception in the Clinic

Friday, Dec. 2 8:30AM - 10:00AM Room: E263

PH SQ

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: 1.00

Participants

Sub-Events

RC825A Impact of Fatigue on Radiologists' Performance

Participants
Elizabeth A. Krupinski, PhD, Atlanta, GA, (ekrupin@emory.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe how fatigue impacts diagnostic accuracy. 2) Describe how fatigue impacts the efficiency with which cases are interpreted. 3) Provide ways to avoid & ameliorate fatigue.

ABSTRACT

Today's radiologists are under increased pressue to read more cases and more complex cases in less time, but are expected to maintain the same level of diagnostic accuracy. This is not however always possible and increasingly it is becoming apparent that radiologists are becoming more fatigued. The question whether this fatigue impacts diagnostic performance. Recent studies have begun to address this issue by exploring methods to objectively characterize visual strain and fatigue by measuring visual accommodation and dark vergence, assessing subjective feelings of fatigue, and measuring the impact of fatigue on diagnostic accuracy. These studies have demonstrated that fatigue negatively impacts accuracy and may impact visual search strategies, especially in ressidents. Radiologists need to be aware of their limits and how fatigue can impact image interpretation.

Active Handout:Elizabeth Anne Krupinski

http://abstract.rsna.org/uploads/2016/16001191/ACTIVE RC825A.pdf

RC825B Perception of Volumetric Image Data

Participants
Geoffrey D. Rubin, MD, Durham, NC, (grubin@duke.edu) (*Presenter*) Consultant, Fovia, Inc; Consultant, Informatics in Context, Inc; Research Consultant, General Electric Company;

LEARNING OBJECTIVES

1) Provide an overview of the role of volumetric imaging in radiology. 2) Describe the perceptual challenges in interpreting volumetric data. 3) Review evidence on differences in visual search between 2D & 3D image set.

ABSTRACT

The depth and complexity of volumetric imaging data such as those acquired using CT or MRI scanning is profound. Early work in medical image perception focused on two-dimensional images represented by radiographs and in particular mammograms and chest radiographs. The paradigm for lesion detection in this setting is limited as all imaging data are presented to the interpreter in a single view or small set of views that are simultaneously available for search. In contrast, volumetric images, which are typically presented as stacks of cross-sections, necessitate active exploration using computer controls in order to being lesions into view, providing an opportunity for recognition. This presentation will review the results of recent investigations that shed light on reader performance in relation to volumetric search strategies and perceptual characteristics.

RC825C Role of Image Quality in Perception

Participants
Justin B. Solomon, PhD, Durham, NC, (justin.solomon@duke.edu) (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Define image quality and its most common metrics. 2) Present the impact of image resolution on diagnostic performance. 3) Present the impact of image noise and dose on diagnostic performance.

ABSTRACT

This session focuses on how physical image characteristics such as noise, contrast, and resolution impact image perception and diagnosis. CT images will be used as examples but the concepts are applicable to any modality. Special attention will be given to CT iterative reconstruction algorithms and the interdependent relationship between noise, resolution, contrast, and anatomical complexity in iteratively reconstructed images.

SST10

Physics (CT-Clinical Applications)

Friday, Dec. 2 10:30AM - 12:00PM Room: E350

CT PH

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

Participants
Patrick J. La Riviere, PhD, Chicago, IL (*Moderator*) Research funded, Toshiba Corporation; Research Consultant, MetriTrack, Inc
Maryellen L. Giger, PhD, Chicago, IL (*Moderator*) Stockholder, Hologic, Inc; Stockholder, Quantitative Insights, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Toshiba Corporation;

Sub-Events

SST10-01 Adaptive Frustum Fly-Over Visualization Enables Robust 3D CT Colonography

Friday, Dec. 2 10:30AM - 10:40AM Room: E350

Participants
Amal Farag, PhD, Louisville, KY (*Presenter*) Nothing to Disclose
Salwa Elshazly, BSc, Louisville, KY (*Abstract Co-Author*) Nothing to Disclose
Abraham H. Dachman, MD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Perry J. Pickhardt, MD, Madison, WI (*Abstract Co-Author*) Co-founder, VirtuoCTC, LLC; Stockholder, Cellectar Biosciences, Inc; Stockholder, SHINE Medical Technologies, Inc; Research Grant, Koninklijke Philips NV
Albert Seow, MD, Louisville, KY (*Abstract Co-Author*) Nothing to Disclose
Robert L. Falk, MD, Louisville, KY (*Abstract Co-Author*) Founder, 3DR Inc Managing Director, 3DR Inc Officer, 3DR Inc
Gerald Dryden, Louisville, KY (*Abstract Co-Author*) Nothing to Disclose
Aly A. Farag, MS,PhD, Louisville, KY (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

CTC enables virtual visualization of colon surface by various methods (Fig. a): Endoluminal **Fly-through** (**FT**), mimicking optical colonoscopy (OC), typically requires antegrade and retrograde viewing. On average, 20% of small polyps (6-9mm) and up to 10% of polyps ≥1cm are missed, causing erroneous diagnosis. **Flattening** maps the 3D colon into a cylindrical representation and then into a 2D image/filet. It induces lumen distortion and causes imprecise definition of polyps. **Panoramic** and **Unfolded Cube** represent the 3D colon by combining virtual camera views for complete visualization, but generate lumen distortion and many false positives. This work promotes "**Fly-over**" (**FO**), where the 3D colon is sliced into two overlapping halves, each visualized by a virtual camera with field of view (**FOV**) perpendicular to 3D colon centerline, enabling lumen visualization without distortion.

METHOD AND MATERIALS

Theory: Visualization in FT and FO with respect to polyp characteristics was quantified by analyzing the FOV using computer vision (Fig b). In FT, the virtual camera is parallel to colon centerline, FOV is restricted and incapable of seeing small-size polyps behind haustral folds. In FO, camera is set perpendicular to the centerline without restriction on FOV angle; thus, FO carries no perspective distortion and polyps hidden by haustral folds are visible.**Evaluation:** A CTC system was established to evaluate FO vs FT on 60 patients (40 males and 20 females). *Group 1:* 20 patients from ACRIN study and 3 from Walter Reed study and 7 patients with synthetic polyps added. *Group 2:* 6 patients from ACRIN, 13 cases from Walter Reed, 7 patients with synthetic polyps, and 4 recurring patients with added synthetic polyps. CT scans were acquired on GE scanners. Clinicians choose reading order (FT/FO) and sequences of cases were randomized. FT and FO had same pre-visualization data (Fig. a).

RESULTS

In readings of 4 expert radiologists, FO had average of 22.3% higher sensitivity than FT (Fig. c); 22.5% for <1cm and 9.2% for ≥1cm (Fig. d). FO has nearly 30% less navigation time.

CONCLUSION

CTC using FO provides state-of-the-art performance for visualization of colonic polyps <1cm over FT and induces no distortion, leading to improved polyp detection and reduced interpretation time.

CLINICAL RELEVANCE/APPLICATION

This fly-over based CTC system enables accurate and efficient colon visualization, which could have a positive benefit on both patients and healthcare costs.

Honored Educators

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

Perry J. Pickhardt, MD - 2014 Honored Educator

SST10-02 Spectral CT Imaging in the Differential Diagnosis of Small Bowel Adenocarcinoma from Small Intestinal Lymphoma

Friday, Dec. 2 10:40AM - 10:50AM Room: E350

Participants
Chuangbo Yang, MMed, Xianyang City, China (*Presenter*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Chenglong Ren, Shanxi, China (*Abstract Co-Author*) Nothing to Disclose
Yong Yu, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Xirong Zhang, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Haifeng Duan, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Ma Guangming, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Tian Xin, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate the value of gemstone spectral CT imaging in the differential diagnosis of small bowel adenocarcinoma (SBA) from primary small intestinal lymphoma (PSIL).

METHOD AND MATERIALS

This retrospective study was institutional review board-
approved, and written informed consent was waived. We retrospectively analyzed the images of 17 cases of small intestinal carcinoma (SBA) and 11 cases of primary small intestinal lymphoma (PSIL). These patient

RESULTS

There were significant differences between SBA and PSIL in IC (2.09±0.71 vs. 1.33±0.15mg/ml), NIC (0.20±0.06 vs. 0.13±0.02) and slope (λHU) (2.78±1.06 vs. 1.86±0.30) in AP and (1.86±0.68 vs. 1.37±0.18mg/ml
60keV energy range ($p<0.05$), but not in the 70-140keV range ($p>0.05$) (Table 1). Using 1.38mg/ml as a threshold value for iodine concentration at AP, one could obtain the area-under-
curve (AUC) for ROC study of 0.93 and sensitivity of 94% and specificity of 85% for differentiating small bowel adenocarcinoma from primary small intestinal lymphoma. These values were significantly higher than th

RESULTS

There were significant differences between SBA and PSIL in IC (2.09±0.71 vs. 1.33±0.15mg/ml), NIC (0.20±0.06 vs. 0.13±0.02) and slope (λHU) (2.78±1.06 vs. 1.86±0.30) in AP and (1.86±0.68 vs. 1.37±0.18mg/ml
60keV energy range ($p<0.05$), but not in the 70-140keV range ($p>0.05$) (Table 1). Using 1.38mg/ml as a threshold value for iodine concentration at AP, one could obtain the area-under-
curve (AUC) for ROC study of 0.93 and sensitivity of 94% and specificity of 85% for differentiating small bowel adenocarcinoma from primary small intestinal lymphoma. These values were significantly higher than th

CONCLUSION

Quantitative parameters obtained in spectral CT, especially iodine concentration in the arterial phase, provide high accuracy for differentiating small bowel adenocarcinoma from primary small intestinal lymphoma.

CLINICAL RELEVANCE/APPLICATION

Spectral CT imaging with its many quantitative parameters may provide a new method for the differential diagnosis of small bowel adenocarcinoma from primary small intestinal lymphoma.

SST10-03 Feasibility of Material Suppressed Iodine Images Derived from Spectral CT in Detecting and Displaying Gastric Tumors

Friday, Dec. 2 10:50AM - 11:00AM Room: E350

Participants
Yaru Chai, MD, Zhengzhou, China (*Presenter*) Nothing to Disclose
Jianbo Gao, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate the feasibility of material suppressed iodine(MSI) images derived from spectral CT in detecting and displaying gastric tumors, and to calculate the potential radiation dose reduction by omitting true no

METHOD AND MATERIALS

This study received institutional review board approval, and all participants provided written informed consent. 103 patients(63 men, 40 women; age range 20-
87, median age 54) with gastric tumors underwent TNE scan with 120kVp mode, arterial phase and venous phase with GSI mode. MSI images were reconstructed in ADW4.6 of GE Healthcare. The subjective image q
test.

RESULTS

The diagnoses of these 103 patients were confirmed by endoscopic biopsy or surgical pathology(gastric cancer, n=86; gastric stromal tumor, n=9; gastric lymphoma, n=6; gastric schwannoma, n=2). Interobserver a

CONCLUSION

MSI images derived from spectral CT can provide good image quality to TNE images and reliable diagnostic information for evaluating gastric tumors, and can reduce radiation dose and scanning time by omitting TNE

CLINICAL RELEVANCE/APPLICATION

In gastric tumors patients, MSI images can replace TNE images to reduce radiation dose and scanning time.

SST10-04 **Texture-preserving Bayesian Reconstruction of Low-dose CT Images for Lung Nodule Detection**

Friday, Dec. 2 11:00AM - 11:10AM Room: E350

Participants
Hao Zhang, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Jerome Z. Liang, PhD, Stony Brook, NY (*Presenter*) Nothing to Disclose
Hao Han, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
William H. Moore, MD, Port Washington, NY (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Lung cancer remains the leading cause of cancer-related deaths in the US. Screening lung nodules by noise-smoothing low-dose CT (LdCT) image reconstruction has shown 25% cancer incidence reduction. We hypothesize that texture-preserving Bayesian reconstruction of LdCT images can further reduce the incident rate by improving the detection of lung nodules.

METHOD AND MATERIALS

Image textures of the major tissues across the chest, e.g. muscle, fat, lung and bone, which are readily available from full-dose diagnostic CT images, are extracted from corresponding segmented tissue regions. Each tissue type's textures are converted into a set of parameters for the Markov random field (MRF) model as a priori probability for maximum a posteriori or Bayesian reconstruction of the LdCT image. Each set of tissue type model parameters is applied to a corresponding tissue region in the LdCT image domain after a fast segmentation is applied in that domain. Since the a priori tissue model is only specific to the region in the LdCT image domain, the segmentation can be less exact on the tissue borders for high speed. The MRF-Texture method was evaluated using 136 patients' sinograms acquired at full-dose (100mAs) as reference, low-dose (40mAs) and ultralow-dose (20mAs) with comparison to the widely cited noise-smoothing MRF-Huber method as well as the well-known FBP method.

RESULTS

The FBP method detected 161 nodules at 100mAs (the reference), 152 at 40mAs and 147 at 20mAs. The MRF-Huber detected 156 at 40mAs and 151 at 20mAs. The MRF-Texture detected 159 at 40mAs and 156 at 20mAs. The MRF-Texture achieved the detection of 159 at 40% of the full dose FBP with detection of 161 nodules.

CONCLUSION

The presented texture-preserving Bayesian LdCT image reconstruction reduced the dose by nearly a half, while retaining the detection of nodules of size as small as 3mm compared to the current gold standard FBP method at the full-dose level. The gain of MRF-Texture over the state-of-the-art statistical MRF-Huber method is similar to the gain of MRF-Huber over the FBP, indicating a noticeable image reconstruction methodology advancement from noising-smoothing paradigm to texture-preserving paradigm.

CLINICAL RELEVANCE/APPLICATION

CT image textures have been shown as useful for various clinical tasks. The presented texture-preserving Bayesian LdCT image reconstruction has demonstrated the potential to improve the detection of lung nodules of size as small as 3mm.

SST10-07 **Clinical Application of Dual Energy Spectral CT in Detecting Cholesterol Gallstones from Surrounding Bile**

Friday, Dec. 2 11:30AM - 11:40AM Room: E350

Participants
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PURPOSE

To investigate the clinical value of spectral CT in the detection of cholesterol gallstones from surrounding bile.

METHOD AND MATERIALS

This study was institutional review board approved. The un-enhanced spectral CT data of 24 patients who had surgically confirmed cholesterol gallstones were analyzed. Lipid concentrations and CT numbers were measured from fat-based material decomposition image and virtual monochromatic image sets (40-140keV), respectively. The difference in lipid concentration and CT number between cholesterol gallstones and surrounding bile were statistically analyzed. Receiver operating characteristic curve was generated to establish threshold value of the lipid concentration required for significant differentiation of cholesterol gallstones from bile.

RESULTS

Cholesterol gallstones were bright on fat-based material decomposition images yielding a 92% detection rate (22/24). Its lipid concentrations (552.65±262.36mg/ml), CT number at 40keV (-31.57±16.88HU) and 140keV (24.30±5.85HU) were significantly different from those of bile (-13.94±105.12mg/ml, 12.99±9.39HU and 6.19±4.97HU, respectively). Using 182.59mg/ml as the threshold value for lipid concentration, one could obtain sensitivity of 95.5% and specificity of 100% with accuracy of 0.994 for differentiating cholesterol gallstones from bile.

CONCLUSION

Virtual monochromatic spectral CT images at 40keV and 140keV provide significant CT number difference between cholesterol gallstones and surrounding bile. Spectral CT provides an excellent detection rate for cholesterol gallstones.

CLINICAL RELEVANCE/APPLICATION

virtual monochromatic images in spectral CT imaging at 40keV and 140keV provide significant CT number difference between cholesterol gallstones and surrounding bile. The combination of virtual monochromatic image and fat-based material decomposition image in spectral CT provides an excellent detection rate for cholesterol gallstones.

SST10-09 **Detector-Based Spectral CT Evaluation of In-Stent Occlusions in Small Cardiac and Vascular Stent Phantoms**

Friday, Dec. 2 11:50AM - 12:00PM Room: E350

Participants
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Xinhui Duan, PhD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Christopher Maroules, MD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
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Anil K. Pillai, MD, Coppell, TX (*Abstract Co-Author*) Nothing to Disclose
Suhny Abbara, MD, Dallas, TX (*Abstract Co-Author*) Author, Reed Elsevier; Editor, Reed Elsevier; Institutional research agreement, Koninklijke Philips NV; Institutional research agreement, Siemens AG

PURPOSE

To assess the performance of a novel detector-based spectral CT (SCT) scanner for evaluation of occlusions in cardiovascular stents. Evaluation of stents <3 mm is difficult due to artificial luminal narrowing secondary to partial volume averaging. SCT has the potential to improve evaluation of these stents and in-stent stenosis through the generation of monochromatic images that can be selected to reduce artifact and optimize contrast conspicuity.

METHOD AND MATERIALS

Stents (2, 2.5, 3, 4 mm) were deployed into 3D printed tubes with inner diameters 0.2 mm larger than the stent. Stents were filled with either 15 or 7.5 mg/ml of elemental iodine to simulate an optimal and more realistic bolus, respectively. Occlusions were simulated with paraffin wax. Stent phantoms were scanned on a SCT scanner (IQon, Phillips Healthcare) using a cardiac protocol at 120 kVp. Images were reconstructed at a 0.67 mm thickness using a cardiac kernel. Multiple monochromatic images were generated. Regions of interest were drawn along the long axis of the vessel in the occluded and non-occluded areas of the stent.

RESULTS

For all stents the non-occluded areas of the stent had increased attenuation compared with occluded areas in conventional and monochromatic images. With a 15 mg/ml bolus, , the attenuation difference between occluded and non-occluded areas of the stent was 612±52 HU on conventional 120 kVp images, 1000±70 HU at 50 keV, 559±51 HU at 70 keV, 341±68 HU at 100 keV and 242±77 HU at 150 keV. A similar trend was seen with the 7.5 mg/ml bolus but with decreased HU differences. Attenuation differences held for all stent sizes but absolute HU of the smaller stents were higher due to blooming.

CONCLUSION

The increased attenuation difference between occluded and non-occluded areas of the stents achieved on lower keV images irrespective of stent size suggests an advantage of monochromatic images over conventional images.

CLINICAL RELEVANCE/APPLICATION

Non-invasive evaluation of small cardiac and vascular stents using CT angiography has the potential to avoid diagnostic invasive angiography and its associated risks. Spectral detector CT has the potential to expand CT evaluation to smaller stents and situations where vascular enhancement is sub-optimal.

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