Physics and Basic Science

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105TH Scientific Assembly and Annual Meeting
December 1–6 | McCormick Place, Chicago

PH001-EB-X

Neuroimaging Protocols for Large Scale Multi-Center Research Studies: From Volumetrics to Structuro-Functional Connectomics

All Day Room: PH Community, Learning Center Hardcopy Backboard

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TEACHING POINTS

The intention with this exhibit is describe and illustrate graphically the criteria used for designing comprehensive neuroimaging protocols for large scale multi-center studies. Specific emphasis on maximizing image information content while minimizing total acquisition time. Including the following: Cross platform design of the protocols and quality control Comprehensive quantitative MRI (qMRI) in as little as 40 minutes total scan time qMRI parameters: volumes, MS-qMRI, dMRI, DTI, resting state-fMRI Key strategies for database organization: serial automated processing

TABLE OF CONTENTS/OUTLINE

Large Scale Multi-Center Research overview From simple volumetrics to quantitative structure-functional connectomics The connection between neurovascular response and functional activation Automated big data organization and processing

Printed on: 10/29/20

PH005-EB-X

How to Manage Image Quality and Radiation Exposure for an X-Ray System Using a Flat-Panel Detector

All Day Room: PH Community, Learning Center Hardcopy Backboard

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TEACHING POINTS

-To understand the importance of management for x-ray system using a flat-panel detector (FPD) -To understand the importance of evaluating FPD imaging performance, not only for stationary objects, but also for moving objects -To understand the importance of quality control (QC) education in FPD system

TABLE OF CONTENTS/OUTLINE

QC for FPD image performance using a stationary phantom consisting of three thicknesses of copper, an aluminum step-wedge, and wires: Spatial and low-contrast resolutions, dynamic range. *A rotatable QC phantom for evaluating the performance of FPDs for imaging moving objects:* Three thicknesses of copper and a rotatable pattern (wires). *Discuss the QC protocol:* Management software for QC data, QC education. OUTLINE: Because the use of x-ray equipment using FPDs has increased, the management of FPD systems is important. FPD systems have a wide dynamic range. To ensure QC of FPD system, an easy method for evaluating FPD imaging performance for both stationary and moving objects is required, especially with fluoroscopy. Evaluating the visibility of moving objects (wires) in the FPD system is also important for evaluating image retention. Our moving phantom is useful for QC of FPD images of moving objects. In addition, it is necessary to have management software for QC data for this process to be easily performed.

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PH006-EB-X

Characteristics and Optimization of Five Company CT-AEC in Pediatric Abdominal CT

All Day Room: PH Community, Learning Center Hardcopy Backboard

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TEACHING POINTS

Pediatric patients need to ensure image quality and reduce exposure based on the ALARA (as low as reasonably achievable) concept. The tool of optimization is the CT automatic exposure mechanism (CT-AEC). However, when children are the subject, it has been found that the usage different from adults is effective. We examine the operation of five manufacturers of CT-AEC in a 64-row multi-slice CT, and show optimization compatible with exposure and image quality in children.

TABLE OF CONTENTS/OUTLINE

1. Original phantom specifications and concepts(Fig.1) 2. The noise index (hereinafter NI), Eff. MAs, and kV were changed in five 64-row MSCTs. a. Image noise for each scan object diameter (Standard Division)(Fig.2,3) b. MTF (Modulation Transfer Function) c. Noise Power Spectrum (NPS)(Fig.4) d. Visual assessment using phantoms for low contrast assessment(Fig.5) 3. Optimal setting with CT-AEC during pediatric abdomen CT examination

PH007-EB-X

Photon Counting Technique: How to Analyze a Novel Quantitative Image?

All Day Room: PH Community, Learning Center Hardcopy Backboard

Awards
Certificate of Merit

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TEACHING POINTS

1) Photon counting techniques can derive novel material identification by analysis of each X-ray energy. 2) Both detector response and beam hardening effect need to be taken into consideration and corrected to achieve highly accurate material identification. 3) In addition to conventional X-ray image, effective atomic number image will give quantitative information to help clinical diagnosis.

TABLE OF CONTENTS/OUTLINE

1) Outline of the physics of the imaging process using a photon counting detector. Analysis of each X-ray energy can derive physical information such as effective atomic number and bone mineral density. 2) Review progress of X-ray imaging detectors for clinical application; an energy integrating detector has been applied to digital radiography and dual energy technique. Currently, a photon counting detector is expected to achieve technical innovation in terms of material identification. 3) Key issue needed to perform material identification using a photon counting detector: detector response and beam hardening effect. 4) Material identification procedure we propose; effective atomic number of an object can be derived regardless of material thickness. 5) Demonstration of clinical application using a proto-type photon counting detector for plain X-ray diagnosis.

PH101-ED-X

Evaluation of the CT Number of Different Iodine Concentration Contrast Media on Different Generations Dual-Energy CT Imaging

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

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TEACHING POINTS

1. In a previous (our) study, the new generation(2nd generation) dual energy CT can provide higher accuracy of detectability of iodine density comparing with the conventional dual energy CT. It is particularly evident at high concentrations. 2. Monochromatic CT image is generated from linear combination of Iodine and Water basis pair material density images with specific weight values based on their mass attenuation coefficients, Therefore, if these basis pair material density accuracy has dependency from different generation CT scanners, CT number (HU) accuracy of Monochromatic CT images may have some impact in the quality. 3. In conclusion the new (2nd) generation dual energy CT imaging can get higher enhancement compared to conventional (1st) generation dual energy CT in high concentration iodine case (scan phase).

TABLE OF CONTENTS/OUTLINE

A. Back ground : A previous our study (accuracy of detectability of iodine density) B. Reconstruction process of monochromatic image. C. Phantom layout D. Comparison of CT number (HU) between different generation CT scanners in phantom study. E. Comparison of CT number (HU) between different generation CT scanners in clinical study. (performed enhanced CT in 30 patient cases)

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PH102-ED-X

Influence of the Center of Rotation of the X-Ray Tube in Tomosynthesis Imaging

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

Participants
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TEACHING POINTS

Tomosynthesis is a three-dimensional imaging technique based on the reconstruction of several planar radiographs. We need to set a height for the center of rotation (COR) of the X-ray tube before the tomosynthesis image acquisition. In most cases, the COR is provided from a default value of the tomosynthesis apparatus. However, we recommend to set each COR according to a height of interest. We clearly described the reason why the COR should be set before the exam. The aim of this exhibit is, 1. to investigate and understand the effect of the resolution property when the COR is changed, 2. to show the clinical images, 3. to learn the cause of the degraded resolution and the remedy. We hope that the tomosynthesis imaging would be improved by our suggestion.

TABLE OF CONTENTS/OUTLINE

1. Introduction, 2. Method, 3. Influence of the COR settings for the resolution property, 4. Influence of the COR for a wrist phantom image, 5. Suggestion.

PH103-ED-X

Improvement of Image Analysis Accuracy on Fast kVp Switching Dual-Energy CT with Optimum Scan Parameter

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

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TEACHING POINTS

1. Understanding beam hardening effect using water phantom CT images. 2. Investigating CT number variation and image noise characteristics on virtual monochromatic X ray imaging. 3. Proposing clinical usefulness of dual energy CT provided by improvement of image analysis accuracy with optimum scan parameter.

TABLE OF CONTENTS/OUTLINE

To evaluate Fast kVp switching dual energy CT, image characteristics were measured changing scan parameters. Optimum scan parameter to improve the beam hardening correction by virtual monochromatic image was confirmed. that virtual monochromatic image i CT number of water at the boundary of acryl was depicted accurately at optimum condition. The shape of noise power spectrum on water was same at different tube voltage and scan conditions. Improvement of beam hardening correction on water is necessary to improve the accuracy of iodine and fat density measurement and image quality was also improved in clinical cases. Fast kVp switching is essential scanning method to improve image diagnosis accuracy of dual energy CT more.

PH104-ED-X

Perfusion CT: Concepts and Applications in Abdominal Imaging

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

Awards
Certificate of Merit
Identified for RadioGraphics

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TEACHING POINTS

1. To understand the background and history of perfusion CT 2. To learn the concepts and techniques of perfusion image post processing 3. To review the clinical applications of perfusion CT in the abdomen

TABLE OF CONTENTS/OUTLINE

A: Concepts of Perfusion and a Brief History of Perfusion CT B: Creating a Perfusion CT Protocol C: Techniques of Image Post Processing D: Clinical Applications of Perfusion CT in the abdomen including mass characterization E: Future of Perfusion CT and its Limitations

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PH105-ED-X

Easier-to-Understand Fast MR Imaging: Pictorial Review of K-Space

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

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TEACHING POINTS

1. To demonstrate the concept of k-space (Fourier space), comprehensible explanatory models and k-space acquisition trajectories. 2. To describe the k-space mapping strategies for fast MR imaging by multiple samplings of k-space at each repetition time (TR) and under-sampling for parallel imaging and compressed sensing.

TABLE OF CONTENTS/OUTLINE

1. Introduction 1. Concept of k space 1) Definition of k-space: space collecting the stripe patterns 2) Fourier transformation and Gradient 3) Mathematical proof: $\Delta k=\gamma G\Delta T=1/FOV$ 2. Comprehensible explanatory models of k-spaces 1) Extended phase graph model 2) Shaded sphere model 3. k-space acquisition trajectories 1) Catesian 2) Noncartesian Radial Spiral 2. k-space acquisition strategies for fast MR imaging 1. Multiple samplings per repetition time(TR) 1) Fast spin echo (FSE) 2) Echoplanar imaging (EPI) 2. Undersampling 1) Classification of undersampling Fractional Regualr (coherent) Semi-random (incoherent) Random (incoherent) 2) Fractional undersampling for Half Fourier or fractional acquisitions 3) Regular (coherent) undersampling for parallel imaging 4) Semi-random (incoherent) undersampling for compressed sensing

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PH106-ED-X

Is Your Head Spinning Yet? MRI Acceleration Techniques for the MSK Guy

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

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TEACHING POINTS

1. To explain 2D and 3D MRI techniques and their associated strategies for accelerated data acquisition 2. To illustrate the advantages and limitations of different acceleration techniques 3. To apply the most appropriate acceleration technique for various clinical scenarios of musculoskeletal MRI

TABLE OF CONTENTS/OUTLINE

1. Review of the basic principles of 2D and 3D pulse sequence techniques commonly used in musculoskeletal MRI 2. Outline of general strategies for accelerated data acquisition 3. Explanation of practical physics of parallel acquisition techniques (PAT), simultaneous multislice sequences (SMS), elliptical scanning, synthetic MRI, and compressed sensing (CS) acceleration 4. Highlight of image quality considerations and trade-offs of the different acceleration techniques 5. Application of current acceleration techniques for the creation of 5-10 min MSK MRI protocols 6. Illustration of advantages and limitations of current and future acceleration techniques in clinical practice

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PH107-ED-X

MR Alphabet Soup: Understanding the Principles of Common Magnetic Resonance Abbreviations

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

Awards
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TEACHING POINTS

From its humble beginnings in the 1970s, magnetic resonance imaging (MRI) has become one of the most utilized imaging modalities. MRI relies on a combination of a variety of advanced sciences including engineering, physics, chemistry and computer science. Over decades of development, MRI has amassed many acronyms and abbreviations that are critical for understanding its basic principles and pulse sequences. This exhibit aims to (1) review the different subcategories of magnetic resonance and clinical applications, (2) explain abbreviations related to the basic principles of magnetic resonance, (3) highlight abbreviations related to image acquisition and optimization, and (4) explore the meaning behind the acronyms of commonly used pulse sequences.

TABLE OF CONTENTS/OUTLINE

a. Introduction to Magnetic Resonance 1) Current Magnetic Resonance Applications 2) Flavors of MR: MRI, MRA, MRS, fMRI 3) Clinical Applications 4)Speaking the Same Language b. Basics of Understanding MRI Physics 1) Magnetic Principles 2) Resonance Principles 3) Physics with Hardware c. Image Acquisition 1) Terms at the Terminal 2) Pulse Sequence Design 3) Spin Echo 4) Gradient Echo 5) Common Clinical Pulse Sequences d. Tips for Understanding New Abbreviations

PH108-ED-X

Recommendation for Optimization Considering Pit Fall of Virtual Monochromatic Image in Dual-Layer Detector CT

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

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TEACHING POINTS

1.Clinical usefulness of Virtual Monochromatic image (VMI) 2.Present image quality degradation of low Kev images 3.Proposal limit point of VMI and optimum use conditions in clinical use

TABLE OF CONTENTS/OUTLINE

1. We present the benefits of VMI such as a reduction in beam hardening artifacts, an increase in contrast agent sensitivity in low Kev areas, an increase in contrast, a reduction in metal artifacts in high keV. 2.We investigate the change in image quality using a low-contrast phantom for the relationship between energy change in the VMI. NPS and imaging dose. We show the effect on clinical images based on a result of this investigation. 3.We visually assess low contrast detectability and look for optimal values in the low Kev region. When contrast agent reduction is performed using contrast agent sensitivity increase, the validity of the contrast agent reduction amount of 3D-CT angiography for small blood vessels is verified including the imaging dose. OUTLINE In the clinical setting, the image quality of VMI can be maintained by setting the optimal imaging conditions (SD, mAs, keV, etc.), and require protocol operation to correspond the purpose of examination.

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PH109-ED-X

Effective Use of Radiation Protective Equipment in Fluoroscopy: Separating Real from Fake News

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

Awards
Certificate of Merit
Identified for RadioGraphics

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TEACHING POINTS

Fluoroscopically-guided interventional procedures may result in high staff radiation dose levels. Various types of radiation protective devices are available, including apparel, pads and shields. While some devices are valuable, others provide limited protection despite marketing claims made by manufacturers. This exhibit will review protective equipment and provide objective evaluation of expected occupational radiation protection.

TABLE OF CONTENTS/OUTLINE

Radiation exposure reduction by the following protective equipment will be reviewed: leaded glasses, radiation-absorbing surgical caps, disposable pads, upper body shields and lower body shields. Leaded eyewear models that have adequate coverage can provide significant protection from scatter, however, the contralateral eye lens may not be protected. Brain dose reduction provided by a radiation-absorbing surgical cap is minimal. The most effective placement of an upper body shield is close to the operator, tight to the patient surface. Poor placement of the upper body shield results in nominal protection. Disposable radiation pads can provide upper body protection from radiation and may be useful in situations where the upper body shield cannot be used. Other novel radiation protection devices will also be summarized.

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PH112-ED-X

Make Your Images Less Susceptible: Improving Magnetic Resonance Imaging Quality in Patients with Implants

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

Awards
Identified for RadioGraphics

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TEACHING POINTS

1. It is important to optimize image quality with the increase in magnetic resonance (MR) conditional implants and unsafe devices in controlled situations.2. Implants may cause a variety of artifacts including signal loss and failure of fat suppression. Understanding basic physics principles is important to be able to develop strategies to minimize metal-related artifacts.3. Various strategies to reduce metallic artifact include optimizing MR parameters, selecting appropriate sequences and using specialized pulse sequences.

TABLE OF CONTENTS/OUTLINE

1. Implanted metallic device artifacts and why they occura. Signal lossb. Failed fat suppressionc. Image distortiond. Hyperenhancement2. Methods to improve MR images in the setting of implantsa. Change MR parameters 1. Lower magnet field strength 2. Increase bandwidth 3. Increase image matrix 4. Increase gradient amplitude 5. Decrease slice thickness 6. Decrease TE 7. Decrease echo train length b. Change MR sequence 1. Fast spin echo instead of spin echo 2. STIR or multi-echo Dixon techniques instead of fat suppression relying on spectral frequency 3. Fast gradient echo instead of SSFPc. Advanced techniques 1. Modified late gadolinium enhancement imaging using wide-bandwidth radiofrequency inversion pulse 2. Metal artifact reduction sequences 3. Parallel imaging

PH114-ED-X

Development of Doppler-like CT Image Using Color Sequential Subtraction

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

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TEACHING POINTS

Dynamic CT angiography makes it difficult to accurately diagnose the direction and velocity of blood flow. In order to this problem, we developed a color sequential subtraction method for dynamic volume CT angiography. We report the development of Doppler like CT display using color sequential subtraction. We developed two types of phantoms. One is time density curve phantom, and another is spiral tube phantom. Dynamic CT scans were performed on these phantoms. By using sequential subtraction, the arriving bloodstream was red, the leaving bloodstream was blue and blood body was yellow. We were able to know the direction and velocity of bloodstream by this image. By displaying the result in color code, it became possible to accurately know the direction and velocity of blood flow. This method has just the same visual effect as Doppler display of ultrasonic examination.

TABLE OF CONTENTS/OUTLINE

Analyze the current problems Development of sequential subtraction method Development of color coding method Development the TDC-phantom and spiral tube phantom Experiment using phantom Proposal of Doppler like CT

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PH115-ED-X

CT Noise Reduction Methods to Facilitate Lower Dose Scanning: Strengths and Weaknesses of Iterative Reconstruction and New Kids on the Block

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

Awards

Certificate of Merit

Identified for RadioGraphics

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TEACHING POINTS

• Because Iterative reconstruction (IR) is a non-linear reconstruction method, its contrast-dependent spatial resolution makes traditional image quality metrics such as image noise and CNR inappropriate • IR can preserve accuracy with aggressive dose reduction for high contrast diagnostic tasks, but has limited ability to preserve accuracy for low contrast diagnostic tasks • Considerable data spatio-spectral data redundancy exists in CT exams, and can be used to reduce image noise for multispectral reconstructions or multiphase CT exams • Convolutional neural networks are increasingly being used to reduce image noise and break the typical trade-off between noise reduction and image sharpness, but extrapolation across CT system platforms may be limited

TABLE OF CONTENTS/OUTLINE

Iterative Reconstruction • Pros, cons (low contrast diagnostic tasks) • Appropriate and inappropriate measures of image quality • Channelized hoteling observers Using redundant information to reduce image noise - prior iterative reconstruction, frequency split algorithms, multispectral noise reduction • Considerations and limitations with these techniques Convolutional neural networks • Commercial implementation (GE, Canon) • What types of validation are meaningful? • Examining generalizability to new sets of images

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PH116-ED-X

Compressed Sensing MRI in Clinical Practice: From Theory to Practical Implementation in a Few Clicks

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

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TEACHING POINTS

Describe the theoretical basis of compressed sensing to accelerate MRI image acquisition Describe the clinical implementation performed on Philips MRI scanners and how to adjust it Show clinical examples of results achievable results. Describe image artifacts associated with this technique and how to recognize them

TABLE OF CONTENTS/OUTLINE

Requisites for compressed sensing Reduction factor and noise filtering Clinical applications and achievable results Impact on productivity

PH117-ED-X

Detection of Tendon for Rheumatoid Arthritis in Ultrasonography

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

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TEACHING POINTS

Rheumatoid arthritis (RA) is a chronic condition that results from a malfunctioning immune system. In RA, the immune system attack on the joints causes a build-up of synovial fluid and inflammation of the tissues that line the joint. Ultrasonography (US) has recently gained prestige as an adjuvant method for the diagnosis of RA. Tenosynovitis is common in early RA. US can evaluate the degree of tenosynovitis due to measuring the thickness of tendon, it is important to predict RA development. Evaluation of the tenosynovitis is necessary but laborious and inaccurate measurements in US. Therefore, a computer-aided diagnosis (CAD) system is expected for the RA diagnosis in the US. We developed a novel CAD system to detect automatically the lumen of synovial joints toward accuracy of the RA diagnosis in order to detect the synovial thickening bulging. The major teaching points of this exhibit is to: 1. Detect automatically the tendon in the US. 2. Understand how to detect scheme in the CAD system. 3. Be useful for the diagnosis of the RA.

TABLE OF CONTENTS/OUTLINE

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

Printed on: 10/29/20

105TH Scientific Assembly and Annual Meeting
December 1–6 | McCormick Place, Chicago
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PH118-ED-X

IAEA Atlas on Quality Control and Image Artefacts in SPECT/CT

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

Participants
Gian Luca Poli, PhD, Vienna, Austria (*Presenter*) Nothing to Disclose
John Dickson, PhD, London, United Kingdom (*Abstract Co-Author*) Consultant, General Electric Company Consultant, BioClinica, Inc
Soren Holm, PhD, MSc, Copenhagen, Denmark (*Abstract Co-Author*) Nothing to Disclose
Osama R. Mawlawi, PhD, Houston, TX (*Abstract Co-Author*) Research Grant, General Electric Company Research Grant, Siemens AG
Cecil Robilotta, Sao Paulo, Brazil (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

In recent years, hybrid imaging has become increasingly prevalent in nuclear medicine. To accurately interpret SPECT/CT images, in addition to understanding the principles of image formation/reconstruction and the biological distribution of the radiopharmaceutical, it is important to recognize image artefacts. The IAEA has developed a freely downloadable guidance document on Quality Control (QC) and image artefacts in SPECT/CT. The Atlas provides nuclear medicine professionals with a series of case studies of image artefacts that can occur in their clinical practice. The main learning/educational objectives are to i) provide the reader with an overview of the basic principles of emission tomography, CT and the use of CT for attenuation correction of SPECT images, ii) describe the required QC procedures for the operation of SPECT and SPECT/CT systems, iii) provide a pictorial teaching guide for potential SPECT and SPECT/CT imaging artefacts and iv) understand the sources of error in image quality and quantification and learn about techniques to identify and suppress them.

TABLE OF CONTENTS/OUTLINE

SPECT and SPECT/CT systems Quality Control: SPECT and SPECT/CT Artefacts (System related artefacts, Acquisition related artefacts, Reconstruction artefacts, Patient related artefacts, CT issues, SPECT/CT artefacts, Quantitative issues)

Printed on: 10/29/20

PH119-ED-X

Improving Head Imaging Quality for Patients with Nervous System Disease who Have Constant Uncontrolled Head Motion

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

Participants
Weibin Gu, Beijing , China (*Presenter*) Nothing to Disclose
Shiyuan Fang, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Guofeng Ma, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Xin-Yi Hou, MD, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Yaou Liu, MD, PhD, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Jianying Li, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company

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TEACHING POINTS

1) To illustrate the limitations of conventional CT in imaging patients with constant head movement due to nervous system diseases 2) To exhibit ways to reduce motion artifacts without helical artifacts and dose penalty 3) To present ways to further improve imaging quality with protocol optimization and iterative recon

TABLE OF CONTENTS/OUTLINE

1) Limitations of current method • Current narrow beam CT system requires >2s to cover the whole head • Higher helical pitches will result in image quality degradation and higher radiation dose due to over-scanning • Sedation for controlling patients' motion may have side effects 2) Ways to reduce motion artifacts • Conduct axial scan(s) using a 16cm wide-detector coverage to cover the whole head in one rotation (scan time<0.5s), and eliminate helical artifacts and over-scanning • Apply cardiac scan mode with fast gantry rotation for better temporal resolution 3) Ways to further improve imaging quality • Use lower kVp with advanced reconstruction to improve grey matter and white matter contrast while reducing beam hardening artifacts • Use iterative reconstruction (IR) to control image noise at the lower dose • Apply post-processing (E2) together with IR (ASIR) to further enhance contrast while controlling image noises

PH120-ED-X

An MDCT Tutorial: Scan Coverage, Speed, Dose Output and Field of View

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

Awards
Cum Laude

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Megan Lipford, PHD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose

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TEACHING POINTS

(1) No CT scanner can simultaneously operate at maximum dose output and maximum scan speed. (2) Wide collimation or the use of two tubes can double dose output. (3) Wide axial scanning and high pitch dual source scanning both introduce field of view limitations, albeit to differing degrees and in different planes.

TABLE OF CONTENTS/OUTLINE

This education exhibit will provide a review of the main imaging modes common to MDCT (i.e. axial, spiral/helical, bolus tracking, cine, shuttle, cardiac gated, respiratory gated, CT fluoroscopy, localizer radiograph). We will then review in detail axial and spiral/helical scanning modes focusing on the interplay between: tube mA limits, scan speed, pitch, rotation time, collimation, single versus dual tube mode, and scan field of view. The clinician will understand how the fundamental acquisition parameters of CT influence each other. Knowledge of these interplays is a skill required for creating optimized CT protocols and evaluating CT scanner bids/quotes. The clinician should walk away from this exhibit with the ability to understand why vendor claims of scan speed, field of view, and tube limits/dose output cannot all be realized at the same time.

Printed on: 10/29/20

PH122-ED-X

Art(ifact) Matters: Brain and Spine MRI Artifacts at 1.5 Tesla with Tips and Tricks on How to Eliminate Them

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

Participants
Bhavana Nagabhushana Reddy, MBBS, MD, Bengaluru, India (*Presenter*) Nothing to Disclose
Srinivasa Reddy, Bangalore , India (*Abstract Co-Author*) Nothing to Disclose
Prashanth Reddy, MBBS,MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Bharath B. Das, MD, MBBS, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Suman T. Prabhakar, MBBS,MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Puneeth K. K N, MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Jainesh V. Dodia, MBBS,MD, Bangalore , India (*Abstract Co-Author*) Nothing to Disclose
Sanjaya Viswamitra, MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose

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TEACHING POINTS

In this quiz based format, various artifacts are showcased and the viewer is asked to identify the artefact and how to eliminate them.Emphasis on: 1. Identification of artefact based on its appearance.2. Cause of the artefact and the physics behind it.3. Technical solution to eliminate them.

TABLE OF CONTENTS/OUTLINE

Artifacts in magnetic resonance imaging (MRI) of brain and spine in 1.5 Tesla scanner may be caused by the MR scanner hardware itself or by the interaction of the patient with the hardware and may be confused with a pathology or just reduce the quality of examinations. Their identification is extremely important in order to avoid false diagnoses and to learn how to eliminate them. Radiologists are frequently not aware of the cause of artifice and technical solution to them. The following artifacts will be discussed in a quiz based format.Equipment related like Zipper and moire fringe artifact, MRI software related like slice overlap artefact, patient related like motion artifact, tissue related like air-tissue interface, CSF pulsation, chemical shift and blood flow related artifacts, foreign body related like susceptibility artefact, fourier transform related like truncation, aliasing and wrap around artefacts.

Printed on: 10/29/20

PH123-ED-X

Whole-Body Clinical Applications and Diagnostic Performance of Dual-Energy Subtraction Radiography

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

Participants
Mingyue Wang, MD,PhD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Yijuan Wei, MMed, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Huizhi Cao, PhD, Beijing, China (*Presenter*) Nothing to Disclose
Amiee Chen, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Jianbo Gao, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

1. To understand the technical concept of dual-energy subtraction radiography and its implementation 2. To understand which type of lesion can be better evaluated under dual-energy subtraction radiography 3. To recognize the limitations and benefits of dual-energy subtraction radiography in radiation exposure and image acquisition.

TABLE OF CONTENTS/OUTLINE

1.Background and physics of dual-energy subtraction radiography 2. Clinical application of dual-energy subtraction radiography in improving detection of cystic fibrosis, diagnosis of interstitial lesion of the lung, coronary artery calcium, intestinal obstruction,renal desease, tumor bone metastasis and delineation of complex anatomic structures. 3. comparison of radiation dose and image quality between dual-energy subtraction radiography and standard conventional radiography. 4. Benefits and limitation of dual-energy subtraction radiography.

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PH124-ED-X

Unusual Cause of PET/CT Artifacts: Collection and Root Cause Analysis

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

Participants
Ashish K. Jha, MSc, Mumbai, India (*Presenter*) Nothing to Disclose
Sneha Mithun, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Nilendu C. Purandare, DMRD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Venkatesh Rangarajan, MBBS, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose

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TEACHING POINTS

Ring artefact in CT image: Ring artifact seen in trans axial image was caused by contrast contamination of CT tube aperture due to improper fitting of Mylar Window. Step wedge artifact in CT image: Step wedge artifact is a kind of wavy artifact seen in coronal and sagittal reformatted CT images and no artifact seen on transaxial images is caused due to poorly aligned CT tube. Tube arching artefact in CT image: Tube arching artifact appears due to voltage fluctuations in the high-voltage supply transformer supplying the rotor of the anode in the X-ray tube. Strike artefact in PET image: Streak artifact seen in PET images are due to sudden failure of one of the detector module. Count shifting artefact in PET image: The cause of this artifact can be attributed to the shifting in PMT gain due to fluctuation of temperature and high humidity. This can be corrected by simply performing daily QC of PET

TABLE OF CONTENTS/OUTLINE

Role of PET/CT has been established in oncology. Poor maintenance of these equipments are the major issue in developing countries, due to fluctuation in electric power supply and humidity. We have shown few PET and CT image artefacts in this exhibit, which we have observed in our department in last few years due to unusual reason which do not appear in the developed countries.

Printed on: 10/29/20

PH125-ED-X

Graph Theory and Resting-State Functional MRI: New Tools to Explore the Brain

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

Participants
Sidney Krystal, MD, Paris, France (*Presenter*) Nothing to Disclose
Jerry Blustajn, MD, Paris , France (*Abstract Co-Author*) Nothing to Disclose
Edouard Saragoussi, MD, Paris, France (*Abstract Co-Author*) Nothing to Disclose
Julien Savatovsky, MD, Saint Mande, France (*Abstract Co-Author*) Nothing to Disclose

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TEACHING POINTS

- To understand the principles of graph theory and its applications on the brain functional network obtained by resting-state functional MRI - To gain an understanding of their potential utility in evaluation of the normal and pathological brain

TABLE OF CONTENTS/OUTLINE

A. Principles of graph theory B. Functional brain network based on resting-state functional MRI C. Normal brain network analysed with graph theory D. Graph theory and Epilepsy E. Graph theory and Psychiatric Diseases

PH134-ED-X

How to Utilize Metal Artifact Reduction for Single Energy and Dual Energy

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

Participants
Tadashi Shimamoto, Oomura, Japan (*Presenter*) Nothing to Disclose
Tetsuya Minamide, Oomura , Japan (*Abstract Co-Author*) Nothing to Disclose
Tukasa Sakemoto, Oomura , Japan (*Abstract Co-Author*) Nothing to Disclose
Nobuyuki Tabata, RT, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Keisuke Hamada, RT, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

Artifacts in CT images due to internal metals reduce diagnostic value. It is possible to reduce metal artifact by using single energy metal artefact reduction (SEMAR) and dual energy (DE). By using SEMAR and DE depending on the type and structure of metal, it provides clinically useful images.

TABLE OF CONTENTS/OUTLINE

Metal artefacts due to internal metals pose problems in diagnostic imaging. It is possible to reduce metal artifact by using SEMAR or DE. Physical evaluation showed that SEMAR was a good result for coarse metal structures. DE was a good result for detailed metal structures. The comparison of clinical images showed that SEMAR was a good result in the imaging of hip prostheses. For spinal fusion, DE was a good result.It is useful to use SEMAR or DE for metal artifact reduction. Using SEMAR for coarse metal structures and DE for detailed metal structures can provide useful diagnostic images.

Printed on: 10/29/20

SPPH01

AAPM/RSNA Physics Tutorial Session 1

Saturday, Nov. 30 12:00PM - 2:00PM Room: E351

IN PH

AMA PRA Category 1 Credits ™: 2.00
ARRT Category A+ Credits: 2.25

Participants
Thaddeus A. Wilson, PhD, Madison, WI (*Moderator*) Nothing to Disclose

Sub-Events

SPPH01A Nuts and Bolts of Informatics

Participants
J. Anthony Seibert, PhD, Sacramento, CA (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Describe essential informatics competencies expected in a radiology environment. 2) Understand the various standards, profiles and lexicons used in imaging informatics. 3) Highlight the role of HL7, DICOM standards and IHE profiles in workflow for acquisition and diagnosis.

SPPH01B Standards and System Integration

Participants
Nabile M. Safdar, MD, Milton, GA (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) To understand why standards are important in healthcare technology. 2) To review most commonly used standards currently in use. 3) To explore the most common methods for integrating clinical systems.

ABSTRACT

The use of standards like HL-7 and DICOM in healthcare information technology have become critical for understanding of the flow of data in patient care settings. In this session, key concepts regarding the use of these standards in today's practice will be reviewed.

SPPH01C Digital Radiography 2D Image Analysis

Participants
Adel A. Mustafa, PhD, New Haven, CT (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Explain the importance of digital image processing. 2) Define the digital image quality metrics. 3) Identify the essential components of the image processing chain. 4) Differentiate between image processing and display processing. 5) Describe the different image processing methods and its effect on image quality. 6) Recommend trouble shooting image processing hints.

ABSTRACT

A major advantage of digital radiography is the avaialabilty of using image porecssing tools to help enhance the diagnostic quality of acquired images. Digital image processing requires subjecting the image raw data to a series of processes in order to render an image that resemles the 'look' of a screen-film radiograph. However, unlike screen-film radiographs, digtially obtained images can be manipulated using pre and postprocessing methodos to enhance its diagnostic interpretation. Such methods include signal filtering and transformation, region of interest segmentation, image field mask enhancement, histogram equalization, anatomy extraction, scatter correction, noise reduction, grid removal and tone-scale generation and optimization. The purpose of this presentation is to discuss those methods and demonstrate its effect on image diagnostic quality. We will also suggest troubleshooting and processing hints appplicable to digital images obtained using different digital radiography equipment from different manufacturers.

SPPH02

AAPM/RSNA Physics Tutorial Session 2

Saturday, Nov. 30 2:15PM - 4:15PM Room: E351

AI PH

AMA PRA Category 1 Credits ™: 2.00
ARRT Category A+ Credits: 2.25

Participants
Thaddeus A. Wilson, PhD, Madison, WI (*Moderator*) Nothing to Disclose

Sub-Events

SPPH02A Nuts and Bolts of Machine Learning and Artificial Intelligence

Participants
Katherine P. Andriole, PhD, Chestnut Hill, MA (*Presenter*) Research funded, NVIDIA Corporation; Research funded, General Electric Company; Research funded, Nuance Communications, Inc; ; ; ;

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SPPH02B AI in Healthcare: Advanced Topics

Participants
Luciano M. Prevedello, MD, MPH, Dublin, OH (*Presenter*) Nothing to Disclose
Paras Lakhani, MD, Media, PA (*Presenter*) Nothing to Disclose
Felipe C. Kitamura, MD, MSC, Sao Paulo, Brazil (*Presenter*) Consultant, MD.ai, Inc

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LEARNING OBJECTIVES

1) Learn about various types of artificial intelligence, including generative adversarial networks (GANs). 2) Learn about their potential applicability towards healthcare, including in image processing/reconstruction, and improving image quality. 3) Discuss strengths and pitfalls of the above solutions. 4) Present use cases.

ABSTRACT

The goal of this session is to discuss advanced topics in Artificial Intelligence (AI) and its applicability to heathcare. The topics may include synthesis of images and image-to-image translation, denoising and improving image quality, and new paradigm of image reconstruction using AI, as well as AI approaches for analyzing text/EHR data. The presentation(s) will cover healthcare use cases, and discuss the strengths/pitfalls of some of the networks used for this type of work, including generative adversarial networks (GANs), and AI-based language models.

Printed on: 10/29/20

ED013-SU

Physics Sunday Case of the Day

Sunday, Dec. 1 7:00AM - 11:59PM Room: Case of Day, Learning Center

AMA PRA Category 1 Credit ™: .50

Participants

Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Christina Brunnquell, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
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Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Karen L. Brown, MPH, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
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Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Canon Medical Systems Corporation; Consultant, Clementia Pharmaceuticals Inc
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John A. Parker, MD, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Frederic H. Fahey, DSc, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

The physics case of the day questions and supplemental material will challenge the learner to combine their basic physics understanding with real clinical scenarios to explain a feature on an image.

Printed on: 10/29/20

SSA20

Physics (Radiation Dose - Radiography/Fluoroscopy)

Sunday, Dec. 1 10:45AM - 12:15PM Room: E351

PH SQ

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

FDA Discussions may include off-label uses.

Participants

Virgina Tsapaki, PHD, Nea Ionia, Greece (*Moderator*) Nothing to Disclose
Adam S. Wang, PhD, Baltimore, MD (*Moderator*) Research support, General Electric Company; Research support, Siemens AG; Research collaboration, Varex Imaging Corporation; Stockholder, Varian Medical Systems, Inc

Sub-Events

SSA20-01 Cohort Study of Patients Receiving Substantial Cumulative Doses from Fluoroscopically-Guided Interventional Medical Procedures Over 9 Years

Sunday, Dec. 1 10:45AM - 10:55AM Room: E351

Participants
Xinhua Li, PhD, Boston, MA (*Abstract Co-Author*) Spouse, Employee, Juniper Pharmaceuticals; Employee, Constellation Pharmaceuticals
Joshua A. Hirsch, MD, Boston, MA (*Abstract Co-Author*) Consultant, Medtronic plc; Data Safety Monitoring Board, Johnson & Johnson; Committee member, Relievant Medsystems, Inc; Consultant, Whale Imaging Inc;
Madan M. Rehani, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Suvranu Ganguli, MD, Brookline, MA (*Abstract Co-Author*) Research Grant, Merit Medical Systems, Inc Consultant, Boston Scientific Corporation
Zhimin Li, PhD, Brookfield, WI (*Abstract Co-Author*) Nothing to Disclose
Kai Yang, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Bob Liu, PhD, Boston, MA (*Presenter*) Nothing to Disclose

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PURPOSE

Fluoroscopically-guided interventional (FGI) procedures deliver the highest radiation dose among all imaging procedures. This study is to explore the medical conditions of patients receiving 1-year cumulative Ka,r (air kerma at the reference point) >= 5 Gy or effective dose >= 100 mSv from FGI procedures over 9 years.

METHOD AND MATERIALS

With IRB approval, this retrospective study examined 25253 patients (average age 58.2±17.0 years, 50.6% male) who underwent 46491 FGI procedures at a tertiary referral center from January 2010 to January 2019. Data was retrieved from an in-house semiautomated dose tracking system by setting the above dose thresholds. Identified patients were characterized by medical conditions documented in longitudinal medical records. Statistical software (R, version 3.5.1) was used to determine 5 percentiles (10th, 25th, 50th, 75th, 95th) and interquartile range (IQR) of age and dose distributions.

RESULTS

Among 411 (1.6%) patients (68.6% male) with 1-year cumulative Ka,r>=5 Gy, median number of FGI procedures was 3 (range 1-34), median age at the first procedure was 59 (IQR 48-68) years, median value of 1-year cumulative Ka,r was 7047 (IQR 5755-9066) mGy, and median effective dose was 260 (IQR 142-369) mSv. Among1011 (4.0%) patients (69.6% male) with effective dose>=100 mSv, median number of FGI procedures was 2 (range 1-38), median age at the first procedure was 60 (IQR 51-69) years, median value of 1-year cumulative Ka,r was 3899 (IQR 2785-5727) mGy, and median effective dose was 177 (IQR 132-261) mSv. Patient medical conditions included trauma, stroke/brain aneurysm, medical bleeding in torso, organ transplant, cancer, benign tumor, and chronic disease. Five of 22 patients with 1-year cumulative Ka,r>=15 Gy deceased as of March 2019.

CONCLUSION

This is a first cohort study of patients receiving substantial cumulative doses from FGI procedures over a long period, revealing the use of substantial dose in the critical care of a sizeable fraction of patients under serious medical conditions. The provided cumulative dose distributions can serve purpose for dose management.

CLINICAL RELEVANCE/APPLICATION

X-ray fluoroscopy guidance can save lives in urgent or critical care of patients under serious medical conditions, and the care of 1.6%-4.0% patients may use substantial dose (1-year cumulative Ka,r>=5 Gy, or effective dose>=100 mSv).

SSA20-02 Source of Errors in Indirect Fluoroscopy Skin Dose Estimation and Peak Skin Dose Position

Sunday, Dec. 1 10:55AM - 11:05AM Room: E351

Participants
Quan Chen, PHD, Lexington, KY (*Abstract Co-Author*) Nothing to Disclose
Jie Zhang, PhD, Lexington, KY (*Presenter*) Nothing to Disclose

PURPOSE

There has been an increasing shift to using dose monitoring software for tracking skin exposure during fluoroscopically-guided interventions. It was reported that indirect skin dosimetry is unlikely to be more accurate than +/-50%, while others reported that compared to direct measurements, the error can be within +/-20%. This study is to identify the source of errors and demonstrate their potential influence on the accuracy of indirect dose estimation.

METHOD AND MATERIALS

We analyzed available indirect skin dose methods using varying levels of procedural details in the patient protocol and identified potential source of errors, including but not limited to gantry angle, source-surface-distance (SSD), table-pad attenuation, and backscatter. Simple algebraic approach was applied to analyze the effects of those such as distance and attenuation, while Monte Carlo was used to simulate the effects of gantry angles (primary & secondary) combing with various field of view (FOV). We also did direct distance and attenuation measurements from a Philips Allura Xper FD10 for quantitative analysis.

RESULTS

Gantry angle shows the largest impact on the magnitude and position of peak skin dose (PSD). Simulation shows that PSD location shifts ~18cm from center with the gantry angle from 0° to 50°, independent of FOV. The ratio of PSD to reference air kerma increases from 1.2 to 1.6 (for gantry angle 0°) and from 1.38 to 1.90 (for gantry angle 40°), with the increased FOV from 5 cm to 40 cm. Both the magnitude and position of PSD with gantry angle show non-linear relationship, which increases the difficulty to accurately estimate skin dose. The simple SSD increase due to the use of the pad (in general not considered) may add up to 18% error in dose, based on its thickness and patient weight. The ratio of the exposure with pad-table to air kerma varies up to 15% as kV increase from 50 to 120 kV due to attenuation, plus about 20% backscatter changes (depending on FOV) due to increased beam energy. The use of an additional Cu filter will aggravate the results, i.e., an additional 0.2mm Cu filter can add ~5% more error in PSD estimate. .

CONCLUSION

Understanding the source of errors in indirect skin dose estimates will improve accuracy of the PSD estimation which determines notification level.

CLINICAL RELEVANCE/APPLICATION

Improving the accuracy of PSD estimation can potentially reduce unnecessary notifications or avoid missing notifications.

SSA20-03 Comparison and Image Evaluation of Mini C-Arm Fluoroscopy System Based on Cold Cathode and Hot Cathode

Sunday, Dec. 1 11:05AM - 11:15AM Room: E351

Participants
Jongmin Lim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
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Jae Kyu Jang, Seoul , Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
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Seung Jun Yeo, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
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Jeong Chang Won, PhD, Iksan, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Kwon-Ha Yoon, MD, PhD, Iksan, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jehwang Ryu, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose

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PURPOSE

In this study, we qualitatively and quantitatively compared and analyzed the X-ray images obtained from the carbon nanotube (CNT) based cold cathode and tungsten based hot cathode ceramic tubes integrated together in mini C-arm fluoroscopy system.

METHOD AND MATERIALS

A commercialized portable type mini C-arm fluoroscopy system (figure a) was constructed with sealed ceramic type cold cathode and hot cathode X-ray tubes (figure c) and a flat panel detector (RAD icon, 0889, Teledyne Rad-icon Imaging Corp., CA, USA). We developed the CNT emitter and the brazed X-ray tubes at our own lab which can work at high anode voltage without arcing. We demonstrated the superiority of CNT based cold cathode (figure e) X-ray sources over thermionic (figure d) counterpart in terms of producing high resolution X-ray images, pulse based active control switching and quantity of radiation dose. X-ray images of alive rat (figure f) and resolution phantom was taken to compare and evaluate the images from both X-ray sources. Herceptin drug was inserted into a live rat to produce cancer cells and detect it through X-ray images from different sources. Imaging was done at various pulses to evaluate the efficiency of converting the digital signals for switching and calculate the radiation dose.

RESULTS

CNT based cold cathode X-ray source showed the 20% less radiation to produce the same quality image with the same exposure time. Cold cathode source had 40% smaller focal spot size compared to hot counterpart. The response to digital pulses was 3 times faster in CNT based cold cathode than hot cathode X-ray sources. Finally, the X-ray images obtained at 80 kV with 1mA anode current exposed, the optimal voltage to take high quality image of rat to detect cancer cells from normal tissue.

CONCLUSION

CNT based cold cathode source in Mini C-arm fluoroscopy system showed better functions, superior quality X-ray Image and safer (reduced radiation dose) compared to the hot cathode X-ray source.

CLINICAL RELEVANCE/APPLICATION

Imaging quality can be greatly improved by CNT based cold cathode source with lower radiation dose and greatly improved the imaging techniques by integrating the digital signals.

SSA20-04 The Effect on the Scattered Radiation Distribution of Moving the Centerline of the Patient Lateral to the X-Ray Beam Isocenter During Fluoroscopic Procedures

Sunday, Dec. 1 11:15AM - 11:25AM Room: E351

Participants
Chao Guo, MS, Amherst, NY (*Presenter*) Research support, Canon Medical Systems Corporation
Sheng-Hsuan Sun, Amherst, NY (*Abstract Co-Author*) University at Buffalo
Jonathan L. Troville, MS,BS, Buffalo, NY (*Abstract Co-Author*) Research support, Canon Medical Systems Corporation
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PURPOSE

The scattered radiation from the patient reaching the interventionalist changes as the patient table is moved left and right of the c-arm gantry isocenter. This study investigates and quantifies the change in the scattered radiation dose distribution as the patient is moved laterally.

METHOD AND MATERIALS

EGSnrc (DOSXYZnrc) Monte-Carlo software was used to calculate the scattered radiation distribution around the Zubal anthropomorphic computational phantom of an average adult male for beams imaging the head, the chest and the abdominal regions. The distributions were calculated as a function of the lateral shift of the phantom from the c-arm isocenter for x-ray beams with different gantry angulation. All comparisons were made with the same exposure factors and each MC simulation used 3E9 primary beam photon histories.

RESULTS

For staff at a fixed distance from the isocenter, the scatter was generally reduced as the patient was moved toward the staff, since in this case the body attenuates more of the scatter, and it conversely increased as the patient is moved away from the staff. The percent differences from the centered patient when averaged over distance from the floor with a PA projection for staff on the right side were: Head, 2.4 cm shift to left, 48% increase; 2.4 cm shift to right, 37% decrease; Chest, 5 cm shift to left, 133% increase; 5 cm shift to right, 54% decrease; Abdomen, 2.5 cm shift to left, 127% increase; 2.5 cm shift to right 47% decrease. The change in scatter with shift for different LAO/RAO and CRA/CAU angles was similar. For zero degrees RAO/LAO chest projections with the patient centered, the scattered dose on the left side was lower than the right side due to differences in internal organ attenuation.

CONCLUSION

During Interventional procedures, only small table lateral movement can substantially impact the scattered dose to the staff in the room. Such changes in scatter is dependent on height from the floor and will have an effect which is dependent on where the staff is located in the room. The information from this study provides a better understanding of the changes in scattered dose distribution and facilitates improved staff dose management.

CLINICAL RELEVANCE/APPLICATION

The position of the x-ray beam relative to the patient centerline has a substantial effect on the room scatter distribution and this information can help staff manage their dose.

SSA20-05 Radiation Doses to Patients from Fluoroscopically-Guided Liver Procedures

Sunday, Dec. 1 11:25AM - 11:35AM Room: E351

Participants
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PURPOSE

To present procedure-specific distributions of air kerma at the reference point (Ka,r) and effective dose for fluoroscopically-guided liver procedures.

METHOD AND MATERIALS

With IRB approval, this retrospective study included 1090 consecutive liver cases (61.6% male) performed from May 2016 to October 2018 in adults. Patient age at the procedure time was 60.8±13.0 years for the men (median 63 years, range 22-93 years, 17.4% in 22-50 years) and 58.7±15.3 years for the women (median 62 years, range 20-90 years, 27.4% in 20-50 years). Ka,r and dose-area product (KAP) were retrieved from an in-house semiautomated dose monitoring system. Effective dose was calculated using KAP and a conversion coefficient [0.26 mSv/(Gy.cm2)] from NCRP Report No. 160. Statistical software (R, version 3.5.1) was used to determine 5 percentiles (10th, 25th, 50th, 75th, 95th) for 9 procedures - endovascular liver biopsy, transjugular intrahepatic portosystemic shunt (TIPS) creation, TIPS revision, pre-selective internal radiation therapy (SIRT), SIRT, hepatic artery embolization, transarterial chemoembolization, portogram, and portal vein embolization.

RESULTS

Number of procedures was 239, 120, 79, 184, 187, 37, 186, 32 and 26; Median Ka,r was 102, 886, 317, 615, 245, 1202, 907, 502 and 1009 mGy; median effective dose was 5.44, 56.1, 19.1, 37.2, 13.3, 48.1, 49.7, 26.9 and 47.1 mSv; ultrasound guidance usage was 99.6%, 97.5%, 91.1%, 17.4%, 19.3%, 56.8%, 22.0%, 87.5% and 96.2% for 9 procedures (in the above order), respectively. Among all cases, the lowest Ka,r was 8 mGy for a male (age 63 years, weight 73 kg) from endovascular liver biopsy under both ultrasound guidance and x-ray fluoroscopic guidance. The highest Ka,r was 11121 mGy for a male (age 65 years, weight 79 kg) from hepatic artery embolization. Effective dose range was 0.4-303 mSv.

CONCLUSION

In interventional liver procedures, ultrasound guidance is used when feasible to reduce patient dose. This is a first study to provide both Ka,r and effective dose for comprehensive liver procedures under fluoroscopy and/or ultrasound guidance.

CLINICAL RELEVANCE/APPLICATION

With the Joint Commission's standard of fluoroscopy dose review, 5 percentiles of Ka,r and effective dose provided in this study for 9 liver procedures can be used to set baselines in dose management.

SSA20-06 Radiation Exposure to Pediatric Patients and Staff During Retrograde Wedge Portography

Sunday, Dec. 1 11:35AM - 11:45AM Room: E351

Participants
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PURPOSE

Most recent surgical procedures such as the meso-Rex bypass shunt requires wedged hepatic venous portography via the transjugular approach for the assessment of the surgical patient. Retrograde Wedge Portography (RWP) is an interventional procedures performed on patients with portal vein cavernoma in cases where the Rex Recessus is not well delineated with the other non-invasive imaging techniques. Usually staff radiation doses during pediatric interventional procedures are associated with a lower occupational radiation risk because the patients are small. However patient radiation doses may be high particularly when the abdominal region is involved; pediatric procedures require the operators to be physically close and, as when transjugular approach occurs, it is often not possible to use protective screens and some more complex case also can result in a longer fluoroscopic time. These can result in increased operator doses. It is well known that a good radiation protection program in daily practice for all procedures reduces radiation risks to patients and staff and electronic dosimeters have proven to be useful for optimization purposes, for studies of radiation exposure by type of procedure or for specific aspects of a procedure. Our study aim is to provide data on radiation exposure to pediatric patients undergoing RWP and effective dose (E) of each operator performing them in a single center using a pediatric adjusted fluoroscopy protocoln in a flat-panel detector based system (FPDS).

RESULTS

Tube voltage range was 60-84 kV; Tube current range was 0.1-9.5 mA; Spectral filtration was 0.3 mmCU. Patients: mean DAP was 11.2±12.9Gy*cm2 (3rd quartile 11.9Gy*cm2); mean KA was 0.16±0.09Gy (3rd quartile 0.2Gy); mean FT was 357±181sec (3rd quartile 420sec). Staff: mean E for the radiologist was 0.50±0.46μSv (3rd quartile 0.75μSv); for the radiographer 0.12±0.11μSv (3rd quartile 0.18μSv); for the anesthesia nurse 0.08±0.17μSv (3rd quartile 0.03μSv). Figure 1 shows the mean E for all operators. Figure 2 shows the operators' positions within the angiosuite during hepatic RWP.

CONCLUSION

In conclusion, this study demonstrated that the radiation doses to the operators in RWP can be very low, remaining well within limits established by the ICRP. The difference in dose among all operators, is related to their position within the angiosuite in relation to the angiographic equipment. Operators performing RWP should be aware of the potential high radiation exposure for themselves and for patients too. Good radiation protection policies and training are necessary in interventional radiology to reduce radiation risks to both patients and staff. No other data about radiation exposure to pediatric patients and staff performing RWP are in the available literature to compare our results. However, in our experience, close liaison between radiologist and radiographer allowed us to vary technical parameters and to select a different fluoroscopy protocol from the pre-set provided by the manufacturer. Although this may have resulted in a small variation in image quality, procedures included in this study were performed safely. New technologies and in-depth knowledge of angiographic equipment can help us to achieve a low radiation dose to patients and staff according to the RWP procedure complexity.

METHODS

Between September 2016 and December 2018, 19 consecutive RWP were performed on 19 children (mean age 7±5 years, 3rd quartile 11.5 years). Two Radiologist, six radiographers and six anesthesia nurses were involved in this study. A pediatric fluoroscopy protocol optimized to produce high contrast images using 50% as threshold dose with modified parameters adjusted on pediatric patients, 7.5 frame/sec and low image detail level was routinely employed. Magnification and normal image detail level was only used when absolutely necessary in technically challenging cases. Digital Subtraction Angiographic acquisition (DSA) was used during which all operators left the angiographic suite and went into the control room while images were acquired. Electronic personal dosimeters, placed outside the lead apron at the left upper chest position, were used to measure radiation doses to radiologist, anesthesia nurse and radiographer. Due to the transjugular access, no additional shielding was used for the interventional radiologist. The Hp(10), the personal dose equivalent at a depth of 10 mm of tissue, registered by the detectors at the end of every procedure was systematically recorded. Effective operator dose (E) was then calculated using a modified Niklason algorithm, by multiplying the Hp(10) value by 0.03, and given in µSv. Patients' radiation exposure was measured with Dose Area Product (DAP) and fluoroscopy time (FT). Descriptive statistics (mean ± SD and third quartile) of the dose area product (DAP, given in Gy*cm2), air kerma (KA, given in Gy) and fluoroscopy time (FT, given in seconds) for each procedure were recorded

SSA20-07 Clinical Evaluation of a Dose Management System-Integrated 3D Skin Dose Map by Comparison with XR-RV3 Gafchromic® Films

Sunday, Dec. 1 11:45AM - 11:55AM Room: E351

Participants
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PURPOSE

Validate the performance of peak skin dose (PSD) and skin dose map (SDM) estimation from a radiation dose management system (RDMS) (DoseWatch™, GE Healthcare) versus the gold standard of XR-RV3 Gafchromic film in interventional vascular and cardiology procedures.

METHOD AND MATERIALS

The study was conducted on a total of 38 cardiac procedures and 60 vascular embolizations between June 2018 to March 2019 on three Philips systems (two Allura Xper FD10 and one Allura Xper FD20). 'Ground truth' PSD measurements (PSDFilm) and spatial dose distributions were obtained from XR-RV3 Gafchromic film, positioned underneath patients' backs for each procedure. These were compared against PSDRDMS and SDMRDMS estimates provided by the dose management system using a triangle mesh of 0.055cm² resolution on ICRP 110 anthropomorphic phantoms, as well as on a planar phantom with a square ROI of 1cm². The RDMS used Radiation Dose Structured Report (RDSR) data to model exposure events, calculating PSD following the methodology described by K. Jones, et al. Statistical analyses were carried out to compare PSDFilm and PSDRDMS.

RESULTS

Preliminary results show that the PSDFilm median (1st quartile; 3rd quartile) was 0.573(0.411; 0.981) Gy for vascular procedures and 0.443(0.297; 0.700) Gy for cardiac procedures. For a flat phantom, the PSDRDMS was 0.553(0.375; 1.031) Gy for vascular procedures and 0.467 (0.311; 0.708) Gy for cardiac procedures, and 0.583(0.388; 1.097) Gy and 0.440 (0.305; 0.750) Gy for anthropomorphic phantom, respectively. For both phantoms, the correlation between PSDFilm and PSDRDMS was strong. For vascular procedures, the mean deviation between PSDFilm and PSDRDMS was 1 ± 16% for flat phantom and 2% ± 19% for anthropomorphic phantom and 5 ± 19% and 2 ± 18% for cardiac procedures, respectively. Dose map representations matched for most patients. Gaps identified are related to the table displacement during fluoroscopy events and the use of a wedge filter.

CONCLUSION

The results found in this patient study show that SDM tool is a suitable alternative to Gafchromic® film to calculate PSD and visualize the skin dose distribution.

CLINICAL RELEVANCE/APPLICATION

The RDMS tool can be used routinely to compute the PSD for all patients with an accuracy close to the one of Gafchromic films, effectively reducing costs and complexity of patient follow-up

SSA20-08 Radiation Dose Audit for Fluoroscopy Procedures Performed with Mobile C-Arms or Performed in Radiography/Fluoroscopy (R/F) Suites: Data From a Tertiary and Quaternary Care Hospital

Sunday, Dec. 1 11:55AM - 12:05PM Room: E351

Participants
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CONCLUSION

Data indicates that with mobile C-Arms or R/F suite, radiation utilization for routine procedures is an order of magnitude lower relative to threshold radiation dose values recommended for patient follow-up. Monitoring such low radiation dose values may not be optimal use of healthcare resources. Alternately, evidence-based exemption should be granted from the requirement of tracking fluoroscopy doses for such low dose procedures.

Background

Accreditation agencies necessitate documenting radiation doses for fluoroscopy procedures. Our hypothesis was that procedures performed with mobile C-Arms or in R/F suites utilize radiation dose levels considerably below the recommended threshold for patient follow-up based on possibility of tissue reactions.

Evaluation

IRB waiver was obtained. All fluoroscopy procedures performed with any one of the 14 mobile C-Arms (GE:OECs, Philips:Veradius, Ziehm:Vision-R) or in an R/F suite (Siemens:Axiom-Iconos-200) from July-2017 till June-2018 were reviewed. Mobile C-Arms were used for surgical, orthopedic, pain-management, gastroenterology and urology procedures. All cases with system-reported cumulative air kerma (CAK) were included in the study. Descriptive statistics were computed from this data-set to characterize radiation utilization.

Discussion

Data from 1122 cases were included (53% female/47% male; age:53.9±17.9years; BMI:28.4±6.7). The mean (±standard deviation) and median CAK values for radiology procedures (n=102; e.g., arthrograms, aspirations, etc.) performed with mobile C-Arms were 16.5(±54.4)mGy and 2.39mGy, respectively. For surgical procedures performed in the operating room (n=549) the mean and median CAK values were 36.8(±79.6)mGy and 11.4mGy, respectively. Mean and median CAK values were 65.2(±90.2)mGy and 32.7mGy for gastroenterology procedures (n=98), 16.1(±14.6)mGy and 12.4mGy for urology procedures (n=24), and 46.3(±84.0)mGy and 28.8mGy for pain-management procedures (n=146) performed in neurosurgery department. For procedures performed in the R/F suite (n=203), the mean and median CAK values were 168.2(±262.1)mGy and 72.6mGy. Depending upon the type of procedure, the mean fluoroscopy time ranged from 71 to 497 secs.

SSA20-09 Experimental Validation of Calculated Skin Dose Variation with Incident X-Ray Beam Angle

Sunday, Dec. 1 12:05PM - 12:15PM Room: E351

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PURPOSE

The incident angle of the x-ray beam on the patient's skin varies during fluoroscopically-guided procedures and accurate estimation of skin dose is important to evaluate the risk of deterministic skin effects. Radiochromic film measurements of skin dose were made as a function of the angle of x-ray beam incidence on a phantom to validate the results of Monte-Carlo calculations.

METHOD AND MATERIALS

To estimate the dose to the skin, a sheet of Gaf-chromic XR-QA2 film was placed on the surface of a 30 cm x 30 cm block of solid water 20 cm thick. To simulate the attenuation of the overlying epidermis, a 1.25 mm thick sheet of PMMA, which is equivalent to 1.5 mm water, was placed over the film. The primary and the scatter dose was measured for incident angles from 90 to 10 degrees at 80 kVp for a field size of 10 cm x 10 cm and the primary entrance air kerma was measured without the phantom. EGSnrc Monte-Carlo (MC) software was used to calculate the skin dose as a function of incident x-ray beam angle for different beam energies and different field sizes. The incident primary dose was calculated in air at the field center and the primary and scatter dose was calculated averaged over various thicknesses of 'skin' to determine the effect on primary attenuation and scatter. All MC simulations used 5x1010 photons incident on the phantom.

RESULTS

The measured skin dose agreed with that calculated by MC with an average difference of about 3 percent over the angular range from 90 to 10 degrees. Both calculated and measured skin dose values decreased with decreasing angle of incidence due primarily to the increased path length and thus increased attenuation of the primary x-rays. In both cases, the total scatter plus primary decreased to about 40% of the primary at an angle of 10 degrees at 80 kVp.

CONCLUSION

Good agreement was obtained between the measured and calculated variation of skin dose with angle of incidence. The skin dose decreases substantially with decreasing incident angle and thus correction factors for angle of incidence should be applied when estimating skin dose for fluoroscopically-guided procedures.

CLINICAL RELEVANCE/APPLICATION

Radiochromic film measurements verified the skin dose dependence on incident angle as calculated with Monte Carlo software so skin dose from fluoroscopic procedures can be more accurately estimated.

SSA21

Physics (CT New Techniques/Systems)

Sunday, Dec. 1 10:45AM - 12:15PM Room: E353B

CT PH

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

FDA Discussions may include off-label uses.

Participants
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Sub-Events

SSA21-01 A Dynamic Numerical Brain Simulation Model for CT Perfusion Optimization

Sunday, Dec. 1 10:45AM - 10:55AM Room: E353B

Participants
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Soren Christensen, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose
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Norbert J. Pelc, DSc, Stanford, CA (*Abstract Co-Author*) Research support, General Electric Company Consultant, General Electric Company Consultant, NanoX Scientific Advisory Board, RefleXion Medical Inc Scientific Advisory Board, Prismatic Sensors AB Medical Advisory Board, OurCrowd, LP Scientific Advisory Board, Izotropic, Inc Stockholder, Izotropic, Inc

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PURPOSE

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

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

The validation and optimization of CT perfusion will improve diagnostic tools for stroke patients and increase physicians' ability to prescribe a plan of care driven by quantitative data.

SSA21-02 Evaluation of a Novel Artificial Intelligence Reconstruction Technology in Abdominal CT

Sunday, Dec. 1 10:55AM - 11:05AM Room: E353B

Participants
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Kristin Jensen, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

To test a new deep learning image reconstruction technique for abdominal CT.

METHOD AND MATERIALS

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

RESULTS

Preliminary results show that image noise was reduced for both IR and DLIR reconstruction compared to FBP for all dose levels and noise reduction was independent of dose. Also, image noise was on the same level for DLIR L and ASIR-V 50%, DLIR M and ASIR-V70% and DLIR H and ASIR-V 90%. However, the NPS peak frequency for all levels of DLIR reconstruction were higher than for the IR indicating less blotchiness and a finer image texture. Moreover, the NTD results indicated less artefacts using DLIR reconstruction (@5mGy: DLIR L/M/H ranges from 0.21-0.24 vs ASIR-V 50/70/ 90% 0.28-0.47, @10 mGy DLIR L/M/H ranges from 0.11-0.18 vs ASIR-V 50-90% 0.20-0.45, @15 mGy DLIR L/M/H ranges from 0.22-0.34 vs ASIR-V 50/70/ 90% 0.40-0.57). MTF @50% was at the same level independently of reconstruction techniques for all dose levels (3.5-3.8 @5mGy, 3.5-3.7 @10mGy, 3.79-3.89 @15mGy). CNR was improved using IR and DLIR reconstruction compared to FBP.

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

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

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

Participants
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PURPOSE

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

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

SSA21-04 Radiation Dose and Contrast Dose Reduction in Combined Coronary CT Angiography and Iliac Artery

CT Angiography with Personalized Scan Protocol for Preoperative Assessment of Renal Transplant Patients

Sunday, Dec. 1 11:15AM - 11:25AM Room: E353B

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PURPOSE

To compare the image quality, radiation dose and contrast medium (CM) dose in combined coronary CT angiography (CTA) and iliac CTA for renal transplant patients with personalized and standard scan protocols.

METHOD AND MATERIALS

A total of 77 patients needing assessment for coronary and iliac arteries before renal transplantation were prospectively enrolled. All patients underwent one-stop combined scans on a 256-row CT scanner with automatic tube current modulation, 50% pre-ASIR-V to control radiation dose. CCTA was performed first using one heartbeat axial scan mode with bolus tracking technique and iliac CTA was performed 3-5 seconds after CCTA using a spiral scan. Group A (n=40) used the standard protocol: 100kVp, 60 ml of 350 mgI/ml CM at the flow rate of 4.5 ml/s. Group B (n=37) used a personalized protocol: kVp: 80 (BMI<24) and 100 (BMI>=24) and CM: 19mgI/kg (BMI<18); 21mgI/kg (18<=BMI<24); and 22mgI/kg (BMI>=24). After scanning, all images were reconstructed with 50%ASIR-V.

RESULTS

There was no significant difference in patient demographic data. The contrast dose and radiation dose in the personalized protocol were significantly lower than that in the standard protocol (3.9ml/s vs. 4.5ml/s in flow rate, $P<0.01$; 31.16ml vs. 60ml in total volume, $P<0.001$ and 3.85±1.38mSv vs. 4.78±1.17mSv in effective radiation dose, $p<0.05$). The personalized group had better objective CCTA image quality than the standard protocol group (CNR: 27.37±15.47 vs. 15.47±3.86, $P<0.01$; SNR: 38.74±16.80 vs. 30.08±20.92, $P=0.05$). Mann-Whitney test showed that there was no significant difference in the subjective scores of arteries between the two scans (all $P>0.05$), except the left crown trunk where the standard scan protocol had a higher score ($p=0.02$).

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

SSA21-05 X-ray CT Image Reconstruction Using Feature Aware Deep Learning Method

Sunday, Dec. 1 11:25AM - 11:35AM Room: E353B

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PURPOSE

In conventional CT, it is difficult to generate consistent organ specific noise and resolution with a single reconstruction. Therefore, it is necessary in principle to reconstruct a single scan multiple times using different reconstruction parameters such as reconstruction kernel and regularization parameters of model based iterative reconstruction (MBIR) in order to obtain clinical diagnosis information for different anatomies. We provide a deep learning solution which can obtain organ specific noise and resolution balance with a single reconstruction. We propose image reconstruction using a deep convolution neural network (DCNN) trained by a specific feature aware reconstruction target.

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

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

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

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PURPOSE

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

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

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

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

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PURPOSE

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

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

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

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

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CONCLUSION

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

Background

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

Evaluation

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

Discussion

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

SSA21-09 High Temporal Resolution C-Arm Cone-Beam CT Perfusion Imaging

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

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PURPOSE

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

METHOD AND MATERIALS

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

RESULTS

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

CONCLUSION

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

CLINICAL RELEVANCE/APPLICATION

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

SSA22

Physics (MRI - New Techniques and Image Quality)

Sunday, Dec. 1 10:45AM - 12:15PM Room: E353A

MR PH SQ

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

FDA Discussions may include off-label uses.

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Sub-Events

SSA22-01 Hybrid MR-OR Siting and Safety

Sunday, Dec. 1 10:45AM - 10:55AM Room: E353A

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CONCLUSION

The hybrid MR-OR environment provides many clinical advantages but is not free of a certain degree of risk. The risk is further compounded with lack of consistent safety standards. Engineering MR safety into the practice design and strict adherence to MRI safety checklists, policy enforcement and regular personnel training is critical to maintaining MR safety in this complex multidisciplinary procedural environment.

Background

Hybrid MR-OR for interventional and intraoperative procedures has emerged from its infancy to a standard setup at major academic medical centers. The American College of Radiology (ACR) white paper on MR Safety is a primary reference used by most sites for designing MR safety best practices; unfortunately, it is lacking specific guidance on hybrid MR-OR siting and safety. We attempt to provide a template for hybrid MR-OR siting and safety that builds on the ACR white paper terminology and covers unique considerations regarding design, layout, access, training, screening, infection control and procedural considerations when developing hybrid MR-OR siting and safety practices.

Evaluation

A key challenge of hybrid MR-OR environment is its multidisciplinary, interdepartmental nature, and as such requiring a strong collaborative approach in the design of the hybrid environment and implementation of education and safety protocols. Safety not only has to be forefront in awareness, but also engineered into the workflow. We highlight three key elements of engineering safety into the practice design through 1) siting considerations 2) workflow and training considerations and 3) procedural safety considerations.

Discussion

Siting considerations should include architectural layout, scanner choice (on rails vs stationary), zone designs, and screening equipment. Workflow and training consideration should include staff training (with emphasis on hands-on training), access control, and patient/staff movement. Procedural safety considerations should include level 2 personnel staffing, patient screening, procedural pause, surgical equipment screening, and infection control. Ongoing evaluation of procedural process is critical as new procedures are added.

SSA22-02 Lower Risk of Hearing Loss Without Sacrificing Image Quality in Fetal MR Imaging: A Feasibility Study Using Acoustic Reduction Technique

Sunday, Dec. 1 10:55AM - 11:05AM Room: E353A

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PURPOSE

The purpose of this study was to evaluate whether ART is reliable and applicable in fetus brain imaging.

METHOD AND MATERIALS

We collected from September 2017 to October 2018 using 3.0T MR scannerfor fetal head exams. 10 subjects underwent ART sequences (group A), the matched 10 subjects underwent traditional sequences (group B). The protocol of tradition sequences includes T2 single short fast spin echo (SSFSE) (axial, sagittal, coronal); while the ART sequences contains ART T2 SSFSE (axial, sagittal, coronal) (Table1). A quantitative assessment by the ROI of 1 mm was manually placed on the different layers of the brain (Fig 1A). A qualitative evaluation including eight criteria (1. Delineation of germinal zone and gray matter, 2. Delineation of white matter, 3. Delineation of internal and external CSF spaces, 4. Delineation of amniotic fluid adjacent to the skull, 5.Delineation of brain stem, 6. Delineation of cerebellum, 7. Severity of motion artifacts, 8. Overall image quality) were evaluated on an ordinal scale regarding signal characteristics, potential dysmorphism and developmental anomalies (5= optimal diagnostic quality; 4= very good image quality;3= diagnostic image quality, 2= image quality below diagnostic standards; 1= image quality too poor to correctly identify anatomy.

RESULTS

The maximum differences of peak and equivalent sound pressure between the two groups are 18.1dBA and 16.1dBA respectively, indicating the ART sequences have lower noise than traditional sequences. Comparative ratios calculated between germinal matrix/air, periventricular layer/air, subplate layer/air, and cortical layer/air for group A (33.97±17.52, 42.45±16.65, 46.37±22.46, 43.03±20.89) were lower than that of group B (52.54±25.61, 33.39±12.91, 69.17±35.21, 64.76±32.53), but with no significant difference (P=0.09,0.20, 0.12, 0.11) . The qualitative results showed that the image quality of group B and group A scored 4.42 + 0.37 and 4.36 + 0.49 respectively. There was no significant difference in image quality score between the two groups.

CONCLUSION

Acoustic reduction sequence can acquire high quality images in 3.0T scanner, meanwhile decrease hearing loss risk in fetal head examinations compared with the conventional method.

CLINICAL RELEVANCE/APPLICATION

Acoustic reduction sequence can acquire high quality images in 3.0T scanner, meanwhile decrease hearing loss risk in fetal head examinations compared with the conventional method.

SSA22-03 Multi-Site, Multi-Vendor, and Multi-Platform Assessment of Accuracy of Quantitative Proton-Density Fat Fraction (PDFF) at 1.5 and 3 Tesla with a Standardized Spherical Phantom: Results from a Study by the RSNA QIBA PDFF Committee

Sunday, Dec. 1 11:05AM - 11:15AM Room: E353A

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PURPOSE

Proton Density Fat Fraction (PDFF) is a popular MRI/S biomarker of hepatic steatosis. The QIBA PDFF Committee was formed in 2015. In this work, the committee conducted a multi-center and multi-vendor phantom study. The objective was to characterize the accuracy of PDFF as a robust biomarker, as measured by various SPGR chemical-shift-encoded sequences against a standardized phantom with known PDFF values.

METHOD AND MATERIALS

9 sites with multiple commercial 1.5T and 3T systems were invikved. The phantom contained 12 vials of known PDFF. Sites were asked to test several protocols, to their best capability. P1: a vendor-sourced 'out-of-the-box' liver PDFF protocol. Each site ran P1 'as is', using default parameters for GE's IDEAL-IQ, Siemens' LiverLab, and Philips' mDIXON-Quant. P2: a complex-based QIBA recommended protocol. P3: a magnitude-based Liver Imaging of Phase-interference signal Oscillation and Quantification protocol. Each site acquired P1-P3 data, which were reviewed by an independent reader. For P1 and P2, each vendor's online multi-fat-peak complex-based data reconstruction algorithm and software was used for PDFF generation, with no modifications to reconstruction parameters. No work-in-progress software was used. For P3, data were sent to an additional independent site for multi-fat-peak magnitude-based reconstruction. A single analyst made all PDFF measurements. Linear regression was performed against reference values.

RESULTS

149 scans of the phantom were performed, 45 on 1.5T (15xP1, 12xP2, 18xP3), and 104 on 3T (33xP1, 24xP2, and 47xP3). Pooled P1 data for 1.5T: (slope=0.97, bias=0.15, r2=0.99), for 3T: (slope=0.99, bias=-0.69, r2=0.99); pooled P2 data for 1.5T: (slope=0.99, bias=-0.35, r2=1.0), for 3T: (slope=1.0, bias=-1.01, r2=0.99); pooled P3 data for 1.5T: (slope=0.96, bias=-0.25, r2=1.0), for 3T: (slope=0.97, bias=-0.02, r2=0.99). Lin's concordance correlation coefficient for all 1.5T data was 0.9973 and 0.9972 for all 3T data.

CONCLUSION

Quantitative PDFF data collected in a standardized phantom are accurate using vendor-source and QIBA-recommended complex-based water-fat separation protocols and an independent magnitude-based protocol.

CLINICAL RELEVANCE/APPLICATION

The PDFF from MRI and MRS is a robust and accurate quantitative imaging biomarker of hepatic steatosis across different magnet field strengths, imager manufacturers, and reconstruction methods.

SSA22-04 Effect of Post Labelling Delay on Arterial Spin Labelling

Sunday, Dec. 1 11:15AM - 11:25AM Room: E353A

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CONCLUSION

Single PLD ASL is a robust technique in obtaining CBF values but the accuracy is still confounded by the PLD settings. This study showed that CBF values at different PLD could be significantly different. 2000ms was the most appropriate settings (27/29 cases) which agreed well with the white paper. We also noticed that ATA signs could present after 2000ms. Radiographers should take up the role in real time image interpretation. If ATA were spotted, repeated examination with a longer PLD would be necessary.

Background

Arterial Spin Labelling (ASL) is a MRI perfusion technique utilizing magnetically labelled blood as endogenous tracers. Post Labelling Delay (PLD) is applied to ensure an equilibrium state is reached. However, a short PLD could not ensure an equilibrium state while a long PLD could lead to reduced SNR. Failure to account for could compromise the accuracy.

Evaluation

29 dementia patients in December 2018 were prospectively recruited. Pseudo-continuous ASL was acquired in a 3T scanner (Achieva, Philips Healthcare) with 3 PLD settings (TR=4000ms, TE=11ms, labeling-duration=1600ms, PLD=1800/2000/2500ms). Data analysis were done by MRIcloud online.

Discussion

Recommended single compartment model should give the same CBF values regardless of the PLD settings but our data showed that CBF values at each PLD were significantly different (Repeated measures ANOVA, p=0.000). After referencing with the buxton's kinetic model, 5 conditions were recognized and summarized in the figure. 2 cases showed 'steady state' in which CBF values were similar at each PLD. 10 cases showed 'ATA effects' in which equilibrium was reached after 2000ms. CBF values at 1800ms was erroneous as it violated the model assumption. 9 cases showed 'SNR penalty' in which there might be measurement errors due to reduced SNR at 2500ms leading to abnormally low CBF values. CBF values could not converge in the remaining 8 cases.'Mixed effects' (n=6) might be due to a combination of 'ATA effects' and 'SNR penalty' where 2000ms, theoretically, would be the acceptable setting. In 'severe ATA effects' (n=2), CBF values at 2000ms were abnormally high due to an incorrect model inversion. 2500ms would be the appropriate choice.

SSA22-05 Using Water-In-Oil Emulsions in Phantom for Quality Control of Diffusion-Weighted Magnetic Resonance Imaging

Sunday, Dec. 1 11:25AM - 11:35AM Room: E353A

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CONCLUSION

We developed a phantom containing control substances with predefined apparent diffusion coefficients ranging from normal tissue to benign and malignant lesions. The use of W/O emulsions as a part of the phantom allowed modeling a restricted diffusion represented in the image by a high-intensity signal in a wide range of the b-value. The proposed substances also allow evaluating the effectiveness of fat suppression.

Background

To control the quality of diffusion-weighted magnetic resonance imaging (DWI), phantoms with control substances (with stable physical characteristics and known diffusion coefficients) are used. According to literature, aqueous solutions of polymer are used to achieve different diffusion coefficients. These materials model only hindered diffusion, while the diffusion of water molecule inside the cell is restricted. In this work we give results of combination water-in-oil (W/O) emulsions and polymer solutions to model not only restricted, but also hindered diffusion.

Evaluation

As a hindered diffusion model, we used aqueous solutions of polyvinylpyrrolidone (PVP) with concentrations of 0-50%. We created W/O emulsions to simulate a restricted diffusion based on substances with high time T2 - siloxanes: cyclomethicone (Cycl) and caprylyl methicone (Cap). We chose emulsions with equal proportions of water/fatty phases: 1:1 Cap:Water and 1:1 Cycl:Water. According to the dispersion analysis, the size of micelles in the emulsions was 4.8±1.8 μm. The apparent diffusion coefficient (ADC) of emulsion depends on the true diffusion coefficient inside micelles and the time interval between diffusion gradients Δ. We also included silicon oil in phantom to control fat suppression. To estimate the effectiveness of phantom, we scanned it on different MR scanners.

Discussion

With the increase of Δ from 44.4 ms to 60 ms, we restated the decrease of ADC of emulsion by 0.02 μm2/ms, whereas this effect wasn't observed for water and Cap. True diffusion coefficients of material were determined with the accuracy of 4%. When comparing the ADC results of different MR scanners, the mean variation reached 5.1%, and the relative error was 9.3%. The use of correction factor allow decreasing the error to 2.5 %.

SSA22-06 Improvement of Late Gadolinium Enhancement Image Quality Using a Novel, Deep Learning Based, Reconstruction Algorithm and Its Influence on Myocardial Scar Quantification

Sunday, Dec. 1 11:35AM - 11:45AM Room: E353A

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PURPOSE

The aim of this study was 1) to evaluate myocardial late gadolinium enhancement (LGE) image quality using a deep learning (DL) based magnetic resonance image reconstruction algorithm and 2) to assess its effect on the quantification of myocardial scar.

METHOD AND MATERIALS

Thirty-five patients (46±17y, 51% male) with suspected ischemic or non-ischemic cardiomyopathy underwent cardiovascular magnetic resonance imaging (CMR) with gadolinium contrast (0.15 to 0.2 mmol/kg; Gadovist) on a 1.5T scanner (SIGNA Artist, GE Healthcare). Short axis 2D LGE images were reconstructed twice: once with the vendor standard reconstruction, and once with vendor supplied DLRecon prototype. The DL reconstruction is based on a deep convolutional residual encoder network trained from a database of over 10.000 images to reconstruct images with high signal-to-noise ratio (SNR) and high spatial resolution. The network offered tunable noise reduction (NR) factors from 0-100% to accommodate user preference. Two observers scored image quality and myocardial nulling of both original images and reconstructed images with 75% NR level using a 5 point scale (1=poor to 5=excellent). SNR and contrast-to-noise ratio (CNR) were measured. In 20 patients with LGE, scar size was quantified using thresholding by 2, 4, and 6 standard deviation (SD) above remote myocardium, and using full width at half maximum (FWHM) technique in images with 25%, 50%, 75% and 100% NR levels.

RESULTS

Both image quality and myocardial nulling improved by DLRecon method (3.3±0.6 vs. 3.7±0.6, $p<0.001$ and 3.3±0.6 vs. 3.4±0.6, $p=0.03$). SNRscar and CNRscar-remote increased significantly with 150% and 158%, respectively at a NR level of 75% (both $p<0.001$). Due to reduction in noise, scar size increased significantly with increasing NR levels using SD methods, however with the FWHM method no difference in scar size was found (figure).

CONCLUSION

Using a novel, deep learning based, reconstruction algorithm myocardial LGE image quality improved significantly. However, these algorithms have important impact on scar size quantification depending on technique used. The FWHM method is preferred because it is independent of the level of noise.

CLINICAL RELEVANCE/APPLICATION

LGE by CMR is the gold-standard technique for assessing myocardial scar and by using a novel, deep learning based, image reconstruction algorithm image quality can be improved.

SSA22-07 Comparison Between Readout Segmented Diffusion Weighted Imaging and Single Shot Echo Planar Imaging in Image Quality

Sunday, Dec. 1 11:45AM - 11:55AM Room: E353A

Participants
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PURPOSE

To compare difference of readout segmented diffusion weighted imaging (RS-EPI) and single shot echo planar imaging (SS-EPI) on image quality with ultra-high b value for prostate cancer detection.

METHOD AND MATERIALS

37 patients with prostate disease who underwent both RS-EPI and SS-EPI were enrolled in this study. All data were collected on a 3T MR scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) with the b value of 0, 1000 ,2000 , 3000s/mm2. The image quality including lesions clarity, anatomical distortion, image sharpness, detail display based on diffusion weighted imaging (DWI) were classified according to Likert score into 1 to 5 grade.(Grade 1 : cannot be used for diagnosis; Grade 2: poor; Grade 3: acceptable; Grade 4: good; Grade 5: very good.) All the images were analyzed by two experienced radiologists blinded to any clinical information as well as MR sequence type. The classification was provided from two radiologists separately. The signal-to-noise ratio (SNR), and contrast ratio, and contrast to noise ratio (CNR) were also measured on workstations by the radiologist.

RESULTS

The scores concluded by the two radiologists have good consistency, Kappa value>0.80. The image quality including lesions clarity, anatomical distortion, image sharpness, detail display obtained from RS-EPI sequences were higher than those obtained from SS-EPI regardless of 1000, 2000, 3000s/mm2 ($P<0.001$). The signal-to-noise ratio (SNR), and contrast ratio, and contrast to noise ratio (CNR) measured on RS-EPI sequences were also higher than those measured on SS-EPI ($P<0.001$) (table1).

CONCLUSION

Compared with the SS-EPI sequence, ultra-high b value RS-EPI sequence significantly improves the image quality, which is more conducive to the detection of prostate lesions.

CLINICAL RELEVANCE/APPLICATION

Compared with the SS-EPI sequence, ultra-high b value RS-EPI sequence significantly improves the image quality, which is more conducive to the detection of prostate lesions.

SSA22-08 Radiologic Technologists' Decision-Making for Protocol Repetition in Whole-Body MR Imaging and the Potential for Automated Image Quality Assessment: A Large Population-Based Cohort Study

Sunday, Dec. 1 11:55AM - 12:05PM Room: E353A

Participants
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PURPOSE

Cost-effectiveness in health care delivery and diagnostic medical imaging have become increasingly important. Such considerations are relevant when repeating protocols in Whole-Body MR imaging, especially when conducting large cohort studies. We studied the frequency of protocol repetition by radiologic technologists who performed whole-body MR imaging protocols in the multi-center German National Cohort (GNC), and the impact of automation on the need for protocol repetition, considering the local, staffing, and technical factors involved. Additionally, we studied its impact on scan time, automated image quality assessment, and protocol repetition.

METHOD AND MATERIALS

A total of 11,347 subjects underwent whole-body MRI as part of the MR sub-study of the GNC cohort (2014-2016). Whole-body imaging was conducted at five sites using a uniform set of twelve protocols. Image acquisitions were independently conducted by radiologic technologists (RT), whose decisions for protocol repetition was compared with image quality parameters that were automatically derived.

RESULTS

At least one repeat protocol by the RT occurred in 12% (n=1,365) of subjects. The frequency of repetition differed across protocols ($p<0.0001$), and across sites (range: 5.28%-24.34%, $p<0.0001$), and varied over time ($p<0.0001$). Mean total scan time of 62.6min increased by 4.8min (95%CI: 4.5-5.2min) in subjects needing protocol repetition. The automatically-derived image quality parameters that retrospectively predicted the need for protocol repetition included image sharpness and signal-to-noise ratio. However, their predictive value was not uniform across all protocols.

CONCLUSION

The need to repeat MR protocols, even in highly standardized settings such as population study cohorts, is highly prevalent. Our findings indicate that automated image quality assessment has predictive value, and reduces the need for protocol repetition, thereby improving workflow efficiency and cost-effectiveness in the conduct of such studies.

CLINICAL RELEVANCE/APPLICATION

Patients find MRI studies daunting, hence MRI protocol repetition by radiologic technologists increase not only costs, but also patient discomfort. Automation of MRI image workflow has the potential to improve both.

SSA22-09 An Experimental Study of MRI Induced Heating in Conductive Loops

Sunday, Dec. 1 12:05PM - 12:15PM Room: E353A

Participants
Wing-Chi E. Kwok, PhD, Rochester, NY (*Presenter*) Nothing to Disclose
William Badger, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose

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CONCLUSION

This work indicates that size and presence of a gap are factors to consider in the risk assessment of piercings. It has important implication for dermal piercings since there may be unknown gap in the piercing under the skin.

Background

Patients who are unable or reluctant to remove metallic piercings before MRI are at risk of injuries due to magnetic force and radiofrequency (RF) heating. While magnetic force risk can be reduced by screening with a ferromagnetic detector, it is harder to assess the risk of RF burn from piercing. The purpose of this investigation is to conduct experiments to evaluate the relationship of RF heating with the size and configuration of conductive loops to provide a better understanding of the factors related to RF heating in piercings.

Evaluation

The study was conducted on a GE 3T MR system. Circular loops of diameter 5cm, 8cm and 11cm with an air gap of 0, 0.3mm or 2.5mm for each diameter were constructed from copper wire (gauge 10). They were placed one at a time horizontally in a container with the loop touching the skin of a pig knuckle specimen at the loop gap position. The setup was mounted on top of a 27cm spherical phantom and scanned using a fast spin echo sequence for 10:33 minutes. Temperature at the contact point between each loop and the specimen skin was measured with a Philips patient monitor temperature sensor. The results show temperature rise of 1.4 and 1.8 deg C in the 8cm loops with a gap of 0.3mm and 2.5mm respectively, and temperature rise of 5.0 and 5.2 deg C in the 11cm loops with a gap of 0.3mm and 2.5mm respectively. There was no measured temperature increase in all loops with zero gap and in the 5cm loops with a gap.

Discussion

This study shows that RF heating risk increases with the size of conducting loops and with the presence of a gap. The result indicates high induced electric field at the gap of the larger loops causes current to flow in the skin with high resistance leading to the heating. However, this study does not imply MRI safety for piercings smaller than a certain size or without a gap since RF heating depends also on other factors and settings not covered in this study.

PHS-SUA

Physics Sunday Poster Discussions

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

CT PH RO SQ

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Samuel L. Brady, PHD, Cincinnati, OH (*Moderator*) Nothing to Disclose

Sub-Events

PH203-SD-SUA1 Impact of Deep-Learning Reconstruction Compared to Iterative Reconstruction: First Use in Cardiac CT in a Stroke Protocol

Station #1

Participants
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PURPOSE

To analyse the radiation dose and the image quality of cardiac CT in an acute stroke protocol using a deep learning reconstruction method compared with a standard iterative reconstruction algorithm.

METHOD AND MATERIALS

296 consecutive patients admitted with a suspicion of stroke in the emergency department of our institution were retrospectively analysed. All patients underwent a stroke CT protocol including a non-enhanced CT, a brain perfusion if necessary, a CTA of the supra aortic vessels, a cardiac CT and a post-contrast brain CT. The cardiac CT was performed with a prospectively ECG gated volume acquisition. 143 CT scans were reconstructed with an iterative reconstruction algorithm (AIDR 3D) and 146 with a deep learning reconstruction algorithm (AiCE). Image noise, signal-to-noise (SNR), contrast-to-noise (CNR) and subjective image quality were assessed. Dose-lenght product (DLP), Volume CT dose index (CTDIvol) and effective dose were obtained.

RESULTS

There was no difference in age and weight between the two groups (all $p>0.05$). The radiation dose was significantly lower with AiCE (DLP 106.4 ± 50 mGy.cm verus 176.1 ± 37.1 mGy.cm, $p<0.0001$) that is a decrease of 39.6 %. The mean SNR and CNR were 10.3 ± 0.29 and 13.17 ± 0.34 respectively with AiCE versus 6.81 ± 2.6 and 8.83 ± 0.27 ($p<0.0001$). SNR and CNR were increased of 51.2 % and 49 % respectively. The image quality was significantly better with AiCE than AIDR 3D.

CONCLUSION

A deep learning reconstruction algorithm for cardiac CT allows both a decrease in radiation dose of 39.6% and an increase in the image quality of around 50% compared to an iterative reconstruction algorithm.

CLINICAL RELEVANCE/APPLICATION

A deep learning reconstruction allows a decrease in radiation dose and a better image quality in cardiac CT included in an acute stroke protocol.

PH236-SD-SUA2 An Experimental Study of MRI - Induced Heating in Conductive Loops

Station #2

Participants
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William Badger, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose

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CONCLUSION

This work indicates that size and presence of a gap are factors to consider in the risk assessment of piercings. It has important implication for dermal piercings since there may be unknown gap in the piercing under the skin.

Background

Patients who are unable or reluctant to remove metallic piercings before MRI are at risk of injuries due to magnetic force and radiofrequency (RF) heating. While magnetic force risk can be reduced by screening with a ferromagnetic detector, it is harder to assess the risk of RF burn from piercing. The purpose of this investigation is to conduct experiments to evaluate the relationship of RF heating with the size and configuration of conductive loops to provide a better understanding of the factors related to RF heating in piercings.

Evaluation

The study was conducted on a GE 3T MR system. Circular loops of diameter 5cm, 8cm and 11cm with an air gap of 0, 0.3mm or 2.5mm for each diameter were constructed from copper wire (gauge 10). They were placed one at a time horizontally in a container with the loop touching the skin of a pig knuckle specimen at the loop gap position. The setup was mounted on top of a 27cm spherical phantom and scanned using a fast spin echo sequence for 10:33 minutes. Temperature at the contact point between each loop and the specimen skin was measured with a Philips patient monitor temperature sensor. The results show temperature rise of 1.4 and 1.8 deg C in the 8cm loops with a gap of 0.3mm and 2.5mm respectively, and temperature rise of 5.0 and 5.2 deg C in the 11cm loops with a gap of 0.3mm and 2.5mm respectively. There was no measured temperature increase in all loops with zero gap and in the 5cm loops with a gap.

Discussion

This study shows that RF heating risk increases with the size of conducting loops and with the presence of a gap. The result indicates high induced electric field at the gap of the larger loops causes current to flow in the skin with high resistance leading to the heating. However, this study does not imply MRI safety for piercings smaller than a certain size or without a gap since RF heating depends also on other factors and settings not covered in this study.

PH237-SD-SUA3 Image Quality Evaluation Using a New Low-Dose Fluoroscopy Algorithm Based on a Deep-Learning Approach

Station #3

Participants
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PURPOSE

Interventional treatment is widely used in clinical practice and the augmented role of these procedures raises concerns about the radiation dose to patients and operators. Howerer, dose reduction may cause the increased noise, which impacts the image quality. We aim to develop a new low-dose fluoroscopy algorithm based on a deep-learning approach to improve image quality using an in-vitro model and in-vivo patient groups.

METHOD AND MATERIALS

All image acquisitions were performed on a DSA machine (Angio30C, Neusoft, Shenyang, China). The proposed network combined De-noising Convolutional Neural Networks (DnCNN) and Visual Geometry Group (VGG)-19 architecture.The radiation dose of the low dose regimen was half that of the conventional dose. We obtained 200 noisy-free phantom images as label via averaging 100 frames in one stable sequence. Noise was added artificially to these labels with specified range of our fluoroscopy to get noisy images. Thus we used these label and noisy images as our training set. Testing set included 20 phantom images for quantitative analysis and 100 clinical patient images for subjective evaluation. Mean squared error(MSE), peak-to-noise ratio(PSNR) and structural similarity(SSIM) were determined for quantitative analysis. The image quality of subjective evaluation was graded (1, excellent; 3, poor). The results were compared with conventional model-based de-noising approaches (temporal recursive filter,TRF), which is commonly used in fluoroscopic noise reduction.

RESULTS

For the quantitative analysis of 20 phantom images, image quality was significant better based on a deep-learning approach (PSNR, SSIM, MSE) than that based on TRF. For subjective evaluation of 100 clinical patient images, image quality was also significant better based on a deep-learning approach.

CONCLUSION

Compared with traditional method, deep learning based noise reduction method showed great improvement of image quality.

CLINICAL RELEVANCE/APPLICATION

Deep learning based noise reduction method may be used in interventional treatment to reduce radiation dose.

PH238-SD-SUA4 High-Resolution Knee Arthrography Using Photon-Counting Detector CT for Grading Osteoarthritis

Station #4

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PURPOSE

To grade cartilage loss in a swine model of osteoarthritis (OA) using high resolution photon-counting detector (PCD) CT.

METHOD AND MATERIALS

A Yucatan swine model of knee OA was developed using chondrotoxic monoiodoacetate (MIA, 1.2 mg per 2 mL saline) administered to a randomized knee of anesthetized pigs (N = 8), while the contralateral control knee received 2 mL normal saline under ultrasound (US) guidance in a blinded fashion by a musculoskeletal radiologist. Twenty one days after the MIA injection, all animals received US-guided contrast injections (anionic Gd-DOTA, 4 to 6 mL/knee) on both knees. The knees were flexed and extended for one minute prior to PCD-CT scanning to ensure uniform distribution of contrast. Both knees were scanned in a single acquisition using the high-resolution Sharp mode (48 x 0.25 mm collimation, 120 kV, 342 mAs, CTDIvol = 40mGy) with energy thresholds at 25 and 51 keV. Animals were euthanized immediately after scanning, and the knees were harvested for visual assessment of joint damage. PCD-CT images were reconstructed using a dedicated sharp kernel V71 with SAFIRE (strength 5). For each animal, each knee was reconstructed separately at an image voxel size of 0.15 x 0.15 x 0.5 mm3. A blinded musculoskeletal radiologist evaluated the 25-120 keV images (axial and sagittal planes) and graded the morphological changes. For each knee, the joint was partitioned into 4 regions for assessment (medial and lateral femur, trochlea and patella). Quantitative scores based on the International Cartilage Repair Society (ICRS score) were used to assess cartilage integrity.

RESULTS

Chondromalacia was detected in the MIA knees with ICRS scores ranging from grade 1/grade 2 (cartilage heterogeneity/0 to 50% loss) for n = 4 knees to grade-3 (50% to 100% cartilage loss) for n = 4 knees. The control knees (n = 8) were scored grade 0 (normal cartilage) by the radiologist. Visual examination of the harvested knees confirmed the extent of cartilage damage in the MIA knees.

CONCLUSION

We demonstrated a high-resolution PCD-CT method to assess cartilage loss in a MIA-induced OA swine model, and visual evaluation of the harvested knees for cartilage damage confirmed the image-based findings.

CLINICAL RELEVANCE/APPLICATION

PCD-CT allows grading of OA-induced cartilage loss at 150-micron resolution previously not achievable with other methods. This could facilitate early detection of OA and mitigate disease progression.

PH205-SD-SUA5 Training a U-Net Deep Learning Network for Tumor Cell Detection and Segmentation in Pathologic Images Using Incomplete Annotation

Station #5

Participants
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PURPOSE

Automated tumor cell segmentation is a fundamental step in radiomics-pathomics correlation studies. This study developed a U-Net deep learning approach to detect and segment cells in pathologic images using a training set with incomplete annotation.

METHOD AND MATERIALS

Deep learning segmentation requires large annotated data for supervised training. In pathologic images, it is nearly impossible to manually outline every cell. We developed a new strategy using a public dataset of 141 samples of 2000x2000-pixel H&E-stained breast cancer pathologic images with incomplete annotation. The data was split into training, validation and test sets of 89, 22 and 30 images, respectively. The positive training samples were generated by extracting a 32x32 patch at each annotated cell and augmenting it with affine translations, resulting in a total of 60,000 patches. The negative training samples were selected to characterize a wide variety of non-cell regions using a histogram-based semi-automatic method. This resulted in a 1:100 ratio of positive to negative patches in the training set. A U-Net model was then trained with a mini-batch stochastic gradient descent algorithm by minimizing a custom loss function that combined a weighted inverse Dice coefficient and binary cross-entropy with class weights to account for the class imbalance in the training set. Using the annotated cells as reference standard, the 22 validation images were used to evaluate the network performance, tune hyperparameters, and adjust the loss function. The final network performance was evaluated with the held-out test set.

RESULTS

For the 30 test cases with 2365 annotated cells, the U-Net achieved a sensitivity of 99.7% for cell detection. The average true positive fraction of the segmented cell area and Dice coefficient were 88.1% and 82.4%, respectively.

CONCLUSION

Fully-annotated data are uncommon in pathology due to the extensive effort it requires. Our method that selectively chooses positive and negative patches from an incompletely annotated pathologic dataset can detect and segment tumor cells with high accuracy. Further work is underway to conduct the correlation study and evaluate the generalizability of the method to other diseases.

CLINICAL RELEVANCE/APPLICATION

Studies suggest that histopathologic features may be correlated with radiologic features for guiding disease management decisions. Cell segmentation is fundamental for these correlation studies.

PH204-SD-SUA6 Point-of-Care Cone-Beam CT of Head Injury: Diagnostic Performance Evaluation

Station #6

Participants
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CONCLUSION

POC CBCT may improve safety for ICU patients requiring monitoring via head CT, providing image quality that is adequate for certain indications.

Background

Obtaining a CT in the ICU is a resource-intensive process and poses significant risk to the patient, requiring coordination between staff to ensure safe transport of the patient and support devices. Point-of-care (POC) imaging is a safer, more convenient alternative which is already widely utilized in the form of portable radiography. We developed a portable cone-beam CT (CBCT) unit and compared its diagnostic quality with that of multi-detector CT (MDCT) in a clinical study of patients in the neuro critical care unit.

Evaluation

A prototype CBCT system was developed for head scanning, incorporating artifact reduction and model-based iterative image reconstruction. We consented 92 eligible patients, of whom 54 were imaged using CBCT and MDCT, and 41 were included in the study (13 excluded due to technical factors). Three neuroradiologists compared the diagnostic quality of MDCT and CBCT scans as it pertained to imaging tasks (detection, discrimination, and/or characterization) in CSF spaces, parenchyma, hemorrhage, surgical devices, and osseous structures using a Likert scale from 1-5 (1 not visible, 3 diagnostic, and 5 excellent image quality). Image artifact was also assessed with a Likert scale from 0-5 (0 minimal, 5 critical). Assessment of surgical devices was comparable (e.g., ventricular shunt) between CBCT and MDCT (median Likert = 5). CBCT images were adequate (median Likert >=3) for assessment of CSF spaces, mass effect, osseous structures, and hemorrhage. Image quality was non-diagnostic (median Likert <=2) for assessment of parenchymal infarctions.

Discussion

The diagnostic quality of head CT performed via portable CBCT was adequate, and in some respects comparable to MDCT, for a specific subset of clinical indications in the ICU setting. CBCT appears best suited as a follow-up exam intended to assess changes in hemorrhage, ventricular size and positioning of intracranial support catheters among other common scenarios. POC CBCT has the potential to mitigate risk and resource utilization associated with head CT for ICU patients.

PH126-ED-SUA7 An Update on Multienergy CT: Physics, Principles and Applications

Station #7

Awards
Certificate of Merit
Identified for RadioGraphics

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TEACHING POINTS

Multienergy CT refers to the acquisition of CT data at multiple energy levels 1. To review the physics of multienergy CT (MECT) 2. To discuss the different implementations of MECT 3. To review the post-processing and image types 4. To illustrate the clinical applications of MECT 5. To evaluate the challenges and pitfalls

TABLE OF CONTENTS/OUTLINE

1. MECT- Basics 2. MECT technologies - Source based (Dual source, rapid kVp switching, Dual spin, split beam) - Detector based

(Dual layer, photon counting CT) 3. MECT reconstruction- Projection-based; Image-based 4. Material decomposition algorithms- 2-material/3-material 5. Image types- Iodine map, virtual non contrast, virtual non calcium, uric acid pair, virtual monoenergetic, CT fingerprinting, Effective atomic number, electron density 6. Noise reduction 7. Clinical applications - Material composition- Stones, gout, lesion characterization, perfusion, tumor response evaluation, targeted contrast - Enhanced visualization- Improved lesion visualization; improved contrast signal (salvage of suboptimal enhanced studies, low contrast dose) - Artifact reduction- Beam hardening, metal, blooming - Radiation reduction- Virtual non contrast saving true non-contrast in multiphasic studies; Incidental finding characterization saves additional tests 8. Pitfalls & Challenges 9. Conclusion

PH139-ED-SUA8 Reliability Assessment of CT-based Texture Analysis Metrics

Station #8

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CONCLUSION

Reliability of CTTA metrics is important when quantitative analysis of studies performed under different conditions are used to assess a single disease process.

Background

To evaluate the intra-, inter- and test-retest variability of CT-based texture analysis (CTTA) metrics.

Evaluation

Using a custom designed texture-phantom, we conducted a series of CT imaging experiments to evaluate the performance of a CTTA panel. The phantom comprises of 3 different regions (ROI) simulating different textures which may be found in tumors. The phantom was scanned on the Philips Brilliance 64 CT and Toshiba Aquilion Prime 160 CT scanners. The intra-scanner variability (robustness) of the CTTA metrics was evaluated across different scan settings such as slice-thickness, field-of-view, post-reconstruction filtering, tube-voltage, and tube-current. For each scanner and scanning parameter combination, we evaluated the performance of 234 different texture metrics extracted using 8 different types of texture quantification techniques on predetermined ROIs within the phantom. For the robustness test, 21 unique image settings were tested on the Philips scanner and 16 unique settings were tested on the Toshiba scanner respectively. A Heatmap was used to plot the percent absolute difference (PAD) between testing scan setting and baseline setting for each of the radiomic metrics. The repeatability test was conducted 15 minutes apart for all the image settings on both scanners under all settings. A Heatmap was used to plot the PAD between 1st and 2nd scan for each radiomic metric. For the reproducibility assessment, we compared PAD of all radiomic metrics between the two scanners using the 1st scan only.

Discussion

Reliable metrics must be robust, repeatable, and reproducible. Literature report a high reliability associated with entropy metrics. Here, we observe entropy of fast Fourier Transform (FFT) magnitude and FFT phase to be reliable. Literature show that these metrics can discriminate between clear cell renal cell carcinoma grades and between benign versus malignant renal masses. The reduced sensitivity of the FFT measures to the scanner and imaging parameters need to be further evaluated.

PH003-EB-SUA Phantom Study of Prone Breast PET/CT Targeted Towards Improving Clinical Applications

Hardcopy Backboard

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CONCLUSION

While a phantom-based reader study may be a useful addition, and clinical pilot studies are also warranted, prone patient orientation appears to have superior image quality, and better compatibility with MR when bridging the two image sets together for improved diagnoses.

Background

Current PET/CT protocols for breast imaging rely on a supine patient orientation. Meanwhile, MR protocols utilize dedicated coils that dictate a prone patient orientation. The differences between the resulting breast shapes and their positioning causes an obvious lack of compatibility between the two modalities. In a supine orientation, breasts reconfigure due to gravity and are closer to the chest wall. In a prone orientation, breasts are more elongated due to gravity and are distal from the chest wall. The chest wall is a source of background activity and noise, due to attenuation and scatter.

Evaluation

Through anthropomorphic phantom studies (using a fillable torso with inserts, two deformable 750mL breasts each containing 8 uniformly disposed lesions of 8 and 10mm diameters) and use of a customized radiolucent foam support (constructed to resemble a commonly used MRI-breast coil support structure), we acquired PET/CT list-mode data with an 8:1 lesion-to-background concentration ratio. The same filled phantom configuration was imaged by PET/CT in both supine and prone orientations. The acquired data was replayed in both variable and equal 0.5 to 8min time intervals to yield different noise realizations. Image metrics of SNR and local contrast are used for the signal evaluation, along with paired-t-test comparison of the oriented data.

Discussion

The larger lesions always presented higher signal, and better SNR and contrast than the smaller lesions. Raw signal was always better (per lesion) in the prone vs supine orientation. The mean SNR for both lesion sizes was ~2x better for the prone orientation ($p<0.003$ and <0.0003 for the 8 and 10mm); mean local contrast was nearly equal for both lesion sizes ($p<0.3$ and <0.08, respectively). Generally, lesion visualization was easier in the prone orientation, and a reader study would be a useful addition.

PH008-EC-SUA The Study of the Effect Factors of Radiation Field in Wide-Detector CT

Custom Application Computer Demonstration

Participants
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CONCLUSION

In a wide-detector CT,the selection of different detector widths can significantly influence the distribution and radiation value of radiation field,thus a suitable detector width and relevant parameters shall be chosen according to the specific clinical requirements to reduce the radiation dose for the on-site operating medical staffs and accompanies.

Background

To explore the distribution characteristics of radiation field on Z-axis and X-axis on wide-detector CT with different scan modes,pitch and detector widths to provide the basis for the radiation protection of the chaperone and the operator.

Evaluation

Thermoluminescence dosimeters (TLDs) were placed at the Z-axis and the X-axis on the frame. The CT head standard-dose phantom was scanned by GE Revolution CT under the sequential scan mode (with detector widths of 40 mm,80 mm and 160 mm) and the spiral scan mode (with detector widths of 40 mm and 80 mm). The scan parameters were as follows:tube voltage 120kV,effective mAs 200, pitch (for spiral scan):40 mm/0.516:1,40 mm/0.984:1,80 mm/0.508:1,80 mm/0.992:1. All scans were repeated for 4 times, and all TLDs were measured after exposure for the further analysis.

Discussion

The radiation in the Z-axis was attenuated by exponential function and the scattered radiation in the X-axis showed a bell-shaped with sequential scan mode and spiral scan mode. In the Z-axis, the scattered radiation on the head side of body were all higher than the foot side of body($Z=-2.366,-2.197,-2.366,-2.371,-2.028,-2.236,-2.028, P<0.05$). There was no statistically significant difference in scattered radiation in the Z-axis and X-axis with the detector width was 40 mm in sequential scan mode and with the detector pitch of 40 mm/ 0.984:1 in spiral scan mode($Z=-0.345$, -0.863, $P>0.05$). The remaining groups scattered radiation of sequential scan mode were smaller than that of spiral scan mode with same detector width. Under the sequential scan mode,the differences in the distribution of Z-axis and X-axis scattered radiation under different detector widths were statistically significant($^2=28.000, 18.500, P<0.05$),The maximum increase for detector width of 40 mm and 160 mm was 67.5μGy.Under the spiral scan,the largest distribution of scattered radiation was found to be the largest at the detector width of 80 mm and the smallest at the detector width of 40 mm. The maximum increase for detector width of 80 mm and 40 mm was 97.67μGy($Z=-2.981,-3.233,-2.353,-2.982, P<0.05$).

PHS-SUB

Physics Sunday Poster Discussions

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

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Samuel L. Brady, PHD, Cincinnati, OH (*Moderator*) Nothing to Disclose

Sub-Events

PH200-SD-SUB1 Super-Resolution Blood Flow Imaging in Human Liver Using Ultrasound Diffraction Attenuation Microscopy

Station #1

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PURPOSE

To provide a tool for fast super-resolution microvascular imaging in clinical based on contrast-enhanced ultrasound.

METHOD AND MATERIALS

Subjects and data acquiring: A vial of Sonovue was diluted with physiological saline (25 mg, 20 mL) and a dose of 0.1mL was injected by intravenous infusion into a young healthy male volunteer. Contrast-enhanced ultrasound (CEUS) frames with sparse microbubble distribution of the liver were acquired during each breath-holding for 20 seconds. Data processing: The frame stack was processed by spatial radiality transformation and temporal fluctuations analysis (Fig. 1e.) using Matlab and Java.

RESULTS

The UDAM attenuates the acoustic diffraction induced point spread functions of microbubbles and a super-resolved vascular structure of the human liver is achieved within 20 seconds (Fig.1d.). Liver microvessels with 100μm diameter are revealed in the UDAM image. Naked eyes can observe significant improvement in microvascular visualization compared with a single CEUS frame and the maximum intensity projection of CEUS frames (Fig. 1(a-c).).

CONCLUSION

In summary, we demonstrate the feasibility of the proposed UDAM method for fast super-resolution blood flow imaging in human liver.

CLINICAL RELEVANCE/APPLICATION

The UDAM is a novel, fast, and non-invasive imaging tool for the in vivo assessment of microvascular structures and is potentially beneficial to the study and diagnosis of liver cancers, cysts, microvascular perfusion et al. Moreover, the application of UDAM can be extended to other organs.

PH201-SD-SUB2 Patient-Informed and Physiology-Based Modelling of Hepatic Contrast Dynamics in Contrast-Enhanced CT Imaging

Station #2

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PURPOSE

Iodinated contrast agents are commonly used in CT imaging to enhance tissue contrast. Consistency in contrast enhancement (CE) is critical in radiological diagnosis. Contrast material circulation in individual patients is affected by factors such as patient body habitus and anatomy leading to significant variability in organ contrast enhancement, image quality, and dose. Toward the goal of improving CE consistency in clinical populations, in this work we developed a contrast dynamics model to predict CT HU enhancement of liver parenchyma in abdominopelvic CE CT scans.

METHOD AND MATERIALS

This study included 700 adult abdominopelvic contrast CT exams performed in 2014-2018 using two scanner models from two vendors. Each CT image was segmented using a deep learning-based segmentation algorithm and the hepatic parenchyma HU values were acquired from the segmentations. A two-layer neural network-based algorithm was used to identify the relationship between patient attributes (height, weight, BMI, age, sex), scan parameters (slice thickness, scanner model), contrast injection protocols (bolus volume, injection-to-scan wait time), and the liver HU CE. We randomly selected 60% studies for training, 10% validation, and 30% for testing the accuracy. The training output was the extracted HU values. The goodness-of-fit of the model was evaluated in terms of R^2, Adjusted R^2, Mean Absolute Error (MAE), and Mean Squared Error (MSE) between the model prediction and ground truth. In addition, the generalizability of the model was evaluated by comparing the R^2 in the training data (leave-one-out validation) and the testing data.

RESULTS

This preliminary model has an 0.51 R^2, 0.40 adjusted R^2, 10.0 HU MAE, 159.1 HU MSE, 0.6±12.8 HU Mean Error, and 2.5 HU Median Error on test data. For training data, the model has 0.59 R^2, 0.56 Adjusted R^2, and 0.5 predicted R^2. The close R^2 between testing and training data results indicate a reasonable generalizability.

CONCLUSION

Results showed considerable predictability of liver CE from patient attributes, scanning parameters, and contrast administration protocol. We envision to expand the model to include other major organs toward a comprehensive predictive model.

CLINICAL RELEVANCE/APPLICATION

A contrast dynamics model can be an essential tool to personalize contrast-enhanced CT protocol and to improve the consistency of contrast enhancement across different patients in diagnostics imaging.

PH239-SD-SUB3 Radiation Dose Exposure During Pelvic Angiography and Intervention: What Can Be Done to Minimize Risk

Station #3

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PURPOSE

Methods to decrease radiation dose during pelvic angiography are of paramount importance as many of the targeted patients are relatively young and desire future fertility. The purpose of this study is to evaluate the relative radiation dose exposure to patients during pelvic angiography and intervention as a function of bladder catheterization and additional factors utilizing an abdominopelvic phantom model.

METHOD AND MATERIALS

Samples cases of pre-specified digital subtraction angiography (DSA) runs were conducted upon a phantom model. The runs were obtained in a protocol which simulated imaging obtained during pelvic intervention and included anteroposterior (AP), bilateral oblique, and magnified views. A total of six sample cases were conducted without (Group 1) and with (Group 2) the presence of an apparatus simulating contrast in a distended bladder. Radiation dose data in the form of dose area product per frame (DAP/f) and air kerma per frame (AK/f) was compared between the groups. Radiation dose as a function of views and magnification was also compared.

RESULTS

The mean total DAP/frame for Group 1 was 141 mGy-cm2/f (137 - 145) compared to Group 2 mean total DAP/frame of 270 mGy-cm2/f (258 - 282), reflecting a significant decrease in radiation dose as a result of bladder catheterization simulation ($p < 0.01$). The mean total AK/frame for Group 1 was also significantly decreased ($p < 0.01$) at 0.446 mGy/f (0.433 - 0.459) versus 0.871 mGy/f (0.816 - 0.925) for Group 2. Dose parameters in the magnification and oblique views were also significantly decreased in Group 1 compared to Group 2.

CONCLUSION

In this controlled simulation of pelvic angiography utilizing an abdominopelvic phantom, there is a 48% reduction in DAP and a 49% reduction in AK on the basis of simulated bladder catheterization. This method of dose reduction during pelvic angiography has not previously been quantified. Other previously described techniques of modulating radiation dose were also investigated and confirmed to effect DAP and AK in a consistent manner. Based on our results, patients undergoing pelvic angiography should receive bladder catheterization unless there is a strong contraindication.

CLINICAL RELEVANCE/APPLICATION

Dose reduction in pelvic angiography is consistently achieved through bladder catheterization in addition limiting oblique views and magnification.

PH240-SD- Comparing 3D MSK-View with 2D Standard Scans: Shortening Imaging Time of the Shoulder MRI

SUB4 **Study - A Clinical Quality Feasibility Study**

Station #4

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CONCLUSION

There is no significant difference in image quality between the 2D scans and one 3D MSK-View in terms of detection of pathology and diagnostic confidence. The average time reduction achieved using one 3D MSK-View in comparison to three 2D scans were 3.35 mins (39%). This study proves the potential of replacing three 2D scans with one 3D scan in shoulder.

Background

2D sequences have been used in practice to evaluate shoulder pathologies. Partial volume and higher thickness make these scans unusable for reformatting to different orientations. Radiologists have to separately acquire multiple 2D fat-suppressed sequences for the complete diagnosis. Attempting lower thickness and higher resolution 2D scans for reformatting purpose is also practically impossible due to longer scan time. The only feasible alternate could be using fat-suppressed 3D turbo-spin-echo (MSKView) sequence, which has higher in-plane and through-plane resolutions for reformat as well as shorter scan time.

Evaluation

18 patients were scanned in a 3.0T wide-bore MRI (Ingenia, Philips Health Systems). The comparative scan protocol comprised of three 2D fat-suppressed PD spin-echo sequences and one isotropic 3D PD fat-suppressed turbo-spin-echo (MSKView) sequence. Sequence details are mentioned in Table-1 attached. Two independennt specialist MRI radiologists reviewed the 2D scans in all three orientations as well as the 3D scan reformatted in all three orientations. Both sets of images were rated on a scale of 1 to 5 on the basis of edge/sharpness, blurring, image artifact/noise, contrast between fluid and cartilage, small ligament delineation. Images were assessed viewing three specific structures Rotator cuff, labrum and ligament.

Discussion

Interrater agreement on image quality was compared between the 2D vs 3D scans via a multivariate non-parametric Hotelling's T2 test. There was no statistically significant difference between the 2D and 3D scans of 18 patients evaluated by each radiologist (alpha < 0.001 level). Further, the mean percentage observed agreement between 2D and 3D scans for all five measures across the radiologists was 91.8%.

PH241-SD-SUB5 **Quantitative Evaluation of Bone Microstructure on a Novel Ultra-High Resolution Whole-Body CT**

Station #5

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PURPOSE

A novel ultra-high resolution multi-detector CT has recently been introduced (Canon Precision UHR CT). The system enables >2x improved spatial resolution (~150 μm detail size) compared to current generation CT. Among clinical applications that might benefit from the enhanced spatial resolution is assessment of microstructural factors affecting bone strength in spine and hips. We evaluate the performance of UHR CT in measurements of trabecular microarchitecture.

METHOD AND MATERIALS

Helical acquisitions (120 kVp tube voltage, ~10 mGy CTDI dose) of human bone samples embedded in a ~16 cm diameter plastic cylinder were performed. Two scanning protocols were compared: an UHR acquisition, featuring 0.25 mm slice thickness, 1796 detector channels, 160 detector rows, and x-ray tube focal spot size of 0.4x0.5 mm, and a Normal Resolution protocol (NR) implementing 0.5 mm slice thickness, 896 channels, 80 rows, and a focal spot of 0.8x1.3 mm. Both UHR and NR data was reconstructed using a sharp bone kernel. Micro-CT (μCT) of the bone samples were obtained at 28 μm voxel size. Trabecular bone metrics (thickness Tb.Th, spacing Tb.Sp and Bone Volume fraction BV/TV) were measured in 10 regions-of-interests (ROIs) distributed at corresponding locations in the CT and μCT volumes. Bone segmentations for the measurements were obtained with Bernsen's local thresholding.

RESULTS

UHR CT yielded noticeably improved delineation of trabecular patterns compared to NR CT. The parameters of the thresholding algorithm were selected so that the correlations against μCT in the measurements of BV/TV (which is fairly insensitive to spatial resolution) were comparable for UHR-CT and NR CT (both ~0.61). At the matched BV/TV correlation, UHR CT achieved ~10% improved correlation in Tb.Th compared to NR CT (0.58 for UHR vs. 0.52 for NR) and ~80% better correlation in Tb.Sp (0.58 for UHR vs. 0.32 for NR).

CONCLUSION

UHR CT achieves improved quantification of bone microarchitecture compared to standard resolution CT. The unique structural information provided by UHR CT will complement bone mineral density measurements to enable accurate estimation of fracture risk in osteoporosis.

CLINICAL RELEVANCE/APPLICATION

A novel whole-body ultra-high resolution CT improves quantitative assessment of vertebral microarchitecture compared to standard CT, enabling more accurate estimation of fracture risk.

PH128-ED-SUB7 Contrast-Enhanced Spectral Mammography (CESM): How Does It Work?

Station #7

Awards

Magna Cum Laude
Identified for RadioGraphics

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TEACHING POINTS

The purpose of this exhibit is: Discuss the physics and physiological basis of contrast-enhanced spectral mammography (CESM) Differentiate the abilities of CESM from conventional digital mammography (FFDM)

TABLE OF CONTENTS/OUTLINE

1. How does mammography (FFDM) work? 2. When does FFDM fail? 2a. Breast Density 3. How does contrast-enhanced spectral mammography (CESM) work? 3a. kV, k-edge, and image subtraction 3b. Contrast dynamics, cancer biology, and the leaky vessel 4. FFDM vs. CESM 4a. Radiation Dose 4b. Contrast Risks 4c. Image Quality 4d. Quality Control

PH127-ED-SUB8 A Handbook of Non-EPI Diffusion Tensor Imaging Sequences: Physical Basis, Technical Adjustments, and Potential Clinical Applications

Station #8

Awards

Certificate of Merit

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Javier Royuela del Val, Cordoba, Spain (*Abstract Co-Author*) Nothing to Disclose
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TEACHING POINTS

1. Review the physical basis of conventional Echo Planar Imaging (EPI) Diffusion Tensor Imaging (DTI) and its limitations. 2. Explain, from an educational point of view, the physical basis and technical adjustments for obtaining non-EPI DTI sequences in different anatomical regions. 3. Show potential applications of non-EPI DTI in different clinical scenarios.

TABLE OF CONTENTS/OUTLINE

1. Introduction 2. Physical basis of conventional EPI-DTI a. Advantages b. Limitations and pitfalls. 3. Non-EPI DTI sequences. a. Physical basis b. Sequences design (multishot, PROPELLER, TSE..) c. Technical adjustments including number of directions and b values. c. Coil selection and patient positioning d. 1.5T or 3T magnet? e. EPI vs. non-EPI DTI acquisitions. 4. Biological meaning of parameters derived 5. Potential indications of non-EPI DTI. a. Central nervous system applications b. Spine applications c. MSK applications d. Body applications. 6. Conclusions and take home messages

PH002-EB-SUB The Need for Virtual X-Ray Fluoroscopic Imaging in Trauma IR: The Best for Proton Irradiation Dose Reduction

Hardcopy Backboard

Participants
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TEACHING POINTS

In this study, we investigated the relationship between supporting images of a new concept and exposure reduction in traumatic

IR.(Fig.1) This is a research on exposure reduction aimed at shortening the procedure time by creating a support image similar to the IR image using CT volume data, in contrast to the existing exposure protection and exposure reduction mechanisms of IR equipment.(Fig.2-3)

TABLE OF CONTENTS/OUTLINE

A virtual fluoroscopic image is a Ray Summation image that is similar to a fluoroscopic image, and blood vessel running and the lesioned part are superimposed and displayed. Thereby it possible to use information intuitively alongside fluoroscopic images, and to avoid unnecessary mapping imaging for anatomical identification and time waste due to blind catheterization under fluoroscopy, aiming at rapid vascular selection and hemostasis. Also, a workstation can be easily installed and implemented, and the CT volume data obtained in advance is used so that there is no need to purchase new and expensive IR equipment.(fig.4) As a result, the number of angiographies required for dissection can be minimized, which not only reduces the amount of contrast agent and exposure, but also reduces complications by shortening the procedure time.(fig.5)

RC121

Innovations in Hybrid Imaging

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

CT MR NM PH

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

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LEARNING OBJECTIVES

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

ABSTRACT

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

Sub-Events

RC121A Innovations in PET/CT

Participants
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LEARNING OBJECTIVES

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

ABSTRACT

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

RC121B Opportunities in PET/MR

Participants
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LEARNING OBJECTIVES

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

ABSTRACT

PET is a non-invasive imaging technique that provides reproducible and fully-quantitative information on preselected metabolic/signaling pathways. PET is highly sensitive, thus, requiring only small amounts of biomarkers to be used for visualization and quantification purposes. By comparison to high-resolution anatomical images PET images appear blurred, which is attributed to the positron range effects and the limited detector size of the PET ring systems.Today, clinical PET imaging systems are offered almost exclusively in combination with CT and MR systems. Combined PET/MR, in particular, offers a number of intrinsic methodological advantages over PET only. These include, the use of MR imaging (e.g., by means of MR navigators) to estimate involuntary patient motion as a pre-requisite for motion compensation, and, thus, subsequent improvement of PET image quality and quantification. Following appropriate motion compensation, PET data can be improved in quality and accuracy through the use of MR-guided partial volume corrections and image reconstruction. In this presentation we will highlight the most important advances of PET instrumentation and data processing that help facilitate fully-integrated PET/MR in the first place, and draw a

benefit from this integration for the PET data. This includes a brief discussion of the effect of the static MR field on positron range effects, in particular for higher-energetic positron emitters. Overall, increase volume sensitivity helps reduce the amount of radiotracer injected into patients or shorten the emission scan time, in combination with increased signal-to-noise in the emission images (thanks to the use of time-of-flight, a concept different from TOF-MR) it helps increase sensitivity and reader accuracy of PET images. Lastly, advances in image reconstruction have brought the level of PET, and the appearance of the PET images, closer to the common understanding of radiologically useful images.

RC121C SPECT/CT Quantitation

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

For information about this presentation, contact:

skappadath@mdanderson.org

LEARNING OBJECTIVES

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

Printed on: 10/29/20

RC122

Dual Energy CT for Radiotherapy Applications

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

CT PH RO

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

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

Sub-Events

RC122A Clinical Need for Dual Energy CT in Proton Radiotherapy

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

LEARNING OBJECTIVES

1) Learn about calibration of Hounsfield Units for determination of relative stopping power for proton therapy planning. 2) Discuss potential sources of error in stopping power determination. 3) Describe treatment planning strategies to mitigate range uncertainties in proton therapy planning.

RC122B State of the Art in Dual Energy CT Technology

Participants
Michael Lawless, PHD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Explain basic dual-energy CT principles. 2) Compare current dual-energy CT techniques and associated limitations.

ABSTRACT

With dual-energy computed tomography (DECT), an additional measurement is obtained, allowing for the reconstruction of supplementary information, such as relative electron density and effective atomic number information. The additional information gained through DECT has potential to aid in several aspects of the radiation therapy process, including improving dose calculation accuracy for proton therapy. This course will discuss the basic principles of DECT and compare different vendor solutions for acquisition of DECT images.

RC122C Technical Challenges in the Integration of Dual Energy CT into Radiotherapy Treatment Planning

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

LEARNING OBJECTIVES

1) Compare range uncertainty to other sources of dosimetric error in proton therapy. 2) Observe clinical examples of range variation in proton therapy.

RC123

Making Patients and Staff Safer in Interventional Procedures

Sunday, Dec. 1 2:00PM - 3:30PM Room: E353A

IR PH SQ

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

Participants
William F. Sensakovic, PhD, Scottsdale, AZ (*Coordinator*) Founder, Telerad Physics Teaching, LLC
Thaddeus A. Wilson, PhD, Madison, WI (*Coordinator*) Nothing to Disclose

For information about this presentation, contact:

wfsensak@gmail.com

LEARNING OBJECTIVES

1) Describe cataract and cancer risks associated with typical interventional radiology procedures and workload. 2) Develop and assess institutional policies for implementing radiation dose tracking and auditing in the interventional setting.

Sub-Events

RC123A Patient Doses (in lab) and Patient Dose Management

Participants
Stephen Balter, PhD, New York, NY (*Presenter*) Speakers Bureau, MAVIG, GmbH

LEARNING OBJECTIVES

1) Understand how in-lab radiation displays and post-procedure radiation use data can be used to optimize patient safety.

Active Handout:Stephen Balter

http://abstract.rsna.org/uploads/2019/18001937/Active RC123A.pdf

RC123B Staff Protection: Cataract and Potential Cancers

Participants
Madan M. Rehani, PhD, Boston, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Explain the results from the studies among interventionalists and support staff on eye lens opacities and comprehend the risks. 2) Identify the evidence or lack thereof of cancer risk among interventionalists. 3) Identify the protective measures for staff in interventional suites.

RC123C Dose Tracking and Audits: Institution-wide Program

Participants
Pei-Jan P. Lin, PhD, Richmond, VA (*Presenter*) Nothing to Disclose
Shelia Regan, MEd, Richmond, VA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

shelia.regan@vcuhealth.org

LEARNING OBJECTIVES

1) Learn how the 'event-by-event' RDSR data exported from the patient radiation dose monitoring and tracking (PRDMT) systems may be employed to better estimate the peak skin dose (PSD) from fluoroscopy equipment. 2) The estimated PSD is then classified into three 'alert level' which leads to a better patient care through a follow up process which will be described in detail at the presentation. 3) Identify establishment of a Clinical Radiation Safety Office (CRSO) to handle the technical aspect of PRDMT and administrative processes of 'documentation' and 'patient follow up' is the key to a successful patient care. 4) It is necessary to establish CRSO as an enterprise wide office to govern the entire process and functions provided by the CRSO. It is essential to learn that successful PRDMT requires both the 'organization' must be setup and it must be properly staffed with qualified 'personnel'.

ABSTRACT

The internal organization structure is described in detail including the 'alert Levels' and what comes next upon receiving the alerts. The Clinical Radiation Safety Office (CRSO) established at VCU Medical Center plays major key rolls in (1) the patient radiation dose monitoring and tracking (PRDMT) and (2) follow up of patients who receved 'confirmed' peak skin dose that is required by the Hospital Policy to follow post fluoroscopy examinations as part of VCU's patient care. The key is to establish a Clinical Radiation Safety Office which manage the technical aspect of PRDMT and follow up of patients process. In other words, an institutinal, enterprise wide organization must be created to handle the total patient care for patients who received high dose radiation which could result in deterministic injury.

Active Handout:Shelia Regan

http://abstract.rsna.org/uploads/2019/18001939/Active RC123C.pdf

Active Handout:Shelia Regan

http://abstract.rsna.org/uploads/2019/18001939/Active RC123C.pdf

RC125

Quantitative Imaging: Promise and Challenges

Sunday, Dec. 1 2:00PM - 3:30PM Room: S404AB

BQ **PH**

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

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Coordinator*) Institutional research agreement, Siemens AG

For information about this presentation, contact:

mmcnittgray@mednet.ucla.edu

LEARNING OBJECTIVES

1) Describe the need for and benefits of implementing quantitative image analyses in clinical trials and clinical practice. 2) Understand the activities that RSNA supports to help move the profession of radiology from a primarily qualitative interpretation paradigm to a more quantitative-based interpretation model. 3) Describe the current status of the NCI's Quantitative Imaging Network and the nature and purpose of research efforts in this area. 4) Describe the role and potential of quantitative imaging in clinical trials and specific activities undertaken within some Clinical Trials Networks.

Sub-Events

RC125A The Perspective of the RSNA Quantitative Imaging Biomarker Alliance (QIBA)

Participants
Timothy J. Hall, PhD, Madison, WI (*Presenter*) Equipment support, Siemens AG; Technical support, Siemens AG; Researcher, F.K.A. Gammex RMI; Researcher, Sun Nuclear Corporation

LEARNING OBJECTIVES

1) Describe the need for and benefits of implementing quantitative image analyses in clinical trials and clinical practice. 2) Describe the key challenges of extracting uniform, standardized quantitative measures from clinical imaging scans. 3) Provide examples of approaches to resolving of these challenges. 4) Understand the activities that RSNA supports to help move the profession of radiology from a primarily qualitative interpretation paradigm to a more quantitative-based interpretation model.

RC125B NCI's Quantitative Imaging Network (QIN) Perspective

Participants
Robert J. Nordstrom, PhD, Rockville, MD (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

nordstrr@mail.nih.gov

LEARNING OBJECTIVES

1) The challenges of transitioning quantitative imaging tools from development verification to clinical validation. 2) How the Quantitative Imaging Network (QIN) benchmarks tools for clinical inclusion. 3) The joint roles QIN and QIBA will play in future quantitative imaging efforts.

RC125C Clinical Trials Perspective

Participants
Lawrence H. Schwartz, MD, New York, NY (*Presenter*) Nothing to Disclose

ED013-MO

Physics Monday Case of the Day

Monday, Dec. 2 7:00AM - 11:59PM Room: Case of Day, Learning Center

AMA PRA Category 1 Credit ™: .50

Participants

Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Christina Brunnquell, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Courtney K. Morrison, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Karen L. Brown, MPH, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Sparsh Gola, MD, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Robert Bujila, Stockholm, Sweden (*Abstract Co-Author*) Intern, General Electric Company
Christin Ekestubbe, Solna, Sweden (*Abstract Co-Author*) Nothing to Disclose
Nathan M. Cross, MD, MS, Seattle, WA (*Abstract Co-Author*) Consultant, Koninklijke Philips NV
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Canon Medical Systems Corporation; Consultant, Clementia Pharmaceuticals Inc
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
John A. Parker, MD, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Frederic H. Fahey, DSc, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

The physics case of the day questions and supplemental material will challenge the learner to combine their basic physics understanding with real clinical scenarios to explain a feature on an image.

Printed on: 10/29/20

RC221

Innovations in Cone-beam CT

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

CT PH

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

FDA Discussions may include off-label uses.

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

For information about this presentation, contact:

jeff.siewerdsen@jhu.edu

LEARNING OBJECTIVES

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

Sub-Events

RC221A Innovations in CBCT for Image-guided Interventions

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

RC221B Innovations in CBCT for Breast Imaging

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

For information about this presentation, contact:

z

LEARNING OBJECTIVES

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

RC221C Innovations in CBCT for Musculoskeletal/Orthopedic Imaging

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

For information about this presentation, contact:

wzbijewski@jhu.edu

LEARNING OBJECTIVES

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

RC222

Advanced PET Imaging for Radiotherapy Planning and Response Assessment

Monday, Dec. 2 8:30AM - 10:00AM Room: N229

BQ NM PH RO

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

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Moderator*) Research Grant, General Electric Company Co-founder, PET/X LLC

Sub-Events

RC222A State of the Art in PET Imaging

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Presenter*) Research Grant, General Electric Company Co-founder, PET/X LLC

LEARNING OBJECTIVES

1) Understand the connections between the capabilities of PET imaging and clinical and research uses. 2) Become familiar with recent technical advances in PET imaging and tradeoffs. 3) Gain awareness of initiative in quantitative imaging for clinical trials.

RC222B Technical Challenges in the Integration of PET Imaging into Radiotherapy Treatment Planning

Participants
Stephen R. Bowen, PhD, Seattle, WA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the differences between diagnostic and treatment planning PET/CT imaging technical requirements. 2) Become familiar with the source and propagation of technical errors in PET/CT-guided radiation therapy. 3) Gain awareness of technical design elements in PET/CT-guided radiation therapy clinical trials.

RC223

ACR Accreditation Updates I

Monday, Dec. 2 8:30AM - 10:00AM Room: S502AB

PH

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

Participants
James M. Kofler JR, PhD, Jacksonville, FL (*Coordinator*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn new and updated information for the ACR CT imaging accreditation program. 2) Become familiar with the requirements for the ACR MRI accreditation program. 3) Learn updated information on the ACR Nuclear Medicant and PET accreditation program.

Sub-Events

RC223A ACR CT Accreditation Update

Participants
Jessica Clements, MS, Los Angeles, CA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

jessicaclements@gmail.com

LEARNING OBJECTIVES

1) To understand the requirements of the ACR CT accreditation program, including updates to the QC manual and accreditation process.

Active Handout:Jessica Clements

http://abstract.rsna.org/uploads/2019/18001926/2019 Dec 2 RSNA ACR CT Update Handout.pdf

RC223B ACR MRI Accreditation Update

Participants
Donna M. Reeve, MS, Silverdale, WA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Provide an overview of the current ACR MRI and Breast MRI Accreditation Program requirements. 2) Present recent changes to the MRI programs and updates to guidance documents. 3) Present planned changes to both ACR MRI programs.

Active Handout:Donna M. Reeve

http://abstract.rsna.org/uploads/2019/18001927/Active RC223B.pdf

RC223C ACR Nuclear Medicine and PET Accreditation Update

Participants
Beth A. Harkness, MS, Detroit, MI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the requirements of the Nuclear Medicine and PET ACR accreditation programs. 2) Describe physics testing and QC requirements. 3) List common pitfalls in the accreditation process.

ABSTRACT

The ACR Nuclear Medicine (NM) and PET Accreditation program is a means of demonstrating that the department is performing quality imaging studies. The program itself evolves to address the current state of nuclear and PET imaging and comments from users. This presentation will review the current status of the physics requirements for this process.

Active Handout:Beth A. Harkness

http://abstract.rsna.org/uploads/2019/18001928/Active RC223C.pdf

Printed on: 10/29/20

RC225

Quantitative Imaging: Image Modality Specific Issues

Monday, Dec. 2 8:30AM - 10:00AM Room: S504AB

BQ PH

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

FDA Discussions may include off-label uses.

Participants

Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Coordinator*) Institutional research agreement, Siemens AG

For information about this presentation, contact:

mmcnittgray@mednet.ucla.edu

LEARNING OBJECTIVES

1) To learn about issues related to quantitative imaging that are specific to CT including image acquisition and reconstruction as well as QA processes. 2) To learn about issues related to quantitative imaging that are specific to PET/CT including image acquisition and reconstruction as well as QA processes. 3) To learn about issues related to quantitative imaging that are specific to DCE MRI including image acquisition and reconstruction as well as QA processes. 4) To understand the current limitations of each modality in quantitative imaging. 5) To understand the role of CT imaging as a biomarker for disease. 6) To describe applications of CT-based quantitative imaging in the clinical and research settings. 7) To appreciate the need for standardization in the extraction of quantitative features from CT scans. 8) To learn issues related to quantitative imaging in PET/CT in single and multi-center setting. 9) To learn about uncertainties related to PET/CT quantification. 10) To learn about ways to increase PET/CT quantification.

Sub-Events

RC225A Quantitative Imaging for Computed Tomography: Applications and Future Directions

Participants

Samuel G. Armato III, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

s-armato@uchicago.edu

LEARNING OBJECTIVES

1) To understand the role of CT imaging as a biomarker for disease. 2) To describe applications of CT-based quantitative imaging in the clinical and research settings. 3) To appreciate the need for standardization in the extraction of quantitative features from CT scans.

RC225B Quantitative Imaging for PET-CT: Applications and Future Directions

Participants

Robert Jeraj, PHD, Madison, WI (*Presenter*) Founder, AIQ Solutions

For information about this presentation, contact:

rjeraj@wisc.edu

LEARNING OBJECTIVES

1) To learn issues related to quantitative imaging in PET/CT in single and multi-center setting. 2) To learn about uncertainties related to PET/CT quantification. 3) To learn about ways to increase PET/CT quantification.

RC225C Quantitative Imaging for DCE-MRI: Applications and Future Directions

Participants

Yue Cao, PhD, Ann Arbor, MI (*Presenter*) Nothing to Disclose

ABSTRACT

1) To understand how to perform QA of acquisition and quantification processes of DCE MRI to derive physiological parameters 2) To understand how to apply quantitative DCE MRI in an adaptive therapy clinical trial 3) To understand how to perfrom real-time QA of quantitative DCE MRI in a clinical trial

RCC21

Core Cybersecurity for Imaging Departments and Imagers: Threats, Vulnerabilities and Best Practices

Monday, Dec. 2 8:30AM - 10:00AM Room: S404CD

IN PH

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

Participants
Christopher J. Roth, MD, Raleigh, NC (*Moderator*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the changing environment of network and internet connected devices and software. 2) Be aware of the motivations and tactics 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.

ABSTRACT

All imaging department devices are potential sites of risk for cybersecurity attack. Such attacks have compromised enterprise data security, modality function, patient health data, and ongoing patient care. This session will describe common insider and outsider threats, and highest yield steps for mitigation at small and large imaging sites.

Sub-Events

RCC21A Sounding the Alarm in Healthcare Cybersecurity: Escalating Threats to Patient Health

Participants
James Whitfill, MD, Scottsdale, AZ (*Presenter*) President, Lumetis LLC; Spouse, Shareholder, Radiology Partners

LEARNING OBJECTIVES

1) Understand the changing environment of network and internet connected devices and software. 2) Be aware of the motivations and tactics of current threat actors. 3) Understand common security issues found in medical devices. 4) Know simple actions that can decrease risk. 5) Understand the steps to implement a medical device security program.

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. There are simple steps to decrease your risk and ways, even with limited resources and skills, to start to evaluate medical devices at your institution.

RCC21B The Bare Minimum Cybersecurity Hygiene for Radiologists

Participants
Christopher J. Roth, MD, Raleigh, NC (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Appreciate the anatomy of a typical healthcare advanced persistent threat cyberattack. 2) Learn the underpinnings and impact of typical protections including anti-malware, multi-factor authentication, personal device managers, firewalls, encryption, password managers, URL and attachment screeners, popup blockers, physical data protections, and identity theft protection. 3) Understand high yield procurement, contingency planning, auditing, training, and hiring next steps. 4) Realize that health care entities will never be completely private or secure, and there is a balance of functionality, efficiency, and care process that must be understood against privacy and security protections.

RCC21C Knowing if Your Imaging Systems are Secure and Keeping Them That Way

Participants
J. Anthony Seibert, PhD, Sacramento, CA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Appreciate the evolving landscape of cyberthreats to healthcare and Radiology. 2) Understand the different targeting strategies used by cyber attackers. 3) Realize imaging system security weaknesses and everyone's responsibilities to keep systems safe.

SSC12

Physics (CT Radiation Dose)

Monday, Dec. 2 10:30AM - 12:00PM Room: S504AB

CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Kai Yang, PhD, Boston, MA (*Moderator*) Nothing to Disclose
Sarah E. McKenney, PhD, Stanford, CA (*Moderator*) Nothing to Disclose
Baojun Li, PhD, Iowa City, IA (*Moderator*) Research Grant, General Electric Company

Sub-Events

SSC12-01 Coronary Calcium Scoring Using Tin Filtration to Dramatically Reduce Radiation Dose

Monday, Dec. 2 10:30AM - 10:40AM Room: S504AB

Participants
Shengzhen Tao, Rochester, MN (*Presenter*) Nothing to Disclose
Emily Sheedy, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Michael R. Bruesewitz, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Nikkole Weber, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Eric E. Williamson, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shuai Leng, PHD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

Leng.Shuai@mayo.edu

PURPOSE

The purpose of this work is to evaluate the ability of tin (Sn) filtration to dramatically reduce radiation dose for CT calcium (Ca) scoring to dose levels comparable to a few chest x-rays.

METHOD AND MATERIALS

Chest phantoms emulating small/medium/large patients were scanned on a dual-source CT (Definition Force, VB10, Siemens). A piece of pork was placed at the center of the phantoms, which contained three cylindrical hydroxyapatite (HA) inserts (diameter/length = 5 mm, HA concentration = 200/400/800 mg/mL) emulating coronary calcifications. Phantoms were scanned at 100 kV and 600 mAs/rot using a Sn filter to remove low-energy photons that increase patient radiation dose but do not substantially contribute to image quality. The same phantoms were then scanned using a standard Ca scoring protocol at 120 kV, with mAs determined by a clinical technique chart designed for different patient sizes. Images were reconstructed using a specially designed reconstruction kernel (Sa36 kernel), which accounts for the different attenuation of Ca materials due to different x-ray spectra of Sn100 and 120 kV, and generates 120 kV-like images. The CT numbers of pork and a 200 mg/mL HA insert were measured, the Ca scores were calculated using commercial software, and the results compared between 120 kV and Sn100 kV scans.

RESULTS

Radiation dose was reduced from 2.3/6.8/14.3 at 120kV to 1.5/1.5/1.5 mGy at Sn100 kV for the small/medium/large phantoms, yielding a 34%/78%/90% dose reduction. CT numbers of soft tissue and HA measured from Sn100 kV images were consistent with those of the 120 kV images (max differences < 7/15 HU for tissue/Ca, respectively). Ca scores of HA inserts measured from Sn100 kV images were consistent with those of 120 kV images for the small/medium phantoms (max difference < 16). Larger differences (40-140) were observed for the large phantom.

CONCLUSION

Ca scoring using a Sn filtered x-ray beam was found to achieve 34-78% dose reduction compared to the standard 120 kV technique while yielding consistent Ca scores for small/medium patients. However, it may not be suitable for large patients due to considerable score elevation.

CLINICAL RELEVANCE/APPLICATION

The evaluated technique can reduce patient dose from coronary calcium screening to levels comparable to a few chest x-rays.

SSC12-02 Impact of Imaging Conditions on Localizer-Based Water Equivalent Diameter Estimation and on Dose Modulation

Monday, Dec. 2 10:40AM - 10:50AM Room: S504AB

Participants
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Canon Medical Systems Corporation; Consultant, Clementia Pharmaceuticals Inc
Xiujiang J. Rong, PhD, Houston, TX (*Presenter*) Nothing to Disclose
Xinhui Duan, PhD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Xinming Liu, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Alexander A. Bankier, MD, PhD, Boston, MA (*Abstract Co-Author*) Consultant, DAIICHI SANKYO Group
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Water equivalent diameter (WED) is a sound patient-size descriptor, and CTs use localizers to determine WED and to guide dose modulation. Localizer-based WED estimation requires a calibration to relate localizer pixel values to attenuation. We investigated how imaging conditions affect the WED calibration and dose modulation performance.

METHOD AND MATERIALS

We acquired localizer and axial images of ACR and body CTDI phantoms on 11 CT models from GE, Siemens, Philips, and Canon. We estimated calibration parameters (slope and intercept) by associating axial images with the corresponding localizer lines using custom built software. Experiments were conducted under combinations of kV, mA, orientation, and imaging kernel of localizer radiographs, and axial kV. In separate experiments, the ACR phantom and body CTDI phantom (iso-centered) were imaged together on table top. We repeatedly acquired 120kV-helical scans with dose modulation, after taking localizers at varied kV and mA levels, to examine their impact on dose modulation.

RESULTS

Calibration slope and intercept depends on localizer kV on all CTs. E.g., on a Canon A-One CT, slope changed from 1.47 to 1.64 for localizers from 80 to 135 kV. Using calibration of 120kV localizers, we simulated errors in WED estimation caused by using unmatched calibrations: WED from 80kV- ~ 135kV-localizers deviated from the truth by 1-5% for the body CTDI phantom and 1-7% for the ACR phantom. Localizer mA and directions have small impacts on calibrations and WED results. Calibration also depends on localizer kernels for Canon CTs. For the A-One, WED calibration slopes under Sharp- and STD-kernels were identical (diff. < 0.01%) but differed from the Soft-kernel slope by 55%. Using the Sharp-kernel calibration, WED from Soft-kernel localizers deviated from the truth by 35% for the CTDI phantom and 42% for the ACR phantom. Localizer kV affected dose modulation performance. On a GE CT750HD, comparing to the CTDIv (11.65 mGy) of a baseline condition (120kV-localizer), CTDIv from the same helical scans after 80kV-, 100kV-, 140kV-localizers were 12.43 (+7%), 11.98 (+3%), and 11.41 mGy (-2%). Localizer mA did not affect dose modulation.

CONCLUSION

Localizer kV and image kernels have stronger impacts on WED calibration and dose modulation than other factors.

CLINICAL RELEVANCE/APPLICATION

Using the same kV and image kernel for localizers may improve consistency of dose modulation and WED estimation.

SSC12-03 Protocol Optimization of Whole-Body Low-Dose CT in Patients with Multiple Myeloma: How Low is Too Low?

Monday, Dec. 2 10:50AM - 11:00AM Room: S504AB

Participants
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PURPOSE

To investigate the minimum radiation dose needed to perform a whole body low dose CT (WBLDCT) with a latest generation CT scanner while maintaining an optimal diagnostic accuracy for bone lesions detection.

METHOD AND MATERIALS

A preliminary image quality and patient dose assessment was retrospectively performed in 25 patients using a GE Revolution CT scanner, highlighting high subjective ranks and differenti reader's agreement in osteolitic lesions detection, with a median effective dose of 1.9 mSv. Base on the reference protocol (120 kV, noise index 25, slice thickness 1.25 mm, iterative ASIR-V 50%, collimation 80 mm, average CTDIvol of 2.3 mGy), an anthropomorphic whole body phantom (PIXY phantom) was repeatedly scanned varying the acquisition parameters with a relative CTDIvol range of 0.3 - 1.5 mGy. For each slice, a noise analysis was performed with means of an automatic segmentation tool and multiple ROI evaluations. Both noise and tube current profiles were compared along z axis in each acquisition. Some phantom details were identified as potential simulation of pathologic bone and assumed as reference for a subjective evaluation by three radiologists (5-point Likert scale). An optimized protocol was defined and employed primarily on 10 patients.

RESULTS

individual reader's scores showed stable high values with average of 4.8 up to a CTDIvol of 0.9 mGy. For the lower doses, significant lower average scores were observed (4.2 for CTDIvol of 0.5 mGy and 3.2 for CTDIvol of 0.3 mGy, $p<0.01$). The minimum CTDIvol without loss of diagnostic information was achieved with different combinations of exposure parameters, and among these, a maximum image quality rank was obtained with a scan performed with 140 kV and a percentage of ASIR-V of 80 %. The overall corresponding medians of automatic noise measurements for the phantom were 49 HU (range 22 - 67) with a sharp convolution kernel and 13 HU (range 7 - 21) with a standard kernel. Using the optimized protocol, the median effective dose for ten patients was estimated 0.7 mSv.

CONCLUSION

Routinary submillisievert WBLDCT can be performed on latest generation CT scanner with a proper balance between tube current modulation parameters and iterative reconstruction strength.

CLINICAL RELEVANCE/APPLICATION

Assessing the lowest achievable dose for WBLDCT with phantom studies and image quality metrics can be useful to optimize this imaging modality in accordance with the ALARA principle.

SSC12-06 The Presence of Contrast Agent Increases Absorbed Organ Radiation Dose in Contrast-Enhanced CT

Monday, Dec. 2 11:20AM - 11:30AM Room: S504AB

Participants
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PURPOSE

Although intravenous iodinated contrast agents are being used in 50 to 60 % of all computed tomography (CT) scans, their presence is not considered in patient dosimetry calculations. The aim of this study is to investigate the impact of contrast agent on absorbed radiation dose in the venous phase of abdominal CT scans.

METHOD AND MATERIALS

10 female and 10 male abdominal contrast-enhanced dual energy computed tomography (DECT) scans were retrospectively selected from our patient database. Organ and tissue doses were calculated by an ad-hoc Monte Carlo (MC) simulation model (ImpactMC) that was experimentally validated (accuracy<5.5%) for the scanner geometry (GE Revolution CT) and acquisition parameters including tube current, tube voltage, beam shape filter, and collimation were modeled. MC simulations were performed in the presence and in the absence of contrast agent using the contrast-enhanced and virtual-unenhanced dataset of DECT as patient models. The simulated dose volumes were segmented (3D slicer) to obtain the dose in the liver, liver parenchyma, left kidney, right kidney, aorta, and spleen. We calculated the relative dose increase due to contrast as (DI-D0)/D0 where DI is the dose in the presence of contrast agent and D0 is the dose in the absence of contrast agent. The iodine concentrations in the simulations were estimated using iodine content calculated by DECT.

RESULTS

The average iodine concentrations among 20 patients are 7.16 ± 1.51 mg I/ml for left kidney, 6.98 ± 1.58 mg I/ml for right kidney, 5.62 ±1.04 mg I/ml for aorta, 3.76 ± 1.03 mg I/ml for spleen, 3.22 ± 0.97 mg I/ml for liver, and 2.95 ± 0.87 mg I/ml for liver parenchyma. Compared to a non-contrast scan, the relative doses increase in the liver (21 ± 5 %), liver parenchyma (20± 5 %), aorta (34 ± 6 %), right kidney (37 ± 7 %), left kidney (39 ± 7 %) and spleen (26 ± 3 %).

CONCLUSION

In abdominal CT, organ radiation doses increase due to the presence of contrast agents. On average, doses increase by 29 %. The highest increase is observed in kidneys, then in aorta, spleen, liver, and lowest in liver parenchyma.

CLINICAL RELEVANCE/APPLICATION

The presence of contrast agents should be considered in patient dosimetry calculations.

SSC12-07 Paradoxical Increase in Eye Lens Dose When Using Automatic Exposure Control During Non-Contrast Head CT and Mitigation by Organ-Based Tube-Current Modulation

Monday, Dec. 2 11:30AM - 11:40AM Room: S504AB

Participants
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PURPOSE

In CT scanning, tube current modulation techniques aim to maintain image quality over a variable anatomy. We examined eye lens dose and image noise when activating a combination of automatic exposure control (AEC, current modulated based on anatomic attenuation measured on localizer) and organ-based tube-current modulation (OBTCM, current decreased over anterior portion of tube arc).

METHOD AND MATERIALS

We performed CT scans of an adult anthropomorphic head phantom on 2 scanners (SOMATOM Force and SOMATOM Definition AS+, Siemens Healthcare) using 4 acquisition modes: 1) fixed mAs; 2) AEC (CARE Dose 4D) only; 3) OBTCM (X-CARE) only; 4) and both AEC and OBTCM active. For both scanners, we used 2 protocols: 'trauma' with 310 and 'follow-up' with 250 effective mAs or quality reference mAs, as applicable. We maintained a constant kV of 120. For each of 6 replicates at each acquisition mode, we placed an optically stimulated luminescence (OSL) dosimeter in each orbit to measure absorbed dose. We averaged OSL doses at each mode to obtain generalized lens dose and characterized image noise (σ) from 4 ROIs placed at the level of the sella on subtraction images derived from consecutive scans with the least interscan motion. We used Student's t-test and distribution to test for significance and to calculate confidence intervals.

RESULTS

For the Force trauma, Force follow-up, AS+ trauma, and AS+ follow-up protocols, respectively, fixed current technique produced average lens doses of 35.8, 28.0, 32.1 and 25.5 mGy. As compared to the benchmark fixed technique, AEC alone paradoxically increased eye lens dose (+11%, +21%, +22%, +21%), while OBTCM decreased lens dose (-33%, -33%, -29%, -35%), and combining both techniques decreased lens dose (-21%, -21%, -21%, -20%). Every acquisition mode produced a significant change from the benchmark ($p<0.05$). Noise measurements revealed a roughly inverse linear relationship between σ and vdose (R2 = 0.88 and 0.72 for Force and AS+, respectively).

CONCLUSION

Compared to the standard fixed technique, activating AEC on non-contrast head CT paradoxically causes a significant increase in eye lens dose. Conversely, OBTCM with or without AEC significantly decreases lens dose.

CLINICAL RELEVANCE/APPLICATION

In designing non-contrast CT head protocols, use of AEC requires careful consideration because it may increase eye lens dose despite reducing overall dose. Adding OBTCM to AEC can mitigate this effect.

SSC12-08 kV Independent Coronary Calcium Scoring: A Phantom Evaluation of Score Accuracy and Potential Radiation Dose Reductions

Monday, Dec. 2 11:40AM - 11:50AM Room: S504AB

Participants
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PURPOSE

Because of the use of a fixed CT number threshold in the Agatston calcium (Ca) scoring method, and the dependence of CT numbers on photon energy, coronary Ca CT exams are required to be performed at a fixed tube potential (120kV). Here, we determine the accuracy of a kV-independent Ca scoring technique and its potential to reduce radiation dose by using tube potentials below 120kV.

METHOD AND MATERIALS

Three hydroxyapatite (HA) cylinders (5 mm diameter and length; 200, 400, 800 mg HA/mL) were inserted into a piece of pork and placed within anthropomorphic chest phantoms representing small, medium, and large adults. Phantoms were first scanned at 8 tube potentials (70-140kV) to compare CT numbers and Ca scores. Next, phantom scans were performed with automatic exposure control (AEC) and automatic kV selection (CareDose4D QRM=180/150/120/90mAs, CarekV setting = 4) to evaluate potential dose reduction. A dedicated reconstruction kernel (Sa36) was used to create 3-mm-thick 120kV-like images every 1.5 mm, from data acquired at other kVs, by appropriately scaling CT numbers above a soft tissue threshold. Phantoms were also scanned at 120kV using our clinical size-dependent mA chart. CT numbers were measured from images at different kVs, and Agatston scores calculated using commercial software.

RESULTS

Absolute CT number differences at different kVs (relative to 120kV) were small (tissue <4 HU; HA/Ca <5 HU for kV > 80 and < 18 HU for kV <= 80). The differences in Ca scores for kV >= 90 (relative to 120kV) were < 13.8 (8%) for 200/400 mg HA/mL, and < 22 (7%) for 800 mg HA/mL cylinders. The use of AEC and lower tube potentials reduced CTDIvol from 4.1/10.0/20.8 mGy (120kV, small/medium/large phantoms) to 2.1/4.4/5.6 mGy (for QRM=90mAs), yielding 48/56/73% reduction in CTDIvol and Ca score difference (for 400 mg HA/mL insert) < 13 (8%) in relative to 120 kV.

CONCLUSION

kV independent Ca scoring methods, coupled with AEC and lower tube potentials, provide a 48-73% reduction in CTDIvol and Ca scores that are consistent with those at 120 kV.

CLINICAL RELEVANCE/APPLICATION

The reported technique benefits patients undergoing coronary Ca scoring CT by considerably reducing radiation dose while maintaining accurate Ca scores.

SSC12-09 Exploring the Limits of Size-Specific Dose Estimates (SSDE) as an Estimate of Organ Dose from Routine Chest and Abdomen/Pelvis CT Examinations

Monday, Dec. 2 11:50AM - 12:00PM Room: S504AB

Participants
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PURPOSE

Size-Specific Dose Estimate (SSDE) adjusts scanner-reported CTDIvol to account for patient size and should be widely available on future scanners. While not intended to represent organ doses, the purpose of this work was to explore the ability of SSDE to provide a reasonable estimate of organ doses in routine chest and abdomen/pelvis exams across a wide range of patient sizes.

METHOD AND MATERIALS

Raw projection data and patient protocol pages for 133 routine chest (71 women, 62 men) and 82 routine abdomen/pelvis (40 women, 42 women) CT exams performed with tube current modulation (TCM) were gathered from two Siemens MDCT scanners (Sensation 64 and Definition AS64, Siemens Healthineers, Forchheim, Germany). Image data were reconstructed and were semi-automatically segmented to identify lung and glandular breast tissues in chest exams and liver, spleen, and kidneys in abdomen/pelvis exams. Segmented image data were used to create voxelized models of chest and abdomen/pelvis anatomy. TCM data was extracted from the raw projection data to describe the tube current values as a function of gantry angle and table location. Voxelized patient models and TCM data were incorporated into a validated Monte Carlo (MC) simulation engine to estimate absolute lung, breast, liver, spleen, and kidney dose using MDCT source models. Normalized lung (nDlung), breast (nDbreast), liver (nDliver), spleen (nDspleen), and kidney (nDkidney) doses were obtained by dividing respective absolute doses by the CTDIvol values from the patient protocol pages. SSDE values were acquired using AAPM Report 204 and the water equivalent diameter (Dw) from the image data. Normalized doses were then compared to SSDE f-factors.

RESULTS

The relative bias of nDlung, nDbreast, nDliver, nDspleen, and nDkidney to the SSDE f-factors was observed to be 17.4%, 35.4%, 16.2%, 17.9%, and 17.1%, respectively. SSDE overestimates organ dose in small and large patients.

CONCLUSION

SSDE may serve as a reasonable estimate lung, liver, spleen, and kidney dose across patient size within 20%, but may overestimate dose in small and large patients. For breast, SSDE may serve as a reasonable estimate within 36%.

CLINICAL RELEVANCE/APPLICATION

SSDE may provide reasonable estimates of organ dose for routine chest and abdomen/pelvis CT exams for most organs; however, estimates of breast dose may require wider tolerances.

SSC13

Physics (Breast X-Ray Imaging)

Monday, Dec. 2 10:30AM - 12:00PM Room: S503AB

BR PH

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

FDA Discussions may include off-label uses.

Participants
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Sub-Events

SSC13-01 Sensitivity of the New ACR QC Phantom for Detecting Degradations in DBT Systems

Monday, Dec. 2 10:30AM - 10:40AM Room: S503AB

Participants
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PURPOSE

Recently the FDA approved the use of the new ACR phantom for QC and to accredit DBT systems. Being new, the extent to which it can capture deficiencies in a 3D system is not well known. In this work we investigate how sensitive the new ACR phantom is to various DBT system degradations.

METHOD AND MATERIALS

Degradations were added to assess the impact on image quality: 1. Focal spot (FS) positioning error, and 2. Dose levels corresponding to 100%, 50%, and 25% of the AEC dose. For error in the FS positions, prior to reconstruction the x-ray angular position for each projection was perturbed by a Gaussian random value. Four levels of error were modeled: σ = 0.1°, 0.3°, 0.5°, and 1.0°. For each σ, five trials with different sets of projection data were created and reconstructed. Acquisitions were taken with both narrow- and wide-angle DBT geometries. The narrow-angle acquisition used 15 projections, a 15° span, and 700 mm SID. The wide-angle used 25 projections, a 46° span, and 655 mm SID. The system used a W/Rh tube at 29 kVp and an Anrad direct conversion detector with 85 µm pixel pitch. To determine the effects, images were evaluated by reader scoring and FWHM of z-axis resolution, according the new ACR QC Manual. Each fiber received 1 point each if the length was >= 8 mm and ½ point if 5-8 mm. Speck clusters each get 1 point if 4-6 specks were seen and ½ point for 2-3 specks. Masses received 1 point each if ¾ of the border was visible and ½ point if ½ - ¾ was visible. Passing required at least 2 points for fibers, 3 for speck groups, and 2 for masses. Z-resolution failed if the FWHM was greater than 30% of baseline (σ = 0°).

RESULTS

For both geometries, reader-averaged results show fiber scores passed until an angular error of σ = 1.0°, speck scores passed until an angular error of σ = 0.5°, and mass scores passed at all error levels. Scores failed at 50% AEC for the 15° geometry, but only show failure at 25% AEC for the 46° geometry. The z-resolution test was more sensitive and failed after σ = 0.1°, for both geometries.

CONCLUSION

In general the ACR phantom was only mildly sensitive to factors that might degrade clinical performance. In the future, we will investigate the impact of these failures on detectability of signals in an anthropomorphic breast phantom.

CLINICAL RELEVANCE/APPLICATION

To our knowledge, no work has been done to assess the utility of the ACR phantom in evaluating DBT systems.

SSC13-02 Comparison of Digital Mammograms, Breast Tomosynthesis and Synthetic Mammograms for Small Detail Detection: Phantom-Based Observer Performance Studies

Monday, Dec. 2 10:40AM - 10:50AM Room: S503AB

Participants
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PURPOSE

Compare small detail detectability in digital mammography (DM), digital breast tomosynthesis (DBT) and synthetic mammograms (SM) of 5 vendors using 2 phantoms: CDMAM (homogeneous background with gold discs) and L1 (structured background with calcification inserts).

METHOD AND MATERIALS

Phantom images were acquired for DM/DBT on Fujifilm Amulet Innovality ST, GE HC Senographe Pristina, Hologic Selenia Dimensions, IMS Giotto Class and Siemens Mammomat Revelation, with SM calculated from DBT. Automatic exposure control (AEC) dose levels for DM/DBT modes were respectively: 1.37mGy/1.93mGy; 1.33mGy/1.33mGy; 1.55mGy/2.02mGy; 1.20mGy/1.48mGy; 1.08mGy/2.09mGy. Twelve acquisitions were made at AEC/2, AEC and 2xAEC levels. Both phantoms were read manually, with CDMAM also read using CDCOM software, both using a 4-alternative forced choice method. Threshold gold thickness (Ttr) at 0.13 mm diameter for CDMAM and threshold calcification diameter (dtr) for L1 were defined from the 62.5% correct score. One-way analysis of variance was performed to test significant differences among dose levels/modalities.

RESULTS

For human reading of CDMAM at AEC dose, SM was inferior to DM/DBT. Ttr results for DM/DBT/SM were for Fuji: 0.59µm/0.70µm/1.02µm, GE: 0.61µm/1.10µm/1.27µm, Hologic; 0.71µm/1.09µm/1.19µm, Giotto: 1.17µm/1.30µm/1.65µm, and Siemens: 0.86µm/1.01µm/1.34µm. CDCOM results were within error bars of human results, however CDCOM failed for SM. For L1, dtr results for DM/DBT/SM at AEC dose were for Fuji: 0.118mm/0.117mm/0.118mm, GE: 0.108mm/0.114mm/0.136mm, Hologic: 0.109mm/0.112mm/0.129mm, Giotto: 0.131mm/0.121mm/0.141mm and Siemens: 0.114mm/0.122mm/0.149mm. SM was significantly poorer than DM/DBT for all vendors, all modalities, all doses, except for Fuji, where dtr was not significantly different at AEC dose. For Giotto, differences were only significant between SM and DBT/DM at high dose. dtr of DM and DBT was never significantly different. Dose had a significant impact on object detectability for both phantoms.

CONCLUSION

For all 5 vendors, better small detail scores were obtained for DM and DBT than for SM. Detectability improved as dose increased.

CLINICAL RELEVANCE/APPLICATION

SM, in its current stage of development for all 5 vendors, cannot be recommended as a stand-alone modality if the small detail detectability levels achieved in DM or DBT is required.

SSC13-03 Comparison of Digital Mammograms, Breast Tomosynthesis, and Synthetic Mammograms for Detection of Masses: An Observer Performance Study

Monday, Dec. 2 10:50AM - 11:00AM Room: S503AB

Participants
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PURPOSE

Compare detectability of masses in digital mammography (DM), digital breast tomosynthesis (DBT) and synthetic mammograms (SM) of 5 vendors with a 3D structured (L1) phantom with embedded mass-like lesions.

METHOD AND MATERIALS

L1 is a hemispherical shaped phantom filled with PMMA spheres and water plus nine 3D-printed lesions: 5 non spiculated (diameter 1.6mm to 6.2mm) and 4 spiculated masses (diameter 3.8mm to 9.7mm). DM, DBT and SM images were acquired on these systems: Fujifilm Amulet Innovality ST, GE HC Senographe Pristina, Hologic Selenia Dimensions, IMS Giotto Class and Siemens Mammomat Revelation. Three dose levels were studied (12 acquisitions at each level): automatic exposure control (AEC) level and manually set at AEC/2 and 2xAEC. A 4-alternative forced choice reading paradigm was used. Threshold diameter to reach a 62.5% correct score was evaluated (dtr). One-way analysis of variance was performed to test for significant differences among dose levels/modalities.

RESULTS

For GE, Giotto and Siemens, DBT performed significantly better than SM, while SM showed no difference with DM. For Fuji and Hologic, there was no significant difference between DBT and SM, while DM was inferior to DBT and SM. The dtr values for non-spiculated masses for DM/DBT/SM at AEC dose, were respectively: Fuji: 4.21mm/2.12mm/2.89mm; GE: 4.87mm/2.15mm/4.21mm; Hologic: 7.21mm/1.87mm/3.28mm; Giotto: 4.96mm/2.37mm/4.30mm; Siemens: 4.44mm/2.22mm/4.64mm and for spiculated masses: Fuji: 6.65mm/2.58mm/3.66mm; GE: 4.27mm/2.04mm/3.55mm; Hologic: 5.04mm/2.54mm/3.68mm; Giotto: 4.97mm/2.37mm/4.30mm; Siemens: 5.6mm/2.99mm/4.67mm. Dose did not impact detection of both mass types for GE and Hologic. For Fuji, Giotto and Siemens DBT, decreasing the dose lead to a significantly inferior dtr for spiculated masses and in the case of Fuji and Siemens also for non-spiculated masses.

CONCLUSION

Detectability of mass-like lesions was higher in DBT compared to DM and SM, except for Fuji and Hologic, where SM was not different from DBT. Increasing dose only influenced mass detection in DBT. The L1 phantom demonstrated the superiority of DBT compared to DM for mass detection, for all 5 systems.

CLINICAL RELEVANCE/APPLICATION

For most vendors, SM, in its current stage of development, cannot be recommended as a stand-alone modality if equal mass detectability as in DBT is required.

SSC13-04 Accurate Local Estimation of Compressed Breast Thickness in Digital Breast Tomosynthesis Using an Iterative Reconstruction Approach

Monday, Dec. 2 11:00AM - 11:10AM Room: S503AB

Participants
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PURPOSE

Our purpose is to describe invasive breast cancer in terms of lipid, water, and protein content using dual-energy tomosynthesis. Previous work for full-field digital mammography required an in-image calibration phantom adhered to the compression paddle to describe thickness, tilt, and warp. We show these parameters can be estimated by using an iterative reconstruction approach on the sinograms resulting in a model of the breast characteristics including local breast thickness, compression paddle tilt, and warp.

METHOD AND MATERIALS

Virtual breast objects (VBO) of known geometries, defined using only five unique parameters (thickness, width, density, warp, and tilt), were constructed in simulation with MATLAB and their corresponding sinograms generated. Breast thicknesses from 1 to 80 mm and chest wall to nipple distances from 1 to 200 mm were generated to sample the space. Single coronal sinograms for training and validation sets of 9600 and 1920 VBO's, respectively, were constructed. Principal component analysis (PCA) was used to generate a model which explains the relationship between the five parameters and the sinograms. Clinical DICOM header thicknesses in 24 tomosynthesis exams were also compared to the local model estimates.

RESULTS

We found that 25 PCA components explained greater than 99% of model variance. A comparison between iterative reconstructed models and phantom measures is ongoing. A mean thickness difference (DICOM - model) of 24 breasts was found to be 2.80 mm (SD = 2.95 mm, Min/Max=-12/11 mm). The PCA model captured the local thickness decline from the chest wall to the nipple.

CONCLUSION

We demonstrate a method to capture local breast thickness using an iterative reconstruction method in the sinogram space. The model was able to describe paddle warp and tilt. Phantom calibration of the model is ongoing and accurate local breast thicknesses were seen when compared to DICOM values in clinical images. This method can be implemented on commercial tomosynthesis systems without modification. Future studies will utilize these thickness measures with dual-energy tomosynthesis to create voxels lipid, water, and protein contents instead of greyscale values alone.

CLINICAL RELEVANCE/APPLICATION

Accurate and local breast thickness measures enable lesions to be characterized by their lipid, water, and protein content through a dual-energy 3-compartment model while still in situ to better assess malignancy status.

SSC13-05 Deep Learning-Driven Sparse-View Reconstruction for Radiation Dose Reduction in Dedicated Breast CT: Quantitative Evaluation

Monday, Dec. 2 11:10AM - 11:20AM Room: S503AB

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PURPOSE

To objectively quantify and demonstrate the feasibility of deep learning-driven reconstruction for sparse-view dedicated breast CT (BCT) to reduce radiation dose and to identify the best method for reader study.

METHOD AND MATERIALS

Projection datasets (300 views, full-scan; 12.6 mGy MGD) from 137 BIRADS 4/5 women who underwent BCT prior to biopsy were reconstructed using FDK algorithm (0.273 mm isotropic voxels) and served as reference. Sparse-view (100 views, full-scan; 4.2 mGy median MGD) projection data were reconstructed using FDK algorithm (0.273 mm isotropic voxels) and three variants of multiscale CNN (ResNet) architecture (individual 2D slices, "ResNet2D"; 5 contiguous 2D slices, "ResNet2.5D"; and, residual dense network with 5 contiguous 2D slices, "ResDenseNet2.5D") were used to train the network with sparse-view and reference FDK reconstructions as input and label, respectively. Each network used 2000/900/900 slices from 20/5/5 breasts for training/validation/testing. Once trained, 42868 slices from the remaining 107 breasts were used to quantify normalized mean-squared error (NMSE), bias and absolute bias, all with respect to the reference, and the standard deviation for all reconstructions.

RESULTS

All 3 deep learning methods suppressed streak artifacts and showed significantly reduced NMSE, bias and absolute bias compared to FDK reconstruction (p<0.001). The NMSE (mean+/-SD, log scale) was significantly lower for ResDenseNet2.5D (-2.59+/-0.27; p<0.001). The bias was lowest for ResNet2.5D (-3.05E-5+/-3.05E-4; p<0.001). The absolute bias was lowest for ResDenseNet2.5D (9.05E-4+/-3.51E-4; p<0.001). The standard deviation for each deep learning sparse-view reconstruction was lower than the reference 300-view FDK reconstruction as the CNN learns from the ensemble of breasts. The standard deviation in ResNet2.5D was lowest (3.67E-3+/-1.38E-3; p<0.001).

CONCLUSION

Quantitatively, ResNet architectures using multiple contiguous slices performed better than that using individual slices. Deep learning-driven sparse-view reconstruction for radiation dose reduction is feasible and needs to be investigated.

CLINICAL RELEVANCE/APPLICATION

Deep learning-driven sparse-view reconstruction can potentially enable radiation dose reduction in breast CT to a level that may be suitable for breast cancer screening.

SSC13-06 Measurements of Resolution in Digital Breast Tomography (DBT) Using a Tomosynthesis Phantom, Special Emphasis on Detecting Calcified Specks

Monday, Dec. 2 11:20AM - 11:30AM Room: S503AB

Participants
David J. Goodenough, PhD, Washington, DC (*Abstract Co-Author*) Consultant, The Phantom Laboratory
Joshua Levy, Salem, NY (*Presenter*) Stockholder, The Phantom Laboratory President, The Phantom Laboratory Stockholder, Image Owl, Inc

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PURPOSE

Investigate measurements of resolution in DBT using a Tomosynthesis Phantom with emphasis on meaning and interpretation of "MTF". The limitations of calcified speck detection in DBT depending on where the speck might occur.

METHOD AND MATERIALS

Tomosynthesis Phantom is used for testing DBT. Small beads (0.09mm radius) are used as both "point sources" and elements along slice width ramps for slice geometry and scan slice incrementation (z). This study examines the use of this PSF when located at intra and inter slice positions. PSF bead, and the scan slice geometry bead ramps isolate where any given bead is located (intra and inter) within the phantom and the slice. Spatial distribution of the (bead) PSF can be examined at a given position. A summation of data from neighboring beads shows study change in PSF increases the z axis slice width. FWHM of the PSF, and Fourier Transform (FT) of the PSF yielding an "MTF" type function, and corresponding Modulation levels. Nine identical DBT images taken on a DBT Tomosynthesis system and the data analyzed from both individual beads as well as combined beads examining highest resolution and average resolution within the slice. A theoretical model of PSF shows PSF tends to move from a typical function at the isocenter of the slice, annular shapes as one moves off center. Annular shapes simulated by combination of Bessel functions.

RESULTS

PSF and "MTF" results show changes in positioning of the bead (calcified speck). Results may have important implications to understanding resolution limitations to finding small calcified specks depending on where in the slice the spec occurs. Result within the slice is different than the best-case result within the slice. High contrast object extends along the z axis, then the average result will better reflect spatial resolution.

CONCLUSION

It is possible to examine the changes in Point Spread Function and "MTF" by using small bead, point sources. It is shown that understanding the resolution differences of location of such specks will depend on inter and intra slice locations. The "MTF" can be used to study this effect.

CLINICAL RELEVANCE/APPLICATION

DBT phantom using small beads to study resolution in DBT systems results help the clinician understand the process of limited angle tomography degrades the highest resolution of a calcified speck location to the more average resolution a bead/speck at some random position in the slice.

SSC13-07 Contrast-Enhanced Spectral Mammography with a Compact Synchrotron X-Ray Source

Monday, Dec. 2 11:30AM - 11:40AM Room: S503AB

Participants
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PURPOSE

Contrast-enhanced spectral mammography (CESM) based on K-edge subtraction (KES) helps to identify uncertain findings in standard mammography. As CESM requires two acquisitions, dose reduction is a crucial issue. Here, two dual-energy dose-compatible CESM approaches are evaluated with a compact synchrotron X-ray source.

METHOD AND MATERIALS

In this study, the commonly used dual-energy KES imaging technique and a two-material decomposition method were used to implement CESM at a quasi-monochromatic compact synchrotron X-ray source. For a better evaluation of the laboratory results, clinical CESM images were also performed. Low-energy attenuation-based images as well as images only showing the contrast agent iodine were acquired with a mammographic accreditation phantom for both the clinical and the laboratory measurements. The phantom has been modified with a tube filled with iodine in a concentration of 6 mg/ml to mimic the contrast agent.

RESULTS

Confirmed by a higher contrast-to-noise ratio (CNR) and spatial resolution, improved image quality has been accomplished with both aforementioned methods carried out in the laboratory for the iodine images while the spectral approach achieved even better results than the KES imaging technique. Exemplarily, we demonstrate the reduction of the applied dose by up to 66% compared to the clinically applied dose. Additionally, the image quality of the laboratory results of the low-energy images - which are comparable to conventional mammography images - also increases compared to the clinical examinations.

CONCLUSION

Our findings regarding the CNR and the spatial resolution suggest the great potential of novel quasi-monochromatic X-ray sources in combination with a two-material decomposition method as a means to improve the diagnostic quality and to reduce the applied dose in clinical examinations. Our results show a significant increase in image quality at the same radiation dose or a significantly reduced dose level required to obtain the same image quality as in the clinical system.

CLINICAL RELEVANCE/APPLICATION

The reduction of radiation dose in mammography, especially for second-level examinations, is a crucial citeria for the improvement of its clinical diagnostic quality.

SSC13-08 Comparison Between Vendor Reported and Physicist Calculated Doses Within a Quality Control Program for a Tomosynthesis Mammography Screening Trial: Interim Results

Monday, Dec. 2 11:40AM - 11:50AM Room: S503AB

Participants
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Sam Zhongmin Shen, MS, Toronto, ON (*Abstract Co-Author*) Research agreement, General Electric Company
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Martin J. Yaffe, PhD, Toronto, ON (*Abstract Co-Author*) Research collaboration, General Electric Company Shareholder, Volpara Health Technologies Limited Co-founder, Mammographic Physics Inc Research Consultant, BHR Pharma LLC

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PURPOSE

We are overseeing the quality control (QC) for a screening trial comparing tomosynthesis (DBT) and 2D mammography. The QC involves weekly, monthly and annual tests. We also collect doses and technique factors used for patient imaging. To understand the reliability of the doses recorded in the DICOM image headers, we are comparing mean glandular dose (MGD_calc) calculated using physicists' measurements of half value layer (HVL) and tube output with those reported in the headers for scans of phantoms (MGD_hdr).

METHOD AND MATERIALS

A set of phantoms is circulated annually among the participating sites and imaged with the DBT mode used for patients. Slabs of PMMA 2, 4, 6 and 8 cm thick, with 0, 0.5, 1.5 and 2.3 cm spacers are used. mR/mAs and HVL values are obtained from the physicist's surveys and used with the imaging technique factors to estimate the MGD_calc using the Dance et al method. Corrections are made for spectrum, fraction of glandular tissue and DBT geometry, as parameterized by Li et al. The dose percent difference (DPD) is calculated as 100x(MGD_hdr-MGD_calc)/MGD_calc . Comparisons of DPDs were made between DBT systems, dosimeter manufacturers and phantom thicknesses.

RESULTS

To date 45 surveys on 4 models from 2 vendors have been conducted. Dosimeters from 4 different manufacturers were used. The doses match best for the 4.5 cm thickness with a DPD of 2.1% (95% CI -1% to +5%). The mismatch is greatest at 22% for 2 cm (95% CI 12% to 25%). The average DPD is larger for one of the dosimeter manufacturers, suggesting a bias with that technology. Differing trends were noted in the size of the DPD vs phantom thickness when separating out by DBT model. QC testing is ongoing and updated data will be available at RSNA.

CONCLUSION

Systematic discrepancies between displayed and calculated doses at different thickness suggest that different dose calculation models and assumptions may be used by the various DBT systems. Care must be taken in drawing conclusions about dose estimates to a population when relying on the figures reported in the DICOM headers. In addition, different biases may be present in the different meters used to measure entrance exposure and HVL, further confounding the assssment of dose.

CLINICAL RELEVANCE/APPLICATION

Differences in assumptions used to calculate dose existing between tomosynthesis mammography systems and in beam quality values mean care must be taken when comparing reported and calculated doses.

SSC13-09 Automatic Exposure Control Intelligence in Digital Mammography for a Diagnostic and Post-Therapy Patient Population

Monday, Dec. 2 11:50AM - 12:00PM Room: S503AB

Participants
Lesley Cockmartin, Leuven, Belgium (*Presenter*) Nothing to Disclose
Stoyko Marinov, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Joke Binst, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Nicholas Marshall, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

Automatic exposure control (AEC) systems are designed to find the most attenuating region and adjust the exposure parameters so this region is imaged at some predefined dose/quality level. This study quantifies the success rate of the AEC in selecting the densest breast tissue in diagnostic and post-therapy patient populations.

METHOD AND MATERIALS

A total of 615 successive mammograms were collected from a GEHC PristinaTM system. The AEC-selected region was placed in one of three categories a) AEC region within the densest breast tissue (considered "optimal") b) region located in pectoral muscle and c) clips present inside the region. Second, the images were divided into 1x1 mm^2 areas and mean volumetric breast density (VBD) estimated for each area using VolparaTM. Third, images where the difference between maximum VBD within the AEC region and other parts of the breast was >15% were retrieved and visually scored for the presence of disturbing noise.

RESULTS

In 84% of all mammograms the AEC selected the optimal region. In 5% of all mammograms the AEC selection missed the densest breast part, but only 3.7% resulted in differences in VBD >15%. Visual inspection of these images did not show excessive noise. In 6% of all mammograms, the AEC region was positioned in the pectoral muscle, where the correct selection should have been in the breast tissue. The mean, minimum and maximum difference in pixel values between the pectoral muscle and the densest breast tissue was 5%, -15% and 29%. In 32% of these cases a larger than targeted dose compared to breast tissue selection was given, being on average 6%. Finally, 179 mammograms (29%) contained clips. In 32 images (5% of all mammograms), the AEC selected a region that included the clips, but in 28 of these images the signal due to the clip was excluded when determining the exposure settings.

CONCLUSION

Automatic exposure control selection within mammograms of breasts with lesions, clips etc. is a challenging task. Region selection by the GEHC PristinaTM AEC is intelligent and overcomes the current challenges via segmentation techniques and local density calculations.

CLINICAL RELEVANCE/APPLICATION

The selection of the automatic exposure control region and subsequent dose level adjustment is a key parameter in the radiation dose/quality balance and should be optimized for all breast types.

PHS-MOA

Physics Monday Poster Discussions

Monday, Dec. 2 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Jaydev K. Dave, PHD, Philadelphia, PA (*Moderator*) Research Grant, Koninklijke Philips NV Equipment support, Lantheus Medical Imaging, Inc Equipment support, General Electric Company

Sub-Events

PH230-SD-MOA1 Advanced Reconstructions Outperform Respect to Traditional Iterative Reconstructions in State-of-the-Art Non-Digital PET/CT Scanners

Station #1

Participants
Roberta Matheoud, Novara, Italy (*Abstract Co-Author*) Nothing to Disclose
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Adriano De Maggi, Cuneo , Italy (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

The aim of this work was to describe the impact of advanced reconstruction techniques of resolution and noise modelling on the image quality of current TOF and non-TOF state-of-the-art non -digital PET/CT scanners (GE Disc. IQ, GE Disc. 710, Siemens mCT flow, Phlips Ingenuity TF).

METHOD AND MATERIALS

A cylindrical 68Ge phantom was used (Ecklert&Ziegler, Valencia, California). The activity concentrations of the radioactive epoxy was measured with a radionuclide calibrator tested against a NIST traceable source and were respectively 11.21 kBq/ml and 39.71 kBq/ml at reference time. Nominal Sphere to Background Ratio (SBR) was 3.54. Seven spheres with nominal internal diameters (ID) of 6, 10, 13, 17, 22, 28, 37 mm were placed in the uniform background region. Acquisition time was adjusted according to the age of the phantom to meet 1.5 min per frame and reconstructed with variable reconstruction parameters (iterations, subset, Gaussian filter) with traditional (OSEM) and by combining advanced modalities, when present: PSF, TOF, TOF+PSF, NSM. Recovery Coefficient (RC) was calculated as the ratio of maximum activity concentration in each sphere respect to maximum activity concentration in the larger (ID=37mm) sphere.

RESULTS

For each reconstructed modality and PET/CT scanner, RC were averaged on different reconstruction parameters for increasing sphere ID. OSEM: IQ 0.34 0.47 0.65 0.78 0.89 0.92 1.00; 710 0.30 0.56 0.64 0.84 0.91 0.93 1.00; mCT 0.31 0.49 0.59 0.84 0.86 1.00 1.00. TOF: 710 0.31 0.61 0.69 0.82 0.91 0.94 1.00; mCT 0.32 0.50 0.59 0.86 0.91 1.00 1.00; Ing 0.32 0.45 0.69 0.88 1.04 1.00 1.00. PSF: IQ 0.31 0.47 0.68 0.84 0.91 0.92 1.00; 710 0.29 0.54 0.67 0.91 0.95 0.95 1.00; mCT 0.30 0.48 0.59 0.90 0.91 0.99 1.00. TOF+PSF: 710 0.29 0.61 0.77 0.90 0.94 0.94 1.00; mCT 0.31 0.50 0.62 0.93 0.94 0.99 1.00; Ing 0.30 0.43 0.69 0.90 1.08 1.04 1.00. NMS IQ 0.32 0.46 0.69 0.89 0.95 0.92 1.00; 710 0.29 0.82 0.97 0.94 0.98 1.03 1.00

CONCLUSION

The RC obtained with the four state-of-the-art non-digital PET/CT scanners demonstrate that modern PET/CT scanner outperforms respect to older ones. Higher differences are recorded for smaller spheres. Applying more advanced reconstruction techniques progressively enhances RC, NSM reconstruction being the most promising algorithm.

CLINICAL RELEVANCE/APPLICATION

Advanced reconstructions outperform respect to traditional iterative reconstructions in state-of-the-art non-digital PET/CT scanners

PH229-SD-MOA2 Impact of Imaging Conditions on Localizer-Based Water Equivalent Diameter Estimation and on Dose Modulation

Station #2

Participants
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PURPOSE

Water equivalent diameter (WED) is a sound patient-size descriptor, and CTs use localizers to determine WED and to guide dose modulation. Localizer-based WED estimation requires a calibration to relate localizer pixel values to attenuation. We investigated how imaging conditions affect the WED calibration and dose modulation performance.

METHOD AND MATERIALS

We acquired localizer and axial images of ACR and body CTDI phantoms on 11 CT models from GE, Siemens, Philips, and Canon. We estimated calibration parameters (slope and intercept) by associating axial images with the corresponding localizer lines using custom built software. Experiments were conducted under combinations of kV, mA, orientation, and imaging kernel of localizer radiographs, and axial kV. In separate experiments, the ACR phantom and body CTDI phantom (iso-centered) were imaged together on table top. We repeatedly acquired 120kV-helical scans with dose modulation, after taking localizers at varied kV and mA levels, to examine their impact on dose modulation.

RESULTS

Calibration slope and intercept depends on localizer kV on all CTs. E.g., on a Canon A-One CT, slope changed from 1.47 to 1.64 for localizers from 80 to 135 kV. Using calibration of 120kV localizers, we simulated errors in WED estimation caused by using unmatched calibrations: WED from 80kV- ~ 135kV-localizers deviated from the truth by 1-5% for the body CTDI phantom and 1-7% for the ACR phantom. Localizer mA and directions have small impacts on calibrations and WED results. Calibration also depends on localizer kernels for Canon CTs. For the A-One, WED calibration slopes under Sharp- and STD-kernels were identical (diff. < 0.01%) but differed from the Soft-kernel slope by 55%. Using the Sharp-kernel calibration, WED from Soft-kernel localizers deviated from the truth by 35% for the CTDI phantom and 42% for the ACR phantom. Localizer kV affected dose modulation performance. On a GE CT750HD, comparing to the CTDIv (11.65 mGy) of a baseline condition (120kV-localizer), CTDIv from the same helical scans after 80kV-, 100kV-, 140kV-localizers were 12.43 (+7%), 11.98 (+3%), and 11.41 mGy (-2%). Localizer mA did not affect dose modulation.

CONCLUSION

Localizer kV and image kernels have stronger impacts on WED calibration and dose modulation than other factors.

CLINICAL RELEVANCE/APPLICATION

Using the same kV and image kernel for localizers may improve consistency of dose modulation and WED estimation.

PH226-SD-MOA3 The Optimal Scanner Settings for Clinical CEUS Imaging with High-Frequency Transducers

Station #3

Participants
MacIej Piskunowicz, MD, PhD, Gdansk, Poland (*Presenter*) Nothing to Disclose
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Laura Poznick, BA, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Elizabeth Silvestro, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Misun Hwang, MD, Ellicott City, MD (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Nowadays more and more of contrast-enhanced ultrasound (CEUS) examination is performed with linear probes. However, CEUS image quality often is suboptimal mainly due to the insufficiency of the signal from microbubbles. We can increase the quantity and quality of the signal coming back to the probe by increasing the volume of ultrasound contrast agent (UCA) or by improving the response from bubbles by increasing mechanical index (MI). The objective of this study was to determine the optimal level of MI for linear probes to obtain the best signal to noise ratio and improve the imaging quality and to avoid extensive destruction of UCA microbubbles.

METHOD AND MATERIALS

For purposes of this in vitro study, a phantom model was built. The small chamber in size 5'x7'x3' was made from acrylic sheets and filled up by the polysiloxane. At a depth of 1.2' under polysiloxane, a 'vessel' was created with a 0.23' mm diameter. The vessel was connected to a small mixing chamber filled with normal saline and then to cyclic flow pump as a circuit to maintain flow through the system. For this study, we used ultrasound systems and probes of two different manufacturers (GE, Philips). For the study, 0.1 ml of SonoVue™/Lumason™ was added to the normal saline in the mixing chamber. The transducer was placed on the ultrasound phantom on the surface to visualize the vessel. Once the UCA was visualized within the vessel, measurements were taken for different MI values beginning from 0.06 up to 0.24 as well as for at least two different presets of frequencies available for each transducer. The microbubbles intensity over time was measured for each transducer and frequency.

RESULTS

The examples of results are presented for GE ultrasound system Logiq e9 (probe 9L and C2-9 for general and high resolution presets). The form of presentation of the results are figures and tables. Placing the remaining figures and tables in the abstract exceeds the possibilities of abstract content.

CONCLUSION

Increasing MI to the range 0.12-0.16 improves the intensity of the signal obtained from the linear and convex transducers without increasing the noise and extensive destruction of UCA. The increment in signal is more appreciable for the medium frequencies than for high frequencies.

CLINICAL RELEVANCE/APPLICATION

For CEUS examinations we found the MI of 0.12-0.16 to be optimal in the signal and the imaging quality which is well below the safety limit.

PH228-SD-MOA5 Task Based MTF Comparison Between a New Deep Learning Based CT Reconstruction and Current Iterative Methods

Station #5

Participants
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Brian E. Nett, PhD, Wauwatosa, WI (*Abstract Co-Author*) Employee, General Electric Company
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PURPOSE

With filtered back projected image reconstruction, spatial resolution performance is not dependent on image contrast or noise/dose. Existing iterative methods have been shown to produce spatial resolution that is dependent on image contrast or noise/dose. Here, we characterize the contrast and dose dependence of TrueFidelity (GE Healthcare), a new deep learning image reconstruction (DLIR) approach.

METHOD AND MATERIALS

We imaged the CT number insert region of an ACR CT Accreditation phantom 5 times at 0.625 mm slice thickness. We imaged at dose levels of 16, 8, and 4 mGy using 120 kV, 80 mm collimation, and 0.992:1 pitch. Images were reconstructed using 6 methods: filtered back projection (FBP), two levels of a statistical iterative reconstruction (ASiR-V), and three levels of the vendor's new deep learning (DLIR) approach. The ASiR-V level was chosen based on a vendor recommendation (AR50, 50%). The tasked based modulation transfer function (MTF task) methodology was used to obtain contrast dependent spatial resolution for air, polyethylene, bone, and acrylic.

RESULTS

The 50% and 10% MTF task values for all DLIR strengths were all comparable to FBP and all ASiR-V levels. The 10% MTF task at 8 mGy for FBP was 0.69/0.65/0.65/0.66 for poly/air/acrylic/bone respectively. The 10% MTF task at 8 mGy for 50% ASiR-V was 0.7/0.65/0.68/0.66 for poly/air/acrylic/bone respectively. The 10% MTF task at 8 mGy for medium strength DLIR was 0.71/0.69/0.69/0.69 for poly/air/acrylic/bone respectively. All reconstruction methods showed a decreased performance, as expected, when the focal spot switched from medium to large between the 8/4 and 16 mGy levels respectively.

CONCLUSION

ASiR-V and TrueFidelity DLIR do not exhibit contrast or dose dependent spatial resolution as do some other advanced model based methods.

CLINICAL RELEVANCE/APPLICATION

Unlike other advanced CT algorithms, this deep learning method did not exhibit contrast or noise/dose dependencies with respect to spatial resolution.

PH130-ED-MOA6 Oncological Applications of Diffusion Kurtosis in the Genitourinary System: How, When, and Why?

Station #6

Participants
Lidia Alcala, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Juan A. Retamero, MD,MSc, Granada, Spain (*Presenter*) Nothing to Disclose
Teodoro M. Noguerol, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
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Antonio Luna, MD,PhD, Jaen, Spain (*Abstract Co-Author*) Speaker, Canon Medical Systems Corporation; Speaker, Koninklijke Philips NV; Speaker, Siemens AG

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TEACHING POINTS

Describe the physical basis and technical adjustments of diffusion Kurtosis Review the clinical applications of Diffusion Kurtosis in the assessment of focal lesions of the genitourinary system Highlight the added value of diffusion kurtosis to clinical MRI protocol in genitourinary imaging

TABLE OF CONTENTS/OUTLINE

1. Introduction 2.Definition of Diffusion Kurtosis 3. Technical adjustments 3. Advanced modeling of diffusion signal decay 4. Clinical applications of Kurtosis in the genitourinary system - Renal masses - Endometrial adenocarcinoma and other uterine masses - Cervical carcinoma - Ovarian lesions - Bladder carcinoma 5. Conclusions

PH129-ED-MOA7 MR Image Artifacts: RF Coil Related or Not?

Station #7

Participants
Wing-Chi E. Kwok, PhD, Rochester, NY (*Presenter*) Nothing to Disclose

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TEACHING POINTS

Image artifacts related to RF coils can affect the diagnostic evaluation of MRI and may indicate patient safety risk if they are caused by coil malfunction, and so it is important to correctly identify them. However, there are other image artifacts that may sometimes be mistaken to be related to RF coils. The aims of this presentation are to: (1) learn about image artifacts that are related to RF coils and artifacts that resemble them, (2) learn how to quickly distinguish these two types of artifacts, (3) learn the mitigations when those image artifacts appear, and (4) improve workflow, image quality and patient safety as a result.

TABLE OF CONTENTS/OUTLINE

This presentation will cover: (1) artifacts caused by RF coil malfunctions, including signal detection failure and RF decoupling failure, (2) artifacts related to the use of RF coils, such as poor coil connection to scanner, parallel imaging and artifacts from signal uniformity correction, (3) artifacts that may appear to be RF coil related but actually are not, such as fat suppression failure, RF interference and motion artifact. The presentation will show examples of the above artifacts, and discuss how they may affect image quality, image interpretation and patient safety. It will also discuss how to distinguish coil-related artifacts from unrelated ones and ways to mitigate the artifact problems.

PH131-ED-MOA8 Ultra-High Field (7T) Two-Dimensional Correlation Spectroscopy to Study Brain Tumors

Station #8

Participants
Sanjeev Chawla, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Gaurav Verma, PhD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Suyash Mohan, MD, Philadelphia, PA (*Presenter*) Grant, NovoCure Ltd Grant, Galileo CDS, Inc
Sumei Wang, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Laurie A. Loevner, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
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TEACHING POINTS

The purpose of this exhibit is: 1. To overview the limitations of conventional one-dimensional (1D) proton MR spectroscopy methods 2. To understand the need and importance of two-dimensional correlation spectroscopy (2D-COSY) sequence 3. Present the salient features of 2D-COSY sequence 4. To discuss the potential utility of 2D-COSY in characterization of brain tumors

TABLE OF CONTENTS/OUTLINE

1. Basic Principle of 2D-COSY • Description of pulse sequence • Concepts of J-modulation • Coherence transfer 2. Benefits and challenges of ultra-high field (7T) MR system for proton MR spectroscopy • Signal to noise ratio • Chemical shift dispersion • Bo and B1 field inhomogeneity • Magnetic susceptibility effects • SAR issues 3. Implementation of 2D-COSY on 7T • Phantom studies • Post-processing of 2D-COSY spectra 4. Assessment of reproducibility and reliability of 2D-COSY on normal human subjects • Magnetic shimming modules • Water suppression modules • Identification and quantification of metabolites 5. Potential clinical applications of 2D-COSY in brain tumors • Emphasize the significance of key metabolites in studying brain tumors

PHS-MOB

Physics Monday Poster Discussions

Monday, Dec. 2 12:45PM - 1:15PM Room: PH Community, Learning Center

BR PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants

Jaydev K. Dave, PHD, Philadelphia, PA (*Moderator*) Research Grant, Koninklijke Philips NV Equipment support, Lantheus Medical Imaging, Inc Equipment support, General Electric Company

Sub-Events

PH206-SD-MOB1 **Proton Radiography for Pre-Treatment Range Verification in Proton Beam Therapy**

Station #1

Participants
Christina Sarosiek, DeKalb , IL (*Presenter*) Nothing to Disclose
George B. Coutrakon, PhD, DeKalb, IL (*Abstract Co-Author*) Nothing to Disclose
Nicholas Karonis, DeKalb , IL (*Abstract Co-Author*) Nothing to Disclose
Don DeJongh, Batavia , IL (*Abstract Co-Author*) Co-Owner, ProtonVDA
Victor Rykalin, Naperville, IL (*Abstract Co-Author*) Co-Owner, ProtonVDA
Caesar Ordonez, PhD, DeKalb, IL (*Abstract Co-Author*) Nothing to Disclose
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Kirk Duffin, DeKalb , IL (*Abstract Co-Author*) Nothing to Disclose
John Winans, DeKalb , IL (*Abstract Co-Author*) Nothing to Disclose
Igor Polnyi, Naperville, IL (*Abstract Co-Author*) Nothing to Disclose
Andrew Best, DeKalb, IL (*Abstract Co-Author*) Nothing to Disclose
Mark Pankuch, PhD, Warrenville, IL (*Abstract Co-Author*) Nothing to Disclose
James S. Welsh, MD, Hines, IL (*Abstract Co-Author*) Speaker, Varian Medical Systems, Inc

PURPOSE

Proton radiography yields anatomic information that x-ray radiography does not offer. Recent advances in detector technology makes proton imaging for proton therapy patients more practical than ever. Proton radiographs give a direct measure of the water equivalent path length (WEPL) across the radiation field in beam's eye view and can therefore detect daily anatomic changes prior to treatment that may affect the depth of the Bragg peak in the patient. In this paper we analyze the proton radiographs of various phantoms taken at the Northwestern Medicine Chicago Proton Center for image quality.

METHOD AND MATERIALS

We report here on a novel detector, its spatial resolution from a line pair resolution phantom, and WEPL resolution from a custom phantom with inserts of known densities from 0.2 to 1.6 g/cm3. Inserts of varying densities are interchanged in a pediatric head phantom and proton radiographs are taken with the phantom in the same location. Difference maps of the WEPL are generated between the images to determine the sensitivity of the detector to WEPL changes.

RESULTS

The proton radiograph show that the WEPL of all inserts in the custom phantom are correct to within 1.5%. In addition, the modulation transfer function calculated on the line pair resolution phantom demonstrates that line pairs with 1.6 mm spacing, center to center, can be resolved. We will report the detector sensitivity to WEPL changes in the phantom.

CONCLUSION

Proton radiographic images have adequate spatial resolution and provide accurate WEPL measurements across the field of view. They may also be useful for detecting range errors prior to proton treatments.

CLINICAL RELEVANCE/APPLICATION

Proton radiography may be a useful tool to detect proton range changes before proton therapy treatment.

PH207-SD-MOB2 **Comparison of Image Quality and Subjective Acceptance in Abdominal CT by Ultrahigh-Resolution CT at Different Radiation Doses Between Model-Based Iterative and Deep Learning Reconstructions: Phantom and Clinical Pilot Studies**

Station #2

Participants
Yuta Shimizu, Mitaka, Japan (*Presenter*) Nothing to Disclose
Haruhiko Machida, Tokyo , Japan (*Abstract Co-Author*) Nothing to Disclose
Makiko Nishikawa, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroyuki Morisaka, MD, Hidaka, Japan (*Abstract Co-Author*) Nothing to Disclose
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Shun Saito, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

Takuya Adachi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Katsuhiro Sano, MD,PhD, Hidaka, Japan (*Abstract Co-Author*) Nothing to Disclose
Takehiro Nakai, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Kousuke Sakaguchi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
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Akihito Nakanishi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Kenichi Yokoyama, MD, Mitaka, Japan (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

Ultrahigh-resolution CT (UHRCT) improves spatial resolution but increases image noise. State-of-the-art model-based iterative (MBIR) and deep learning reconstructions (DLR) have been clinically introduced to reduce image noise in abdominal CT by UHRCT. We performed phantom and clinical pilot studies to compare image quality and subjective acceptance in abdominal CT by UHRCT at different radiation doses between MBIR and DLR.

METHOD AND MATERIALS

We scanned a quality assurance phantom by UHRCT at 100 and 120kV with 896 (NR mode) and 1792 channels (HR mode) using automatic exposure control with noise index (SD) settings of 15-40HU (5-HU interval) and reconstructed the images by hybrid IR (HIR), MBIR, and DLR. Using the phantom images acquired at 120kV, NR mode, and SD 15 by HIR (our routine protocol) as the reference, we compared modular transfer function (MTF) and noise power spectrum (NPS); 12 observers compared subjective acceptance based on texture for these images at 100kV, HR mode, and 5 SD settings of 20-40 between MBIR and DLR. Using the routine protocol as the reference, 2 independent observers used a 5-point scale (1, much worse; 3, similar; 5, much better) to grade subjective acceptance based on image quality and diagnostic confidence in abdominal CT at 100kV, HR mode, and SD 20 and 35 by MBIR and DLR in 11 patients. We used Wilcoxon signed-rank test to compare both the acceptance between MBIR and DLR and κ-statistics to assess the interobserver agreement.

RESULTS

Compared with the reference, at 100kV and HR mode, sharpness was similar at SD 35 and 40 by MBIR but always greater by DLR with MTF; low-frequency noise at SD 35 and 40 was greater by MBIR but similar by DLR with NPS. Significantly less SD settings achieved the acceptance by MBIR (1.5±0.5; only SD 20 in 50%) than by DLR (4.2±0.6; SD 20-35 in 67%) (P=0.002). The subjective acceptance in clinical abdominal CT was significantly better by DLR than by MBIR at SD 20 (P=0.014) and 35 (P=0.003) and <3 by MBIR at SD 35 in 91%. The interobserver agreement was excellent (κ=0.87).

CONCLUSION

DLR can more robustly preserve image quality and acceptance in abdominal CT even at low doses than MBIR.

CLINICAL RELEVANCE/APPLICATION

Combined use of UHRCT and DLR is useful for improving spatial resolution and preserving image quality and acceptance in abdominal CT with lower radiation dose and reasonable computation time.

PH235-SD-MOB3 Deep Learning Image Reconstruction for CT Neuro Perfusion Imaging

Station #3

Participants
Aaron So, PhD, London, ON (*Presenter*) Nothing to Disclose
Jiang Hsieh, PhD, Waukesha, WI (*Abstract Co-Author*) Employee, General Electric Company
Jie Tang, PhD, Madison, WI (*Abstract Co-Author*) Employee, General Electric Company
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Ting-Yim Lee, MSc, PhD, London, ON (*Abstract Co-Author*) License agreement, General Electric Company; License agreement, Neusoft Digital Medical Systems Co, Ltd

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PURPOSE

We investigated the performance of a deep learning based image reconstruction algorithm (TrueFidelity) from GE Healthcare (GE) in CT neuro perfusion imaging.

METHOD AND MATERIALS

Perfusion imaging of the brain was performed on two pigs after intravenous bolus injection of iodinated contrast at 150, 100, 75, 50 and 25 mA tube current with a GE Revolution CT scanner using the following settings: 80 kV tube voltage, 0.28 s gantry speed, 20 axial scans every 2.1 sec. Images were reconstructed using TrueFidelity and 100% Adaptive Statistical Iterative Reconstruction V (ASIR-V). The TrueFidelity algorithm is an image reconstruction technique employing deep convolution neural network (CNN) based models, including millions of trained parameters, to emulate very high dose filtered backprojection (FBP) image texture, low noise, and high resolution. TrueFidelity and 100%ASIR-V images were analyzed with CTP4D (GE) to generate brain perfusion maps. Regions of interest encompassing the whole brain were drawn on 16×2.5 mm slices to obtain the mean and standard deviation (SD) of perfusion values. The quality of TrueFidelity and 100%ASIR-V perfusion maps was characterized by the figure of merit (FOM), calculated as the ratio of SD to mean.

RESULTS

The average brain perfusion measured from the TrueFidelity maps over the five mA levels in two pigs was 39.2±7.1 mL/min/100g, which was almost identical to that measured from the 100%ASIR-V images (38.0±6.2 mL/min/100g). At each individual mA level, perfusion and the corresponding FOM from the TrueFidelity maps were within 5% of the 100%ASIR-V maps.

CONCLUSION

TrueFidelity and 100%ASIR-V maps showed comparable neuro perfusion and FOM. These results suggest the robustness of the TrueFidelity algorithm in reducing noise presented in the perfusion scans at a wide range of dose settings, even though the algorithm was not trained with data acquired at extremely low dose levels.

CLINICAL RELEVANCE/APPLICATION

TrueFidelity similar to 100%ASIR-V can reduce excessive image noise arising from low dose scanning to facilitate extremely low dose neuro perfusion imaging with CT.

PH231-SD-MOB4 Denoising and Scatter Correction for Contrast-Enhanced Digital Breast Tomosynthesis

Station #4

Participants
Hailiang Huang, MS, Stony Brook, NY (*Presenter*) Nothing to Disclose
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Xiaoyu Duan, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

Contrast-enhanced digital breast tomosynthesis (CEDBT) is being investigated for cancer detection and lesion assessment. However, its image quality is still limited. The scatter radiation in DBT projections leads to cupping artifacts and reduces the contrast of iodine signal, especially for high energy (HE) acquisition. Low projection dose results in high noise level and dual energy (DE) image subtraction further increases the noise in CEDBT, which hinders the detection of low-contrast signal. We aim to develop noise reduction and scatter correction techniques to improve the image quality for CEDBT.

METHOD AND MATERIALS

Scatter correction is based on the scatter point spread functions (PSF) generated from Monte-Carlo simulation for various projection angles and breast thicknesses. Convolution of the scatter kernel with the raw image forms the initial guess of scatter, which was then updated iteratively after scatter-free image was estimated. The noise reduction for DBT projections utilizes a deep-learning based convolution neural network (CNN). A generative adversarial network was trained using low and high dose projection images of digital breast phantoms simulated from a virtual clinical trial software (OpenVCT) and emulating the acquisition geometry of Siemens Mammomat Inspiration DBT system. To process clinical CEDBT images, the low energy (LE) and HE projection images at each angle were first aligned by image registration. Scatter correction was then applied on LE and HE images separately, followed by noise reduction. Logarithmic weighted subtraction was performed to generate DE-subtracted projections. Images were reconstructed by filtered-back-projection (FBP) using a ramp filter with non-zero response at zero frequency and a spectral apodization filter. The proposed method was tested on CEDBT images from an IRB-approved pilot clinical study and compared with images without correction.

RESULTS

Our results show reduced noise and suppressed cupping artifacts in CEDBT after correction. The contrast to noise ratio (CNR) of the contrast-enhanced lesions is increased.

CONCLUSION

The proposed scatter correction and denoising technique improves the image quality of CEDBT.

CLINICAL RELEVANCE/APPLICATION

The improvement in CEDBT image quality could benefit the detection and 3D assessment of contrast enhanced breast lesions, and the evaluation of background parenchymal enhancement.

PH232-SD-MOB5 The Safety and Feasibility of Intravenous Contrast-Enhanced Sonography in Children - A Single Center and Prospective Study in China

Station #5

Participants
Muyi Mao, Shenzhen , China (*Presenter*) Nothing to Disclose
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Lei Liu, Shenzhen , China (*Abstract Co-Author*) Nothing to Disclose

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CONCLUSION

The adverse effects of CEUS in children is similar to that in adults. It is safety and feasible for the pediatric applications of CEUS using SonoVue®.

Background

Intravenous contrast-enhanced ultrasound (CEUS), using the second-generation ultrasound contrast agent SonoVue®(Bracco, Switzerland) , has already been approved for pediatric applications in 2018 by American Food and Drug Administration (FDA). However, it has not been approved by Chinese Food and Drug Administration (CFDA). The study was to evaluate the safety and feasibility of CEUS in children prospectively at a single center in China.

Evaluation

A total of 312 Chinese children (179 boys, 133 girls; from one month to 14.5 years old; weight (4.7-62) kg) were enrolled in clinical trials in Shenzhen Children's Hospital between November 2015 and April 2019. Contrast agent was given intravenously with two different doses of SonoVue®, including 2.4ml/time before June 2016 and 0.03ml/kg After June 2016. A total of 600 intravenous injections was performed for evaluating adverse effect and the diagnostic accuracy comparing with the pathology and enhanced CT.

Discussion

(1) 312 subjects underwent CEUS successfully. Most of studies were performed for evaluating renal microcirculation and assisting renal biopsy (193/312[61.9%]), which had a 98.4% of effective rate of the pathological specimens. Some were used to identify the mass, including 103(33.0%) cases for the liver (36 cases), retroperitoneum(14 cases), Abdominal cavity(12 cases), mediastinum(6 cases), kidney(9 cases), testicle(4 cases) and so on, which had a 98.7% high accuracy. The others were for identifying 16(5.13%) cases for trauma, vascular malformation, infection, thrombosis, hemorrhage and infarction, which had the same accuracy compared with enhanced CT. (2) In the renal CEUS, the wash-out time of dose 0.03ml/kg was shorter than that of dose 2.4ml/time, and there was significant difference ($P<0.05$). (3) Adverse drug reactions, there were 3 cases of transient rash and 2 cases of hypotension in the 600 intravenous injections, and total of six patients (5/312[1.60%]), and the patients recovered quickly after anti-allergic treatment of intravenous methylprednisolone and epinephrine.

PH233-SD-MOB6 Discussion on the Accurate Measurement of Organ Dose in CT Scanning

Station #6

Participants
Zhang Yongxian, Beijing, China (*Presenter*) Nothing to Disclose
Yantao Niu, Beijng, China (*Abstract Co-Author*) Nothing to Disclose
Dandan Liu, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Yu Binbin, BA,BA, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Jianxing Wu, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Lili Zhang, Beijing , China (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To investigate the method of accurate measurement of organ dose in CT scan.

METHOD AND MATERIALS

Background:When measuring the dose of CT scanning organs, it was found that the same parameters were repeatedly measured more than ten times, and almost every measurement was not equal, and the extreme difference was even more than 40 %; Analyzing the reason, the X-ray tube rotates to a random position in the frame and begins scanning, so that the TLD or long rod ionization chamber receives different radiometric angles from the X-ray tube: the ionization chamber is before the X-ray tube rotates to the human body but in the next lap, the back is rotated to the ionization chamber, and the dose measurement is the highest, whereas the measurement is the lowest. MATERIALS:GE RevolutionTM CT,a long rod ionization chamber. METHODS: Based on the clinical chest scanning scheme, the chest module was scanned using a combination of two detector widths(40, 80 mm) and three pitches(0.500, 1.000, and 1.375) under the same parameters. The long rod ionization chamber was placed in a fixed position in front of the right breast area. Each group of scanning parameters is repeatedly measured 7 times to record the measured breast skin dose D. The two groups of D values with detector widths of 40 and 80 mm respectively were compared using independent sample T test, and the radiation dose of three groups(0.500, 1.000, and 1.375) was compared using single factor variance analysis.

RESULTS

The same parameters were repeated and the difference between the maximum and minimum values of D measured 7 times was from 14.5 % to 44.4 %. 80 mm detector width standard deviation greater than 40 mm; The greater the pitch, the greater the standard deviation; the difference of the dose between the detector width and among the pitches was statistically significant were statistically significant.

CONCLUSION

When measuring organ dose in CT scan, the average value needs to be measured several times. In this way, the organ dose can be more accurately assessed.

CLINICAL RELEVANCE/APPLICATION

The organ dose in CT scan may also be different or even very different from the same parameter repeated scan; Even if the left and right sides are measured at the same time or multiple points, they are still not accurate enough and must be measured multiple times to assess the dose.

PH234-SD-MOB7 Clinical Trial Qualification of PET-CT Scanners in Onco-Haematological Clinical Trials Performed with 68Ge Pre-Filled Phantom Permits to Achieve a Lower Inter-Scanner Variability Respect to Standard 18F Phantoms

Station #7

Participants
Fabrizio Bergesio, Cuneo, Italy (*Abstract Co-Author*) Nothing to Disclose
Federico Dalmasso, Cuneo, Italy (*Abstract Co-Author*) Nothing to Disclose
Luca Guerra, Monza, Italy (*Abstract Co-Author*) Nothing to Disclose
Luca Ceriani, Bellinzona, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Monica Coronado Poggio, Madrid , Spain (*Abstract Co-Author*) Nothing to Disclose
Stephane Chauvie, PhD, Turin, Italy (*Presenter*) Stockholder, Dixit srl

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PURPOSE

The aim of this study was to compare the Clinical Trial Qualification (CTQ) performed with 68Ge pre-filled phantom respect to standard 18F phantoms. The two approaches were adopted within several PET-driven onco-haematological clinical trials conducted by the Italian Foundation on Lymphoma (FIL), the Grupo Espanol de Linfomas/Transplante Autologo de Medula Osea (GELTAMO), the International Extranodal Lymphoma Study Group (IELSG) and the Swiss Group for Clinical Cancer Research (SAKK).

METHOD AND MATERIALS

The CTQ process consisted in the scanning with the default acquisition and reconstruction parameters used for whole-body oncological PET/CT studies of the same model of NEMA/IEC image quality phantom. In the standard approach the phantom background and spheres were filled with a 18F solution by local imaging experts. In the other approach the phantom's background and the six spheres were all pre-filled with a 68Ge epoxy. Background activity concentration (BAC) was defined as the difference between the average activity concentration in a large homogenous region and the expected activity concentration. Sphere to background ratio (SBR) was defined as the ratio between the maximum of the activity concentration in the largest 37 mm diameter sphere and the BAC. Inter-scanner variability (ISV) was estimated as the 95% confidence level of BAC and SBR. The 18F phantom was used in IELSG, GELTAMO and FIL-1 (first phase) clinical trials while the 68Ge phantom was used in SAKK and FIL-2 (second phase).

RESULTS

For the 18F approach the ISV BAC, ISV SBR values vary between (39-62)% and (44-62)% respectively, the CTQ was obtained at the first round in the (30-35)% of the PET/CT scanner. For the 68Ge approach the ISV BAC, ISV SBR values vary between (20-25)% and (20-24)% respectively, the CTQ was obtained at the first round in the (65-95)% of the PET/CT scanner.

CONCLUSION

68Ge approach permits to achieve a lower inter-scanner variability respect to 18F one. Indeed, ISV of both BAC and SBR are reduced of 2-3 times. This is mostly due to the difficulty in phantom preparation for 18F phantom. Moreover, the number of iterations required to achieve the clinical trial qualification is much lower and 64%-95% of CTQ are done at first round.

CLINICAL RELEVANCE/APPLICATION

Clinical trial qualification of PET-CT scanners performed with 68Ge pre-filled phantom permits to achieve a lower inter-scanner variability respect to standard 18F phantoms.

PH132-ED-MOB8 Pocket Guide for Understand (and Successfully Apply) US and MRI Elastography Techniques

Station #8

Awards
Cum Laude

Participants
Teodoro M. Noguerol, MD, Jaen, Spain (*Presenter*) Nothing to Disclose
Mariano Volpacchio, MD, Buenos Aires, Argentina (*Abstract Co-Author*) Nothing to Disclose
Marcelo Potolicchio, MD, Cadiz, Spain (*Abstract Co-Author*) Nothing to Disclose
Alvin C. Silva, MD, Scottsdale, AZ (*Abstract Co-Author*) Nothing to Disclose
Antonio Luna, MD,PhD, Jaen, Spain (*Abstract Co-Author*) Speaker, Canon Medical Systems Corporation; Speaker, Koninklijke Philips NV; Speaker, Siemens AG

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TEACHING POINTS

1. Review the physical basis of elastography techniques applied to ultrasound (US) and magnetic resonance imaging (MRI). 2. Explain, from an educational point of view, the differences between the diverse types of elastography techniques focusing on strain imaging and shear-wave imaging. 3. Show the potential applications of both US and MRI elastography approaches in several clinical scenarios

TABLE OF CONTENTS/OUTLINE

1. Introduction 2. General concepts about elastography 3. US elastography: Physical basis and technical adjustments. 4. MRI

elastography: Physical basis and technical adjustments. 5. US elastography: Clinical scenarios 1. Liver and other abdominal organs 2. Thyroid and salivary glands 3. Breast 4. MSK 5. Testes 6. MRI elastography: Clinical scenarios 1. Liver 2. Spleen 3. Pancreas 5. General considerations and Potential applications a. When do I have to perform DTI for skeletal muscle evaluation? b. Is necessary to integrate DTI in routine protocols? c. How should I report DTI studies? d. Quantitative assessment of fiber tracking? e. Skeletal muscle trauma and sport injuries related lesions f. Primary and secondary myopathies g. Training and Treatment monitoring 6. Conclusions and take home messages

SPPH21

Basic Physics Lecture for the RT: Radiation Safety Refresher Course

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

CT PH RO SQ

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

Participants
Scott J. Emerson, MS, Royal Oak, MI (*Moderator*) Nothing to Disclose
Rebecca M. Marsh, PHD, Aurora, CO (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Understand and describe the risks and benefits associated with patient shielding. 2) Critically evaluate common radiation safety practices. 3) Apply current data about radiation risk from diagnostic imaging exams to clinical practice.

Printed on: 10/29/20

SPPH22

Physics Symposium: Highlights of AAPM Clinical Brachytherapy Physics Summer School

Monday, Dec. 2 1:30PM - 5:45PM Room: S503AB

CT GU MR PH

AMA PRA Category 1 Credits ™: 4.25
ARRT Category A+ Credits: 5.00

FDA Discussions may include off-label uses.

LEARNING OBJECTIVES

1) Explain the role of model-based dose calculation algorithms and their affects for several anatomic site. 2) provide an in-depth understanding on the application of brachytherapy for prostate, gynecological, breast, and skin diseases. 3) Clarify emerging technologies such as electronic brachytherapy, clinical modalities, and intensity-modulated brachytherapy.

ABSTRACT

The Symposium will cover the highlights from the 2017 AAPM Summer School on Clinical Brachytherapy Physics. Presentations by the School Program Directors will include the experiences from experts on eight key aspects of clinical brachytherapy physics: model-based dose calculations, prostate brachytherapy, gynecological brachytherapy, skin brachytherapy, breast brachytherapy, electronic brachytherapy, intensity modulated and anisotropic brachytherapy sources, and early clinical advancements in 3D printing, tracking technologies, and robotic brachytherapy.

Sub-Events

SPPH22A Overview of Commercial Algorithms: Needs and Availability

Participants
Luc Beaulieu, PhD, Quebec, QC (*Presenter*) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Understand the need for advanced dose calculation algorithms in brachytherapy. 2) Provide an overview of the basis of the underlying algorithms used in brachytherapy commercial treatment planning systems. 3) Know the key strength and limitations of each algorithm.

ABSTRACT

Brachytherapy is a very efficient cancer treatment modality, essentially due to a best in class dose deposition kernel dominated by 1/r2 spearing tissue at a distance from the source. Furthermore, the energy deposition from the ionizing photons emitted by brachytherapy sources can be calculated, in theory, with very high accuracy. Until recently, the field of brachytherapy relied on a factor-based approach, TG-43, to deal for dose calculation. While TG43 is extremely fast for dose computation and optimization, its accuracy is limited to specific conditions, often not met in clinical situations. This presentation will provide an overview of these different situations and provide ballpark estimates of the expected differences. We will further look at alternatives to solve this issue and briefly described the approaches chosen by the major vendors in providing the next generation of dose calculation engines in their treatment planning system offering. We will finally describe how these new algorithms performed under various scenarios, highlighting both their strength and weakness.

SPPH22B Emphasis on MBDCA Commissioning Infrastructure and Process

Participants
Luc Beaulieu, PhD, Quebec, QC (*Presenter*) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Review the commissioning requirements set forth in TG186. 2) Provide an overview of the existing infrastructure and resources available to the clinical medical physicists. 3) Understand the various steps necessary in the commissioning of model-based dose calculation algorithms.

ABSTRACT

With the publication in 2012 of the AAPM/ESTRO/ABG TG-186 report, early adopters were provided with a set of guidelines to help in the integration of advanced dose calculation algorithms in brachytherapy, beyond TG43, and ensuring safe and efficient use of the new features that are enabled by these new algorithms. However, the commissioning aspects were minimal in that report. In the following, the work from a subsequent working group, established to tackle this issue, will be presented. It is intended to provide the clinical users (the clinical medical physicists) with a set of comprehensive commissioning guidelines as well as to provide the necessary information for resources that are available to the community in making the transition from TG43 to TG186.

SPPH22C Prostate Brachytherapy: Real-time Intra-operative

Participants
Luc Beaulieu, PhD, Quebec, QC (*Presenter*) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Underline the system components of a real-time prostate brachytherapy program. 2) Understand the possible workflows of real-time ultrasounds based prostate brachytherapy. 3) Understand the difference between real-time LDR and HDR prostate brachytherapy workflows.

ABSTRACT

Prostate brachytherapy is a highly effective treatment option for localized prostate cancer. For low-risk prostate cancer patients, LDR seed implants has proven its long-term efficacy. For intermediate risk and high risk localized prostate cancer, both LDR and HDR brachytherapy boost combined to EBRT (either 3D-CRT or IMRT/VMAT) are providing compelling clinical outcomes. Both approaches deliver very high local dose to the cancerous regions while providing enhanced dose spearing to the organs at risk. The move to real-time intra-operative prostate brachytherapy further enables simplified treatment options to patients, in many cases performed as a single day outpatient procedure while improving the overall treatment accuracy by limiting the uncertainties due to moving the patients from the OR to imaging to finally the treatment room. This presentation will look at the key components of an efficient real-time intra-operative as well as the associated workflows.

SPPH22D Prostate Brachytherapy: Post-implant Evaluation Using CT or MR

Participants
Mark J. Rivard, PhD, Providence, RI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn the importance of post-implant dosimetric analysis. 2) To convey how to evaluate prostate brachytherapy implants using CT or MRI. 3) Be able to utilize modern techniques for post-implant evaluation of prostate brachytherapy implants.

SPPH22E Gynecological Brachytherapy: MRI Guidance and Targeting

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the rationale for MR targeting in gynecological brachytherapy. 2) To become familiar with techniques and difficulties in MR targeting.

ABSTRACT

Cervical brachytherapy has changed greatly over the last few years. The conventional techniques that served well for the last six decades provided many cures; however, failures still plagued the higher staged disease. The challenges to improving outcomes rested with two issues: 1. Visualizing, localizing and assessing the disease, and 2. Adequately treating the disease once it is demarcated. This presentation will address the first of the challenges, imaging and targeting the disease.

Active Handout:Bruce Robert Thomadsen

http://abstract.rsna.org/uploads/2019/19001779/Active SPPH22E.pdf

SPPH22F Gynecological Brachytherapy: Applicators

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the evolution of brachytherapy applicators for treatment of cervical cancer. 2) To become familiar with the latest generations of cervical brachytherapy applicators.

ABSTRACT

This presentation continues addressing the challenges for cervical brachytherapy, looking at recent developments in applicator design to facilitate treating the target tissues.

SPPH22G Gynecological Brachytherapy: Comparisons with Conventional

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the differences in dosimetry between the conventional approach and the MR-guided approach to cervical brachytherapy. 2) To appreciate the benefits to patients of the newer approach.

ABSTRACT

This presentation completes the discussion of cervical brachytherapy by comparison of the newer approaches with the conventional treatments, reviewing the dosimetry and outcomes.

SPPH22H Skin Brachytherapy

Participants
Mark J. Rivard, PhD, Providence, RI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Develop a sense for the physics concerns surrounding skin brachytherapy. 2) Convey how to dosimetrically evaluate skin brachytherapy treatment plans. 3) Learn several methods for delivering skin brachytherapy.

SPPH22I Breast Brachytherapy: Applications and Applicators

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the geometry, dosimetry and nature of applicators used in breast brachytherapy.

ABSTRACT

Breast brachytherapy has been shown to be a highly effective treatment with very low toxicity. Many types of applicators have been developed to perform the procedure, each with strength and limitations. This presentation will discuss the various applicators and how they apply to applications.

Active Handout:Bruce Robert Thomadsen

http://abstract.rsna.org/uploads/2019/19001784/09-10 Breast Brachytherapy2019 RSNA.pptx

SPPH22J Breast Brachytherapy: Plan Evaluation

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand what should be checked during a treatment plan review for breast brachytherapy. 2) To understand the quantities used in performing the reviews.

ABSTRACT

Review of a treatment plan serves to help improve quality and prevent errors in treatment. Plan evaluations are crucial for breast brachytherapy. This presentation will discuss the techniques used, and quantities evaluated during a treatment plan review.

SPPH22K Electronic Brachytherapy

Participants
Mark J. Rivard, PhD, Providence, RI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the radiological physics differences between electronic brachytherapy and radionuclide-based brachytherapy. 2) Describe several different systems, contrasting and comparing them. 3) Learn how electronic brachytherapy is used clinically.

SPPH22L Intensity Modulated and Anisotropic BT Sources

Participants
Mark J. Rivard, PhD, Providence, RI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Comprehend the designs and goals for intensity modulated and anisotropic brachytherapy sources. 2) Explain how intensity modulated and anisotropic brachytherapy sources can provide improved dose distributions over conventional brachytherapy sources. 3) Learn how to evaluate and commission intensity modulated and anisotropic brachytherapy sources.

SPPH22M 3D Printing and Tracking Technologies

Participants
Luc Beaulieu, PhD, Quebec, QC (*Presenter*) License agreement, Standard Imaging, Inc; Researcher, Elekta AB; Researcher, Koninklijke Philips NV;

LEARNING OBJECTIVES

1) Understand the potential role of 3D printing in brachytherapy. 2) Have an overview of various tracking technologies that can be integrated into catheters, needles and applicators. 3) Discuss envisioned usage in the brachytherapy clinical workflow.

ABSTRACT

This portion of the AAPM summer school was dedicated to an outlook of the use of novel technologies tot her field of brachytherapy. First, brachytherapy relies heavily on applicators in which one or more sources can travel. As such, custom-made applicators derived from patient-specific 3D imaging or any other relevant information constitute a potential use of 3D printing technology. Second, to proceed with an optimal treatment the location in space of one or more applicators as well as the full 3D path (called channels in brachytherapy) the source will be traveling needs to be known with precision. Tacking technology can simplify the acquisition and validation of this information, thus simplifying the overall clinical workflow. This presentation will look at the various technologies involved with both the steps described above and how they could impact the current clinical workflows. Prerequisites for clinical use will also be discussed.

SPPH22N Robotics and Brachytherapy

Participants
Bruce R. Thomadsen, PhD, Madison, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand some of the principles of robotics in brachytherapy. 2) To learn about some of the robots, their designs and limitations.

ABSTRACT

As with much of medicine, and life in general, automation is improving consistency and ability. Robots have become part of the surgical landscape and are found in most large pharmacies. Robots are just coming into brachytherapy but promise to improve dose distributions and access to procedures. This presentation will review the current, dynamic sate of robotic brachytherapy.

Active Handout:Bruce Robert Thomadsen

http://abstract.rsna.org/uploads/2019/19001789/Active SPPH22N.pdf

Active Handout:Bruce Robert Thomadsen

http://abstract.rsna.org/uploads/2019/19001789/Active SPPH22N.pdf

SSE22

Physics (Ultrasound)

Monday, Dec. 2 3:00PM - 4:00PM Room: E352

PH US

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

FDA Discussions may include off-label uses.

Participants
Timothy J. Hall, PhD, Madison, WI (*Moderator*) Equipment support, Siemens AG; Technical support, Siemens AG; Researcher, F.K.A. Gammex RMI; Researcher, Sun Nuclear Corporation
Thaddeus A. Wilson, PhD, Madison, WI (*Moderator*) Nothing to Disclose

Sub-Events

SSE22-01 Photoacoustic Imaging for Assessing Sonoporation of Pancreatic Cancer in a Pre-Clinical Model

Monday, Dec. 2 3:00PM - 3:10PM Room: E352

Participants
Teena Dhir, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Corinne Wessner, Philadelphia, PA (*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

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PURPOSE

To evaluate the disruption of different US contrast agents (UCAs) for augmenting chemotherapy treatment (i.e., sonoporation) in a murine model of pancreatic cancer.

METHOD AND MATERIALS

Athymic, nude mice (n=140) were injected with MIA PaCa-2 cells in the right flank and randomized into 2 control groups (untreated or chemotherapy only) and 8 treatment groups. The latter consisted of chemotherapy and one of 4 UCAs: Definity® (Lantheus Medical Imaging, N Billerica, MA), Lumason® (Bracco, Milan, Italy), Optison™ (GE Healthcare, Princeton, NJ) or Sonazoid™ (GE Healthcare, Oslo, Norway) imaged with a Logiq E9 (GE Healthcare, Waukesha, WI) in a high or low acoustic power cohort (ISPTA of 200 or 60mW/cm2). Groups were treated once a week for 3 weeks. Hemoglobin and oxygenation measurements were obtained weekly (at baseline, during treatment and 1 week post treatment) using photoacoustic imaging with a Vevo 2100 LAZR scanner (Fujifilm Visualsonics, Toronto, Canada). Mice were followed for tumor growth and survival and compared with two-way ANOVAs.

RESULTS

All tumor volumes in the 8 treatment groups and in the chemotherapy only group were statistically smaller than those from the untreated group ($p<0.02$). When comparing tumor volumes from the treatment groups in the high acoustic power cohort to the group receiving chemotherapy alone, all 4 UCA treated groups had significantly smaller tumors ($p<0.006$) with Optison achieving the greatest reduction ($p=0.001$). In the low acoustic power cohort, only mice receiving Definity showed a significant tumor volume reduction ($p=0.003$), while all other comparison were not significant ($p>0.07$). Total hemoglobin and oxygenation values across tumors as well as within areas of detected blood flow were greater in the high acoustic power cohort ($p<0.001$), while the impact of UCAs was statistically significant for oxygenation (Definity and Sonazoid; $p<0.05$) and for hemoglobin within areas of detected blood flow (Optison; $p=0.014$).

CONCLUSION

Preliminary results indicate that chemotherapy treatment of pancreatic xenografts can be augmented with high acoustic power sonoporation, and optimal acoustic parameters may be UCA-dependent.

CLINICAL RELEVANCE/APPLICATION

Sonoporation of pancreatic cancer was successful in a pre-clinical model and the best imaging parameters studied will form the basis for a Phase II clinical trial.

SSE22-02 Ultrasound Monitoring of Myofascial Pain Syndrome Treatment and Response: Assessing Botulinum Toxin Propagation without Contrast Media with a Novel B-Flow Sequence and Bite Force Stiffness with Shear-Wave Elastography

Monday, Dec. 2 3:10PM - 3:20PM Room: E352

Participants
Sergio J. Sanabria, PhD,MENG, Zurich, Switzerland (*Presenter*) Nothing to Disclose
Lisa Ruby, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Jasmine Kuonen, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Susanne Dettwiller, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Vera Colombo, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Thomas Frauenfelder, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
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Marga B. Rominger, MD, Wettenberg, Germany (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

Idiopathic masticatory myalgia (IMM) is related to multifocal tissue stiffening. Botulinum Toxin (BT) can alleviate synthoms, yet the procedure (number, amount) is empirical. Our goal is to use ultrasound imaging (US) to quantify both IMM treatment and response.

METHOD AND MATERIALS

Porcine ex-vivo masseter was used to compare US BT imaging with optic assessment of excised tissue specimens (dyed with Indigocarmin). A novel B-flow sequence based on 2D-digital image correlation (2D-DIC) was used to compensate for tissue deformation during injection, allowing high sensitive detection of B-mode changes due to BT propagation without contrast medium. Then 50 units of BT toxin type A dissolved in 1 ml normal saline (0.9% NaCL) were injected in both left and right masseters of an female IMM patient. A 3D printed setup was used to co-register BT injection with US imaging. Shear wave velocity (SWV) values of the left masseter muscle were prospectively assessed in a volunteer with alternating relaxed states and biting states of varying force using a Logiq E9 (GE Healthcare) US. Bite force was measured of the right and left second molar teeth, respectively, using the Occlusal Force-Meter GM10 (Nagano Keiko).

RESULTS

2D-DIC allowed visualization of the injected fluid without a contrast medium. In ex-vivo tests, rs = 0.95 with optic tissue area, and Dice Coefficient = 0.85. In vivo, BT propagated along the fiber structure of the muscle, with threefold larger axial compared to lateral expansion. A compressive strain was observed both above and below the needle. SWV ranged between 1.52 and 3.98 m/s for bite force between 0 and 450 N. For bite force and SWV, we found a correlation of rs = 0.908 with the force-meter placed on the contralateral (right) side.

CONCLUSION

Due to greater axial compared to lateral propagation, multiple injections of smaller amounts of BT in masseter instead of a single injection with larger amount are recommended. SWE provides imaging modality of bite force through correlating activation of the masseter muscle when the force-meter is placed on the contralateral side with respect to the ultrasound probe.

CLINICAL RELEVANCE/APPLICATION

The presented B-flow method is promising for a wide range of applications, where Contrast-Enhanced US is not feasible. SWE could have diagnostic properties for differentiating idiopathic masticatory myalgia from other diseases affecting the masticatory muscles.

SSE22-03 US-Triggered Bulk Antibiotic Release from Novel Hardware in a Rabbit Spinal Infection Model

Monday, Dec. 2 3:20PM - 3:30PM Room: E352

Participants
Lauren J. DeLaney, PhD, Philadelphia , PA (*Abstract Co-Author*) Nothing to Disclose
Alex M. Sevit, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
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Keith FitzGerald, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
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Priscilla Machado, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Taolin Fang, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Samantha L. Knott, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Steven M. Kurtz, PhD, Philadelphia, PA (*Abstract Co-Author*) Exponent; Active Implants Corporation; B. Braun Melsungen AG; Celanese; Ceramtec; Johnson & Johnson; DJO GLobal, Inc; Ferring Group; Formae; Kyocera Medical ; Medtronic plc ; Simplify Medical; Smith & Nephew plc; Stelkast; Stryker Corporation ; Wright Medical Technology, Inc; Zimmer Biomet Holdings, Inc; Invibio; Reed Elsevier
Noreen J. Hickok, PhD, Philadelphia, PA (*Abstract Co-Author*) Researcher, Zimmer Biomet Holdings, Inc; Researcher, Synergy Technologies, Inc; Research collaboration, Acuitive Technologies, Inc
John R. Eisenbrey, PhD, Philadelphia, PA (*Abstract Co-Author*) Support, General Electric Company Support, Lantheus Medical Imaging, Inc

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PURPOSE

This study evaluated the efficacy of ultrasound (US)-triggered drug delivery devices to combat bacterial infection in an *ex vivo* cadaveric rabbit spine model.

METHOD AND MATERIALS

Polylactic acid (PLA)-coated, vancomycin (VAN)-loaded polyether ether ketone (PEEK) devices (1 cm3) with a drug-loading reservoir (0.785 cm3) were 3D printed. Two device designs were evaluated: 1 large hole for drug release vs 2 smaller holes. Clips were implanted medial to the spinal midline in mature (~6 months, 3 kg) female White New Zealand cadaveric rabbits (n = 4) under an IACUC-approved protocol. To simulate infection, 104 cfu of *Staphylococcus aureus* were added to 2 of the 4 sites; the other 2 sites were left clean. Two of the 4 sites (1 inoculated, 1 clean) were insonated for 20 minutes with a Logiq E9 ultrasound scanner (GE Healthcare, Waukesha, WI) equipped with a C1-6 curvilinear probe, using power Doppler imaging (1.7 MHz frequency, 6.4 kHz PRF, 100% acoustic output power) to induce rupture of the PLA coating for VAN release. In parallel, positive and negative bacterial controls were evaluated. All implanted devices were incubated for 2 hours post-insonation, then retrieved for analysis. Results were collected in duplicate (n = 16 total) and compared with a two-way ANOVA.

RESULTS

Infected sites showed marked reduction in bacterial colonization following US-triggered VAN release, while uninsonated sites exhibited little reduction in bacterial colonization. At 48 hours, there was significantly greater VAN release from the insonated clips compared to the uninsonated clips ($p < 0.04$). There was significantly greater US-triggered total VAN release from the 1-hole device design than from the 2-hole design (7420 ± 2992 µg vs. 3500 ± 954 µg, $p < 0.0001$). These levels are sufficient to prevent adhesion of *S. aureus* to implant materials.

CONCLUSION

This study demonstrated the feasibility of an US-mediated antibiotic delivery device, which could become a potent weapon against spinal surgical site infections.

CLINICAL RELEVANCE/APPLICATION

This system will aggressively combat post-surgical bacterial infection with great versatility in applications for wide clinical impact.

SSE22-04 Development of Dedicated Anatomical Breast Ultrasound Phantoms for Ultrasound System Performance Evaluation and Image Optimization Training Tools

Monday, Dec. 2 3:30PM - 3:40PM Room: E352

Participants
Jacinta Browne, PhD, Dublin 8, Ireland (*Presenter*) Nothing to Disclose
Donald J. Tradup, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Alisa Walz-Flannigan, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Scott Stekel, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Robert T. Fazzio, MD, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Nicholas J. Hangiandreou, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

In this study, a range of novel anatomical breast ultrasound phantoms were developed for ultrasound system performance evaluation and image optimization tools. The anatomical phantoms had moderate technical complexity associated with them and simulated the sonographic characteristics of the different breast tissues and contained a range of lesion pathology such as cysts, Mondor's disease, fibroadenoma and angular, spiculated lesions representing malignant findings. Both a system performance evaluation plan and a pedagogical plan were developed for use with these novel phantoms.

METHOD AND MATERIALS

Design specifications for the anatomical breast phantom were developed through consultation between Radiologists, breast US sonographers as well as taking into consideration the typical profile of patients presenting to a large Radiology Department. The phantoms were scanned using General Electric Logiq 9, Logiq e and Philips Epic ultrasound systems using the breast pre-set; the individual lesions were scanned using a focused optimization approach. The images were evaluated by breast radiologists and sonographers to determine the performance of each ultrasound system. The image images were scored using a 5-point Likert scale (1=poor to 5=excellent). A pedagogical plan was developed to augment the function of these phantoms as training tools; it included the elements outlined in Fig1b.

RESULTS

No one system consistently performed the best at imaging all types of lesions; however system 3 had the overall best performance (Fig 1c). In particular, it had excellent performance for imaging cystic structures. It was found that the cystic structures provided information about the systems noise level, lesion detectability performance and spatial resolution of the different systems. While, the fibroadenoma and malignant lesions provided information about the system's dynamic range, contrast and spatial resolution performance.

CONCLUSION

The anatomical breast phantoms were able to effectively demonstrate differences between ultrasound systems identifying differences between individual lesion features, such as reduction of haze and noise in cystic structures as well as demonstrate the impact of different image optimization controls.

CLINICAL RELEVANCE/APPLICATION

This study demonstrates the utility of "life-like" ultrasound breast phantoms in the performance evaluation of systems as well as the demonstration of different image optimization controls.

SSE22-05 Photoacoustic Lymphangiography: The Promising Imaging Modality for Lymphatic Vessels

Monday, Dec. 2 3:40PM - 3:50PM Room: E352

Participants
Hiroki Kajita, Tokyo, Japan (*Presenter*) Nothing to Disclose
Anna Oh, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
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Hiroyuki Sekiguchi, Kyoto, Japan (*Abstract Co-Author*) Employee, Luxonus Inc
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Sadakazu Aiso, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Kishi, Shinjuku-ku, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Photoacoustic lymphangiography (PAL) is a new optical imaging technique based on photoacoustic technology, which visualizes small blood vessels and lymphatic vessels in the extremities by high-resolution three-dimensional images. In this report, we introduce the still images and videos obtained with PAL in healthy subjects and lymphedema patients.

METHOD AND MATERIALS

We used the PAI-05 system with semi-spherical ultrasonic detector array. Twenty healthy volunteers and 30 lymphedema patients were recruited. To image the lymphatic structures of the limbs, 0.5 mL of indocyanine green (5 mg/mL) was administered subcutaneously to the dorsal aspect of each foot or hand. PA images were acquired by irradiating the tissue using a laser at wavelengths of near-infrared region. We first obtained the lower leg or forearm of the subjects with a wide-field still images, and then recorded the videos of the targeted vessels with the scope of 20 mm in diameter.

RESULTS

In the still images, the lymphatic vessels up to the diameter of 0.2 millimeters could be observed three-dimensionally with the venules around them in the still images. We could distinguish between blood vessels and lymphatic vessels by colors using the difference of molar extinction coefficient. PAL also revealed the depth of each vessel from the skin surface. In the patient-group, dermal backflow patterns were often observed as dense interconnecting three-dimensional structures of lymphatic vessels. Extended or twisting collecting vessels passing below the fine complex network of dermal lymphatics were also observed. In the videos, lymphatic pump was observed intermittently with various intervals. It was difficult to detect the lymphatic flow in the patients because the lymphatic fluids in the channels are stagnated.

CONCLUSION

In this study, three-dimensional high spatial and temporal resolution images were obtained using the PAI-05 system, allowing the visualization of fine lymphatic vasculature and its pumping movement. The morphologic and dynamic characteristics of the vessels were significantly different in the volunteers and patients.

CLINICAL RELEVANCE/APPLICATION

The actual anatomical course of each lymphatic vessel and venul visualized by PAL is useful in both planning of lymphatico-venous bypassing surgery for lymphedema and locating them during the surgery.

SSE22-06 Tissue Viscoelastic Estimates Using a Reverberant Shear Wave Field in Tissues Exhibiting a Power Law Behavior: Generation of 2-D Shear Wave Dispersion Images

Monday, Dec. 2 3:50PM - 4:00PM Room: E352

Participants
Juvenal Ormachea, Rochester, NY (*Presenter*) IP disclosures, Reverberant shear wave elastography; Commercial agreement, Elastance Imaging LLC
Kevin J. Parker, PhD, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Richard G. Barr, MD, PhD, Campbell, OH (*Abstract Co-Author*) Consultant, Siemens AG; Consultant, Koninklijke Philips NV; Research Grant, Siemens AG; Research Grant, SuperSonic Imagine; Speakers Bureau, Koninklijke Philips NV; Research Grant, Bracco Group; Speakers Bureau, Siemens AG; Consultant, Canon Medical Systems Corporation; Research Grant, Esaote SpA; Research Grant, BK Ultrasound; Research Grant, Hitachi, Ltd

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CONCLUSION

Dispersion images are shown to have contrast between tissue types and with quantitative values that align with previous studies. Further study is required to define the practical upper limits of SW frequencies, and the range of normal dispersions expected within a healthy population.

Background

We analyze the case of shear waves (SW) established as a fully reverberant field, in which the waves propagate in all directions. The application of reverberant shear wave (R-SW) fields can be accomplished by applying external sources that can be excited by multiple frequencies within a bandwidth. This enables the analysis of the dispersion of shear wave speed (SWS) as it increases with frequency, indicating the viscoelastic nature of the tissue under study. Furthermore, dispersion images can be created alongside the SWS images. We report preliminary studies on breast and liver tissues using the multi-frequency R-SW technique.

Evaluation

A custom-made portable trifold futon with multiple embedded vibration sources was mounted to a clinical bed to generate the R-SW field. Vibration frequency ranges between 40-400 Hz were used for both CIRS phantoms and liver experiments and 117-702 Hz was used for breast experiments. A Verasonics ultrasound system (Vantage-128TM, WA, USA), was used to track the induced displacements. The wavenumber was estimated by evaluating the autocorrelation function of the R-SW signal. The relationship between SWS and frequency was evaluated over the vibration frequency range. Our multi-frequency data was analyzed for both the traditional linear dispersion slope (LDS) and for power law coefficient (PLC) dispersion.

Discussion

In liver, mean LDS of 0.35±0.06, 0.52±0.11 (m/s/100Hz) and PLC of 0.25±0.04, 0.40±0.10 were obtained for a thin and an obese patient, respectively. In breast, LDS of 0.13±0.06, 0.49±0.09 (m/s/100Hz) and PLC of 0.24±0.11, 0.69±0.10 were obtained for a fibroadenoma and dense tissue, respectively. This work shows that R-SW fields can be produced in deep tissues using external sources, up to 400 Hz in obese patients' livers and over 700 Hz in breast tissue. The dispersion can be analyzed as LDS or as a PLC consistent with a more advanced framework of tissue rheology.

Printed on: 10/29/20

SSE23

Physics (Nuclear Medicine)

Monday, Dec. 2 3:00PM - 4:00PM Room: E351

NM PH

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

Participants

Chin-Tu Chen, PhD, Chicago, IL (*Moderator*) Board Member, BioMed Global Board Member, EVO Worldwide, Inc Board Member, AEPX Board Member, EnDepth Vision Systems, LLC Research Grant, DxRay, Inc Advisor, RefleXion Medical Inc Shareholder, EDDA Technology, Inc
Srinivas C. Kappadath, PhD, Houston, TX (*Moderator*) Research Grant, General Electric Company; Research Grant, BTG International Ltd; Consultant, BTG International Ltd; Consultant, ABK Biomedical Inc; Consultant, Terumo Corporation

Sub-Events

SSE23-01 Comparison of Post-Therapy Y-90 PET/CT Dosimetry Methods in Liver Therapy with Y-90 Microspheres

Monday, Dec. 2 3:00PM - 3:10PM Room: E351

Participants
Karin Knesaurek, PhD, New York, NY (*Presenter*) Nothing to Disclose
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CONCLUSION

The MIM and Planet Dose DPK dosimetry values were practically interchangeable. Y-90 disimetry values obtained by all methods were similar, but LDMwS tended to produce slightly higher values.

Background

The aim of our study was to compare dosimetry methods for Y-90 PET/CT, using commercially available software packages.

Evaluation

As a part of continuing study, 25 patients were taken to a PET/CT suite (mCT, Siemens Medical) following therapy with Y-90 microspheres. The low mA, non-diagnostic CT images were used for attenuation correction and localization of the Y-90 microspheres in PET/CT studies. The acquisition time was 15 min, the reconstruction matrix size was 200x200x75 mm and voxel size 4.07x4.07x3.00 mm. Two commercially available software packages, MIM 6.8 (MIM software Inc., Cleveland, Ohio) and Planet Dose (DOSIsoft SA, Cachan, France) were utilized to calculate Y-90 dosimetry from PET images. Three methods were used for voxel-based dosimetry calcualtions; the Local Deposition Method (LDM), LDM with scaling (LDMwS) for known injected activity, and a Dose Point Kernel (DPK) method using the MIRD kernel. Only the DPK approach was applied to the Planet Dose software and these walues were comapred with MIM DPK dosimetry values. LDM and LDMwS were only applied to the MIM software. The average total liver dosimetry values (mean±SD) were 53.59±23.47 Gy, 60.93±28.62 Gy, 55.33±24.80 Gy and 54.25±23.70 Gy, for LDM, LDMwS, DPK with MIM and DPK with Planet Dose (DOSI), respectively. In most cases the LDMwS method prodused slightly higher values than the other methods. The MIM and Planet Dose DPK dosimetry values (i.e., DPK vs. DOSI) were higly comparable. Bland-Altman analysis calculated a mean difference of 1.1 ± 1.6 Gy. The repeatability coefficient was 3.1(5.7% of the mean).

Discussion

The slightly higher values produced by LDMwS compared to the other methods is due to the difference between dose calibrator scaling, and the quantitative accuracy of the Y-90 PET imaging. Although, the differences are not great, they should be diminished by better quantifiable Y-90 PET imaging and improved dose calibrator quality control.

SSE23-02 Accuracy Dose Evaluation in Radioembolization Procedures Using 99mTc-SPECT/CT and 90Y-PET/CT

Monday, Dec. 2 3:10PM - 3:20PM Room: E351

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CONCLUSION

In this paper it is emphasized that, in radioembolization procedures, 99mTc-SPECT/CT images can be used to predict directly the final dose distribution for 90Y microspheres with accuracy. In particular, pixel's intensity uniformity, noise and sensitivity in 99mTc-SPECT/CT images are obviously much better than those observed in 90Y-PET/CT scans. The 90Y-PET/CT dosimetric accuracy, in comparison to 99mTc-SPECT/CT dosimetric accuracy, is still acceptable for dosimetric purpose and it remains a necessary tool for theranostic analysis with therapeutic and diagnostic capabilities.

Background

Radioembolization with 90Y-microspheres is increasingly used in HCC treatment. In terms of the impact of tumoral dose, many studies confirmed a tumor dose response relationship. For pre-therapeutic dosimetry, 99mTc-MAA is used as a surrogate of microsphere distribution to assess tumoral targeting and dosimetry. In the same way, 90Y-PET/CT following radioembolization has been established as a viable diagnostic tool for tumoral targeting and dosimetry. The aim of this study is to evaluate dosimetry accuracy both in 99mTc-SPECT/CT and in 90Y-PET/CT.

Evaluation

iDVH and dDVH obtained from 99mTc SPECT-CT and 90Y PET-CT were evaluated to analyze mean and voxel dose accuracy in tumor and liver dose evaluation, as implemented in MIM software vs. 6.8, with three different dosimetric approach both in a torso phantom and patients. Images were acquired in a Siemens Biograph mCT PET/CT and in a Siemens Intevo 2 SPECT/CT. Figure 1 shows dose distribution in the phantom liver compartment for 99mTc SPECT-CT and 90Y PET-CT. iDVH and dDVH for all the dose calculation methods, both for 99mTc and 90Y, are reported in Figure 2 and 3, respectively. Figure 4, 5 and 6 show same results in patient study with 99mTc SPECT-CT.

Discussion

Mean doses, standard deviation and coefficient of variation obtained from iDVH, for 99mTc SPECT-CT and 90Y PET-CT, shows deviations from MIRD dose between -9% and -4% while deviations between -27% and -9% are reported for 90Y PET-CT. Finally, the CoV dispersion index 1 confirm the better dose distribution estimation obtained in the 3D dosimetry for 99mTc SPECT-CT with respect to those obtained for 90Y PET-CT.

SSE23-03 Development of Wearable Technology to Enable Therapy Personalization of 177Lu DOTATATE for Neuroendocrine Tumors

Monday, Dec. 2 3:20PM - 3:30PM Room: E351

Participants
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PURPOSE

The goal of this work is to enable patient specific 177Lu-DOTATATE organ dosimetry without requiring serial imaging sessions at a medical facility. This will be accomplished by developing wearable monitoring technology to allow quantitative measurements to be made through at home usage. This will support accurate estimation of the washout from individual organs at risk (OAR) enabling physicians to tailor the number of treatments based upon personalized organ dosimetry information .

METHOD AND MATERIALS

The enabling technologies are the development of a precision sensing belt (PSB) and software methods that can determine the optimal placement of a sparse set (e.g., 8-15) of small radiation detectors around the mid-section of the patient. A CT image will be used to register the PSB with a patient's internal organs. Based upon the patient specific CT image, Monte Carlo simulations and optimization methods are used to select the optimum positioning of a small set of detectors around the patient. Measurements from the PSB are then correlated with a quantitative SPECT/CT image acquired 24 hours after dose administration. After being sent home, the patient will wear the PSB for 2 minutes per day for 7-21 days. The basic methodology was tested using Monte Carlo simulation. The testing phantom consisted of anthropomorphic objects representing the liver, spleen, right and left kidneys and two tumors. Activity ratios for the liver, spleen, right and left kidneys, 2.5 cm and 1.5 cm tumors to background were 2, 10, 10, 8, 48 and 60. The washout half-lives were 74, 66, 40, 46, 92, 96, and 95 hours, respectively. One hundred simulations were run and the root mean squared error (RSME) was determined for the estimated and actual decay constants for the OAR, background and tumors .

RESULTS

Using only 4 PSB measurements at 4 hrs and 1, 3 and 7 days, the RSME between the estimated and actual washout constants for the OAR and background were all <5%. The 2.5 cm tumor had the worst RMSE of ~12%. However, when 21 daily PSB measurements were made all OAR, background and tumors had a RSME of <4% .

CONCLUSION

The initial results based upon simulation studies indicate that the precision sensing belt is able to estimate washout from OAR and tumors to within ±5%. Use of the PSB could significantly lower the cost of any clinical trial to investigate personalized 177Lu DOTATATE therapy and lead to FDA approval for personalized therapy.

CLINICAL RELEVANCE/APPLICATION

The goal of the precision sensing belt is to enable low cost, patient friendly methods for the personalization of 177Lu DOTATATE therapy.

SSE23-04 Quantitative Impact of Iterative Reconstruction Settings for Next-Generation Digital Photon Counting PET/CT

Monday, Dec. 2 3:30PM - 3:40PM Room: E351

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PURPOSE

The introduction of next generation, digital PET/CT enables high definition reconstruction with decreased voxel volumes, improving image quality, lesion detectability, and quantitative accuracy. However, using a larger reconstruction matrix without changing reconstruction parameters leads to increases in image noise. We assessed the impact of iterative reconstruction settings on PET quantification in order to overcome the perceived limitations of image noise.

METHOD AND MATERIALS

80 patients injected with 13 mCi 18F-FDG were imaged 90sec/bed on a digital photon counting PET/CT system (Philips Vereos, dPET). PET listmode data were reconstructed with 4 and 2mm3 isometric voxel volumes, initially using 3 iterations with 29 subsets. Secondary reconstructions then completed using 13, 15, and 17 subsets for the 4mm standard definition (SD) images, and 11, 13, and 15 for the 2mm high definition (HD) images. We evaluated visual quality and quantitative precision in target tumors and background tissues, using the 29 subset images as a reference.

RESULTS

Visual review revealed that the lower subset images were more preferable than the reference 29 subset images, particularly for the HD reconstructions where image noise is more apparent. Quantitative evaluation was revealed to be quite stable over a range of reconstruction settings. On average, quantification of physiologic uptake varied less than 2% and 3% for SD and HD reconstructions. In target lesions, the SUVmax decreased on average 4.4%, 4.1%, and 4.2% for SD images with 13, 15, and 17 subsets. In the HD images, the average decrease was 8.7%, 7.2%, and 6.4% for 11, 13, and 15 subsets.

CONCLUSION

The improved sensitivity and time of flight timing resolution of the dPET system allow for more accurate lesion detection and quantification, enhanced by the use of HD reconstructions. Here we have shown that when modifying the reconstruction settings to optimize visual quality of the images, quantitative parameters remain stable. Thus the optimization can be tailored to chosen voxel volumes and expected count densities in order to best leverage the capabilities of new digital photon counting PET.

CLINICAL RELEVANCE/APPLICATION

Higher definition PET imaging is readily achieved after optimization of iterative reconstruction parameters to account for increased noise in the now more count sparse voxels.

SSE23-05 A Study of Pseudo CT Generation for PET/MR Attenuation Correction Using Deep Learning

Monday, Dec. 2 3:40PM - 3:50PM Room: E351

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PURPOSE

Accurate attenuation correction (AC) remains a challenging problem in today's PET/MR systems. Specialized UTE MR images have been used for generating AC map in conventional scanners. However, the UTE acquisitions are time-consuming and provide little information for clinical diagnostic purpose. In this study, we investigated the feasibility of a deep learning approach using conditional generative adversarial network (cGAN) (Isola et. al., arXiv:1611.07004) to synthesize pseudo CT images from T1-weighted MR images for AC map generation in brain PET/MRI imaging.

METHOD AND MATERIALS

The cGAN network was trained to provide continuously valued CT images. The network structure was adopted from the original paper, which consists of a U-Net generator and a PatchGAN discriminator. Both MR and CT images were acquired at the head position for 100 patients. The T1-GRE-FSP-ISO images, which were included in the clinical scanning protocol, were chosen as the input MR images. The MR and CT images were registered and transformed into 2D axial images with 1mm*1mm pixel size and 2mm slice thickness. Images of 80 patients were used in the training procedure and those of

the other 20 patients were used for validation. The performance of the trained model was evaluated by comparing the generated pseudo-CT to the acquired CT images using structural similarity index (SSIM). Dice coefficients were also calculated via segmenting the images into air (<-500 HU), bone (>500 HU), and soft tissue regions.

RESULTS

For the validation image set of 20 patients, the SSIM between the pseudo-CT images generated by the trained model and acquired CT images is 0.894±0.049. The Dice coefficients are 0.987±0.008 for air, 0.736±0.094 for bone, and 0.938±0.028 for soft tissues.

CONCLUSION

The initial results show that this deep learning approach based on cGAN technique has the potential to synthesize continuously-valued pseudo-CT images from T1-weighted MR brain images, which can then be further used to generate AC map for PET/MR imaging. Future work may include training of 2.5D or fully 3D models as well as employing additional MR sequences as the model input.

CLINICAL RELEVANCE/APPLICATION

This study provides an alternative approach for attenuation correction in PET/MR systems, which may potentially improve the current PER/MR imaging procedure and quality.

SSE23-06 Total-body Parametric Imaging on EXPLORER

Monday, Dec. 2 3:50PM - 4:00PM Room: E351

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PURPOSE

Dynamic PET can estimate physiologically relevant parameters. Current PET scanners offer whole-body dynamic imaging but require a multi-pass scan protocol, which results in low signal-to-noise and misses temporal information at each bed position. To overcome these limitations, a 2-meter long PET/CT (EXPLORER) has been developed. In this work, we perform total-body parametric imaging and demonstrate its potential benefit for clinical imaging.

METHOD AND MATERIALS

We conducted the first human dynamic total-body PET study using the EXPLORER scanner in a healthy female subject. A 60min dynamic scan was performed immediately after an intravenous injection of 256 MBq of 18F-FDG. We divided the one-hour dynamic dataset into 187 frames and reconstructed it using a 3D TOF list-mode OSEM algorithm with all quantitative corrections (normalization, attenuation, scatter and random corrections) incorporated in the forward model. The linear Patlak model was implemented to analyze total-body FDG metabolism. The Patlak slope Ki image was estimated from the reconstructed 30-60min frames and was compared with the standard uptake value of the static scans at different times post-injection. The input function was obtained from the aorta time activity curve.

RESULTS

First, the reconstructed dynamic images show good image quality with low noise and demonstrate the high sensitivity of the EXPLORER and the benefit of total-body coverage. Second, the Patlak Ki image show good contrast and high signal-to-noise ratio for detecting abnormally high FDG uptake which may potentially increase lesion detectability using FDG PET. In this volunteer study, a hot spot in the right collarbone, possibly representing bone healing processes, can be clearly seen in the Patlak Ki image using the 30-60min data. The hot spot is confirmed in the delayed scan acquired at 4-hr post injection. This result suggests that we may be able to use dynamic scans to obtain improved lesion conspicuity without the inconvenience of late time-point scanning.

CONCLUSION

In this study we performed a total-body parametric imaging study using the EXPLORER and demonstrated its high image quality for clinical imaging.

CLINICAL RELEVANCE/APPLICATION

FDG PET images glucose metabolism and has been widely used in cancer detection and staging. Total-body parametric imaging can potentially improve lesion detection over existing static scans.

Printed on: 10/29/20

SSE24

Physics (Deep Learning - X-Ray Scatter Correction and Denoising)

Monday, Dec. 2 3:00PM - 4:00PM Room: S104A

AI CT PH

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

FDA Discussions may include off-label uses.

Participants

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Timothy P. Szczykutowicz, PhD, Madison, WI (*Moderator*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited

Sub-Events

SSE24-01 Low-Contrast Detectability of Image-Based Denoising Algorithm using Deep Learning in CT: A 12-Reader Study Comparing with Advanced Modeled Iterative Reconstruction and Filtered Back Projection

Monday, Dec. 2 3:00PM - 3:10PM Room: S104A

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PURPOSE

To compare the low-contrast detectability of deep learning-based denoising algorithm (DLA) with those of advanced modeled iterative reconstruction (ADMIRE) and filtered back projection (FBP).

METHOD AND MATERIALS

Using abdomen and pelvis CT images of 100 patients reconstructed with both ADMIRE and FBP, we trained DLA while feeding FBP images as input and ADMIRE images as the ground truth. To compare the low-contrast detectability of the DLA with those of ADMIRE and FBP, randomized repeat scans of Catphan® low-contrast phantom module (CTP 515) were performed under various conditions of radiation exposures (100 kVp; 200, 100, 50, 25 mAs). All images were reconstructed or denoised using each algorithm. We used 9 mm and 5 mm supra-slice targets with +10 HU difference to the background in measuring the low-contrast detectability. Twelve radiologists reviewed 960 images and evaluated target presence on a five-point confidence scale. Task transfer function (TTF) and noise power spectrum (NPS) of each algorithm were evaluated using American College of Radiology CT accreditation phantom module 1 under the condition of 100 kVp and 200 mAs. To compare the low contrast detectability, multireader multicase area under the receiver operating characteristic curve (AUC) was calculated and noninferiority tests were performed. To compare the TTF and NPS across the algorithms, TTF50, area under the NPS (AUNPS), and NPS peak frequency were compared using paired t-test.

RESULTS

AUC of DLA in detecting low contrast targets was noninferior to that of ADMIRE (AUC difference [95% confidence interval], -0.013 [-0.038-0.012]; $P < 0.001$) and superior to that of FBP (0.039 [0.017-0.060], $P < 0.001$). TTF50 of DLA was significantly higher than those of FBP and ADMIRE ($P < 0.001$), except comparing with that of ADMIRE in the disc simulating hypothetical bone. AUNPS of DLA was significantly lower than those of ADMIRE and FBP ($P < 0.001$, respectively). The NPS peak frequency of DLA was not different from that of ADMIRE ($P > 0.99$) and was significantly lower than that of FBP ($P < 0.001$).

CONCLUSION

The low-contrast detectability of the deep learning-based denoising algorithm was noninferior to that of ADMIRE and was superior to that of FBP.

CLINICAL RELEVANCE/APPLICATION

The deep learning-based denoising algorithm can potentially imitate and substitute the advanced modeled iterative reconstruction, as the image quality of the deep learning-based denoising algorithm was comparable to that of ADMIRE and was superior to that of FBP.

SSE24-02 Patient-Specific Noise Reduction Using a Deep Convolutional Neural Network

Monday, Dec. 2 3:10PM - 3:20PM Room: S104A

Participants
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PURPOSE

To develop and evaluate patient-specific training to improve performance for convolutional neural network (CNN)-based CT denoising.

METHOD AND MATERIALS

Two training methods were investigated for CNN-based denoising of CT images: one using abdominal CT data from multiple patient cases to perform generic CNN training, and the other using patient-specific data to fine-tune the generic CNN for use with images from that same patient. A deep residual CNN was trained with routine dose (RD) abdominal CT images from 10 patients, and the corresponding low-dose (LD) images, which use noise insertion into the projection data to simulate data acquired at 25% of RD. The mean squared error (MSE) between LD and RD images was used as the loss function. After training for 300 epochs, the model was referred to as CNN-General. The model was then fine-tuned for 300 epochs using RD images from a new patient (Patient A) and 19 additional LD image realizations achieved through repeated insertion of random noise. After fine-tuning, the model was referred to as CNN-A, since it was tuned to the anatomy of Patient A. Simulated LD (25, 50, and 75%) data from 3 patients (A,B,C) not included in the original 10-patient training cohort were used for validation data; the LD data for Patient A that was used for validation was a different LD realization than the 19 simulated exams used for Patient-A-specific training. Performance was assessed by comparing the minimum MSE values achieved during training and various anatomic features in the original RD images of Patient A after denoising with both methods.

RESULTS

After the first 50 epochs of fine-tuning, CNN-A converged to a lower MSE than CNN-General when applied to Patient A for 25%, 50%, and 75% of RD by factors of 12%, 22%, and 22% respectively. When applied to the original RD images for Patient A, we found that CNN-A improves the visibility of subtle anatomic features compared to CNN-General.

CONCLUSION

A CNN-based denoising algorithm trained using a random patient cohort can be fine-tuned for a specific patient to improve denoising performance using a single CT exam with multiple random noise realizations.

CLINICAL RELEVANCE/APPLICATION

Patient-specific fine-tuning of a CNN-based denoising algorithm can improve performance compared to one that was only trained on a general patient cohort.

SSE24-03 Deep Learning Based Adaptive Filtering for Projection Data Noise Reduction in X-Ray Computed Tomography

Monday, Dec. 2 3:20PM - 3:30PM Room: S104A

Participants
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PURPOSE

Raw data noise reduction is often applied in CT before reconstruction in order to improve the quality of reconstructed images. Adaptive data filtering methods have been widely used for this purpose. However, most of adaptive filtering methods choose the kernel parameter based on empirical knowledge which may lack robustness depending on data conditions. In this research, we leverage the deep learning technique to mitigate this limitation. We propose a parametric kernel prediction network (PKPN) which can automatically generate kernel parameters that are adaptive to various data statistics.

METHOD AND MATERIALS

We develop a deep neural network, PKPN, which can automatically predict the spatially variant kernel parameter based on various input data statistics. PKPN includes two major components: a linear sequence network and a spatial variant filtering module (see figure 1). The network is to generate parameters for every data pixel required by the filtering module. Note that when training the network, we still compute the loss between the predicted projection and the reference projection. This ensures that the data after adaptive filtering can still be optimal in terms of training criteria.

RESULTS

We calculated the RMSE and the SSIM with the high-dose reference. For low-dose abdominal (120 kVp, simulated 35 mAs) and thoracic (120 kVp, simulated 45 mAs) projection data, PKPN shows both better RMSE and SSIM on the reconstructed images compared to conventional filtering method (Relative Noise Level) processed data (see figure 2). Anatomical detail is also clearer at the PKPN set compares to the RNL set.

CONCLUSION

PKPN can learned through the training process with a relatively simple three-layer neural network. For both simulated and clinical low-dose cases, PKPN shows very competitive performance in terms of both image accuracy and resolution compared to the conventional approach. Moreover, the proposed method can be readily extended to kernel functions other than the simple 2-D isotropic Gaussian function.

CLINICAL RELEVANCE/APPLICATION

PKPN for sinogram/projection denoising improves the overall reconstructed CT image quality compared to the conventional approach especially for the low-dose acquisitions.

SSE24-04 Deep Learning based Material Image Denoising for Dual Energy CT with Only Noisy Training Images

Monday, Dec. 2 3:30PM - 3:40PM Room: S104A

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PURPOSE

Basis material images such as iodine map are noisy in dual energy computed tomography (DECT) due to ill-posed decomposition matrix. This study aimed to reduce noise level of basis material images with deep neural networks which could be trained without noiseless data.

METHOD AND MATERIALS

Most existing deep learning methods for image denoising require noiseless images as ground truth during training, which are not available for real basis material images in DECT. In this work we proposed a novel deep learning based denoising method for DECT which required only noisy data for training. The projections were split to odd and even sets and each set was reconstructed by filtered backprojection (FBP) separately to acquire xi1 and xi2 with nearly independent noise from each other. Two networks (UNet) were trained to map xi1 to material decomposition of xi2 and vice versa. The final denoised material images were the averaged results from the two networks. The method was validated on chest DECT scans from 45 patients for iodine map denoising. 30 patients were randomly selected as training images and the rest 15 were used for testing.

RESULTS

The method was compared against direct inversion and non-local mean based guided filtering (HYPR-NLM) on the 15 testing subjects. 5 ROIs were drawn on aortas for each subject to study bias and noise level of the basis material images. Bias was calculated by subtracting mean of direct inversion's ROIs from mean of the other two methods' ROIs. The proposed method achieved bias of -0.0015 ± 0.0055, which was small enough to be considered unbiased. The proposed method achieved standard deviation of 0.026 ± 0.009 on ROIs and was consistently reduced compared to direct inversion (0.123 ± 0.019) and HYPR-NLM (0.030 ± 0.010), both with $p < 0.01$ under dependent t-test. The images of iodine maps decomposed by the proposed method demonstrated significantly reduced noise level compared to direct inversion. It also showed less structural bias and block / spiky artifacts compared to HYPR-NLM.

CONCLUSION

The proposed deep learning method which required only noisy images to train could significantly reduce noise in basis material images of DECT without introducing bias.

CLINICAL RELEVANCE/APPLICATION

The proposed method could greatly reduce the noise in material decomposition images of DECT and improve image quality in relevant applications such as pulmonary embolism, renal mass, gout, etc.

SSE24-05 Scatter Correction for Contrast-Enhanced Digital Breast Tomosynthesis (CEDBT) Using Deep Learning Approach

Monday, Dec. 2 3:40PM - 3:50PM Room: S104A

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PURPOSE

Contrast enhanced digital breast tomosynthesis (CEDBT) utilizes weighted subtraction of high energy (HE) and low energy (LE) DBT to generate a 3D iodinated contrast enhancement map of the breast, and potentially improve breast lesion detection and characterization. However, the increased scattered radiation at HE exacerbates the cupping artifact. Monte Carlo (MC) based scatter correction (SC) method suffers from long computation time, and kernel-based method is less accurate, especially near the breast edge due to thickness roll-off. This work is aimed at developing fast and accurate SC using Convolutional Neural Network (CNN).

METHOD AND MATERIALS

The FDA open-source VICTRE tool was used to create digital breast phantoms with various shapes, sizes, and breast densities. HE DBT projection images with and without scatter were generated from MC simulation based on the acquisition geometry of Siemens Mammomat Inspiration DBT system. A U-Net CNN was trained to obtain scattered radiation map from projection images with scatter. To minimize the effect of quantum noise on scatter estimate, a gaussian filter was applied to smooth the scatter maps in the training dataset. The segmented breast region, compressed breast thickness, and projection angle were provided to the CNN as separate channels. Mean absolute percentage error (MAPE) was used as the loss function. The number of projections used for training, validation, and testing was 526, 125, and 150 respectively. The accuracy of the CNN-based SC was compared with the accuracy of kernel-based SC using projection images without scatter from MC simulation as ground truth. The proposed SC method was tested on the HE projection images and DBT volume acquired from an IRB-approved clinical study investigating CEDBT.

RESULTS

After training, the CNN performed SC in real-time. CNN-based SC shows higher accuracy in scatter estimate for HE projections compared to kernel-based SC in the breast peripheral region. The cupping artifact in HE DBT is suppressed post SC.

CONCLUSION

The proposed CNN-based SC provides a fast and accurate scatter correction for CEDBT.

CLINICAL RELEVANCE/APPLICATION

The scatter removal in HE DBT improves the image quality of CEDBT, which can potentially make high clinical impact on breast cancer detection and 3D assessment of contrast-enhanced lesions.

SSE24-06 Monte-Carlo-Free Deep Scatter Estimation (DSE) for X-Ray CT and CBCT

Monday, Dec. 2 3:50PM - 4:00PM Room: S104A

Participants
Julien Erath, MSc, Forchheim, Germany (*Presenter*) Employee, Siemens AG
Joscha Maier, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Eric Fournie, Forchheim, Germany (*Abstract Co-Author*) Siemens AG
Karl Stierstorfer, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Marc Kachelriess, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To provide an accurate real-time scatter correction algorithm that uses CT measurements of a few simple-to-manufacture phantoms for calibration.

METHOD AND MATERIALS

DSE is a neural network that maps measured CT data onto scatter-free data. To train DSE a Monte Carlo (MC) simulation of scatter had been used [J. Nondest. Eval. 37:57, 2018] [Med. Phys. 46(1):238-249, 2019]. While being very accurate, this simulation-based approach (sbDSE) highly relies on the quality of the MC simulation which needs to be tailored to the CT scanner. To avoid the need for MC we define a limited set of geometric phantoms in several arrangements to provide a training set for the DSE. The advantage of geometric phantoms is that on the one hand they can be measured in a physical setup, providing the sum of primary and scattered radiation. On the other hand the primary radiation can accurately be determined in a polychromatic simulation of the objects. Thus, the scatter intensity can be estimated by subtracting the simulated primary intensity from the measured intensity. The DSE network is trained to map the measured intensity onto the difference of the measured intensity minus the forward projected intensity. This measurement-based DSE (mbDSE) is evaluated using simulations of the calibration procedure (Siemens Somatom Force system, without anti scatter grid). We apply mbDSE to simulations of semi-anthropomorphic phantoms of different sizes.

RESULTS

The mean absolute relative error of the mbDSE scatter estimate is between 2 and 3%. Without scatter correction the CT values of the thorax phantom deviated from the scatter-free ground truth by 102 HU (mean of heart ROI), 140 HU (mean of soft tissue ROI close to vertebra), and 15 HU (mean of lung ROI). DSE is able to correct these values to 2 HU, 1 HU, and 0 HU. An MC-based scatter correction did not perform better. Visually the artifacts introduced due to the scatter are completely removed.

CONCLUSION

The proposed mbDSE may outperform sbDSE and the conventional MC-based scatter estimation since it does not require modeling the scanner's x-ray and scattering properties in detail. Instead it can extract the features relevant for scatter from a set of phantom measurements.

CLINICAL RELEVANCE/APPLICATION

Accurate scatter estimation allows for accurate correction of scatter artifacts and is thus crucial for providing good image quality.

ED013-TU

Physics Tuesday Case of the Day

Tuesday, Dec. 3 7:00AM - 11:59PM Room: Case of Day, Learning Center

AMA PRA Category 1 Credit ™: .50

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Christina Brunnquell, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Courtney K. Morrison, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Karen L. Brown, MPH, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Sparsh Gola, MD, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Robert Bujila, Stockholm, Sweden (*Abstract Co-Author*) Intern, General Electric Company
Christin Ekestubbe, Solna, Sweden (*Abstract Co-Author*) Nothing to Disclose
Nathan M. Cross, MD, MS, Seattle, WA (*Abstract Co-Author*) Consultant, Koninklijke Philips NV
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Canon Medical Systems Corporation; Consultant, Clementia Pharmaceuticals Inc
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
John A. Parker, MD, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Frederic H. Fahey, DSc, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

The physics case of the day questions and supplemental material will challenge the learner to combine their basic physics understanding with real clinical scenarios to explain a feature on an image.

Printed on: 10/29/20

SPDL30

Houston, We Have a Problem (Case-based Competition)

Tuesday, Dec. 3 7:15AM - 8:15AM Room: E451B

CA GI GU MK NR OB PD PH SQ VA

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 0

Participants

Adam E. Flanders, MD, Narberth, PA (*Presenter*) Nothing to Disclose
Sandeep P. Deshmukh, MD, Philadelphia, PA (*Presenter*) Nothing to Disclose
Christopher G. Roth, MD,MS, Philadelphia, PA (*Presenter*) Nothing to Disclose
Vishal Desai, MD, Philadelphia, PA (*Presenter*) Nothing to Disclose

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Special Information

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

LEARNING OBJECTIVES

1) Be introduced to a series of radiology case studies via an interactive team game approach designed to encourage 'active' consumption of educational content. 2) Use their mobile wireless device (tablet, phone, laptop) to electronically respond to various imaging case challenges; participants will be able to monitor their individual and team performance in real time. 3) Receive a personalized self-assessment report via email that will review the case material presented during the session, along with individual and team performance.

Printed on: 10/29/20

RC321

Innovations in MR

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S102CD

MR PH

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

FDA Discussions may include off-label uses.

Participants
Matthew A. Bernstein, PhD, Rochester, MN (*Coordinator*) Former Employee, General Electric Company; Intellectual property, General Electric Company

LEARNING OBJECTIVES

1) Review newer techniques that can be used to accelerate MR including simultaneous multislice (SMS), compressed sensing, and MR fingerprinting. 2) Review the basic principles of chemical exchange saturating transfer, and discuss its emerging applications. 3) Review recent advances in novel MR systems, including low cryogen magnets, dedicated and compact systems.

Sub-Events

RC321A New Directions in Fast MR

Participants
Kawin Setsompop, Charlestown, MA (*Presenter*) Research Grant, Siemens AG; Royalties, General Electric Company; Royalties, Koninklijke Philips NV; Scientific Advisory Board, Kineticor;

LEARNING OBJECTIVES

1) Describe emerging MR acquisition approaches and their ability to provide faster and higher quality imaging. 2) Identify the most suitable acquisition approach for improving the quality of various imaging sequences/clinical applications.

RC321B New Directions in CEST

Participants
Peter C. van Zijl, PhD, Baltimore , MD (*Presenter*) Research support, Koninklijke Philips NV; Patent agreement, Koninklijke Philips NV; Speakers Bureau, Koninklijke Philips NV

LEARNING OBJECTIVES

1) Understand the basics of CEST, endogenous and exogenous contrast. 2) Be aware of latest applications of CEST in the clinic. 3) Understand interpretation of Amide Proton Transfer weighted (APTw) MRI for assessing brain tumors, including for separating high/low grade, separating progression/pseudoprogression, relationship to IDH status. 4) Be aware of possible contrast agents for CEST MRI.

ABSTRACT

Chemical Exchange Saturation Transfer (CEST) is a relatively new field of magnetic resonance (MR) that combines principles of MR spectroscopy (MRS, chemical selectivity of proton pools) and MRI (imaging of water protons with high sensitivity). It is based on magnetization transfer, especially exploiting the interaction of the exchangeable protons of probe molecules with the water protons to achieve large sensitivity enhancements (several orders of magnitude) for the imaging of molecular information with MRI sensitivity. CEST MRI can be done both using paramagnetic and diamagnetic probes, but the ultimate strength and hope for fast clinical translation lies in the presence of endogenous contrast (e.g. cellular proteins and tissue metabolites, such as glutamate) and in the use of diamagnetic agents, expected to have lower toxicity and to be more applicable for regulatory approval and patient acceptance.After an introduction of the basic principles of CEST MRI to provide insight into the type of molecules that can be studied and the sensitivity of this approach, I will explain the main contributions to the in vivo saturation spectrum (Z-spectrum) and its relationship to the proton MR spectrum. Several application examples will be presented to illustrate the potential of using these signals for clinical diagnosis and prognosis.1) imaging of endogenous proteins, especially the use of amide proton transfer weighted (APTw) MRI for brain tumor diagnosis, including separation of high and low grade, judging progression versus pseudoprogression and the effect of IDH status. 2) Imaging of glutamate.3) Use of simple diamagnetic probes such as D-Glucose and its polymers for imaging tissue perfusion, membrane permeability and metabolism.4) Novel approaches for the future.These examples are only early illustrations of this relatively new field, which has great potential due to the presence of exchangeable protons in most molecular agents.Literature:1) van Zijl PC, Yadav NN. Chemical exchange saturation transfer (CEST): what is in a name and what isn't? Magn Reson Med. 2011 Apr;65(4):927-48. 2) Zhou J, Heo HY, Knutsson L, van Zijl PCM, Jiang S. APT-weighted MRI: Techniques, current neuro applications, and challenging issues. J Magn Reson Imaging. 2019 Jan 20. doi: 10.1002/jmri.26645. [Epub ahead of print] Review. 3) Jones KM, Pollard AC, Pagel MD. Clinical applications of chemical exchange saturation transfer (CEST) MRI. J Magn Reson Imaging. 2018 Jan;47(1):11-27

RC321C New Directions in MR Scanners

Participants
Yunhong Shu, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

shu.yunhong@mayo.edu

LEARNING OBJECTIVES

1) List a variety of emerging technologies for MRI scanner design. 2) Understand major driving forces for these technology advancements. 3) Identify the advantages and suitable applications for specific MR scanners.

Active Handout:Yunhong Shu

http://abstract.rsna.org/uploads/2019/19001802/Active RC321C.pdf

Printed on: 10/29/20

RC322

Advances in Cone Beam CT Acquisition and Reconstruction in Radiotherapy

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S503AB

CT PH RO

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

Participants
Douglas Moseley, PhD, Toronto, ON (*Moderator*) License agreement, Modus Medical Devices Inc

Sub-Events

RC322A State of the Art in Advanced CBCT Acquisition and Reconstruction

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

For information about this presentation, contact:

wzbijewski@jhu.edu

LEARNING OBJECTIVES

1) Identify key challenges to image quality in CBCT. 2) Discuss latest developments in CBCT instrumentation. 3) Describe recent advances in reconstruction algorithms and artifact correction methods for CBCT. 4) Compare CBCT image quality achievable on their systems to state-of-the-art.

RC322B Clinical Need for Advanced CBCT Imaging in Radiotherapy

Participants
Tianyu Zhao, PhD, St. Louis, MO (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Gain greater understanding on the clinical need of CBCT in radiotherapy in the following applications: a) Image-Guided Radiotherapy (IGRT) with more precise tumor localization and better patient setup, b) 4D CBCT in managing respiratory motion, and c) adaptive radiotherapy (ART).

RC322C Technical Challenges in the Integration of CBCT Imaging into Radiotherapy

Participants
Douglas Moseley, PhD, Toronto, ON (*Presenter*) License agreement, Modus Medical Devices Inc

LEARNING OBJECTIVES

1) Identify the technical challenges when using CBCT imaging for image-guided radiation therapy. 2) Discuss strategies for commissioning and QA of the IGRT workflow in the clinic. 3) Describe the future direction of in-room image guidance.

ABSTRACT

The Scan-Plan-Treat paradigm is becoming too simplistic to do describe the workflow in the modern radiation therapy clinic. Multiple CBCT scans are performed during the treatment delivery that may trigger, re-Scans and re-Plans. This presents several challenges.

Active Handout:Douglas Moseley

http://abstract.rsna.org/uploads/2019/18001993/Active RC322C.pdf

RC323

Advanced Ultrasound Technology and Applications

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S104B

PH US

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

FDA Discussions may include off-label uses.

Participants

William F. Sensakovic, PhD, Scottsdale, AZ (*Coordinator*) Founder, Telerad Physics Teaching, LLC
Thaddeus A. Wilson, PhD, Madison, WI (*Coordinator*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Understand the role of contrast agents in ultrasound. 2) Explain the science and technology behind strain imaging. 3) Implement strain imaging and ultrasound contrast in clinical practice.

Sub-Events

RC323A Contrast Agents

Participants
Peter N. Burns, PhD, Toronto, ON (*Presenter*) Research collaboration, Koninklijke Philips NV

LEARNING OBJECTIVES

1) Understand the physical composition of microbubble contrast agents and how they interact with an ultrasound field. 2) Describe the principles of contrast specific imaging modes found on modern ultrasound scanners. 3) Review the characteristics of contrast images and flow measurements as the basis for their interpretation in a clinic setting.

RC323B Elasticity Imaging

Participants
Stephen McAleavey, PhD, Rochester, NY (*Presenter*) Research collaboration, Siemens AG; Research Grant, Carestream Health, Inc;

LEARNING OBJECTIVES

1) Explain the physical principles of several elasticity imaging methods in clinical use. 2) Understand capabilities and limitations of elasticity methods. 3) Describe current and emerging clinical applications of elasticity imaging.

RC323C Practical Clinical Advice on the Use of Contrast and Strain Imaging

Participants
Richard G. Barr, MD, PhD, Campbell, OH (*Presenter*) Consultant, Siemens AG; Consultant, Koninklijke Philips NV; Research Grant, Siemens AG; Research Grant, SuperSonic Imagine; Speakers Bureau, Koninklijke Philips NV; Research Grant, Bracco Group; Speakers Bureau, Siemens AG; Consultant, Canon Medical Systems Corporation; Research Grant, Esaote SpA; Research Grant, BK Ultrasound; Research Grant, Hitachi, Ltd

LEARNING OBJECTIVES

1) To review appropriate use of ultrasound contrast in the clinical setting. 2) Discuss which patients would benefit from a contrast enhanced ultrasound. 3) Review the requirements for performing a contrast enhanced ultrasound. 4) Review which applications are appropriate for elastography. 5) Discuss how elastography can help in diagnosis.

RC325

Quantitative Imaging: Modality Independent Issues

Tuesday, Dec. 3 8:30AM - 10:00AM Room: S403B

BQ PH

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

Participants

Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Coordinator*) Institutional research agreement, Siemens AG

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LEARNING OBJECTIVES

1) To learn the role that physical phantoms can play in quantitative imaging, especially in understanding and quantifying sources of bias and variance. 2) To explain why digital reference objects (DROs) are useful for evaluation of software packages used to derive quantitative imaging biomarkers. 3) To understand quantitative image analysis methods such as tumor segmentation and feature extraction and the roles that these tools have in quantitative imaging. 4) To understand the role that these modality independent methods have in the standardization of imaging acquisition and image quantification techniques.

ABSTRACT

In Quantitative Imaging, there are some issues that are independent of the imaging modality. Therefore, tools and processes may be developed that are modality independent.

Sub-Events

RC325A The Role of Physical Phantoms in Quantitative Imaging

Participants

William D. Erwin, MS, Houston, TX (*Presenter*) Research Grant, FUJIFILM Holdings Corporation; Research Grant, Alfasigma S.p.A.; Research Grant, Oncosil Medical, Ltd.; Research Grant, Ipsen SA; Research Grant, Advanced Accelerator Applications SA; Research Grant, Y-mAbs Therapeutics;

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LEARNING OBJECTIVES

1) Explain definitions of and requirements for quantitative medical imaging. 2) Describe the role of phantoms and tradeoffs in comparison with simulations and patient studies. 3) Differentiate between classes of phantoms available: commercial, experimental and virtual (digital reference objects).

Active Handout:William Daniel Erwin

http://abstract.rsna.org/uploads/2019/19001543/Active RC325A.pdf

RC325B Digital Reference Objects

Participants

Daniel P. Barboriak, MD, Durham, NC (*Presenter*) Advisory Board, General Electric Company; Medical Advisory Board, Blue Earth Diagnostics Ltd

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LEARNING OBJECTIVES

1) Explain why digital reference objects are useful for evaluation of software packages used to derive quantitative imaging biomarkers. 2) Understand the difference between aggregated and disaggregated metrics of software performance.

ABSTRACT

This lecture will familiarize the audience with digital reference objects (DROs) and their place in the development of quantitative imaging biomarkers (QIBs). To determine whether a quantitative imaging study is measuring a pathological or physiological process in an unbiased way, the quantitative imaging result would need to be compared to an independently ascertained unbiased measurement in the imaged subject or animal. Unfortunately, obtaining a precise and unbiased measurement (also known as ground truth) is generally impractical or impossible. Frequently there may be several software packages available that can be used to create maps reflecting the spatial distribution of the QIB. Because different software packages often give different quantitative results, the choice of software contributes to the variability of the result. Without ground truth data, it can be difficult to determine which softwares calculate the underlying biomarker with sufficient precision and lack of bias to be applicable for a particular use case. DROs are synthetic images whose pixel values are most often either partially or completely determined by

mathematical equations. Although these images may be designed to mimic real imaging data, their content is ultimately determined by mathematical models. Even though DROs do not perfectly simulate real data, they are useful because they are created assuming particular underlying parameter values, which can be regarded as ground truth for these objects. DROs can be particularly valuable for evaluation of software packages. Because they are created using known ground truth, they can be used to determine whether a particular image analysis strategy introduces biases when used to extract a QIB. (This is not possible with real data if the ground truth is not known). Assuming that realistic image noise and/or artifact can be included in the DRO, they can also be used to estimate how precisely a software package is deriving quantitative metrics in real images. This lecture will describe how DROs are used in the RSNA Quantitative Imaging Biomarker Alliance (QIBA) process. Topics that will be discussed include: 1) the variety of metrics that can be used to evaluate software performance with DROs; 2) the differences between aggregated and disaggregated measures of performance, and the relevance of this for determining whether software complies with a standard; and 3) best practices for creation of DROs.

RC325C Radiomic Analysis and Sources of Variation

Participants
Binsheng Zhao, DSc, New York, NY (*Presenter*) Royalties, Varian Medical Systems, Inc; License agreement, Keosys SAS; License agreement, Hinacom Software and Technology, Ltd;

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LEARNING OBJECTIVES

1) To familiarize the audience with tumor imaging phenotype characterization and its applications in oncology (e.g., cancer diagnosis, patient stratification). 2) To discuss sources of variation in tumor characterization, using both phantom and in vivo image data. 3) To raise awareness of the need for reproducible and robust radiomic features / prediction models via harmonization of imaging acquisition parameters and tumor quantification techniques.

Printed on: 10/29/20

PS31

Tuesday Morning Plenary Session

Tuesday, Dec. 3 10:30AM - 12:00PM Room: E451B

PH

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

Participants
Valerie P. Jackson, MD, Tucson, AZ (*Presenter*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Introduction*) Research Grant, Siemens AG

Sub-Events

PS31A RSNA/AAPM Symposium: Integrated Diagnostics: Why Does it Matter and How Do We Get There?

Participants
Paul E. Kinahan, PhD, Seattle, WA (*Moderator*) Research Grant, General Electric Company Co-founder, PET/X LLC

LEARNING OBJECTIVES

1) To become familiar with the concept of Integrated Diagnosis, which combines Radiology, Pathology and Genomics seeking to improve outcomes. 2) To understand how the modern computational and concepts provide a basis for the cross-disciplinary implementation of integrated diagnosis. 3) To learn the potential of new methods to combine imaging and other data from multiple diagnostic approaches.

PS31B The Path to Integrated Diagnostics

Participants
Mitchell D. Schnall, MD, PhD, Philadelphia, PA (*Presenter*) Research Grant, Siemens AG

PS31C Radio-Patho-Genomics: Computationally Integrating Disease Specific Features across Scales

Participants
Anant Madabhushi, PhD, Cleveland, OH (*Presenter*) Stockholder, Elucid Bioimaging Inc; Stockholder, Inspirata Inc; Consultant, Inspirata Inc; Scientific Advisory Board, Inspirata Inc; Scientific Advisory Board, AstraZeneca PLC; Scientific Advisory Board, Merck & Co, Inc; Researcher, Koninklijke Philips NV; Researcher, Inspirata Inc; License agreement, Elucid Bioimaging Inc; License agreement, Inspirata Inc; Grant, PathCore Inc; Grant, Inspirata Inc

SSG12

Physics (CT Image Quality)

Tuesday, Dec. 3 10:30AM - 12:00PM Room: S501ABC

CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Moderator*) Institutional research agreement, Siemens AG
Taly Gilat Schmidt, PhD, Milwaukee, WI (*Moderator*) Research Grant, General Electric Company; Research Consultant, General Electric Company
Christopher P. Favazza, PhD, Rochester, MN (*Moderator*) Nothing to Disclose

Sub-Events

SSG12-01 DQE of Si and CdTe Detectors for Photon-Counting CT: Impact of Object Scatter

Tuesday, Dec. 3 10:30AM - 10:40AM Room: S501ABC

Participants
Mats Persson, PhD, Stockholm, Sweden (*Presenter*) Stockholder, Prismatic Sensors AB; Consultant, Prismatic Sensors AB; Researcher, General Electric Company
Adam S. Wang, PhD, Baltimore, MD (*Abstract Co-Author*) Research support, General Electric Company; Research support, Siemens AG; Research collaboration, Varex Imaging Corporation; Stockholder, Varian Medical Systems, Inc
Norbert J. Pelc, DSc, Stanford, CA (*Abstract Co-Author*) Research support, General Electric Company Consultant, General Electric Company Consultant, NanoX Scientific Advisory Board, RefleXion Medical Inc Scientific Advisory Board, Prismatic Sensors AB Medical Advisory Board, OurCrowd, LP Scientific Advisory Board, Izotropic, Inc Stockholder, Izotropic, Inc

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PURPOSE

Silicon (Si) and cadmium telluride (CdTe) have been proposed as detector materials for photon-counting CT, but the relative performance of these materials is incompletely understood. Previously, a linear-systems model has been used to compare the DQE of Si and CdTe detectors, but this model ignores scatter from the object. This work extends this comparison by incorporating object scatter and the anti-scatter grid, resulting in a more complete model for photon-counting detector DQE at low flux.

METHOD AND MATERIALS

Monte Carlo simulation was performed of a CT geometry with a water cylinder of 30 cm diameter in the isocenter and a curved detector with 79 mm isocenter coverage and sensitive absorption lengths of either 60 mm Si or 3 mm or 1.6 mm CdTe. A 1D or 2D anti-scatter grid with 25 mm high W lamellae was placed in front of the detector. From the resulting scatter-to-primary ratio (SPR) in the central 20 cm of the detector, a DQE factor could be calculated as (geometric efficiency)/(1+SPR) where SPR is the scatter-to-primary ratio. This factor was combined with the intrinsic detector DQE obtained from linear-systems models of Si and CdTe detectors incorporating intradetector scatter, fluorescence and charge sharing.

RESULTS

For all studied detector configurations, the optimal DQE factor is 0.79-0.81, attained for an 1D grid of 0.1 mm thick lamellae with 1 mm spacing. Combined with the linear-systems model for typical detector configurations, so far ignoring pulse pileup and signal induction crosstalk but adding object scatter, this gives the 1.6 mm CdTe detector 5-25% higher zero-frequency DQE for detection and 44-54% lower DQE for two-material quantification compared to a 60 mm Si detector with interspersed W foils.

CONCLUSION

A geometric efficiency of 86-90% is optimal for photon-counting detectors, in contrast to the ~70% used in current CT scanners. Including interspersed W foils in the Si detector can reduce object scatter, and together with an orthogonal 1D anti-scatter grid can give an SPR comparable to that of a 2D grid without interspersed foils. This work is an important step towards a future, complete model for detector performance incorporating pileup and improved charge transport models.

CLINICAL RELEVANCE/APPLICATION

Photon-counting CT detectors promise better image quality. The improved performance model presented here will help developers optimize detector design and attain the best possible imaging performance.

SSG12-02 Innovative Methodology to Mimic Lung Parenchyma Based on Voronoi Models: Application to 3D-Printed Anthropomorphic CT Image Quality Phantoms

Tuesday, Dec. 3 10:40AM - 10:50AM Room: S501ABC

Participants

Susanne v. Hooff, MSc, Dordrecht , Netherlands (*Presenter*) Nothing to Disclose
Imane Tarrahi, MSc, Rotterdam, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Wouter J. Veldkamp, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Chiel Den Harder, PhD, Amsterdam , Netherlands (*Abstract Co-Author*) Nothing to Disclose
Geert J. Streekstra, PhD, Amsterdam, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Jacob Geleijns, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Irene Hernandez-Giron, PhD, Leiden, Netherlands (*Abstract Co-Author*) Research Grant, Dutch Research NWO Organization; Research funded, Canon Medical Systems Corporation; ;

For information about this presentation, contact:

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PURPOSE

To design and develop voronoi 3D-printed structures resembling lung parenchyma, to be used in realistic anthropomorphic lung vessel phantoms for CT image quality assessment.

METHOD AND MATERIALS

Voronoi grids were created using Rhino software (McNeel, Barcelona, Spain) to resemble lung parenchyma. The designs (eight samples, 2x2x1cm3) varied in number of cells and cell border thickness and were 3D printed (ProJet® MJP 2500+) with VisiJet Armor material (ρ=1.14 g·cm-3). The samples were placed in foam, inserted inside a thorax-shaped PMMA holder (300x200x2.5cm3), and scanned (Canon Aquilion Genesis CT). Comparisons were made to CT image volumes of interest (VOIs) of 3 patients parenchyma (5 samples per patient) using the same CT acquisition and reconstruction protocol (High Resolution-thorax). Analysis was performed in terms of attenuation (mean pixel value of VOIs), pixel value distribution (histograms) and visual comparison.

RESULTS

The CTDIvol for the thorax phantom was 2.1 mGy and for the 3 patients 2.1, 2.2 and 4.1 mGy. The attenuation of the voronoi samples (0.2mm cell border thickness) increased linearly with the number of cells [-972±3HU (200 cells);-953±2HU (350 cells);-941±3HU (500 cells);-921±3HU (800 cells);-916±5HU (900 cells)]. Attenuation also increased linearly with cell border thickness (samples with 350 cells) [-953±2HU (0.2mm);-924±3HU (0.3mm);-885±7HU (0.4mm);-837±5HU(0.5mm)]. For patients the average attenuation values were [(-859±7HU);(-849±5HU);(-902±4HU)]. The sample of 350 cells and 0.4mm cell border thickness resembled lung parenchyma most closely, according to visual comparison of CT images and histogram pixel distribution, by three human observers. The mean pixel value of this sample (-885±7HU) was within the HU value range for patients lung parenchyma (-870±27HU).

CONCLUSION

CT appearance and attenuation of human lung parenchyma was mimicked by CT scans of 3D printed voronoi grids. A sample of 350 cells and 0.4 mm cell border thickness showed best resemblance with patient CT images. These voronoi structures will be added to an in-house developed lung vessel phantom to create a more realistic anthropomorphic surrogate for patients in CT image quality assessment.

CLINICAL RELEVANCE/APPLICATION

Our method to 3D-print lung parenchyma (missing in most commercial CT image quality phantoms) can be used to create realistic patient surrogates, especially required with iterative reconstruction.

SSG12-03 Improving Visualization of Basilar Artery Branches by Combining Spectral CT Imaging and Adaptive Statistical Iterative Reconstruction-V Algorithm

Tuesday, Dec. 3 10:50AM - 11:00AM Room: S501ABC

Participants
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PURPOSE

Improving visualization of basilar artery branches by combining spectral CT imaging and adaptive statistical iterative reconstruction-V algorithm

METHOD AND MATERIALS

A total of 15 patients with suspected posterior cerebral circulation ischemia underwent head-neck CT angiography (CTA) using a 256-row MDCT (Revolution CT, GE Healthcare). The scanning parameter were tube voltage of 80/140kVp fast switch and GSI Assist with a noise index of 6. The contrast medium was Iohexol (370mgI/ml) with amount of 50ml and injection rate of 5.0ml/s. 100 kVp-like with FBP (group A) and 40keV monochromatic energy image with 50% ASiR-V (group B) were reconstructed. For both image sets, the CT value and contrast to noise ratio (CNR) were measured at maximum diameter of the basilar artery. maximum intensity projection (MIP) images were used for evaluation the visualization of vertebrobasilar arteries and branch vessels (post-cerebral arteries, superior cerebellar arteries, anterior inferior cerebellar artery, and posterior inferior cerebellar artery). Vessel visibility was quantified by counting the number of artery branches. A five-point scale (from 1= poor to 5 = excellent) was used to evaluate the image quality.

RESULTS

40keV images had higher enhancement of basilar artery (664.95±106.11 vs 288.81±31.03, P=0.001) and higher CNR (27.36± 7.01 vs 20.49±6.48, P=0.009) than 100 kVp-like images. A total of 165 blood vessels was visible on 40keV images, compared to 160 vessels in 100 kVp-like image. The subjective image quality of 40keV images was better that of 100 kVp-like image (4.53±0.54 vs 3.38±0.81, P=0.012).

CONCLUSION

Combining 40keV images and 50% ASiR-V can significantly improve image quality of basilar artery branches, compared to 100 kVp-like images.

CLINICAL RELEVANCE/APPLICATION

Combining monochromatic image and ASiR-V can significantly improve image quality of artery. This protocol is expected to provide more reliable information for the diagnosis and treatment of patients with posterior cerebral circulation ischemia

SSG12-04 CT Protocol Optimization in Neck Imaging Using Anatomically Realistic 3D Printed Phantoms

Tuesday, Dec. 3 11:00AM - 11:10AM Room: S501ABC

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PURPOSE

To simulate patient neck CT imaging with 3D printed phantoms for a systematic evaluation of CT acquisition protocol settings regarding dose and image quality.

METHOD AND MATERIALS

Radiopaque 3D printed patient head and neck phantoms manufactured with potassium iodide doped ink were used for simulation of patient imaging. Two tube voltage settings, six tube current settings, and three pitch settings were systematically combined. Images were reconstructed with filtered back projection (FBP) and iterative reconstruction (IR). Image quality was evaluated with rater experiments (ten radiologist readers) and contrast-to-noise ratios. Dose reduction was evaluated with multiple phantoms with different anatomies and compared with patients that were retrospectively identified from our clinical database. A protocol with fixed 120 kVp, AEC (SD 7.5), a pitch of 0.8, and iterative reconstruction was used as reference to illustrate protocol optimization potential.

RESULTS

54 data sets were acquired and analyzed. Inter-rater reliability of the image grading experiments was excellent (ICC = 0.921; 95%CI 0.882 to 0.950). The benefit-to-risk ratio in terms of achievable image quality and required dose exposure was optimal with ATVS, AEC (SD 14), a pitch of 0.8, and IR. However, image quality was limited (46% for subjective and 26% for objective image quality). An optimal balance between dose and high image quality was achieved with lower noise level AEC (SD 7.5). This protocol required 37% lower dose than the reference protocol. The retrospective analysis of patients that were imaged with different protocol settings yielded similar dose reduction.

CONCLUSION

Patient simulation with 3D printed phantoms provides opportunities for testing and optimization of CT acquisition protocols in a clinical context. The results from this study were in good agreement with clinical observations.

CLINICAL RELEVANCE/APPLICATION

CT protocol optimization entails significant dose reduction potential. Patient simulation with 3D printed phantoms provides opportunities for systematic and rapid protocol optimization.

SSG12-06 Analysis of the 3D Modulation Transfer Function (MTF) of a High-Resolution Diagnostic CT Scanner

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S501ABC

Participants
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PURPOSE

The spatial resolution characteristics of a recently introduced high-resolution diagnostic CT scanner (Precision, Canon Medical) is investigated using a multi-sphere phantom designed to probe the 3D modulation transfer function (MTF), quantifying performance among various scan protocols.

METHOD AND MATERIALS

The phantom presented an array of 9 acrylic spheres (25.4 mm diameter) as a basis for measurement of the oversampled edge-spread function (ESF) and presampling 3D MTF. Spherical edge profiles were converted to spherical coordinates and analyzed as a function of direction (elevation: \phi=0, axial, to \phi~90, z longitudinal). Directionality was held to \phi <= 80 to avoid cone-beam sampling effects. The 3D MTF was measured for 3 detector modes [normal-res NR (0.5x0.5mmx80slice), high-res HR (0.25x0.5mmx80slice), and super-high-res SHR (0.25x0.25mmx160slice)], filtered backprojection with 3 nominal filters [smooth Fc 18, bone Fc30, and high-res Fc81], 3 focal spot settings, and 3 pitch settings (0.57-1.38).

RESULTS

The 3D MTF provided quantitative insight on performance, limitations, tradeoffs, and the degree to which resolution was isotropic. The SHR detector mode increased the axial MTF (f50=1.03/mm) compared to NR (f50=0.84/mm) and improved z-resolution (f50=0.91/mm) compared to HR (f50=0.71/mm) for the Fc30 filter. SHR and HR modes gave the same axial MTF, as expected. Analysis of the 3D MTF characteristics showed that the 3 nominal filters acted primarily in the axial plane, imparting non-isotropic 3D resolution characteristics. Improvement in MTF with finer focal spot was quantified, and the 3D MTF was observed to be invariant with to helical pitch.

CONCLUSION

A multi-sphere phantom and ESF oversampling method provided an insightful probe of 3D MTF characteristics for a recently introduced ultra-high-res CT scanner, demonstrating the resolution advantages and limitations for various scan protocols. The SHR detector mode demonstrated improved axial and z direction MTF compared to NR mode, evident in clearer depiction of anatomical structure (e.g., temporal bone).

CLINICAL RELEVANCE/APPLICATION

Quantitative characterization of the 3D MTF is an important aspect of technical assessment for new CT scanner technology claiming high-resolution performance beyond that of previous systems.

SSG12-07 Whole-Body Low-Dose CT Combined with Model-Based Iterative Reconstruction Algorithm in the Follow-Up of Oncologic Patients: Image Quality and Dose Deduction

Tuesday, Dec. 3 11:30AM - 11:40AM Room: S501ABC

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PURPOSE

To compare radiation dose and image quality of low-dose CT protocol combined with iterative model-based reconstruction algorithm (IMR) with standard-dose CT approach combined with hybrid-iterative reconstruction algorithm (iDose) in the follow-up of oncologic patients.

METHOD AND MATERIALS

We enrolled a hundred and thirty patients with known oncological diseases; all patients were examined, during their clinical follow-up, with both a low-dose CT performed on 256-row scanner,with 100 kV and automated mAs modulation (depending on patient weight),and a standard-dose CT performed on 256-row scanner, with 120 kV and automated mAs modulation. Images were reconstructed with IMR for the low-dose CT protocols and iDose algorithm for the standard-dose CT studies. In both studies we measured density values and image noise in liver and spleen and we calculated the signal-to-noise ratio(SNR) and the radiation dose exposure. The diagnostic quality evaluation was also performed with a 4-point scale.

RESULTS

Noise of images expressed as SD values, measured in liver and spleen, was significantly lower in IMR images (liver 11,63 vs 14,79, p<0,001) whereas SNR was statistically higher (liver 10,46 vs 7,86, p<0,001) compared to iDose reconstruction. Volumetric-CT-Dose-Index (CTDIvol) and Dose-Length-Product (DLP) were significantly lower in IMR compared to iDose studies (DLP 624,40 vs 1013,90 mGy*cm, p<0,001), with an overall dose reduction of 38,42%. The qualitative analysis did not reveal any significant differences in terms of diagnostic quality (p=0,04).

CONCLUSION

MAs modulation combined with IMR algorithm and low kV setting allows dose reduction of 45,72% in whole body CT imaging without loss of diagnostic quality. Therefore, it represents a useful diagnostic approach to reduce radiation dose exposure in oncologic patients who undergo several follow-up CT studies.

CLINICAL RELEVANCE/APPLICATION

CT has a main role in the follow-up of oncologic patients; therefore, lowering doses is desirable, according to the A.L.A.R.A. principle. Low-kV CT with IMR allows to significantly reduce doses, offering a high diagnostic image quality.

SSG12-08 Machine Learning and Deconvolution to Improve the Spatial Resolution of the Adaptive Statistical Iterative Reconstruction (ASir-V) at the Same Noise Level

Tuesday, Dec. 3 11:40AM - 11:50AM Room: S501ABC

Participants
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PURPOSE

For the same noise reduction characterized by the noise power spectrum (NPS), the machine learning approach of PixelShine (PS) by AlgoMedica preserves better the central frequency ratio (CFR) in NPS than the adaptive statistical iterative reconstruction (ASir-V) by GE. CFR was taken between the central frequencies of the NPS of the noise reduction and the baseline CT images to indicate the degree of shift in central frequency after noise reduction. Smaller CFR means more shift of the NPS curve or more image blurring. As the noise texture is highly correlated with CFR, PS may be preferred over ASir-V. The purpose of this study is to improve ASir-V by deconvolution to decrease the blurry appearance of the ASir-V while maintaining the same level of noise reduction already achieved by ASir-V.

METHOD AND MATERIALS

The homogeneous module of the ACR CT phantom (model 464, Gammex-RMI, Wisconsin) was scanned on a GE revolution HD 64-slice CT at 3.6 mGy (CTDI-16 cm). Each scan was repeated twice for NPS calculation. Radiation exposure was increased from 3.6 to 72 mGy to simulate ideal noise reduction without PS or ASir-V. We designed a set of deconvolution filters for the various strengths of ASir-V, followed by PS and name this approach as ASir-VDPS. The images of the ASir-V and ASir-VDPS settings from 10 to 100% and the PS settings of 1 to 9 were compared. Noise magnitude ratio (NMR) was taken between the areas under the NPS curve of the noise reduction and the baseline FBP images to indicate the amount of noise removed by the reconstruction. Smaller NMR means more noise reduction. A desirable noise reduction shall maintain CFR of close to 1 and a NMR of close to 0.

RESULTS

When the radiation exposure was increased from 3.6 to 72 mGy, NMR can be reduced without any change of CFR for the ideal noise reduction. At 3.6 mGy, noise reduction was better achieved by either ASir-VDPS or PS, followed by ASir-V. However, the results of ASir-VDPS (80 to 100%) demonstrated that our current design of deconvolution was not sufficient for resolution recovery introduced by ASir-V.

CONCLUSION

Combination of deconvolution and machine learning can improve ASir-V in spatial resolution or image sharpness without sacrificing the noise reduction already achieved by ASir-V.

CLINICAL RELEVANCE/APPLICATION

ASir-V blurs the CT images during noise reduction. Our approach rectifies this issue without sacrificing the noise reduction already achieved by ASir-V.

SSG12-09 Investigating the Relationship between Image Noise and Noise Index of Dose Modulation Behavior

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S501ABC

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CONCLUSION

Save the efforts of clinical protocol development/management and improve the operational work flow.

Background

Purpose: To evaluate the behavior of dose modulation performance for optimizing clinical image acquisition protocols. Methods: Four tissue equivalent abdominal CT dose phantoms (CIRS 007TE) were scanned using a GE Revolution CT scanner. To simulate an extra-large size patient, a 5th phantom (60cm by 40cm) was assembled from a QRM-Abdomen phantom attached to two extension rings. Abdominal CT protocol: 120kVp, 0.6s rotation time, 80mm beam width, 0.508 pitch, 2.5 mm image thickness and Large Scan Field-of-View. With Auto-mA and Smart-mA enabled, Noise Index (NI) was varied resulting in various levels of image quality. Images were reconstructed using Standard algorithm. For each phantom size/NI combination, ROI (n=3/image) and noise measurements (standard deviation of ROI) in 5 consecutive images of the central portion of the phantom were performed. The relationship of noise versus NI was plotted for each phantom size.

Evaluation

Results: For the scans of each phantom size, the achieved mA values functioned as expected to the set NI values. For each phantom size, the measured noise increased linearly as NI value increased ($R2 = 0.9981, 0.9978, 0.9980, 0.9963$, for 15-yr old, small adult, medium adult, large adult, respectively). The noise values were within 7% of the mean noise values at a NI level among phantom of different sizes, indicating that the measured noise values were similar as a function of NI value regardless of the sizes of the phantoms. Moreover, the measured noise were within 12% of the 10 NI levels that were evaluated, at 2.5mm nominal image thickness; this suggests a direct correlation of the anticipated image noise to the NI value under this 2.5mm acquisition condition.

Discussion

Conclusion: The same NI value produced similar noise level in images across phantoms of different sizes. Unlike the multiple patient size-based approach for optimizing protocols of other GE scanner platforms, the one-size based protocol approach on the Revolution CT could save the efforts of clinical protocol development/management and improve the operational work flow.

SSG13

Physics (Deep Learning - Clinical Applications)

Tuesday, Dec. 3 10:30AM - 12:00PM Room: S502AB

AI PH

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

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Sub-Events

SSG13-01 Pre-Trained Deep Learning Convolutional Neural Network for Feature Extraction: Pitfalls and Potential

Tuesday, Dec. 3 10:30AM - 10:40AM Room: S502AB

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PURPOSE

Pre-trained deep convolutional neural network (DCNN) are often used as feature extractor due to small data sets in medical imaging. We analyzed the pitfalls and potential of pre-trained DCNNs as feature extractor for mass classification in mammograms.

METHOD AND MATERIALS

With IRB approval, 4577 masses were collected and divided into 3222 training, 508 validation and 847 independent test sets. Pre-trained ImageNet-AlexNet DCNN without fine-tuning was deployed to the mammography data, a total of 4096 features from *F1* layer were extracted for each mass. Four types of analysis were studied: (#1) For a baseline study without feature selection, two classifiers: (#1a) random forest (RF) and (#1b) 5-layer neural network using the 4096 features as input were trained on the training set to optimize the classifier weights, and independently deployed on the validation and the test sets. (#2) Two feature selection methods: (#2a) genetic algorithm (GA) and (#2b) sequential forward selection (SFS), were studied using the validation set to guide feature selection and linear discriminant analysis (LDA) as the classifier. Area under the ROC curve (AUC) was used as performance measure. The trained classifiers with the selected features were applied to the test set for evaluation of generalizability.

RESULTS

Without feature selection, no over-fitting was observed for #1a and #1b, with validation and test AUCs between 0.71 and 0.73. GA evolved over 7000 feature combinations in 9 generations. SFS was analyzed with over 12 million selected feature combinations. With GA (#2a), moderate over-fitting was observed with AUC of 0.80 on the validation set and 0.73 on the test set. With SFS (#2b), severe over-fitting was observed with AUCs of >0.90 on the validation set and ~0.72 on the test set.

CONCLUSION

ImageNet-trained DCNNs without fine-tuning has moderate discriminative power for masses (AUC~0.7). Future studies could leverage this characteristic of pre-trained DCNNs when available data set is small. Reporting the performance on a data set that is used to guide feature or parameter selection can optimistically bias the result. It is important to evaluate the generalization performance using a truly independent test set.

CLINICAL RELEVANCE/APPLICATION

Feature selection from the large feature space extracted from DCNN risks the curse of dimensionality. The generalizability of classifiers with the selected features should be tested with unseen data.

SSG13-02 Do Different Deep Convolutional Neural Nets Learn Differently? An Analysis Using Lung Nodule Detection in Computed Tomography

Tuesday, Dec. 3 10:40AM - 10:50AM Room: S502AB

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PURPOSE

Different types of deep neural nets (DCNNs) are used for a variety of medical imaging tasks. In this study we analyzed if different DCNNs learn differently for lung nodule detection in CT.

METHOD AND MATERIALS

From 1,010 LIDC-IDRI cases, we used 651 cases for training and cross-validation and 254 cases for independent testing. All nodules marked by at least one radiologist and of diameter > 3mm were included. Three popular DCNNs, VGG16, InceptionV1 (IC1), and Inception-ResNet (ICRes) pre-trained with ImageNet were studied. Top 200 lung nodule candidates detected in each CT volume using multiscale Hessian enhancement were used to extract 184 radiomics features and fine-tuning the DCNNs. Features from the first fully connected layer of the DCNNs and the output DCNN scores were analyzed with two methods: (a) feature embedding and (b) score ranking. Feature embedding was performed using uniform manifold approximation and projection (UMAP), which is a fast and highly scalable method to reduce high dimensional features to 2 dimensions. DCNN scores were analyzed using rank-rank hypergeometric overlap (RRHO) distributions to visualize the degree of correlation between scores from different DCNNs. Features extracted from the DCNNs fully connected layer were merged with radiomics features and used to train a random forest classifier. Competition Performance Metric (CPM) calculated from FROC curves used in the LUNA16 challenge was used for comparison.

RESULTS

UMAP analysis shows TPs and FPs have different distributions of overlap. RRHO maps show varied correlation for different levels of high to low ranking DCNN scores indicating potential complementary information if combined. Merging features from VGG16 (CPM=0.62) and IC1(CPM=0.65) improved the performance to CPM=0.69. Merging ICRes (CPM=0.70) and IC1(CPM=0.65) improved the performance to CPM=0.73. For comparison, the CPM obtained by 10-fold cross-validation ranged from 0.61 to 0.81 in the LUNA16 challenge for the LIDC-IDRI set.

CONCLUSION

Different DCNNs learn different feature representations for the same task, which may offer complementary information. Further research is needed to intelligently merge relevant information to improve performance.

CLINICAL RELEVANCE/APPLICATION

With the availability of large number of different DCNN structures, understanding their characteristics and leveraging the complementary information can potentially improve machine learning.

SSG13-03 Deep Learning for Automatic Landmark Localization in CTA for Transcatheter Aortic Valve Implantation

Tuesday, Dec. 3 10:50AM - 11:00AM Room: S502AB

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PURPOSE

Fast and accurate automatic landmark localization in CT angiography (CTA) scans can aid treatment planning for patients undergoing transcatheter aortic valve implantation (TAVI). Manual localization of landmarks can be time-consuming and cumbersome. Automatic landmark localization can potentially reduce post-processing time and interobserver variability. Hence, this study evaluates the performance of deep learning for automatic aortic root landmark localization in CTA.

METHOD AND MATERIALS

This study included 672 retrospectively gated CTA scans acquired as part of clinical routine (Philips Brilliance iCT-256 scanner, 0.9mm slice thickness, 0.45mm increment, 80-140kVp, 210-300mAs, contrast). Reference standard was defined by manual localization of the left (LH), non-coronary (NCH) and right (RH) aortic valve hinge points, and the right (RO) and left (LO) coronary ostia. To develop and evaluate the automatic method, 412 training, 60 validation, and 200 test CTAs were randomly selected. 100/200 test CTAs were annotated twice by the same observer and once by a second observer to estimate intra- and interobserver agreement. Five CNNs with identical architectures were trained, one for the localization of each landmark. For treatment planning of TAVI, distances between landmark points are used, hence performance was evaluated on subvoxel level with the Euclidean distance between reference and automatically predicted landmark locations.

RESULTS

Median (IQR) distance errors for the LH, NCH and RH were 2.44 (1.79), 3.01 (1.82) and 2.98 (2.09)mm, respectively. Repeated annotation of the first observer led to distance errors of 2.06 (1.43), 2.57 (2.22) and 2.58 (2.30)mm, and for the second observer to 1.80 (1.32), 1.99 (1.28) and 1.81 (1.68)mm, respectively. Median (IQR) distance errors for the RO and LO were 1.65 (1.33) and 1.91 (1.58)mm, respectively. Repeated annotation of the first observer led to distance errors of 1.43 (1.05) and 1.92 (1.44)mm, and for the second observer to 1.78 (1.55) and 2.35 (1.56)mm, respectively. On average, analysis took 0.3s/CTA.

CONCLUSION

Automatic landmark localization in CTA approaches second observer performance and thus enables automatic, accurate and reproducible landmark localization without additional reading time.

CLINICAL RELEVANCE/APPLICATION

Automatic landmark localization in CTA can aid in reducing post-processing time and interobserver variability in treatment planning for patients undergoing TAVI.

SSG13-04 Improving Detection of Microcalcification Clusters in Low-Dose Digital Breast Tomosynthesis Using Deep Residual Learning

Tuesday, Dec. 3 11:00AM - 11:10AM Room: S502AB

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PURPOSE

To improve the detectability of microcalcification (MC) clusters in low-dose digital breast tomosynthesis (DBT) by using very deep convolutional neural network (DCNN).

METHOD AND MATERIALS

To generate a synthesized high-dose (SHD) image from a low-dose image, we trained a 20-layer super-resolution CNN (SRCNN) to learn the residual image between the high-dose (HD) and low-dose (LD) images. The loss function is a weighted sum of the Euclidean distances between the gray levels over the image and between the contrast-to-noise ratios (CNR) of the MCs in the LD and HD patches. With IRB approval and informed consent, DBTs of human subjects were acquired with a GE prototype system at 21 projections over a 60º arc and reconstructed as HD DBT volume. LD DBTs were simulated by reconstructing with the central 9 projections over a 24º arc. The SRCNN was trained to generate SHD patches using 449 pairs of corresponding HD and LD MC patches extracted from the training DBT set. Each patch was 32 x 32 pixels at a pixel size of 0.1 mm x 0.1 mm and centered at an MC. A validation set of 191 LD MC patches was used to assess the improvement in CNR in the SHD patches. We previously developed a computer-aided detection (CAD) system that detects MCs in the HD DBT by using joint information from the reconstructed DBT volume and a 2D planar projection image generated from the same DBT volume. In this study, we adapted the joint-CAD system to MC detection in the LD DBT and compared the detection performances with and without deploying the trained SRCNN to the MC candidates detected at the pre-screening stage. The detection performance was evaluated by FROC analysis using an independent test set of 104 DBT volumes with MC clusters and 76 DBT volumes without MC clusters.

RESULTS

For MC cluster detection in the LD DBT, at 85% case-based sensitivity, the FP rate was reduced from 2.6 without to 1.1 FPs/DBT volume with the SRCNN for CNR enhancement. The improvement was statistically significant (p = 0.0001) by JAFROC analysis.

CONCLUSION

SRCNN significantly improves MC cluster detection by the CAD system in low-dose DBT, indicating a potential for reducing dose in DBT imaging.

CLINICAL RELEVANCE/APPLICATION

Improved performance of CAD in low-dose DBT has potential implications on reducing patient dose for DBT imaging particularly during screening.

SSG13-05 Fuzzy Edge Attentional Generative Adversarial Network for Automated Fibroglandular Tissue Segmentation in Breast MRI

Tuesday, Dec. 3 11:10AM - 11:20AM Room: S502AB

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PURPOSE

To investigate the efficacy of a fuzzy edge attentional deep learning approach for automated fibroglandular tissue (FGT) segmentation in breast MRI as an essential step for FGT and background parenchymal enhancement (BPE) quantitative analysis.

METHOD AND MATERIALS

Previous research has shown that deep learning with U-Net outperformed the traditional image processing methods for FGT segmentation. However, U-Net segmentation performed poorly around the fuzzy edges of FGT region. In this study, we proposed a robust fuzzy edge attentional generative adversarial network(FEA-GAN) to overcome this difficulty. An improved U-Net was designed as generator to generate FGT candidate areas while a patch deep convolutional neural network (DCNN) was designed as discriminator. To reconcile the semantic features from different scales, the convolutional layers in generator were replaced by inception-like multiscale blocks. Residual convolutional layers were incorporated with the skip connections to reduce the semantic gap between encoder and decoder. To reduce false candidate areas caused by fuzzy edges, the patch DCNN restricts attention to edge structures in local image patches. With IRB approval, we retrospectively collected 100 patients aged 22-78 years old at an academic hospital. Axial T1-weighted fat-suppressed images from 200 breasts were acquired from 1.5T Siemens Magnetom Espree system. An experienced radiologist manually marked contours of FGT on 3D slices as the reference standard. Five-fold cross-validation was applied for training and testing. The results were evaluated in three measures: Dice similarity coefficient (DSC), Jaccard index (JI) and Hausdorff distance (HD).

RESULTS

With five-fold cross-validation, the DSC, JI and HD for segmentation with FEA-GAN were 87.0±7.0%, 77.6±10.1%, 3.69±0.71mm, respectively. With U-Net, the corresponding values were 81.1±8.7%, 69.0±11.3%, 4.18±0.77mm, respectively. Compared with U-Net, the improvement for all measures achieved statistically significant ($p<0.0001$).

CONCLUSION

The proposed FEA-GAN model significantly outperformed the U-Net model in terms of DSC, JI and HD. Further work is underway to apply the proposed FGT segmentation method for FGT and BPE quantitative analysis.

CLINICAL RELEVANCE/APPLICATION

Automated FGT segmentation is a crucial step for quantitative assessment of FGT and BPE in breast MRI, which are strong risk factors for breast cancer.

SSG13-06 Evaluation of the Performance of Deep Learning Models Trained on a Combination of Major Abnormal Patterns on Chest Radiographs for Major Chest Diseases at International Multi-Centers

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S502AB

Participants
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PURPOSE

To evaluate the abnormal classification performance for major chest diseases using a deep learning model that was trained on a combination of major abnormal patterns on chest radiographs.

METHOD AND MATERIALS

We experimented with the abnormal classification performance for a deep learning model for major diseases (tuberculosis and pneumonia) that was trained on a combination of different patterns (nodule, consolidation and interstitial opacity) on CRs. To evaluate the effect of each pattern combination on performance for major diseases, we tested five cases of patterns, which is composed of the nodule case, the consolidation case, the interstitial opacity case, the combination of consolidation and interstitial opacity case, and the combination of all three cases. When training each case, all normal data was used for training. CRs with three abnormal patterns and normal patterns were used as training datasets, which were received from two hospitals and consisted of 2095, 2401, 1290, and 3000 images for nodule, consolidation, interstitial opacity, and normal patterns, respectively. And all abnormal CRs were clinically confirmed by CT scans. For an explicit evaluation, the public dataset was used as the test dataset, which consists of the Shenzhen (normal: 326, tuberculosis: 336) and PadChest (normal: 300, pneumonia: 127, randomly selected) dataset, which was used to evaluate tuberculosis and pneumonia, respectively.

RESULTS

In the test dataset, for tuberculosis and pneumonia, the classification performance of the models trained with the five cases of patterns showed AUC 0.58 / 0.69 for nodule case, 0.76 / 0.82 for consolidation, 0.52 / 0.76 for interstitial opacity case, 0.79 / 0.83 for combination of consolidation and interstitial opacity case, 0.79 / 0.82 for combination of all three case, respectively.

CONCLUSION

We have shown through experimentations that the deep learning model trained from data with major patterns (nodule, consolidation, interstitial opacity) can classify major diseases (tuberculosis, pneumonia) as abnormal. Also, consolidation was highly correlated with tuberculosis and pneumonia. On the other hand, interstitial opacity and nodule were more correlated with pneumonia, tuberculosis, respectively.

CLINICAL RELEVANCE/APPLICATION

The diagnosis based on the patterns of abnormal findings allows detection of various diseases.

SSG13-07 Automatic Quantification of 3D Body Composition from Abdominal CT with an Ensemble of Convolutional Neural Networks

Tuesday, Dec. 3 11:30AM - 11:40AM Room: S502AB

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PURPOSE

Analysis of body composition based on CT, primarily comprising quantification of fat and muscles, is an important prognostic factor in cardiovascular disease and cancer. However, manual segmentation is time consuming and in 3D practically infeasible. The purpose of this study is to investigate the use of a deep learning-based method for automatic segmentation of subcutaneous fat, visceral fat and psoas muscle from full abdomen CT scans.

METHOD AND MATERIALS

We included a dataset of 20 native CT scans of the entire abdomen (Siemens Somatom Volume Zoom / Siemens Somatom Definition, 120 kVp, 375 mAs, in-plane resolution 0.63-0.75 mm, slice thickness 5.0 mm, slice increment 5.0 mm). Trained observers defined the reference standard by voxel-wise manual annotation of subcutaneous fat, visceral fat and psoas muscle in all slices that visualize the psoas muscle. Images of 10 patients were used to train a dilated convolutional neural network with a receptive field of 131 × 131 voxels to distinguish between the three tissue classes. To ensure robust results, 5 different networks were trained and subsequently ensembled by averaging the probabilistic results. Voxels were assigned to the class with the highest probability. Images from the remaining 10 patients were used to evaluate the performance of the method. Performance was evaluated with Dice coefficients between the manual and automatic segmentations. Additionally, linear correlation coefficients (Pearson's r) were computed between the manual and automatic segmentation volumes.

RESULTS

The average Dice coefficients over 10 test scans were 0.89 ± 0.02 for subcutaneous fat, 0.92 ± 0.04 for visceral fat, and 0.76 ± 0.05 for psoas muscle. At the L3 vertebrae level, the average Dice coefficients were 0.92 ± 0.02 for subcutaneous fat, 0.93 ± 0.05 for visceral fat, and 0.87 ± 0.04 for psoas muscle. Pearson's r between the manual and automatic volumes were 0.996 for subcutaneous fat, 0.997 for visceral fat, and 0.941 for psoas muscle. On average, segmentation of a full scan was performed in about 15 seconds.

CONCLUSION

The results show that accurate fully automatic segmentation of subcutaneous fat, visceral fat and psoas muscle from full abdominal CT scans is feasible.

CLINICAL RELEVANCE/APPLICATION

The proposed method allows fast and fully automatic analysis of 3D body composition in abdominal CT that can aid in individualized risk assessment in cardiovascular disease and cancer.

SSG13-08 Perceptive Feature Learning with Deep Semantic Network for Breast Mass Diagnosis on Digital Mammography

Tuesday, Dec. 3 11:40AM - 11:50AM Room: S502AB

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PURPOSE

Malignant/Benign classification on digital mammography (DM) remains challenging in current clinical practice. Our purpose of this study is to use a perceptive feature learning scheme for computerized breast mass diagnosis on DMs.

METHOD AND MATERIALS

Recently, deep learning (DL) has been widely used for computerized cancer diagnosis. However, most of the DL approaches have the poor clinical interpretation. Aimed to improve breast cancer diagnosis and increase DL's interpretability, we proposed a perceptive feature learning scheme with a deep semantic network (DSN) for breast mass diagnosis on DMs. With IRB approval, DMs of 220 Chinese women were retrospectively collected. In total, 220 biopsy-proven masses (108 benign and 112 malignant) were reviewed by an experienced breast radiologist. Shape and margin of each mass were assessed based on ACR's BI-RADs lexicon and the assessment results were empirically encoded into five labels: irregular shape, round/lobulated shape, microlobulated margin, speculated margin and circumscribed/obscured/indistinct margin. Our DSN with 5 encoded labels as target was designed to learn the human reader's visual perceptions of masses. A mass-centered patch and its corresponding segmentation mask were concatenated as an input of DSN (patch size of 288x288x2). The trained DSN without output layer was served as feature learning network for the extraction of 128 perceptive features. We compared the perceptive features with previously developed radiomics features. Ten-fold cross validation was used for model selection. At each fold, we applied stepwise linear discriminant analysis (LDA) for dimension reduction and malignant/benign classification. Area under the ROC curve (AUC) was used as a figure of merit for the performance evaluation.

RESULTS

In model selection, we selected an average of 30 features in each fold. It was found that the improvement of the classifier with radiomics+perceptive features (AUC of 0.95 ±0.03) to radiomics alone (AUC of 0.91±0.03) was statistically significant ($p < 0.05$).

CONCLUSION

The features learned by DSN with expert's visual perceptions of masses significantly improved the diagnostic performance of breast mass on DMs.

CLINICAL RELEVANCE/APPLICATION

Perceptive features learned from reader's visual perception have the added value for computerized breast mass diagnosis on DMs and such features have potential to increase the interpretability of CAD.

SSG13-09 A PIRADS Based Similar MRI Retrieval System for Prostate Cancer

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S502AB

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PURPOSE

To compare different deep learning algorithms to retrieve images with similar lesions in term of PIRADS score. In particular we evaluate the performance of a Siamese convolutional neural network (SIAM-CNN) against a standard convolutional Autoencoder (AE-CNN). We hypothesize that SIAM-CNN works better at retrieving similar images based on PIRADS score.

METHOD AND MATERIALS

We use a set of 601 consecutive multiparametric prostate MRIs from 2016 acquired in our hospital that contains 890 PIRADS reported lesions. The image similarity was based on the axial computed high b-value series. Both CNNs were designed to operate with 40x40x3 voxel ROIs selected around the reported lesion location. SIAM-CNN is a supervised algorithm that is trained to find the most similar images with the same PIRADS score. Instead, AE-CNN is unsupervised and assesses similarity only based on image appearance. We used 672, 90 and 128 images as training, validation and test set, respectively, and used a 3-fold cross validation for the performance estimation. The performance was quantified in terms of Mean Absolute Error (MAE) between the PIRADS of the query and that of the retrieved images. We provide the score for the TOP-1 and 3 retrieved lesions.Additionally, qualitative visual assessment was performed.

RESULTS

The TOP-1 MAE for the SIAM-CNN is 0.75±0.12 while the AE-CNN score is 0.87±0.02 (p-value=0.15). The TOP-3 score for the SIAM-CNN is 0.75±0.09 while the AE-CNN score is 0.97±0.05 (p-value=0.02).

CONCLUSION

The Siamese CNN is better than the Autoencoder CNN at retrieving similar images based on PIRADS, both quantitatively (MAE) and qualitatively based on visual assessment. Future work aims at integrating multi-parametric and/or multi-view MRI, in order to obtain further performance improvements.

CLINICAL RELEVANCE/APPLICATION

Siamese CNN can be a valuable aid in prostate cancer MRI assessment by retrieving similar images with similar PIRADS score. This could help reduce prostate MRI interpretation variability.

SSG14

Physics (MRI - Clinical Applications)

Tuesday, Dec. 3 10:30AM - 12:00PM Room: S504AB

MR PH

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

FDA Discussions may include off-label uses.

Participants
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Matthew A. Bernstein, PhD, Rochester, MN (*Moderator*) Former Employee, General Electric Company; Intellectual property, General Electric Company

Sub-Events

SSG14-01 Development of Respiratory Motion-Resolved Hepatobiliary Phase Cine-MRI Using Compressed SENSE for Stereotactic Body Radiotherapy in Liver Tumor

Tuesday, Dec. 3 10:30AM - 10:40AM Room: S504AB

Participants
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CONCLUSION

The CS with denoising improved tumor-to-liver contrast and image quality in high temporal resolution HBP cine-MRI, which can be potentially applied for stereotactic body radiotherapy.

Background

For radiotherapy of the liver, cine-MRI has been used to track respiratory-induced motion of the liver and tumor, and to assist accurate delineation of tumor volume. However, tumor boundaries cannot be clearly defined when using balanced SSFP and single-shot T2-weighted sequences because of poor tumor-to-liver contrast. Recent development of Compressed SENSE (CS) enables to accelerate temporal resolution while maintaining contrast resolution. This study aimed to develop and assess hepatobiliary phase (HBP) cine-MRI using CS.

Evaluation

Twenty patients underwent HBP cine-MRI after gadoxetic acid injection, consisted of modified 2D-GRE T1-weighted TFE sequence with saturate recovery prepulse (TR/TE, 3.1/1.46 ms; FA, 30°; FOV, 380 mm; acquisition matrix, 112×201; slice thickness, 3mm) in every 0.5 second for one minute. The images were acquired with SENSE (factor, 4), CS (factor, 4) without denoising (CS-no), and CS with strong denoising level (CS-strong) to assess the capability of CS for image quality improvement. For quantitative analysis, signal noise ratio of the liver and tumor (SNRLiv, SNRTum) and liver-to-tumor contrast ratio (CRLiv/Tum) were measured. For qualitative analysis, two radiologists evaluated lesion conspicuity, contrast enhancement, image noise, motion smoothness, and overall quality on a 4-point scale. The SNRLiv and SNRTum were 6.8 ± 2.7 and 2.8 ± 0.8 for SENSE, 6.7 ± 2.8 and 3.0 ± 1.0 for CS-no, and 14.4 ± 3.9 and 5.7 ± 2.8 for CS-strong, respectively (P<.001, repeated measures ANOVA). The CRLiv/Tum was 0.47 ± 0.13 for SENSE, 0.43 ± 0.12 for CS-no, and 0.49 ± 0.16 for CS-strong (P>.05). The CS-strong showed significantly higher image quality (P<.01, Kruskal-wallis H test) except for motion smoothness (P=.11).

Discussion

The CS can suppress aliasing artifact using random undersampling of k-space trajectory, enabling to apply wavelet transformation and denoising. This algorithm substantially increased SNR, contributed to improvement of contrast ratio and image quality in HBP cine-MRI.

SSG14-02 Multi Band-SWeep Imaging with Fourier Transformation (MB-SWIFT) MRI Can Quantify Bone Mineral Density while Concurrently Characterizing Material-Level and Biochemical Changes in Bone In Vivo

Tuesday, Dec. 3 10:40AM - 10:50AM Room: S504AB

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PURPOSE

Multi-Band SWeep Imaging with Fourier Transformation (MB-SWIFT) MRI could have novel and specific application in bone where capturing mineral and remaining 40% of the composite tissue that confers to bone quality and strength is desired. We describe a comprehensive set of biomarkers to characterize material-level and biochemical components that are "missed" when using gold-standard bone imaging approaches (clinical DXA, pre-clinical µCT). Further, we establish the efficacy of MB-SWIFT to measure bone mineral density (BMD) in comparison to µCT.

METHOD AND MATERIALS

In vivo µCT (Bruker SkyScan1176, 35 µm3) and MB-SWIFT MRI (Agilent 9.4T, 156 µm3) of the proximal tibiae were obtained at baseline and 2, 4, 10 and 12 wks post ovariectomy (OVX) in 7 rats (F, 6 wks old). µCTs were registered to corresponding MRIs per timepoint and resulting transforms were applied to µCT-derived cortical and trabecular VOIs guiding analysis across modalities. Cortical water fraction, marrow fat fraction and cortical matrix volumetric T1 relaxation using the variable flip angle method were quantified from MB-SWIFT images. Sensitivity to cortical water loss during sequential drying was confirmed in excised tibia. µCT and MRI images were converted to Hounsfield units and BMD was calculated using a concurrently imaged calcium hydroxyapatite standard. Pearson's correlation coefficients, simple linear regressions and RM-ANOVAs were employed and significant at $p \leq 0.05$.

RESULTS

MB-SWIFT cortical and trabecular BMD correlated significantly with µCT BMD (cortical: $R=0.67$, $p<0.0001$; trabecular: $R=0.62$, $p<0.0001$) which significantly increased longitudinally. Growth appeared to overcome estrogen-deficient changes in bone mass yet MB-SWIFT distinguished significant decreases in cortical water, increases in marrow fat and increases cortical matrix volumetric T1 relaxation consistent with OVX by 10 weeks. MB-SWIFT cortical water fraction significantly correlated to cortical water loss (% by volume) during sequential drying ($R=-0.98$, $p=0.01$).

CONCLUSION

MB-SWIFT MRI could have a novel and specific application in bone where capturing information on both mineral and matrix properties that confer quality and strength is highly desired.

CLINICAL RELEVANCE/APPLICATION

MB-SWIFT can quantify biomarkers of bone quality and mineral phase of bone without the use of harmful ionizng radiation holding promise for clinical adaptation allowing for safe longitudinal analysis of bone.

SSG14-03 Quantitative Biliary Tree Imaging by MRI: A Novel Method of Assessing Change Over Time in Hepatobiliary Disease via MRCP

Tuesday, Dec. 3 10:50AM - 11:00AM Room: S504AB

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CONCLUSION

We demonstrate that state-of-the-art quantitative MRCP enables the extraction of quantitative biomarkers of biliary anatomy able to objectively identify changes in ducts over time, which correlates with biliary disease that were not identified via biochemical markers. Quantitative biliary tree imaging warrants ongoing investigation prospectively as a means of a potential standardised application for disease and therapy monitoring in PSC.

Background

Magnetic resonance cholangiopancreatography (MRCP) is a non-invasive imaging technique for the evaluation of hepatobiliary disease. Despite widespread use there remains a lack of objective assessment of biliary duct changes, and detecting changes in scans can be difficult, hindering monitoring of disease progression. Furthermore, serum biomarkers for hepatobiliary disease lack sensitivity to longitudinal changes biliary disease status. Here we evaluate the utility of novel quantitative biomarkers of biliary anatomy, extracted from 3D MRCP scans, to assess changes in biliary ducts over 1 year in patients with autoimmune liver diseases.

Evaluation

Patients with primary sclerosing cholangitis (PSC, n=44), autoimmune hepatitis (AIH, n=35) and primary biliary cholangitis (PBC, n=59) were recruited for heavily T2-weighted MRCP imaging at base-line and 1-year follow-up. A total of 284 scans were processed with quantitative image analysis to enhance and quantify the tubular structures. The underlying algorithms combine multi-scale Hessian analysis, gradient vector flow analysis, intelligent path search algorithm and novel duct modelling algorithms.

Discussion

Quantitative imaging, evaluating MR-apparent biliary duct size and length distinguished PSC from AIH and PBC patients (p<0.001). At baseline, the number of strictures was a better classifier of PSC and AIH patients (AUC=0.72) than bilirubin (AUC=0.65). At 1 year follow up PSC patients contained significantly more strictures (p<0.01) and greater stricture severity (p<0.01) compared to AIH and PBC, whilst alkaline phosphatase (ALP) and bilirubin were found to exhibit no significant changes from baseline across the 3 cohorts. High risk PSC patients (ALP>1.5xULN) were found to have more dilatations (p<0.01) and greater stricture severity (p<0.01) than low risk at baseline. Abnormal length sum, stricture length sum (AUC=0.74, 0.73 respectively) were found to accurately classify high and low risk patients. Interestingly, metrics in high risk patients did not change from baseline at follow up, whilst low risk PSC patients were found have an enlarged tree volume (p<0.01), duct length (p<0.01) and stricture severity (p<0.01) at follow up.

SSG14-04 Validation of Highly Accelerated Wave-CAIPI 3D-T1 Sampling Perfection With Application Optimized Contrast Using Different Flip-Angle Evolutions (Wave-3D-T1 SPACE) with Conventional 3D-T1 SPACE for Post-Contrast Brain Imaging

Tuesday, Dec. 3 11:00AM - 11:10AM Room: S504AB

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PURPOSE

To evaluate the image quality and diagnostic performance of highly-accelerated Wave-CAIPI 3D-T1 Sampling Perfection with Application-optimized Contrasts by using flip angle Evolution (Wave-T1 SPACE) compared to conventional 3D-T1 SPACE for the detection of intracranial enhancing lesions on post-contrast brain MRI.

METHOD AND MATERIALS

Consecutive patients (N=38) undergoing 3T clinical brain MRI with contrast were prospectively enrolled. The most common indications for MRI were screening for brain metastases (N=21), and evaluation of primary brain tumors (N=8). All MRI scans included a conventional post-contrast T1 SPACE (R=4, acquisition time TA=4min 19s) and resolution-matched (slice thickness = 0.9mm) post-contrast Wave-T1 SPACE sequence (R=9, TA=1min 40s). Studies were performed on a clinical 3T MRI scanners (MAGNETOM Prisma; Siemens, Erlangen). Two neuroradiologists evaluated the images head-to-head for the visualization of enhancing lesions and nonenhancing pathology, grading of motion artifacts and noise, and diagnostic quality using a predefined 5-point scale. Discrepancies were adjudicated by a third reader. Wave-T1 SPACE was tested for non-inferiority compared to conventional T1 SPACE using a 10% non-inferiority margin.

RESULTS

Compared to conventional post-contrast T1 SPACE, Wave-T1 SPACE showed no difference in the visualization of enhancing lesions (P<0.001) and non-enhancing pathology (P=0.003), and no difference in diagnostic quality (P<0.001). Wave-T1 SPACE images demonstrated comparable or reduced motion artifact in the majority of cases and slightly greater image noise, with no impact on overall diagnostic quality. The figure shows representative examples demonstrating the comparable image quality of the post-contrast Wave- and conventional T1 SPACE sequences in delineating leptomeningeal disease and brain tumor.

CONCLUSION

A 1.6-minute Wave-T1 SPACE acquisition demonstrates comparable performance to a 4.3-minute resolution-matched conventional T1 SPACE sequence in identifying enhancing lesions, with an approximate 3-fold reduction in acquisition time. The findings support clinical application of Wave-T1 SPACE over conventional T1 SPACE for routine post-contrast clinical brain imaging.

CLINICAL RELEVANCE/APPLICATION

Wave-T1 SPACE is comparable to conventional T1 SPACE in detecting enhancing lesions with up to 3-fold reduced scan time and less motion, supporting its clinical application in routine brain imaging.

SSG14-05 Application of Magnetic Resonance Imaging with Free-Breathing T1-Weighted Star-VIBE for Improving Image Quality in Chest: A Study Compared with T1-Weighted Conventional Breath-Hold VIBE

Tuesday, Dec. 3 11:10AM - 11:20AM Room: S504AB

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PURPOSE

To explore the application of free-breathing T1-weighted Star-VIBE sequence for improving image quality in chest compared with T1-weighted conventional breath-hold VIBE sequence in magnetic resonance(MR) imaging.

METHOD AND MATERIALS

Twenty patients underwent MR chest examination on a 3.0T scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). The scan sequences included T1-weighted conventional breath-hold VIBE(group A: TE 1.29 ms, TR 3.97 ms) and free-breathing T1-weighted Star-VIBE (group B: TE 1.39 ms, TR 2.79 ms). The signal intensity (SI) and standard deviation (SD) of ascending aorta, main pulmonary artery and descending aorta were measured at the level of main pulmonary artery. The signal-to-noise ratio (SNR=SI/SD) and coefficient of variation (CV=SD/SI) of signal intensity were calculated. The image quality was subjectively scored double-blindly using a 5-point scoring system by two radiologists who had five or more years of working experience (5 point, the image quality is best; 4 point, the image quality is better; 3 point, the image quality is general; 2 point, the image quality is poor; 1 point, the image can not be evaluated).

RESULTS

There was no significant difference in population characteristics between the two groups ($P>0.05$). The signal-to-noise ratio (SNR) of ascending aorta, main pulmonary artery and descending aorta in group B were significantly higher than those of group A($P<0.05$), while the coefficient of variation of signal intensity about group B were significantly lower than those of group A($P < 0.05$). The subjective scores of image quality by the two MR radiologists had excellent consistence (kappa value>0.80, $P<0.05$), the subjective score of group B were significantly higher thangroup A ($P < 0.05$).

CONCLUSION

Magnetic resonance imaging with free-breathing T1-weighted Star-VIBE sequence can significantly improve image quality in chest compared with T1-weighted conventional breath-hold VIBE sequence.

CLINICAL RELEVANCE/APPLICATION

In thoracic magnetic resonance imaging, free-breathing T1-weighted Star-VIBE sequence can be used to improve image quality, which can obtain better image quality compared with T1-weighted conventional breath-hold VIBE sequence.

SSG14-06 Design Your MSK MRI: It Needs to be Planned by Radiologist

Tuesday, Dec. 3 11:20AM - 11:30AM Room: S504AB

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PURPOSE

To evaluation the recall rate and causes of musculoskeletal MRI scanned at a tertiary center

METHOD AND MATERIALS

From January to July 2018, 1639 musculoskeletal MRI were performed in our institution. Two musculoskeletal radiologists reviewed, recalled, and rescanned cases. Evaluation for reasons of recalled cases by consensus were in the following categories: resolution issue, field of view issue, coil issue, artifact issue, missed sequence issue, newly detected lesion issue, and miscellaneous. Then radiologists reviewed the rescanned images and assessed a 4-point confidence level before and after an additional scan. Finally, they were asked if a rescan could have been avoidable if they were asked to designed the protocol before scanning (yes, not sure, no).

RESULTS

The total recalled cases were 47 out of 1639 (2.8%). The causes of recall were FOV issue (14), adding the sequence (9), resolution issue (8), coil issue (3), metal artifact control (3), incidental lesion (2), changing position (2), and miscellaneous (5). The confidence score significantly increased after a rescan compared with the initial image (3.2 vs. 2.7, respectively, $P<0.05$). Two radiologists reported 33 out of 47 cases would not need a rescan if the radiologist were able to design the protocol prior to the scan.

CONCLUSION

Musculoskeletal MRI can offer insufficient information at an initial scan for various reasons; and for a better diagnosis, a rescan is necessary. However, the number of rescans may decrease when radiologists design the protocol prior to the scan

CLINICAL RELEVANCE/APPLICATION

Musculoskeletal MRI is complex when designing the protocol compared to other MRI (e.g., brain, breast, liver, etc.). Hence, musculoskeletal MRI needs planning well before scanning, and this is best done by a radiologist.

SSG14-07 Dynamic Contrast-Enhanced Magnetic Resonance Imaging during Free Breathing for Hepatic Lesions: Clinical Applicably and Limitations

Tuesday, Dec. 3 11:30AM - 11:40AM Room: S504AB

Participants
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PURPOSE

To evaluate the clinical applicability and limitations of this new prototype volume-interpolated breath-hold examination (VIBE) with compressed sensing (VIBEcs) for rapid multiphase MRI with free selectable variable temporal resolution for hypervascularized hepatic lesions.

METHOD AND MATERIALS

Twenty patients with hypervascularized hepatic lesions were included in this study and underwent contrast-enhanced liver MRI at 3 T. In all patients, VIBEcs was used for rapid arterial multiphase imaging. Results were analyzed regarding image quality and clinical applicability of the dynamic lesion evaluation. Evaluation of image quality, visibility and conspicuity was performed by three independent radiologist, each with more than 5 years of experience in oncology imaging, based on a 5-point Likert scale (5=excellent). Results were correlated with the lesion entity. Limitations for the use of VIBEcs in image acquisition were defined. Time curves of dynamic contrast enhancement were plotted for each patient and quantification of attenuation performed to isolate the optimal time-point for image acquisition.

RESULTS

All patients were successfully evaluated. Individual setting of acquisition time point (best point 8 seconds) instead of fixed delay allowed high reading scores for image quality, visibility and conspicuity for all lesions (mean score >4). Lesion entity showed no significant impact on the reading performance ($p=0.765$). Limitation were defined as following: small lesion size (<8 mm), subdiaphragmatic localization, large necrotic area (>80% of lesion).

CONCLUSION

Free-breathing MRI with VIBEcs allows image acquisition with high temporal and spatial resolution using individual acquisition time points during contrast phase to gain optimal results with a robust acquisition protocol.

CLINICAL RELEVANCE/APPLICATION

VIBEcs allows image acquisition with high temporal and spatial resolution for variable time points with a robust acquisition protocol and is recommended quantitavie measurements of hypervascularized liver lesions.

SSG14-08 Myocardial Extracellular Volume from T1 Mapping Measurements by Magnetic Resonance Imaging in Healthy Volunteers

Tuesday, Dec. 3 11:40AM - 11:50AM Room: S504AB

Participants
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PURPOSE

To investigate the characteristics of myocardial extracellular volume fraction (ECV) derived from pre- and post-contrast T1 measurements among healthy volunteers.

METHOD AND MATERIALS

A total of 57 healthy volunteers underwent standard CMR imaging with administration of gadolinium. T1 measurements were performed with a Look-Locker sequence followed by gradient-echo acquisition (GRE). We tested the segmental, interslice,inter-, intra-, and test-retest characteristics of the ECV ,as well as the association of the ECV with other variables.

RESULTS

57 healthy volunteers were recruited and were included in the analysis. There were 26 men (46%) and 31 women. The mean age of volunteers was 47±17 years(range 21 to 78 years). The average body mass index was 27±4kg/m2,systolic blood pressure was 119±11mmHg,diastolic blood pressure was 74±4mmHg,heart rate was 67±6 beats/min, and hematocrit was 43±2%. The ECV

averaged 0.27±0.04(range 0.21 to 0.34). The intraclass coefficients for the intraobserver, interobserver and test-retest absolute agreements of the ECV were 0.95 (95% confidence interval: 0.85 to 0.98), 0.87 (95% confidence interval: 0.64 to 0.96), and 0.97(95% confidence interval: 0.84 to 0.99), respectively. In volunteers, the ECV was associate with age ($r=0.81$, $P<0.001$), maximal left atrial volume index ($r=0.38$, $P=0.00036$($P<0.01$)), and indexed left ventricular mass. There were no differences in the ECV between segments in a slice or between slices.

CONCLUSION

In summary, the ECV is a novel and potentially useful index for quantification of the myocardial extracellular volume fraction. The findings suggest that in healthy volunteers, the myocardial ECV ranges from 0.21 to 0.34, In humans, the myocardial ECV increases with age, is associated with left ventricular mass and left atrial volume, and has reliable test characteristics. Further work will need to be done to test the application of this technique to patients with cardiovascular disease associated with the development of myocardial fibrosis.

CLINICAL RELEVANCE/APPLICATION

In cardiac magnetic resonance (CMR) imaging, the T1 relaxation time for the 1H magnetization in myocardial tissue may represent a valuable biomarker for a variety of pathological conditions

SSG14-09 CAIPIRINHA-Dixon-TWIST (CDT)-Volume-Interpolated Breath-Hold Examination (VIBE) Imaging of the Abdomen at 3.0 Tesla: Optimization and Comparison of Time Resolution and Image Quality

Tuesday, Dec. 3 11:50AM - 12:00PM Room: S504AB

Participants
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Chen-Peng Liu, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

In order to get a higher time resolution or spatial resolution of CAIPIRINHA-Dixon-TWIST (CDT)-Volume-Interpolated Breath-Hold Examination (VIBE) imaging of abdomen at 3.0 Tesla, we optimized the scanning parameters at three conditions and evaluated the time resolution and image's quality of them.

METHOD AND MATERIALS

Twelve patients (8 males, age 42±3.52; 4 females, 39±2.35) with focal liver lesions and eight healthy volunteers (5 males, age36±4.23; 3 females, 40±3.89) were enrolled and underwent abdomen CDT-VIBE imaging MR exam with breath-hold mode before and after contrast-enhancement. The scanning sequences, which included 4 phases within a breath hold, include three optimized sequence with time resolution of 0.4s/phase, 0.6s/phase and 1.5s/phase. The quantitative evaluation index included the signal-to-noise ratio (SNR) of spleen, left and right liver lobe, and the contrast to noise ratio (CNR) of left and right liver lobe. All quantitative indexes were measured in in-phase, opp-phase and water-phase images before and after contrast enhancement. Finally, the homogeneity, the sharpness and the artifacts of whole image was scored by two radiologists independently on the basis of a three-point scale, and the average of data was used as the final scores. All the quantitative and quality parameters were analyzed with One-way ANOVA and Kruskal-Wallis One-way ANOVA were applied for group comparison with Bonferroni correction.

RESULTS

After optimization of the parameters of CDT-VIBE, the highest time resolution can reach 0.4s/phase, and when compared with the optimized protocols with time resolution of 0.6s/phase and 1.5s/phase, no significant difference was found for CNR and SNR at spleen, left and right liver lobe ($p>0.05$) (Table 2-7). About subject evaluation scores, the average scores of image quality for sharpness in sequence with time resolution of 1.5s/phase was significantly higher than the other two optimized sequence ($p<0.001$). No significant difference was found for the homogeneity and the artifacts of image quality among three optimized conditions

CONCLUSION

Through optimization of the parameters of CDT-VIBE in abdomen imaging, a higher time resolution (0.4s/phase) or a higher spatial resolution can be acquired, which means a wider clinical application in abdomen imaging of the CDT-VIBE sequence.

CLINICAL RELEVANCE/APPLICATION

CDT-VIBE sequence will be a wider clinical application in abdomen imaging

PHS-TUA

Physics Tuesday Poster Discussions

Tuesday, Dec. 3 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Kenneth R. Hoffmann, PhD, Buffalo, NY (*Moderator*) Nothing to Disclose

Sub-Events

PH210-SD-TUA1 Assessment of the Performance of a Multifrequency Doppler Spectral Analysis (MFDSA) Algorithm in the Screening of Cardiovascular Disease

Station #1

Participants
Andrew Malone, BSC,MSc, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Jacinta Browne, PhD, Dublin 8, Ireland (*Presenter*) Nothing to Disclose
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PURPOSE

Current methods for diagnosis of cardiovascular disease (CVD) rely on detecting the obstruction of an artery through the use of Doppler ultrasound and digital subtraction angiography, when the disease is already well established. The purpose of this work was to design and assess an early diagnostic ultrasound screening technique for CVD using fluid dynamics prior to arterial obstruction.

METHOD AND MATERIALS

A potential early biomechanical marker of CVD susceptibility is wall shear stress (WSS), which is related to arterial wall stiffening. Assessment of WSS requires the accurate mapping of blood velocity close to the arterial wall, which is challenging for current imaging modalities. Multifrequency Doppler spectral analysis (MFDSA) allows for more precise velocity quantification by capturing additional spectral information in a transmitted pulse through 2-dimensional Fourier analysis. In addition utilising UltraFast acquisitions allows for complete vessel velocity quantification in a single insonation. A series of anatomically realistic walled arterial flow phantoms were constructed exhibiting a range of vessel stiffness values (60 kPa, 110kPa, & 320 kPa) corresponding to different stages of arterial disease. Flow data was collected on Aixplorer (Supersonic Imagine, France) ultrasound scanner using traditional pulsed wave (PW) Doppler as well as UltraFast Doppler. The data was analysed using three WSS assessment techniques: unaltered PW Doppler, an approximation based on the Hagen-Poiseuille equation, and the MFDSA algorithm. The outputs from each technique underwent a series of paired t-tests to determine whether they could detect a difference in WSS between the phantoms.

RESULTS

All techniques tested were capable of detecting a significant difference between the high and low stiffness phantoms ($p=0.041$, $p=0.044$, $p=0.032$). Only the MFDSA technique could detect a significant difference between the low and intermediate stiffness phantoms ($p=0.045$).

CONCLUSION

The MFDSA algorithm provides a clear advantage in WSS quantification over traditional ultrasound methods and, when used in conjunction with UltraFast acquisition times, it allows for complete velocity quantification in a region of interest in a single insonation, strengthening the case for the technique further.

CLINICAL RELEVANCE/APPLICATION

MFDSA can provide a significant improvement in the assessment of WSS, potentially providing a robust screening diagnostic for CVD

PH248-SD-TUA3 Distinction between Benign and Malignant Breast Masses at Breast Mammography Using Deep-Learning Method with Mask-R Convolutional Neural Network

Station #3

Participants
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PURPOSE

We aimed to use deep learning with Mask-R convolutional neural network (Mask-R-CNN) to discriminate between benign and malignant breast mass images from mammography.

METHOD AND MATERIALS

In total, 2000 patients (1196 benign masses and 804 malignant masses) were randomly divided into the training cohort (1600 patients) and the two validation cohorts (200 patients for each cohort). Deep learning model was constructed using Mask-R-CNN architecture in two views (craniocaudal, CC and mediolateral oblique, MLO). The performance of the trained neural network was tested with this one validation cohort. Four radiologists (2 senior and 2 junior) interpreted the test data set. In a second step, the neural network was re-trained with all cases and then was tested with another validation cohort. Sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive value(NPV)and area under the receiver operating characteristic curve (AUC) were compared between readers and the neural network.

RESULTS

For initially constructed Mask-R-CNN model, the Sensitivity, specificity, accuracy, PPV, NPV and AUC in CC view and MLO view were 92.30% Vs. 96.20%, 85.40% Vs. 81.30%, 89% Vs. 89%, 85.70% Vs. 87.40%, 91.90% Vs. 95.10%, 0.845 Vs. 0.858, respectively. The proposed model achieved better classification performance than the junior radiologists and inferior to that of senior radiologists ($P < 0.05$). With the re-trained Mask-R-CNN model, the Sensitivity, specificity, accuracy, PPV, NPV and AUC in CC view and MLO view were 96.10% Vs. 96.10%, 95.90% Vs. 91.80%, 96% Vs. 94%, 96.10% Vs. 92.50%, 95.90% Vs. 95.70%, 0.949 Vs. 0.908, respectively. There was no significant difference in classification performance between AI model and senior radiologists ($P < 0.05$).

CONCLUSION

The results obtained demonstrate that the proposed Mask-R convolutional neural network is performant and can indeed be used to predict if the mass lesions are benign or malignant.

CLINICAL RELEVANCE/APPLICATION

The study demonstrates that deep learning with Mask-R-CNN have higher performance in classifying mammography mass lesions.

PH249-SD-TUA4 Detector Sampling and Dose Reduction in Whole-Body Photon Counting Computed Tomography

Station #4

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PURPOSE

To evaluate the dose-normalized contrast-to-noise ratio (CNRD=CNR/sqrt(D)) of data acquired using the high-resolution mode of a photon counting (PC) whole-body computed tomography (CT) scanner, reconstructed at the spatial resolution of conventional energy-integrating CT acquisitions.

METHOD AND MATERIALS

To avoid pulse pileup PC-CT uses small detector pixels. In many cases the high spatial resolution achievable with such pixels is not of interest and the data are rather reconstructed at a similar spatial resolution as today's energy integrating (EI) systems achieve. From [Med. Phys. 32(5):1321-1334, 2005] it is known that reconstructing images below the system's resolution limit results in image noise reduction and thus improved CNRD compared to measurements with a system with larger pixels. We quantify this effect using measured data from a PC and from an EI detector. An anthropomorphic abdominal phantom, extendable with fat rings, in three sizes (S = 20×30 cm, M = 25×35 cm, L = 30×40 cm) equipped with iodine inserts, animal cadavers, and human corpses were measured at different tube voltages (80 to 140 kV). The images were acquired with the EI detector (0.6 mm pixel size in isocenter) and the PC detector operating in Macro mode (0.5 mm pixel size) and UHR mode (0.25 mm pixel size). Both detectors are components of the same dual source system (SOMATOM CounT, Siemens Healthineers, Germany). During image reconstruction the MTF was matched to the one of the EI detector. CNRD values are evaluated as a figure of merit.

RESULTS

Images acquired in UHR mode achieve higher CNRD values compared to EI at the same spatial resolution. E.g., for 120 kV, the CNRD improves up to 23.5%, corresponding to a possible dose reduction of 34.5% in comparison with conventional CT imaging. Compared to Macro mode, UHR mode shows a CNRD improvement of up to 12.2% at the same EI-matched resolution. These findings are valid for all tube voltages and phantom sizes.

CONCLUSION

Reconstruction of UHR data with an MTF below the system's resolution limit reduces image noise for all phantom sizes and tube voltages compared to standard acquisitions. Thus, a clinically relevant dose reduction is possible while maintaining image quality.

CLINICAL RELEVANCE/APPLICATION

The small pixel effect can be used to either improve image quality or to reduce the administered radiation dose and is applicable to most clinical CT exams.

PH250-SD-TUA5 Differentiating between Low-Grade and High-Grade Clear Cell Renal Cell Carcinoma Using CT Image Texture Analysis

Station #5

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PURPOSE

To evaluate the efficiency of differentiating between low-grade and high-grade clear cell renal cell carcinoma (ccRCC) using CT image texture analysis (TA).

METHOD AND MATERIALS

This retrospective study included 113 patients with ccRCC. Renal carcinoma was regraded according to 2016 WHO/ISUP criteria into low-grade (n=81, Grade I and II)) and high-grade (n=32, Grade III and IV). Images in cortical phase were put into ITK-SNAP software, and 3D-ROIs of total tumor were drawn manually to extract 42 different TA features (Histogram and grey level co-occurrence Matrix) from each tumor. LASSO regression was used to reduce data dimensionality, TA was constructed to identify risk scores of ccRCC of different grades. The pathological result was taken as the response variable, and the TA and clinical data with statistically significant differences between the two groups were included in the binary logistics regression multifactor analysis. A ROC was drawn to evaluate the diagnostic efficacy of each parameter. Decision curves analysis (DCA) was used to analyze TA and clinical data, and the patient's net benefit from their combination.

RESULTS

The tumor size, capsule, venous involvement and enlargement of locoregional LNs were statistically different between the two groups (all p<0.01). The TA risk score build in the low- and high-grade ccRCC was -1.30±0.70 and -0.40±0.77, respectively. The TA risk scores and enlargement of locoregional LNs were independent risk factors in identifying low-grade or high-grade ccRCC with odds ratio of 4.45 and 5.01, and AUC of 0.81 and 0.75, respectively. The combined AUC was 0.85. Based on Delong analysis, the combined AUC was higher than using the enlargement of locoregional LNs (p<0.001), but was statistically the same as using the TA risk scores (p=0.09). DCA showed that the decision curve of combined diagnosis was higher than the results of TA risk scores in the range of 0.21-0.77 probability threshold, which could improve the patients' net benefit.

CONCLUSION

TA risk score combined with enlargement of locoregional LNs is more effective in simplified WHO/ISUP classification of ccRCC. It improves the net benefit of patients.

CLINICAL RELEVANCE/APPLICATION

Texture analysis risk score combined with enlargement of locoregional LNs can provide a reference for evaluating the prognosis of patients with ccRCC.

PH251-SD-TUA6 The Value of Advanced Reconstruction Algorithms in Improving Upper Abdominal CT Image Quality

Station #6

Participants
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PURPOSE

To explore the value of new generation model based iterative reconstruction (MBIR), adaptive statistical iterative reconstruction (ASIR) in improving the upper abdominal CT image quality.

METHOD AND MATERIALS

20 upper abdominal patients underwent three-phase contrast-enhanced scans on a Discovery CT750HD were included. The scan protocol was: tube voltage 120kVp, automatic tube current modulation for noise index of 20HU at 0.625mm thickness, pitch 1.375:1, rotating speed 0.6s/r. Images of the delay phase were reconstructed at 0.625mm thickness with FBP, 40%ASIR and MBIR with a standard setting (MBIRstnd). The CT values and standard deviation values of the liver, spleen, pancreas, renal parenchyma and subcutaneous fat at the same imaging level were measured to calculate the signal to noise ratio and contrast to noise ratio of each measured organ. The reduction rate of SD and the improvement rate of SNR and CNR using 40%ASIR and MBIRstnd compared with FBP were also calculated. Single factor analysis of variance was used to analyze the difference of SD, SNR and CNR among the three reconstruction groups with p< 0.05 being statistically significant. The subjective image scores of the three groups were assessed blindly by two experienced physicians using a 5-point system and the score consistency was compared by the Kappa test.

RESULTS

The subjective scores of the three groups with FBP, 40%ASIR and MBIRstnd were 3.12±1.03, 4.08±1.14 and 4.82±1.25, respectively with significant difference among them ($p<0.05$) and there was good consistency between reviewers. The SD values (in HU) of the liver, spleen, pancreas and kidney using MBIRstnd were 10.96±0.73, 10.76±1.01, 12.35±1.67 and 12.54±1.78, statistically lower than those with 40%ASIR and FBP ($p<0.05$). The SNR values of liver, spleen, pancreas and renal parenchyma with MBIRstnd were 6.84±0.95, 6.81±0.88, 4.96±0.76 and 9.09±1.27, respectively while their respective CNR values were 14.58±3.94, 14.40±3.75, 13.31±3.69 and 17.83±4.35, both sets were statistically higher than those of 40%ASIR and FBP ($p<0.05$) (See Table 1).

CONCLUSION

Comparing with FBP, the new generation MBIR) and ASIR algorithms can significantly reduce image noise and improve image quality in upper abdominal CT imaging.

CLINICAL RELEVANCE/APPLICATION

Advanced reconstruction algorithms such as MBIR, can significantly reduce image noise and improve image quality in upper abdominal CT imaging, which provides a basis for reducing the radiation dose.

PH252-SD-TUA7 Fast MRI Connectomics with the Dual-Echo Turbo Spin Echo (DE-TSE) Pulse Sequence and White Matter Fibrography

Station #7

Participants
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CONCLUSION

A fast connectome rendering technique using the DE-TSE pulse sequence has been developed, which improves image acquisition efficiency by 30% as compared to tri-TSE; hence WMF could be widely implemented across MRI platforms using commercial MRI scanners. 1. Fatouros PP et al. Magnetic Resonance in Medicine. 1991; 17(2):402-13.

Background

White matter fibrography (WMF) is a recently developed MRI technique for in vivo brain connectomics. In the original implementation WMF used images generated with the triple turbo spin echo pulse (Tri-TSE) to generate qMRI maps of PD, T1=1/R1 and T2, and connectome renditions via R1-weighted Synthetic-MRI. Owing to the previously published relationship between PD and R1 that is applicable to white matter and gray matter (1/PD= A*R1 + B, where A, B are phenomenological constants (Ref.1)), the question arises as to whether WMF connectomes could be rendered from images generated by the faster and simpler dual-echo (DE-) TSE pulse sequence. The purpose of this work was to develop computer algorithms for mapping *pseudo*R1= (1/PD-B)/A, and use these maps for WMF.

Evaluation

All images used for this study were obtained with IRB approval. The directly-acquired images of the DE-TSE acquisition were used to create maps of the relaxation times (T2, and pseudo-R1), and of normalized proton density (qPD). *Pseudo*R1 heavily-weighted images of the intracranium were generated with a synthetic MRI engine based on the equation: SynthMR = PD·exp[-R1w/R1]. Algorithms were coded in Python 3.5, using the Canopy integrated development environment (Enthought, Austin, TX). These pseudo-R1-weighted synthetic images were further processed with ImageJ (https://imagej.nih.gov/ij/) leading to 3D-to-2D projections depicting the full brain connectome.

Discussion

Using the DE-TSE pulse sequence and *pseudo*R1 qMRI is advantageous because all images, and therefore maps, are self-coregistered, and the scan time is approximately 30% shorter than tri-TSE. Furthermore, the DE-TSE pulse sequence is available across vendors. This work could have implications for in vivo connectomics in routine MRI and for the generation of very high and isotropic spatial resolution connectomes with commercial scanners.

PH133-ED-TUA8 Impact of 4D- Ultra-Short Echo Time MR Angiography on Neuroimaging

Station #8

Participants
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TEACHING POINTS

-To know basic principles and differences of ultra-short echo time (UTE) MR Angiography on 3D and 4D. -To know its current usefulness in clinical neuroimaging. -To know the pitfall of UTE-MRA based on a its principle.

TABLE OF CONTENTS/OUTLINE

- A technical review of UTE imaging and recent application for MRA. - Our experience in applying the UTE-MRA in patients with cerebral aneurysms (pre, post coil embolization, and post clipping), dissecting cerebral aneurysms, Moyamoya disease, intracranial carotid occlusion and carotid-cavernous sinus fistula. Principally, images are compared with conventional time-of-flight (TOF)-MRA. - Impact and certainty of 4D-MRA with UTE against recently developed neuro-IVR with mass metal (Flow diverter stent, carotid stent) are displayed. -Discussion is made of regarding important factors, including differences towards TOF-MRA, further application for clinical practices, pitfalls for interpretation.

Printed on: 10/29/20

PHS-TUB

Physics Tuesday Poster Discussions

Tuesday, Dec. 3 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Kenneth R. Hoffmann, PhD, Buffalo, NY (*Moderator*) Nothing to Disclose

Sub-Events

PH212-SD-TUB1 CT Radiation Dose in a Developing Nation: Justification, Acquisition, and Reconstruction Issues

Station #1

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PURPOSE

The IAEA-led initiative on CT radiation dose optimization in the Republic of North Macedonia (RNM) uncovered several strengths and challenges. We assessed the CT dose-related issues related to justification, CT acquisition and reconstruction parameters in the RNM.

METHOD AND MATERIALS

With approval of the RNM Radiation Safety Directorate, we collected information pertaining to CT vendors, slice-profiles, acquisition and reconstruction parameters, patients' age and weight, and CT dose descriptors (CTDIvol and DLP) from several institutions located in different parts of the country. An EXCEL template was created for recording the information and sent to all 19 state CT sites. CT technologists filled out the requested information for head, chest, and abdomen-pelvis CT examinations performed for clinically-indicated reasons. Separately, we reviewed clinical indications for CT from an electronic ordering system (MyTerm). Descriptive statistical analyses were performed.

RESULTS

Iterative reconstructions were available on 2/35 CT in the RNM (13/35 were <=16-slice MDCT). Only 5/19 Institutions (26 %) returned the requested dose-related information. Frequently, the referring physicians did not provide relevant clinical indication for ordering CT (i.e. asthma, schizophrenia or weak heart as indications for abdomen-pelvis CT). Although AEC was applied, high image quality requirement and/or thin prospective sections maximized the applied tube current. Most institutions did not have indication-based protocols, and performed 2/3-phase routine chest CT (4/5: CTDIvol >10 mGy) and 3/4-phase routine abdomen-pelvis CT (5/5; CTDIvol > 15 mGy) at 120 or 140 kV. Non-contrast CT series were acquired at equal (3/5 sites) or higher (2/5 sites) radiation doses compared to post-contrast series.

CONCLUSION

Despite regulatory intervention collection of CT dose related information was not successful in RNM. We discovered serious issues related to inadequate clinical information and/or overuse of multiphase CT across all surveyed institutions.

CLINICAL RELEVANCE/APPLICATION

Developing nations face serious challenges to CT dose optimization without a strict regulatory oversight, robust order entry and dose monitoring software.

PH213-SD-TUB2 Can We Estimate Metabolic Risk on Low-Dose Chest CT? A New Index of Pericardial and Intrathoracic Fat Depots Estimated from a Series of Low-Dose Screening Chest CT

Station #2

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PURPOSE

Intrathoracic fat represent a useful marker for increased metabolic risk and visceral adiposity on thoracic imaging. This study aimed to develop an automated computerized scheme to estimate a new index of pericardial and intrathoracic fat depots (PIF) on a series of low-dose screening chest CT.

METHOD AND MATERIALS

The retrospective study included 730 general population aged 26-90 who underwent a low-dose chest CT, visceral fat scans, BMI (body-mass index), and waist circumference measurement during medical checkups between 2009 and 2012 at our health care center. The original low-dose CT was obtained with 20mAs, 120kV, and slice thickness of 5 mm. The 3D iso-voxel volume data was reconstructed from a series of chest CT images (512x512 matrix size). The PIF was defined as a number of voxels within CT values of -195 and -45 in cardiac region. The cardiac region was automatically segmented by using Deep Convolutional Neural Network. A new index of %PIF was defined as the volume ratio of PIF and cardiac region. As a reference standard, a cutoff point of visceral fat area of 100 cm2 was adopted for definition of visceral fat accumulation group in Japanese.

RESULTS

Among 730 cases (Females n=260), there were 405 cases (Females n=99) classified into a visceral fat accumulation group. Average %PIF values for a visceral fat accumulation group and the others were 21.1% and 14.8% ($p<0.001$), respectively. The Pearson correlation coefficient of the relationship between %PIF and an area of visceral fat was 0.754 ($p<0.001$). In addition, an ROC analysis for assessing the visceral fat accumulation revealed that the AUC of %PIF (0.865) was better than that of the BMI (0.786) ($p<0.001$) and the waist circumference (0.825) in Japanese female ($p<0.05$), respectively.

CONCLUSION

We developed a computerized scheme for estimating a new index of %PIF from a series of low-dose screening CT images. The %PIF was significantly correlated with visceral fat accumulation, suggesting a useful marker for visceral adiposity on thoracic imaging.

CLINICAL RELEVANCE/APPLICATION

On the basis of the data of low-dose chest CT, a new index of %PIF may represent a potential marker for increased metabolic risk, particularly when volumetric data on visceral fat is unavailable.

PH255-SD-TUB4 Direct Measurement of CT Scatter Distribution Using a Long Linear Array Detector

Station #4

Participants
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CONCLUSION

Direct measurements of scatter spatial distribution and strength were feasible at locations important for shielding design yet are not available from the vendor scatter map. The high sensitivity, long span and small pixel size allowed the detector to perform very efficient and detailed evaluation of distant scattered radiation.

Background

CT vendors provide scattered radiation for a limited range (typically up to 3.35 or 3.8 meters from isocenter, based on sparse spatial sampling). But CT shielding needs scatter data at distant locations. This work was to directly measure scatter using a long linear array detector at room-boundary locations far beyond the vendor-provided stray radiation maps.

Evaluation

Preliminary measurements of scatter were done using a model 0.8f3-512 detector (640 pixels, 0.8mm pixel pitch) from Detection Technology Inc., Finland. The signal-to-dose calibration of all detector pixels was completed at four kVs (80, 100, 120, 140) using a GE lightspeed scanner. In the horizontal plane at the isocenter height inside a Siemens Force CT room, phantom scatter near wall locations close to the operator window were evaluated by the detector along a straight line that's perpendicular to the CT table, whose intersection with the table was four meters away from the CT isocenter.

Discussion

The calibration factors from the four kVs were highly consistent, suggesting insensitivity of the calibration process to CT beam quality variations. The final calibration of DT was done with the help of a survey meter at the center location of 4 meter.The long detector length of 51cm allowed efficient derivation of scatter maps with high spatial resolution (0.8mm), which greatly reduced the need to do repeated exposures. Our measurement at the 4m location yielded a smoothly-varying scatter map of 0.9 to 1.2 µGy per 100 mAs.

PH257-SD-TUB6 Application of MT in Kidney: A Comparison Analysis with Physiological Features

Station #6

Participants
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PURPOSE

To evaluate the correlation between parameters from magnetization transfer (MT) technique and physiological features in normal people.

METHOD AND MATERIALS

A total of 35 healthy volunteers without renal disease were enrolled in this study. The gender, age, BMI (Body Mass Index), WHR (Waist-to-Hip Ratio), family history of diabetes and hypertension of all subjects were recorded. All subjects underwent examination on a 3.0T MRI scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) with an 18-channel body phased-array surface coil. A 3D fast low angle shot (FLASH) sequence was scanned for two times to acquire MT data, first time with a MT saturation pulse (MTon) and second time without (MToff). For MT quantification, the magnetization transfer rate (MTR) was calculated using following equation: MTR =(MToff-MTon)×100/MToff. MTR value was measured on the MT map of each subject using the region of interest method. Multiple regions of interest were drawn and averaged in the medullitary region of the upper kidney, renal hilum, and the lower pole. The Pearson correlation analysis was performed to determine the relationship between the age, BMI, WHR and blood pressure with the value of MTR. A two-sample t-test was used to compare the difference in MTR values between gender and family history.

RESULTS

The MTR value of the cortex was significantly higher with the increasing of systolic pressure ($p<0.05$) (Figure 1). Although there is no statistical difference the MTR values of the cortex and medulla were increased with the increasing of age, BMI, WHR and diastolic pressure, ($p>0.05$) (Figure 1, Figure 2); and the MTR values of the medulla were decreased with the increasing of systolic pressure ($p>0.05$) (Figure 1), and the MTR value from subjects who had family history of diabetes was higher than that without family history diabetes ($p>0.05$) (Figure 2) .

CONCLUSION

The MTR value of kidney was significantly correlated with of systolic pressure in normal people, and it may indicate early renal microvascular changes before hypertension.

CLINICAL RELEVANCE/APPLICATION

MT can reflect changes in microstructure of and provide a more scientific basis for clinical changes in the kidney.

PH258-SD-TUB7 Principle Component Analysis (PCA) in Photon-Counting Spectral CT and Its Implementation in Projection Domain and Image Domain with Denoising

Station #7

Participants
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PURPOSE

Photon-counting spectral CT has gained growing attention in research and development due to its clinical potential in material decomposition and virtual monochromatic analysis. The principal component analysis (PCA) technique provides a tool to extract valuable information from the multidimensional data acquired in photon-counting spectral CT. This work investigates the feasibility and compares the performance of PCA in projection and image domain, with the content-oriented sparse representation (COSR) based denoising as an enhancement approach.

METHOD AND MATERIALS

Two contrast agent phantoms consisting of targets of iodine and nanoparticulated gold and a small animal (mouse) are used to evaluate the feasibility and performance of PCA in photon-counting spectral CT. The PCA is carried out in both projection and image domains, in which either projection or image data are transformed into representation in an orthogonal coordinate system that maximizes the covariance and thus enhance the contrast between clustered data corresponding to various materials. Since the noise in photon-counting spectral CT data, especially in the high energy bins, may degrade PCA's performance, the COSR denoising is applied on the reconstructed images to investigate how denoising can benefit the PCA.

RESULTS

It is found that the first principle component (PC) images extract vast majority (more than 98.9%~99.8%) of the information (covariance) carried by the images corresponding to all energy bins. The PCA enhance image quality that is assessed as noise and contrast-to-noise ratio significantly while the data dimensionality is being reduced substantially. Moreover, with denoising in reconstructed images, the image quality can be further improved.

CONCLUSION

The preliminary results showed PCA's feasibility in extracting dominant contrasts between materials in photon-counting spectral CT, with a significant reduction of data dimensionality in photon-counting spectral CT, in either projection or image domain, especially in the image domain with proper denoising.

CLINICAL RELEVANCE/APPLICATION

The preliminary data presented in this study may provide information and reference for the technical and/or clinical community to better understand the feasibility and potential of PCA in photon-counting spectral CT.

PH259-SD-TUB8 Weakly Supervised Learning for Classifying A Cardiomegaly Disease from Normal and Other Diseases on Chest Radiographs

Station #8

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PURPOSE

To develop a weakly supervised classification for screening of cardiomegaly disease with chest radiograph (CXR).

METHOD AND MATERIALS

We collected a total of 16,730 CXRs including normal (n = 6903), abnormal CXRs with cardiomegaly (n = 1184) and other five disease patterns including nodule, consolidation, pleural effusion, pneumothorax, interstitial opacity (n = 8619) from our institution. All CXRs were annotated by 5 - 10 years experienced thoracic radiologists. These datasets were randomly split into 70 percent for training, 10 percent for tuning, and 20 percent for final evaluation. To classify cardiomegaly, other disease patterns, and normal, we used densenet169 with convolutional neural network (CNN) for weakly supervised learning. When this algorithm was trained, normal and other disease patterns were randomly extracted from train datasets to balance the number of cardiomegaly. The performance of this classifier was evaluated with statistical analysis such as sensitivity, specificity, and accuracy.

RESULTS

In the test dataset, the algorithm showed 98.18% accuracy in classification of normal, cardiomegaly, and other diseases CXR. Sensitivity and specificity of CNN was measured at 81.85%, 93.06%, and 96.79%, and 95.45%, 94.35%, and 90.15% for cardiomegaly, other disease patterns, and normal CXRs, respectively.

CONCLUSION

Weakly supervised learning with deep CNN demonstrated high diagnostic performance in the classifying normal, cardiomegaly, and others disease patterns CXRs.

CLINICAL RELEVANCE/APPLICATION

Automated classifier with weakly supervision shows high diagnostic performance in classifying cardiomegaly from normal and others disease patterns CXRs, which could be used as a screening tool for cardiomegaly disease with CXR

SSJ21

Physics (Diagnostic X-Ray Imaging)

Tuesday, Dec. 3 3:00PM - 4:00PM Room: N228

PH

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

FDA Discussions may include off-label uses.

Participants
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Sub-Events

SSJ21-04 Weakly Supervised Learning for Classifying A Cardiomegaly Disease from Normal and Other Diseases on Chest Radiographs

Tuesday, Dec. 3 3:30PM - 3:40PM Room: N228

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PURPOSE

To develop a weakly supervised classification for screening of cardiomegaly disease with chest radiograph (CXR).

METHOD AND MATERIALS

We collected a total of 16,730 CXRs including normal (n = 6903), abnormal CXRs with cardiomegaly (n = 1184) and other five disease patterns including nodule, consolidation, pleural effusion, pneumothorax, interstitial opacity (n = 8619) from our institution. All CXRs were annotated by 5 - 10 years experienced thoracic radiologists. These datasets were randomly split into 70 percent for training, 10 percent for tuning, and 20 percent for final evaluation. To classify cardiomegaly, other disease patterns, and normal, we used densenet169 with convolutional neural network (CNN) for weakly supervised learning. When this algorithm was trained, normal and other disease patterns were randomly extracted from train datasets to balance the number of cardiomegaly. The performance of this classifier was evaluated with statistical analysis such as sensitivity, specificity, and accuracy.

RESULTS

In the test dataset, the algorithm showed 98.18% accuracy in classification of normal, cardiomegaly, and other diseases CXR. Sensitivity and specificity of CNN was measured at 81.85%, 93.06%, and 96.79%, and 95.45%, 94.35%, and 90.15% for cardiomegaly, other disease patterns, and normal CXRs, respectively.

CONCLUSION

Weakly supervised learning with deep CNN demonstrated high diagnostic performance in the classifying normal, cardiomegaly, and others disease patterns CXRs.

CLINICAL RELEVANCE/APPLICATION

Automated classifier with weakly supervision shows high diagnostic performance in classifying cardiomegaly from normal and others disease patterns CXRs, which could be used as a screening tool for cardiomegaly disease with CXR

SSJ21-01 Quantitative Flow Velocity Analysis of 1000 Frames Per Second (fps) High Speed Angiography (HSA) Image Sequences

Tuesday, Dec. 3 3:00PM - 3:10PM Room: N228

Participants
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Abhinandan Sharma, MS, Buffalo, NY (*Abstract Co-Author*) Nothing to Disclose
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Stephen Rudin, PhD, Buffalo, NY (*Abstract Co-Author*) Research Grant, Canon Medical Systems Corporation

PURPOSE

As minimally invasive image-guided endovascular interventions continue to replace invasive surgical procedures, quantification of parameters for impact evaluation such as blood velocity distributions and their changes due to the deployment of interventional devices become more important. We are developing a unique high spatial and high temporal resolution capability based on analysis of 1000 fps angiographic sequences for measuring such blood velocities in the intracranial vessels.

METHOD AND MATERIALS

A prototype system based on an Xcounter Actaeon photon counting detector (PCD) with 100 um pixels was used with a standard c-arm source set to 70 kVp, 100 mA to take a sequence of 1 ms exposures of a 3D-printed patient-specific aneurysm model connected to a pulsatile pump. Contrast was auto-injected into the phantom via a catheter maneuvered a short distance proximal of the aneurysm. Sequential frames were subtracted from one another creating a difference image where the contrast front would appear dark. Measurement of velocity from successive images was achieved by manually tracking the location of the center of mass of contrast fronts as they progressed through the phantom.

RESULTS

Over 200 individual points were sampled from the image sequence corresponding to different points of time and different locations throughout the phantom having varying vessel diameter. For this study, the average measured velocity for points sampled from the inflowing portion of the vessel was found to be 91.7 cm/s while for the outflow vessel the average velocity was 135.3 cm/s due to its reduced diameter. Points measured within the aneurysm sac had an average velocity of 80.0 cm/s, though directionality was highly dependent on location.

CONCLUSION

Detailed velocities of simulated intracranial blood flow as demonstrated here could be a valuable means of evaluating the impact of an interventional device deployment during planning, delivery, and post-deployment stages.

CLINICAL RELEVANCE/APPLICATION

A new way to measure intracranial vascular flow velocities with 1000 fps angiography has great potential to benefit the planning, conduct, and outcome of endovascular image guided interventions.

SSJ21-02 Analogous Lubberts Effect in Single Photon Counting Semiconductor Detectors

Tuesday, Dec. 3 3:10PM - 3:20PM Room: N228

Participants
Ke Li, PhD, Madison, WI (*Presenter*) Nothing to Disclose

PURPOSE

DQE loss due to depth (z)-dependent x-ray conversion gain and MTF in scintillator detectors was analyzed by G Lubberts half a century ago. The effect is associated with the spatial transport of optical quanta, which is not applicable to direct-conversion photon counting detectors (PCDs). However, mechanisms exist in PCDs to create variations of the MTF and the so-called x-ray multiplicity along z. The purpose of this work was study a Lubberts-like effect in PCDs and analyze the potential impacts on the detector design.

METHOD AND MATERIALS

Four major physical factors may contribute to depth-dependent PCD response: the escape fraction of K-fluorescent x-rays, height of voltage pulse generated by the motion of charge carriers, the lateral diffusion width of charge carriers, and the voltage (energy) threshold level. To analyze how the z-dependence of the PCD output is linked to each factor, a parallel + serial cascaded systems model of PCD was leveraged. Accuracy of the model in predicting DQE was experimentally validated using a CdTe-based PCD operated under 4 different radiation conditions and 40 threshold levels. Using the model as a theoretical tool, the impacts of each physical factor to the variation of PCD output along z was analyzed.

RESULTS

For a PCD with 2 mm CdTe, 3 μs mean electron lifetime, 20 keV low energy threshold, and 0.1 mm charge-collecting pixel electrode located at the back-end of CdTe, the Lubberts fraction (L) is 0.94 at zero-frequency and 0.91 at 5 lp/mm for a typical 120 kV CT spectrum. The Lubberts loss is primarily caused by the z-dependencies of K-escape fraction and electric (E) field; contribution of diffusion is negligible. When a front-end pixel design was used, an across-the-board improvement in L (>=4%) was achieved for the same input condition.

CONCLUSION

Compared with scintillator detectors, an improvement in the average Lubberts fraction was found in PCD, adding another benefit to this technology. The remaining small but non-negligible Lubberts loss is primarily caused by variations of K-escape fraction and E-field along z. Location of the pixel electrode needs to be optimized based on the input x-ray energy and pixel size in order to minimize the remaining Lubberts loss.

CLINICAL RELEVANCE/APPLICATION

As DQE is closely related to diagnostic image quality and dose efficiency, understanding the DQE-degrading Lubberts effect and engineering the corresponding remedy have direct clinical relevance.

SSJ21-03 Study of a Single-Shot Dual-Energy Flat Panel Detector with High Detective Quantum Efficiency

Tuesday, Dec. 3 3:20PM - 3:30PM Room: N228

Participants
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PURPOSE

Dual-energy (DE) imaging is well-known to aid in diagnosis by reducing anatomical noise and enabling material classification. Current approaches to DE imaging have trade-offs, such as motion artifacts due to the two exposures required or low sensitivity due to losses in a middle filter. Recently, a triple-layer flat panel detector (FPD) for use in single-shot DE imaging was proposed to address these trade-offs by eliminating motion artifacts while preserving high sensitivity. The purpose of this study is to evaluate the feasibility of such a detector by building and studying a prototype. Various image quality metrics are measured and clinical images are examined.

METHOD AND MATERIALS

An FPD prototype consisting of three stacked sensors each with its own cesium iodide (CsI) scintillator was used for all measurements. This detector generates three images per exposure: a digital radiography (DR) image -equivalent to one obtained with a conventional detector- and two tissue-subtracted (TS) images obtained through logarithmic subtraction: a bone and a soft-tissue image. To evaluate DR image quality, detective quantum efficiency (DQE) and modulation transfer function (MTF) were measured as per IEC 62220-1-1:2015 for multiple radiation quality (RQA) beams. The triple-layer detector's TS capabilities were qualitatively evaluated by studying three chest X-ray images obtained from an on-going clinical trial.

RESULTS

DQE and MTF on par with state-of-the-art single-layer DR detectors were observed across all RQA beams used, since the triple-layer design allows for a large total amount of CsI without increasing scintillator blur. The obtained clinical DE TS images showed good tissue separation and uniformity with no motion or alignment artifacts visible.

CONCLUSION

The high DQE and MTF measured indicate that the addition of DE capabilities is not detrimental to the main function of the triple-layer FPD as a DR detector, while the TS image quality indicates that it is a potential replacement to current DE technologies. We conclude that the triple-layer FPD design is promising for clinical use since both high-quality DR and DE images can be obtained in a single exposure.

CLINICAL RELEVANCE/APPLICATION

DE imaging is known to aid in diagnosis in certain clinical applications. The triple-layer FPD design is a compelling alternative to current technologies that could improve DE quality and adoption.

SSJ21-05 Comparison of Software for Retrospective Calculation of Applied Pressure in Mammography

Tuesday, Dec. 3 3:40PM - 3:50PM Room: N228

Participants
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CONCLUSION

The de Groot-script to calculate mean breast contact area is a useful tool for small datasets where obvious outliers can be removed after visual inspection, but should not be used in larger sets to prospectively predict the effect of the introduction of pressure-based compression in mammography.

Background

The subjectivity of 'appropriate' compression in mammography may cause concerns for variations in pain, dose and image quality. An objective compression guideline is possible by using a paddle with an indicator for the applied pressure (force per unit contact area). To study its impact on clinical practice, comparison with previously applied pressures is necessary. We compare two methods to retrospectively calculate pressure from mammogram pairs before (force-based) and after implementing the pressure-based paddle: Proprietary software (Volpara Analytics) and our own script (de Groot et.al., MedPhys 41: 023501).

Evaluation

Applied force was retrospectively obtained from the DICOM header of 826 randomly selected CC-view mammographic image pairs (2009: force-based, 2014: pressure-based). Mean breast contact area were calculated from all mammograms using Volpara and de Groot-script. Subsequently, applied pressure (force over contact area) was calculated. In both the force- and pressure-based group the applied pressure was higher with a much larger standard deviation when using de Groot-script compared to Volpara. (Force-based: Volpara 22.1±10.0 kPa, de Groot: 26.6±17.6 kPa, Pressure-based: Volpara 16.2±6.3 kPa, de Groot: 130.3±1888.0 kPa).

Discussion

The applied pressures as calculated with the de Groot-script in the pressure-based group were unrealistically high. In previous publication from our group, data obtained from de Groot-script were only used on small datasets after visual inspection of the results, something that is time-consuming in large datasets.

SSJ21-06 Material Characterization with Spectral Photon-Counting Radiography - An Experimental Approach

for Crystal Arthropathies

Tuesday, Dec. 3 3:50PM - 4:00PM Room: N228

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PURPOSE

We aimed to assess whether spectral photon-counting radiography (SPCR) was able to differentiate the three most common crystals involved in crystal arthropathies, and secondly to compare SPCR with dual-energy CT (DECT).

METHOD AND MATERIALS

Industry-standard cylindrical solid rods of monosodium urate (MSU), calcium pyrophosphate (CPP) and calcium hydroxyapatite (HA) in three different clinically relevant concentrations (MSU: 200, 400 and 600 mg/ml, CPP and HA: 50, 100 and 200 mg/ml) were first imaged with SPCR, using a vendor X-ray tube and a prototype detector. Four energy thresholds were set at 15, 25, 30 and 35 keV. All samples were subsequently scanned with a dual-source dual-energy CT (DECT) of the latest generation. Respective attenuation values (AV), Hounsfield units (HU) and effective atomic numbers (Zeff) of the different rods were compared among each other and between imaging modalities.

RESULTS

MSU, CPP and HA showed statistically significant differences in AV, HU and Zeff with both imaging modalities (Zeff MSU: 6.52-6.96; CPP: 7.47-9.47; HA: 7.57-9.56). For each material, AV/HU/Zeff differed significantly among different concentrations (all $p< 0.001$; except between MSU at low vs. medium concentrations with DECT, $p= 1$). Mean Zeff measured with SPCR and DECT were comparable ($p= 0.9$). For each respective concentration, Zeff was significantly different between CPP and HA ($p<= 0.04$).

CONCLUSION

Characterization of the three most common crystals involved in crystal arthropathies is comparable between SPCR and DECT, with MSU clearly distinguishable from calcium-containing crystals. Zeff and attenuation values of CPP and HA show some overlap complicating their clear-cut differentiation. Future research should focus on findings in vivo.

CLINICAL RELEVANCE/APPLICATION

We present experimental results of a novel imaging technique approach for the characterization of crystalline compositions. This could impact the future diagnostic workup of crystal arthropathies, with inherent impact on patient management.

SSJ22

Physics (Photon Counting Detector CT)

Tuesday, Dec. 3 3:00PM - 4:00PM Room: N226

CT PH

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

FDA Discussions may include off-label uses.

Participants
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Sabee Y. Molloi, PhD, Irvine, CA (*Moderator*) Research Grant, Canon Medical Systems Corporation

Sub-Events

SSJ22-01 Low Dose Ultra-High Resolution Sinus and Temporal Bone Imaging Using Photon-Counting Detector (PCD) CT and an Additional Tin Filter

Tuesday, Dec. 3 3:00PM - 3:10PM Room: N226

Awards
Trainee Research Prize - Fellow

Participants
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PURPOSE

To reduce radiation dose while maintain high resolution in sinus and temporal bone (T-bone) CT scans using photon-counting detector (PCD) CT with an additional tin (Sn) filter.

METHOD AND MATERIALS

A head phantom was scanned on a clinical energy-integrating detector (EID) CT and a PCD-CT system. EID-CT scans were acquired using routine clinical protocols with120kV, 13.5 mGy for sinus, and 120kV, 49 mGy for T-bone exams which also employed a comb filter for ultra-high resolution (UHR) imaging. PCD-CT data were acquired using UHR mode (32x0.25 mm collimation), Sn-100kV, 10 mGy for both sinus and T-bone acquisitions. Patients referred for clinically indicated sinus and T-bone exams were scanned with PCD-CT following their clinical scans. Sinus scans were performed using 120kV, 95mAs, 13.6mGy for EID-CT, and Sn-100kV, 350 mAs, 7 mGy for PCD-CT. T-bone images were acquired using 120kV, 300mAs, 65mGy on EID-CT (comb filter-based UHR), and Sn-100kV, 500 mAs, 10 mGy on PCD-CT using UHR mode. Sinus images were reconstructed using H70 kernel, 0.75mm slice thickness, and T-bone images were reconstructed using a U70 kernel, 0.6mm slice thickness. Image contrast and noise were measured in uniform regions. Dose reduction was evaluated using the percentage change in image noise between EID-CT and PCD-CT for a given reconstruction kernel.

RESULTS

Sinus phantom results showed lower noise on PCD-CT (110 HU, 10mGy) compared to EID-CT (150 HU, 13.5mGy), yielding a total dose reduction of 72% if matched image noise is targeted. Phantom results using T-bone protocol showed lower image noise for PCD-CT (129 HU, 10 mGy) at 79% lower dose compared to EID-CT (148 HU, 49mGy). Sinus patient images showed lower noise on PCD-CT (129 HU, 7mGy) than EID-CT (152 HU, 13.6mGy) at 49% lower acquisition dose for PCD-CT without compromising spatial resolution. At matched image noise and kernel, this corresponds to a total dose reduction of 76%. Patient T-bone images showed comparable image noise between EID-CT (65mGy) and PCD-CT (10mGy) at six-fold reduced dose for PCD-CT.

CONCLUSION

We have demonstrated 72 to 84% dose reduction for sinus and T-bone imaging using PCD-CT with an additional Sn filter in comparison to the current clinical protocols.

CLINICAL RELEVANCE/APPLICATION

Using ultra-high resolution PCD-CT with additional tin filter, the image quality can be preserved while the patient radiation dose can be reduced to about one-fifth of the current clinical dose.

SSJ22-02 Comparison of Low Dose Image Quality in Conventional and Photon-Counting CT

Tuesday, Dec. 3 3:10PM - 3:20PM Room: N226

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PURPOSE

To compare the task-based performance of conventional (EID) CT and photon-counting CT (PCCT) in low dose imaging conditions.

METHOD AND MATERIALS

The largest section of a multi-tier phantom (Mercury Phantom, Gammex) was imaged using a prototype photon-counting CT scanner (Siemens, Germany) containing conventional and photon-counting subsystems. The largest section (36 cm diameter) was used to simulate the most difficult clinical imaging scenario. The phantom contains two sections: a uniform section for noise measurement and a section with five cylindrical inserts (8.5 mg/mL I, air, water, polystyrene (fat), bone) for resolution and detectability measurements. Images were acquired at matched low doses (1.7, 2, 2.5, 3, 4, 6 mGy CTDIvol) and reconstructed with a clinical protocol (medium-soft kernel (I40), 3 mm slices). An automated program was used to evaluate noise in the noise region and contrast, contrast-to-noise ratio (CNR), and detectability index (d') of bone and iodine inserts.

RESULTS

Noise was slightly higher in EID images (29.9-53.7 HU) than PCCT images (28.7-51.7 HU). Photon-counting images showed improved contrast in both bone (9.5%) and iodine inserts (12.9%) leading to improvements in CNR of 10.8% for bone and 14.0% for iodine. CNR improvement was found to be significant ($p < .01$) for both inserts. Detectability index improved for both bone (3.1%) and iodine (10.1%) with p-values of .05 and .01 respectively.

CONCLUSION

Photon-counting CT images had slightly lower noise and improved contrast compared to conventional CT at low doses. This further translated into improved contrast-to-noise ratio and detectability index for both iodine and bone.

CLINICAL RELEVANCE/APPLICATION

Photon-counting CT offers improved performance over conventional CT for low dose imaging tasks in terms of noise, contrast-to-noise ratio, and detectability index.

SSJ22-03 K-edge Photon Counting CT-Based Virtual Nonenhanced CT Imaging

Tuesday, Dec. 3 3:20PM - 3:30PM Room: N226

Participants
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PURPOSE

Virtual noncontrast (VNC) images derived from contrast enhanced dual energy CT (DECT) data can obviate the need for a separate noncontrast CT scan. An important premise of DECT-based VNC imaging is that the attenuation coefficient of an arbitrary material can be represented by a linear combination of two energy-dependent basis functions. However, this assumption is violated by the presence of iodine (I) K-edge. As a result, erroneous subtractions occur to calcium in the VNC images. The purpose of this work was to investigate the use of photon counting CT (PCCT) to accomplish K-edge PCCT imaging to improve the quantitative accuracy of VNC reconstruction.

METHOD AND MATERIALS

An experimental PCCT system was used to scan objects with known material types and concentrations: 50 and 25 mg/mL $CaCl_2$, 20 and 10 mg/mL iodine, and a mixture of $CaCl_2$ (25 mg/mL) and iodine (10 mg/mL). The energy bin width and position (bin 1: [15, 34] keV; bin 2: [34, 55] keV; bin 3: [55, 80] keV) were optimized to provide the highest overall accuracy for iodine and $CaCl_2$ concentration estimation. Similarly, the beam filtration (160 mg/cm2 of iodine) was optimized to achieve K-edge imaging. Three-material decomposition was performed using the multi-bin PCCT data. The CT number enhancement due to iodine was found from the iodine basis image, and was then subtracted from the full energy bin attenuation image to generate the final VNC image. These were then compared with VNC images from a commercial DECT system with projection domain material decomposition.

RESULTS

For the two objects that do not contain iodine (50 and 25 mg/mL CaCl2), their CT numbers were incorrectly reduced by 130±5 and 67±5 HU in DECT-based VNC images. The CT number errors for 20 and 10 mg/mL iodine, and the CaCl2-iodine mixture were -5±7, -3±5, and -74±7 HU, respectively, in DECT VNC images. In comparison, CT number errors of K-edge PCCT VNC images were -2±2 HU (50 mg/mL CaCl2), 3±13 HU (25 mg/mL CaCl2), -4±12 HU (20 mg/mL iodine), -4±4 HU (10 mg/mL iodine), and -3±8 HU (iodine-CaCl2 mixture).

CONCLUSION

K-edge PCCT-based VNC imaging effectively removes iodine signal while preserving the CT number accuracy of non-iodine structures such as bone and calcifications.

CLINICAL RELEVANCE/APPLICATION

VNC images derived from contrast enhanced PCCT can obviate the need for a separate noncontrast CT scan, reducing dose and scan time and providing important baseline tissue attenuation information.

SSJ22-04 Material Decomposition of Clinical Full-Field Photon Counting CT Data Using a 'One-Step' Direct Estimation Approach

Tuesday, Dec. 3 3:30PM - 3:40PM Room: N226

Participants
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PURPOSE

To demonstrate feasibility of material decomposition of clinical photon-counting head CT data using the constrained 'one-step' Spectral CT Image Reconstruction (cOSSCIR) method. The cOSSCIR method directly estimates the basis material images from the photon counts data, which allows constraints to be placed on the basis images to improve the decomposition.

METHOD AND MATERIALS

Head CT data of a human subject was acquired on a clinical full-field photon-counting CT prototype with silicon detectors (Prismatic Sensors, Sweden). Calibration data of a polyvinyl chloride (PVC) and polyethylene step wedge phantom was also acquired and used to estimate the effective spectra and a pileup correction for each energy bin. The cOSSCIR algorithm directly estimated the PVC and polyethylene basis material images from the photon-counts data using an optimization-based algorithm. The basis image were combined to form virtual monoenergetic images.

RESULTS

Basis material images of PVC and polyethylene were successfully reconstructed by the cOSSCIR algorithm, representing the composition of bone and soft tissue, respectively. Additional investigations are underway to evaluate the performance of cOSSCIR in correcting metal artifacts due to dental hardware and to compare the results to other material decomposition approaches

CONCLUSION

The results demonstrate feasibility of proposed cOSSCIR algorithm to reconstruct basis material images from clinical photon-counting head CT data.

CLINICAL RELEVANCE/APPLICATION

The cOSSCIR method previously demonstrated the ability to reduce metal artifacts in experimental photon counting images of phantoms. This study demonstrates the feasibility of using cOSSCIR for clinical head CT images, which can be degraded by dental metal artifacts.

SSJ22-05 Scan Protocol Design and k-Edge Imaging in a Clinical Whole-Body Photon-Counting CT

Tuesday, Dec. 3 3:40PM - 3:50PM Room: N226

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PURPOSE

To investigate the influence of threshold settings on the contrast-to-noise ratio (CNR) in a whole-body photon-counting (PC) CT system using potential novel high-Z contrast agents and to propose accordant scan protocols for clinical practice.

METHOD AND MATERIALS

Semi anthropomorphic phantoms of different sizes (XS=10×10 cm, S=20×30 cm, M=25×35 cm, L=30×40 cm) are measured at tube voltages between 80 kV to 140 kV using a prototype photon-counting CT system (SOMATOM CounT, Siemens, Germany). The phantoms are equipped with vials containing potential high-Z contrast agents (elements I, Gd, Yb, W, Bi). The PC detector intrinsically acquires data using two energy bins with the first bin covering an energy range of [20 keV, T] and the second bin covering [T, eU] with U being the tube voltage. The threshold T is varied in steps of 5 keV between the available 50 keV to 90 keV. The resulting bin images are combined in a statistically optimal manner to maximize the CNR of the contrast agent relative to the soft tissue background. The resulting CNR is evaluated as figure of merit in all bins and the combined images for all tube voltages, phantom sizes and contrast agents.

RESULTS

While CNR varies in individual bins as a function of threshold settings, the CNR in the combined images is nearly constant and independent of the thresholds used for image acquisition. This holds true for each given combination of patient size and tube voltage and is verified for all available contrast media in measurements and accompanying simulations. Furthermore, the effect of the agents' k-edges can be seen in the acquired data. Potentially, the remaining freedom to set T can be used to enable clinical k-edge imaging which is illustrated using Ytterbium.

CONCLUSION

An adaption of threshold settings for patient size or tube voltage is not required in clinical practice as an image with maximum CNR can always be provided by combination of bin images. Hence, the thresholds could be chosen on-demand to enable other applications, e.g. material decomposition with high-Z contrast agents exploiting k-edges of the elements used therein.

CLINICAL RELEVANCE/APPLICATION

Maximum CNR in PC-CT can always be provided independently of the thresholds. Hence, novel scan protocols can be designed enabling applications on-demand, e.g. using high-Z contrast agents.

SSJ22-06 Experimental Feasibility of Photon-Counting Spectral X-Ray Phase-Contrast Computed Tomography

Tuesday, Dec. 3 3:50PM - 4:00PM Room: N226

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PURPOSE

To evaluate the potential of the combination of photon-counting spectral CT and grating-based differential phase-contrast (gbDPC) CT.

METHOD AND MATERIALS

We propose a novel imaging approach, namely spectral differential phase-contrast CT, which merges the modalities of attenuation based and phase-contrast based imaging. Thereby, we introduce a new polychromatic forward-model for spectral phase-contrast imaging with multi-bin photon counting detectors, which uses spectral attenuation and phase-contrast information simultaneously by correlating the electron density determined by each modality. We performed a dual-energy gbDPC CT scan of a phantom containing tissue simulating materials. The data was acquired with a photon-counting detector (FliteX1, Direct Conversion AB, Danderyd, Sweden) equipped with two energy thresholds per pixel, which were placed at 23 and 64 keV. The phase contrast information was extracted by using a Talbot-Lau interferometer in step-and-shot mode. The phantom has been imaged with the following parameters: 140 kVp, 8000mAs, 1200 tomographic angles, 5 phase-steps per angle.

RESULTS

Similar to conventional spectral CT the inversion of the proposed forward-model yields basis-material line-integrals, which are reconstructed afterwards to obtain material specific volume data. Compared to conventional spectral X-ray imaging a considerably lower noise level in the basis-material images can be observed in experimental measurements. We observe a reduction of the variance by a factor of up to 3 for a constant radiation dose at the position of the sample without a significant loss in image resolution. Apart from basis-material images, the proposed method provides X-ray dark-field images, which arise due to small-angle scattering at microscopic structures.

CONCLUSION

Spectral differential phase-contrast CT yields material-specific images with strongly reduced image noise compared to conventional spectral CT. Different from conventional spectral CT an additional X-ray dark-field image is obtained.

CLINICAL RELEVANCE/APPLICATION

The basis-material images obtained in spectral CT suffer from noise amplification when compared to conventional CT images. Spectral differential phase-contrast CT is capable of diminishing this noise amplification, providing material specific images with strongly reduced radiation dose delivered to the patient.

Printed on: 10/29/20

SSJ23

Physics (CAD/Machine Learning, Quantitative Imaging)

Tuesday, Dec. 3 3:00PM - 4:00PM Room: N229

PH **BQ** **AI**

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

Participants

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Sub-Events

SSJ23-01 Automatic Prediction of Coronary Heart Disease Events Using Coronary and Thoracic Aorta Calcium among African Americans in the Jackson Heart Study

Tuesday, Dec. 3 3:00PM - 3:10PM Room: N229

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PURPOSE

Coronary artery calcium (CAC) and thoracic aorta calcium (TAC) are predictors of CHD events. Given that CAC and TAC identification is time-consuming, methods for automatic quantification in CT have been developed. Hence, we investigate whether subjects who will experience a CHD event within 5 years from acquisition of cardiac CT can be identified using automatically extracted calcium scores.

METHOD AND MATERIALS

We included 2532 participants (age 59±11, 31% male) of the Jackson Heart Study without CHD history: 111 participants had a CHD event within 5 years from CT acquisition, defined by death certificates and medical records. For each subject a cardiac CT scan(GE Healthcare Lightspeed 16Pro, 2.5mm slice thickness, 2.5mm increment, 120kVP, 400mAs, ECG-triggered, no contrast) was available. Per-artery Agatston CAC scores (left anterior descending, left circumflex, right coronary artery) and TAC volume were automatically extracted with a previously developed AI algorithm. Scores were log transformed, combined with age and sex and all continuous variables were normalized to zero-mean and unit variance. We evaluated 3 models with 3-fold cross-validation where subjects were classified according to occurrence of CHD event using LASSO regression with 1) age, sex and CAC scores, 2) age, sex and TAC scores, and 3) all variables. Performance was evaluated with the area under the ROC curve (AUC).

RESULTS

In 1468 (58%) subjects no CAC and in 1240 (49%) no TAC was found. In remaining scans, median (range) CAC score was 78.7(1.6-5562.1): 49.5(0.0-4569.4), 0.0(0.0-2735.3), 3.9(0.0-3242.7) in the LDA, LCX and RCA, respectively. Median TAC volume was 116.8(4.7-7275.9). Prediction of CHD events using Model 1, 2 and 3 resulted in an AUC (95% CI) of 0.721(0.672-0.771), 0.735(0.686-0.785) and 0.727(0.678-0.776). Differences between the ROC curves were not significant (Model 1 and 2: p=0.80; 1 and 3: p=0.29; 2 and 3: p=0.76).

CONCLUSION

Identification of subjects at risk of a CHD event can be performed using automatically extracted CAC or TAC scores from cardiac CT.

CLINICAL RELEVANCE/APPLICATION

Prediction of CHD events from cardiac CT using TAC instead of CAC is feasible and may be advantageous in scans acquired without ECG-triggering or low image resolution.

SSJ23-02 Identifying Changes in Regional Autonomy of the Brain Using Resting State-Functional MRI in Patients with HIV-Associated Neurocognitive Disorder

Tuesday, Dec. 3 3:10PM - 3:20PM Room: N229

Participants
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PURPOSE

To evaluate a machine learning framework using Mutual Connectivity Analysis (MCA) for investigating changes in brain regional autonomy in patients with HIV-Associated Neurocognitive Disorder (HAND) using resting-state fMRI (rsfMRI).

METHOD AND MATERIALS

A total of 120 rsfMRI runs (3T, EPI sequence, TR=1.65s, 250 volumes, 3 runs per subject) were acquired in a cohort of 40 age-matched subjects (20 HIV+, 16 of whom had HAND symptoms, 20 HIV- controls). Regional activity was estimated by averaging voxels belonging to regions obtained using the Automated Anatomical Labeling atlas. Using MCA (DSouza et al, NeuroImage 2018), we investigate, if discernable changes exist in self-influence of brain regions, i.e. regional autonomy, once patients show HAND symptoms. MCA reveals non-linear measures of influence, which conventional correlation-based approaches cannot estimate. With these measures as features, a support vector machine classifier was trained to distinguish between healthy controls and subjects with HAND. Additionally, feature selection revealed regional connections that differed between the groups. For both feature selection and classification, strict data separation (90% train/10% test) was carried out in a 100-iteration cross-validation scheme. Area Under the receiver operator characteristics Curve (AUC) and accuracy (ACC) was used to quantitatively evaluate diagnostic quality.

RESULTS

Classification with MCA measures performed significantly better ($p<0.05$, Wilcoxon signed-rank test) with AUC=0.86 ± 0.17 and ACC=0.78 ± 0.16 than conventional correlation analysis with AUC=0.58 ± 0.29 and ACC=0.57 ± 0.18. Feature selection revealed regions of the frontal cortex, temporal pole, and default mode network affected by HAND, which is in line with other literature on HAND.

CONCLUSION

Our results suggest that an analysis capturing regional autonomy is more discriminative than conventional measures for imaging-based identification of patients with HAND, as MCA-derived nonlinear network measures significantly outperform correlation-based analysis in capturing relevant differences between patient groups. In addition, studying relevant features can identify specific brain regions affected by HAND-related activity changes.

CLINICAL RELEVANCE/APPLICATION

MCA is a novel method for investigating brain connectivity changes in HIV-related neurologic disease. Such changes can potentially serve as useful imaging biomarkers for therapy monitoring of HAND.

SSJ23-03 Independent Prospective Evaluation of a Quantitative MRI Biomarker for Early Response Prediction in Treatment of Multiple Myeloma

Tuesday, Dec. 3 3:20PM - 3:30PM Room: N229

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PURPOSE

Predicting early response to treatment of multiple myeloma (MM) is challenging. This study evaluated the generalizability of a MRI biomarker that we developed for this task using a prospective test set from an ongoing two-site study.

METHOD AND MATERIALS

With IRB approval and informed consent, 35 pairs of pre- and post-treatment spinal MR scans with an average interval of 2.4 ± 1.1 months were prospectively collected from 35 MM patients who underwent a variety of therapeutic regimens in two hospitals in US and China. The MRI data were acquired with GE or Philips 1.5 T or 3.0 T scanners. We have previously developed a 3D dynamic intensity entropy transformation (DIET) method to transform MR signal to a voxelwise quantitative entropy enhancement value, from which predictor variables were derived and combined into a DIET response index (qERI) to assess treatment response. The qERI was trained in a retrospective data set with 64 MRI cases from patients who underwent bone marrow transplant, and achieved an area under the receiver operating characteristic (ROC) curve (AUC) of 0.89 in leave-one-case-out testing in our previous study. In this study, we applied our DIET method directly without re-training to the pairs of MRI scans of 35 new patients to predict clinical outcomes.

RESULTS

Of the 35 patients, 22 and 13 were clinically diagnosed as responders and non-responders, respectively, by using International Myeloma Working Group Uniform Response Criteria (URC) in more than 6-month fellow-up. Using a decision threshold previously chosen with the developmental set, the qERI correctly predicted 20 responders (90.9% sensitivity) and 10 non-responders (76.9% specificity) at an AUC of 0.79. Of 20 qERI-responders, URC initially determined 2 as non-responders at 3-month time point and re-assessed them as responders in 6-month follow-up. The agreement between the DIET method and the clinical outcome reached 0.86 (30 of 35) with a kappa value of 0.69.

CONCLUSION

The substantial agreement between qERI prediction and clinical outcomes demonstrated that qERI has the potential for early assessment of the clinical outcome of MM response, which usually requires longer-term follow-up, to a wide variety of treatment regimens.

CLINICAL RELEVANCE/APPLICATION

Quantitative MRI-based biomarker may improve the accuracy and efficacy for early assessment of treatment response for MM, allowing clinicians to optimize therapy of individual patients.

SSJ23-04 Standardization in Quantitative Imaging: A Multi-Center Comparison of Radiomics Feature Values Obtained by Different Software Packages on Digital Reference Objects and Patient Datasets

Tuesday, Dec. 3 3:30PM - 3:40PM Room: N229

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Presenter*) Institutional research agreement, Siemens AG
Sandy Napel, PhD, Stanford, CA (*Abstract Co-Author*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc
Jayashree Kalpathy-Cramer, MS, PhD, Portland, OR (*Abstract Co-Author*) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd;
Akshay Jaggi, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose
Nastaran Emaminejad, MSc, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Mark Muzi, BS, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose
Dmitry Goldgof, PhD, Tampa, FL (*Abstract Co-Author*) Nothing to Disclose
Hao Yang, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Ella F. Jones, PhD, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Muhammad W. Wahi-Anwar, BS, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Yoganand Balagurunathan, PhD, Tampa, FL (*Abstract Co-Author*) Nothing to Disclose
Mahmoud Abdalah, PhD, Tampa, FL (*Abstract Co-Author*) Nothing to Disclose
Binsheng Zhao, DSc, New York, NY (*Abstract Co-Author*) Royalties, Varian Medical Systems, Inc; License agreement, Keosys SAS; License agreement, Hinacom Software and Technology, Ltd;
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Apurva Virkud, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Research collaboration, General Electric Company; Institutional Grant, General Electric Company ;
Larry A. Pierce II, PhD, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose
Keyvan Farahani, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Radiomics features are being increasingly proposed for clinical applications such as predicting patient response to therapy or prognosis. The purpose of this work was to investigate the agreement among these features when computed by several groups utilizing different software packages with standardized feature definitions and common image datasets designed to identify possible differences.

METHOD AND MATERIALS

Nine sites from the NCI's Quantitative Imaging Network PET-CT working group participated in this project. Nine common quantitative imaging features were selected for comparison including features that describe morphology, intensity, shape and texture. A standard lexicon developed by the International Biomarker Standardisation Initiative (IBSI) was adopted as the feature definition reference. The common image data sets were: (a) two sets of 3D Digital Reference Objects (DROs) developed specifically for this effort (200mm and 50 mm diameter objects): a uniform sphere, a sphere with intensity variations, and a complex shape object with uniform intensity; and (b) 10 patient image scans from the LIDC dataset using a specific lesion in each scan. To eliminate variation in feature values caused by segmentation differences, each object (DRO or lesion) was accompanied by a Volume of Interest (VOI), from which the features were calculated. Feature values for each object (DRO or lesion) were reported. The percent coefficient of variation (CV) was calculated across software packages for each feature on each object.

RESULTS

10 sets of results were obtained for the DROs. Six of the nine features demonstrated excellent agreement with CV < 1%. Larger variations (CV>= 13%) were observed for the remaining three features. Only 2 sets of results from patient datasets were obtained so far, but similar trends were observed with the exception being kurtosis, which showed higher CV than in the DROs.

CONCLUSION

By computing common radiomics features on a common set of objects using the same VOIs for each object, we have shown that while several features agree strongly across software packages, others do not. This highlights the value of feature definition standardization as well as the need to further clarify definitions for some features.

CLINICAL RELEVANCE/APPLICATION

Remaining disagreement in the community as to radiomic feature definitions and implementation details should be resolved before radiomic analysis becomes part of routine practice.

SSJ23-05 Participants

Liver and Lung Texture Feature Redundancy in Conventional and Photon-Counting CT

Tuesday, Dec. 3 3:40PM - 3:50PM Room: N229

Faraz Farhadi, Bethesda, VA (*Presenter*) Nothing to Disclose
Jayasai R. Rajagopal, BA, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Pooyan Sahbaee, Mount Pleasant, SC (*Abstract Co-Author*) Employee, Siemens AG
Babak Saboury, MD, MPH, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company Research Grant, Siemens AG Advisory Board, medInt Holdings, LLC License agreement, 12 Sigma Technologies License agreement, Gammex, Inc
Elizabeth C. Jones, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

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PURPOSE

To evaluate relative contribution of different acquisition and reconstruction protocols for the extraction of radiomics features of lung and liver, in photon-counting (PCCT) and energy integrated detector (EID) CT.

METHOD AND MATERIALS

A texture phantom containing lung and liver texture modules was imaged with a prototype photon-counting CT scanner (Siemens, Germany) using conventional and photon-counting subsystems. The phantom was scanned at 80 and 140 kV, matching clinical standards for lung and abdominal imaging respectively, and 5 different mAs values (14, 50, 100, 200, 274). Images were reconstructed with several different kernels appropriate for each clinical task, with uniform slice thickness and pixel size. Three 4.1 x 4.1 x 8 mm3 regions of interest (ROIs) were extracted from each image and analyzed for twenty texture features. Feature redundancy was defined as features presenting an intra-class correlation coefficient of >0.9.

RESULTS

For liver texture, all features extracted from EID data showed some redundancy while three features (Variance, Gray Level Non-Uniformity, Short Run High Gray Level Emphasis) extracted from PCCT data did not correlate with any other features. Fifteen of twenty features showed less (average: 33%) redundancy in PCCT data when compared to EID data, and 3 were more redundant (average 19%). For lung texture, all features extracted from both PCD and EID images showed some level of redundancy. Eleven features showed less (average 16%) redundancy while 8 had increased (average 20%) correlation with other features.

CONCLUSION

Radiomic features extracted from photon counting data showed less redundancy between individual texture features extracted from liver but not for lung.

CLINICAL RELEVANCE/APPLICATION

Sensitivity of radiomics features to CT acquisition and reconstruction parameters can introduce nonbiological differences to these values. Improvements in CT acquisition techniques could resemble more accurate representation of biologically important features.

SSJ23-06 Predictive Ability of Radiomic Features Calculated Using 2D versus 3D Region-of-Interest: A Multi-Energy CT Study of Lymphadenopathy in Head and Neck Cancer Patients

Tuesday, Dec. 3 3:50PM - 4:00PM Room: N229

Participants
Avishek Chatterjee, Montreal, QC (*Presenter*) Nothing to Disclose
Martin Vallieres, PHD, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Caroline Reinhold, MD, MSc, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Reza Forghani, MD,PhD, Cote Saint-Luc, QC (*Abstract Co-Author*) Researcher, General Electric Company; Institutional research collaboration, General Electric Company; Consultant, General Electric Company; Speaker, General Electric Company ; Founder, 4intelligent Inc; Stockholder, 4intelligent Inc; Stockholder, Real-Time Medical, Inc
Jan Seuntjens, PHD, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Examine the hypothesis that radiomic features calculated using entire tumor volume as region-of-interest (ROI) are more predictive than features based on the central tumor slice.

METHOD AND MATERIALS

This study concerns the use of primary tumor radiomic features for predicting cervical nodal metastases. Dual energy CT data from 87 patients with head-and-neck squamous-cell-carcinoma were reconstructed at 21 energies (40, 45... 140 keV). Each of the 94 matrix-derived texture features was calculated 64 ways (4 voxel sizes, 4 binning algorithms, 4 gray level discretizations), in 2D and 3D. A promising feature was defined as having absolute Spearman correlation > 0.3 with the outcome. The number of such features was plotted vs energy, for 2D and 3D. The correlation between the same feature in 2D and 3D was calculated, and the median correlation value for a feature set was plotted vs energy. Feature sets used were (a) all features, and (b) promising features in 2D/3D. Net improvement fraction (NIF) was defined as number of features more predictive in 2D minus number of features more predictive in 3D divided by total features. This was plotted vs energy. To evaluate the relation of performance to tumor size, the entire analysis was performed on 3 cohorts: (A) all 87 patients, (B) patients with fewer than median number of tumor slices, (C) patients with more than median number of tumor slices.

RESULTS

For cohorts (A) and (C), the number of promising features were greater in 2D than in 3D; the opposite was seen for (B). Correlation between 2D and 3D features was best for (A) and worst for (C). NIF was positive for (A) and (C), i.e., 2D better than 3D, but negative for (B). While some curves show energy dependence, the stated results are true for all energies.

CONCLUSION

For our dataset, 3D features only outperform 2D features for small tumors (fewer than median number of slices). For large tumors or all tumors considered together, 2D outperforms 3D. A possible explanation is that the heterogenous parts of the tumor are key for radiomic discrimination, reflecting the "tumor habitat", and for larger tumors, these are less well represented in the whole volume.

CLINICAL RELEVANCE/APPLICATION

Counter-intuitively, whole tumor volume radiomic analysis may not be the ideal approach. Central-slice-only analysis or sub-segmentation may be required for optimal radiomic biomarker development.

Printed on: 10/29/20

RC421

Innovations in Dual- and Multi-energy CT

Tuesday, Dec. 3 4:30PM - 6:00PM Room: S102CD

CT PH

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

Participants
Lifeng Yu, PhD, Rochester, MN (*Coordinator*) Nothing to Disclose

For information about this presentation, contact:

yu.lifeng@mayo.edu

LEARNING OBJECTIVES

1) Review dual-energy CT systems that are commercially available and multi-energy CT systems that are currently under development. 2) Review basic data processing and material decomposition techniques for dual-energy and multi-energy CT data. 3) Review current and potential clinical applications of dual-energy and multi-energy CT.

ABSTRACT

This session will provide an overview of CT systems, data processing, and clinical applications of dual-energy and multi-energy CT.

Sub-Events

RC421A Dual- and Multi-energy CT Systems

Participants
Taly Gilat Schmidt, PhD, Milwaukee, WI (*Presenter*) Research Grant, General Electric Company; Research Consultant, General Electric Company

LEARNING OBJECTIVES

1) Describe and compare the different approaches for acquiring multi-energy CT data. 2) Identify the important features of multi-energy CT systems and how they impact the acquired multi-energy data.

RC421B Dual- and Multi-energy Data Processing

Participants
Katsuyuki Taguchi, PhD, Baltimore, MD (*Presenter*) Research Grant, Siemens AG; Consultant, JOB Corporation

RC421C Clinical Applications of Dual- and Multi-energy CT

Participants
Joel G. Fletcher, MD, Rochester, MN (*Presenter*) Grant, Siemens AG; Consultant, Medtronic plc; Consultant, Takeda Pharmaceutical Company Limited; Grant, Takeda Pharmaceutical Company Limited; ;

For information about this presentation, contact:

fletcher.joel@mayo.edu

LEARNING OBJECTIVES

1) Review different types of standard dual energy images (e.g., linearly blended mixed kV, virtual monoenergetic images, virtual non-contrast, virtual non-calcium, iodine maps) and understand how they can be reconstructed and utilized in an efficient, protocol-driven, heterogeneous radiology practice. 2) Understand multiple clinical scenarios where clinical benefit is obtained by using the ability of dual energy to enhance iodine signal or quantify iodine content. 3) Illustrate how to use dual energy information quickly in exam interpretation.

RC422

Anatomical MR Imaging for Radiotherapy Planning and Guidance

Tuesday, Dec. 3 4:30PM - 6:00PM Room: S501ABC

MR PH RO

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

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

Sub-Events

RC422A State of the Art in Anatomical MR Imaging

Participants
Aradhana M. Venkatesan, MD, Houston, TX (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

avenkatesan@mdanderson.org

LEARNING OBJECTIVES

1) Review opportunities and unmet needs for state of the art imaging techniques to inform radiotherapy strategies. 2) Summarize the current state of the art role for contemporary MRI in radiotherapy, with an emphasis on gynecologic and prostate cancer therapy. 3) Describe emerging solutions enabled by MR imaging guidance and their potential gains for patients.

RC422B Clinical Need for Anatomical MR Imaging in Radiation Therapy

Participants
Cynthia Menard, MD, Montreal, QC (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

Cynthia.Menard@umontreal.ca

LEARNING OBJECTIVES

1) Understand the various roles of MRI in radiotherapy practice. 2) Identify pitfalls in integrating MRI in radiotherapy planning. 3) Describe anatomical sites where the integration of MRI is established as standard-care.

RC422C Technical Challenges in the Integration of Anatomical MR Imaging into Radiotherapy

Participants
Carri Glide-Hurst, PHD, Detroit, MI (*Presenter*) Researcher, ViewRay, Inc; Research Consultant, Koninklijke Philips NV; Researcher, Koninklijke Philips NV; Researcher, Modus Medical Devices Inc; Equipment support, Medspira, LLC; Equipment support, QFix

LEARNING OBJECTIVES

1) To understand the unique imaging challenges and benefits for incorporating MRI into radiation therapy treatment planning. 2) To describe the magnetic resonance simulation (MR-SIM) process to yield images that are more robust for radiation therapy planning. 3) To describe emerging technologies in MR-only treatment planning and MR-guided radiation therapy and opportunities for collaboration between imaging and radiation therapy colleagues.

Printed on: 10/29/20

RC423

Evolving Perspectives on Ultrasound Safety

Tuesday, Dec. 3 4:30PM - 6:00PM Room: E353A

PH SQ US

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

FDA Discussions may include off-label uses.

Participants

J. Brian Fowlkes, PhD, Ann Arbor, MI (*Coordinator*) Equipment support, Koninklijke Philips NV; Equipment support, General Electric Company; Equipment support, Canon Medical Systems Corporation; Research collaboration, Sonetics Inc; Stockholder, HistoSonics, Inc; Founder, HistoSonics, Inc

For information about this presentation, contact:

fowlkes@umich.edu

LEARNING OBJECTIVES

1) Understand the physical principles related to ultrasound safety and the potential for biological effects of ultrasound. 2) Utilize ultrasound in a safe and effective manner in clinical practice. 3) Increase their knowledge and understanding of the regulatory environment associated with medical ultrasound.

Sub-Events

RC423A Ultrasound Safety: Understanding the Potential Bioeffects

Participants

J. Brian Fowlkes, PhD, Ann Arbor, MI (*Presenter*) Equipment support, Koninklijke Philips NV; Equipment support, General Electric Company; Equipment support, Canon Medical Systems Corporation; Research collaboration, Sonetics Inc; Stockholder, HistoSonics, Inc; Founder, HistoSonics, Inc

For information about this presentation, contact:

fowlkes@umich.edu

LEARNING OBJECTIVES

1) Understand the physics associated with the potential bioeffects of ultrasound. 2) Increase basic knowledge of the controls and operator feedback related to ultrasound safety. 3) Be sufficiently proficient to utilized on-screen displays related to ultrasound safety. 4) Identify additional resources for understanding the physical effects of ultrasound.

Active Handout:J. Brian Fowlkes

http://abstract.rsna.org/uploads/2019/17000402/Active RC423A.pdf

RC423B Ultrasound Safety: What the Clinician Should Know

Participants

Jacques S. Abramowicz, MD, Chicago, IL (*Presenter*) Author with royalties, Wolters Kluwer nv; Medical Advisory Board, Samsung Electronics Co, Ltd

For information about this presentation, contact:

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ABSTRACT

Ultrasound is, arguably, one of the most common diagnostic procedures in clinical obstetrics. Its use for over more than 60 years has not been associated with fetal scientifically-proven harmful effects. Ultrasound, however, is a form of energy with potential rise of temperature and mechanical effects in insonated tissues. Knowledge of end-users on bioeffects of ultrasound and how to keep it safe is grossly lacking, but slowly improving, thanks to the efforts of various professional organizations. When a clear medical indication exists and the scan is performed by a professional knowledgeable in ultrasound bioeffects and safety and with respect to the As Low As Reasonably Achievable (ALARA) principle, risks to the fetus are minimal, if at all present. Education of clinical end-users continue to be of major importance, particularly given the ever-increasing use of new ultrasound technologies, such as Doppler and three/four-dimensional ultrasound.

RC423C Ultrasound Safety: What You Should Know About Therapeutic Ultrasound

Participants

Kenneth Bader, Chicago, IL (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

baderk@uchicago.edu

LEARNING OBJECTIVES

1) An overview of the physical principles by which ultrasound can be utilized for therapeutic benefit will be reviewed. 2) Image guidance methods and metrics for evaluating treatment efficacy will be outlined. 3) An overview of potential off-target effects will be discussed in the context of As Low As Reasonably Achievable (ALARA) principle.

ABSTRACT

Ultrasound is known most ubiquitously as a diagnostic imaging modality. High-intensity insonation conditions can be utilized for therapeutic benefit, generally categorized as ablation or enhanced permeability.

Printed on: 10/29/20

RC425

Quantitative Imaging: Statistical Analysis/Metrology Issues

Tuesday, Dec. 3 4:30PM - 6:00PM Room: S502AB

BQ PH

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

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Coordinator*) Institutional research agreement, Siemens AG

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LEARNING OBJECTIVES

1) Understand issues related to quantitative imaging (QI) with regard to initiating a research question, developing an appropriate study design, and employing the specific statistical methods required to evaluate the QI method. 2) Understand methods to assess technical performance such as assessing repeatability and reproducibility through test-retest studies as well as bias and linearity through phantom studies. 3) Understand objectives of algorithm comparison studies and study design principles including methods for testing hypotheses, estimating performance, and producing descriptive summaries for algorithm comparison.

Sub-Events

RC425A The Role of Metrology in Quantitative Imaging

Participants
Hyung J. Kim, PhD, Los Angeles, CA (*Presenter*) Research Consultant, MedQIA Imaging Core Laboratory

For information about this presentation, contact:

gracekim@mednet.ucla.edu

LEARNING OBJECTIVES

1) Understand the role of quantitative imaging (QI) and the measurement. 2) Apply a study design for developing, evaluation, and validating a measurement of QI in a targeted population. 3) Contribute a unified terminology for aggregating information toward bias and variation of QI markers.

ABSTRACT

Challenges and benchmarks have been used successfully in a number of scientific domains to make significant advances in the field by providing a common platform for collaboration and competition. By providing a common dataset and a common set of metric of evaluation, QI driven biomarkers and measurements from radiomics can facilitate rigorous evaluation of algorithms and eventually can be used clinically. Metrology is the science of measurement, including all theoretical and practical aspect of measurement at any level of uncertainty. Statistical design and evaluation in metrology is for describing the uncertainty of measurement and deriving a clinically meaningful metric in quantitative imaging. Many applications of using QI biomarkers or radiomics have been reported in numerous scientific publications. Challenges are to obtain a universally consistent terminology or methods in reporting a variation of QI marker or radiomics under the various conditions of scanners, readers, and software. Understanding variation of 'measureland' (the quantity intended to be measured (VIM clause 2.3) in radiological imaging is critical to set a clinically meaningful benchmark of a QI or radiomics. To estimate a variation of measureland or smallest detectable changes (SDC) using a standard metric of variation, the study design is a critical basis for the each stage of development, evaluation, and validation of a QI biomarker or measurement from radiomics. Reporting an estimated measureland is an initial step for combining the knowledge across studies and centers as part of evaluation and validation by an independent party. We will discuss the procedure: initialing research question, study design, and corresponding statistical methods toward development, evaluation, and validation of a measurement of QI marker in a targeted population. Furthermore, we will discuss meta-analysis when we use the common terminology of QI biomarkers and measurements from radiomics.

RC425B Methods for Technical Performance Assessment: What to Assess and How

Participants
Nicholas Petrick, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

Nicholas.petrick@fda.hhs.gov

LEARNING OBJECTIVES

1) Understand how to assess bias and linearity through phantom studies (or studies with an established reference standard). 2) Understand how to assess repeatability and reproducibility through test-retest studies. 3) Understand how technical performance impacts the utility of a quantitative imaging biomarker or radiomic signature.

ABSTRACT

Developments in extracting biological information from medical images have given rise to a wide range of quantitative imaging (QI)

functions and the field of radiomics. Critical to these research areas are the establishment of accurate and reproducible QI functions and the establishment of appropriate and widely accepted assessment methods. In this section of the refresher course, we will update the audience on the latest recommendations for assessing QI technical performance. I will also present examples of applying the concepts discussed in this course to specific clinically-relevant QI functions.

RC425C Statistical Evaluation of Quantitative Imaging Algorithms

Participants
Gene Pennello, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand principles, objectives, common study designs, and common agreement metrics in the statistical evaluation of quantitative imaging algorithms. 2) Perform descriptive analysis, hypothesis testing, and estimation of algorithm performance. 3) Apply statistical methods appropriate to particular data structures and interpret the results.

ABSTRACT

A quantitative imaging biomarker can be defined as a physical quantity for which a measurement can be extracted from medical image(s), e.g., pulmonary nodule volume from CT scan and fracture callus size (mm2) from plain radiograph. Algorithms for deriving these measurements may be evaluated for accuracy (agreement with true value of the measurand), imprecision (variability of repeated measurements) and clinical performance (association with current or future health state). Algorithms may also be compared for agreement with each other in a method comparison study. In this talk, I'll survey performance evaluations of quantitative imaging algorithms, including graphical representations, unscaled performance metrics that are in the units of measurement, and scaled performance metrics that standardize the evaluation to a unitless scale. I'll review recent advances in measurement assessment as well as traditional metrics. I'll also review study designs including those with repeated measurements, and statistical analysis of a performance metric that account for random sampling variability, algorithm measurement error, and missing data.

Active Handout:Gene Pennello

http://abstract.rsna.org/uploads/2019/19001553/Active RC425C.pdf

ED013-WE

Physics Wednesday Case of the Day

Wednesday, Dec. 4 7:00AM - 11:59PM Room: Case of Day, Learning Center

AMA PRA Category 1 Credit ™: .50

Participants

Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
Christina Brunnquell, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Courtney K. Morrison, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Nicholas B. Bevins, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Matt Vanderhoek, PhD, Detroit, MI (*Abstract Co-Author*) Nothing to Disclose
Karen L. Brown, MPH, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Sparsh Gola, MD, Hershey, PA (*Abstract Co-Author*) Nothing to Disclose
Robert Bujila, Stockholm, Sweden (*Abstract Co-Author*) Intern, General Electric Company
Christin Ekestubbe, Solna, Sweden (*Abstract Co-Author*) Nothing to Disclose
Nathan M. Cross, MD, MS, Seattle, WA (*Abstract Co-Author*) Consultant, Koninklijke Philips NV
Da Zhang, PhD, Boston, MA (*Abstract Co-Author*) Investigator, Canon Medical Systems Corporation; Consultant, Clementia Pharmaceuticals Inc
Matthew R. Palmer, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
John A. Parker, MD, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Frederic H. Fahey, DSc, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

The physics case of the day questions and supplemental material will challenge the learner to combine their basic physics understanding with real clinical scenarios to explain a feature on an image.

Printed on: 10/29/20

RC521

Practical Aspects of MR

Wednesday, Dec. 4 8:30AM - 10:00AM Room: E351

MR PH

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

FDA Discussions may include off-label uses.

Participants
Matthew A. Bernstein, PhD, Rochester, MN (*Coordinator*) Former Employee, General Electric Company; Intellectual property, General Electric Company

LEARNING OBJECTIVES

1) Understand basic aspects of MR Safety in the clinical environment, including how to avoid projectile incidents and manage patients with implanted devices. Understand the differences between MR Safe, MR Conditional, and MR Unsafe. 2) Understand the origin of MR artifacts that commonly occur in clinical practice. Acquire techniques to reduce or eliminate these artifacts. 3) Understand the basics of MR Siting and Acceptance testing. Review environmental factors such as vibration and moving metal. Review tests that can be performed after the MRI system is installed to verify its proper operation.

Sub-Events

RC521A MR Safety

Participants
Robert E. Watson JR, MD, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

Watson.robert16@mayo.edu

LEARNING OBJECTIVES

1) Provide a general framework about essential elements of MR safety, to include a) risks associated with the main magnetic field, radiofrequency field, and time varying gradient fields; b) MRI zones I, II, III, IV; c) MRI safe, MRI conditional, and MRI unsafe device labeling; d) Quenches; e) Patient screening and ferromagnetic detection; and f) management of patients with implanted devices.

RC521B MR Artifacts and How to Solve Them

Participants
Xiaohong J. Zhou, PhD, Chicago, IL (*Presenter*) Owner, Medical Physics Services; Consultant, Horizon Medical Physics Services; Consultant, General Electric Company; Consultant, Rush University; Advisor, Chinese Academy of Sciences; Consultant, Chinese Academy of Sciences; Reviewer, American College of Radiology; Royalties, Reed Elsevier

For information about this presentation, contact:

xjzhou@uic.edu

LEARNING OBJECTIVES

1) Recognize common artifacts in MR images. 2) Understand the root cause of the artifacts. 3) Describe the strategies to reduce or remove the artifacts.

RC521C MR Site Planning and Acceptance Testing

Participants
Lisa C. Lemen, PhD, Cincinnati, OH (*Presenter*) Consultant, General Electric Company; Consultant, Johnson & Johnson

LEARNING OBJECTIVES

1) Describe environmental factors which may impact the site selection or planning, including potential sources of vibration and moving metal. 2) Review a preliminary site layout for potential problems, including necessary support areas and access routes. 3) List environmental and system tests that can be performed after the MRI system is installed to verify its proper operation.

RC522

Machine Learning for Radiotherapy Applications

Wednesday, Dec. 4 8:30AM - 10:00AM Room: E352

AI PH RO

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

Participants
Jayashree Kalpathy-Cramer, MS, PhD, Portland, OR (*Moderator*) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd;

Sub-Events

RC522A Deep Learning for Image Segmentation, Analysis and Reconstruction

Participants
Jonas Teuwen, MSc,PhD, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

jonas.teuwen@radboudumc.nl

LEARNING OBJECTIVES

1) Learn about the types of clinical problems which are best suited for deep learning solutions. 2) Learn about the current state-of-the-art deep learning technology in the analysis and segmentation of medical images, and learn about the advantages of reconstructing images using deep learning technology. 3) Being able to critically estimate the impact and assess the applicability of newly developed deep learning technology.

ABSTRACT

Deep learning has recently attracted much interest from the medical community, mainly due the successful application to problems which were previously considered to be purely within the human realm. The availability of an ever growing amount of medical images, and the increasing availability of affordable computation resources allows to apply deep learning technologies to many different problems. However, the scope of problems for which deep learning currently performs on par or outperforms humans is rather narrow. The required human and financial effort makes it important to be able to determine clinical problems where deep learning could bring an advantage. After this refresher course, you will be aware of the state-of-the-art in deep learning for image segmentation, analysis and reconstruction. You will be able to critically assess the impact and applicability of deep learning technology in radiation oncology and be able to find future clinical opportunities.

RC522B Machine Learning Tumor Classification

Participants
Jayashree Kalpathy-Cramer, MS, PhD, Portland, OR (*Presenter*) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd;

LEARNING OBJECTIVES

1) Learn about applications of machine learning including radiomics and deep learning in classifying tumor sub-types. 2) Learn about risk stratification using machine learning of MR and CT images. 3) Understand the challenges when applying machine learning to tumor analysis. 4) Review best practices for applying machine learning in cancer imaging.

ABSTRACT

Machine learning has shown great potential for a range of applications in oncology from diagnosis to therapy planning and response assessment. Large repositories of clinical and imaging data typicially available at most institutions can be be used to train and validate models. We will discuss the use of machine learning including radiomics and deep learning for the analysis of CT and MR imaging in a variety of cancer types for risk stratification, radiogenomics and response assessment..

RC522C Machine Learning for Automated Treatment Planning

Participants
Carlos E. Cardenas, PhD, Houston, TX (*Presenter*) Research Grant, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Learning about treatment planning problems which are suited to machine learning solutions. 2) Learn how deep learning approaches are being used to automated treatment planning. 3) Be able to discuss how machine learning tools can be safely introduced into clinical practice.

RC523

ACR Accreditation Updates II

Wednesday, Dec. 4 8:30AM - 10:00AM Room: S502AB

PH

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

Participants
Heidi A. Edmonson, PhD, Rochester, MN (*Moderator*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn new and updated information for the ACR breast x-ray imaging accreditation program. 2) Become familiar with the requirements for the ACR ultrasound accreditation program, including data acquisition methods and common deficiencies. 3) Understand how to prepare for an ACR site visit.

Sub-Events

RC523A ACR Breast X-Ray Imaging Accreditation Update

Participants
Eric A. Berns, PhD, Lone Tree, CO (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the ACR Mammography accreditation program requirements. 2) Understand the 2D and DBT recent changes. 3) Review frequently asked questions on the program. 4) Present resources for personnel and facilities undergoing accreditation.

RC523B ACR US Accreditation Update

Participants
Zheng Feng Lu, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand ACR ultrasound accreditation requirements. 2) Describe the methods and tools for ultrasound QA/QC with an explanation of common deficiencies. 3) List key resources for ACR ultrasound accreditation.

Active Handout:Zheng Feng Lu

http://abstract.rsna.org/uploads/2019/18001931/Active RC523B.pdf

RC523C ACR Accreditation: Preparing for a Site Visit

Participants
Heidi A. Edmonson, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

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LEARNING OBJECTIVES

1) Identify key elements of an ACR Accreditation Program. 2) Understand what data to prepare for an ACR Site Visit. 3) Improve departmental organization for continual accreditation readiness.

Active Handout:Heidi A. Edmonson

http://abstract.rsna.org/uploads/2019/18001932/Active RC523C.pdf

Printed on: 10/29/20

RC525

Radiomics: Promise and Challenges

Wednesday, Dec. 4 8:30AM - 10:00AM Room: S102CD

BQ PH

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

Participants
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

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LEARNING OBJECTIVES

1) Appreciate the motivation and scientific premise of quantitative image analysis (radiomics). 2) Learn about the role of computer-extracted hand-engineered radiomics and deep learning in quantitative radiomics and machine learning. 3) Understand the role of quantitative radiomics in multi-omics cancer discovery studies and development of predictive models for precision medicine. 4) Learn about the motivation and methodology of A.I. technologies in Radiology. 5) Learn about the existing and future potential role of radiologic AI with other -omics data for precision medicine. 6) Learn about open-source informatics developments. 7) To understand some of the challenges in radiomics and radiogenomics and the crucial role of statistics in the study design and evaluation, to gain an understanding of the additional challenges brought along by the increasingly popular use of deep learning in radiomics, and to learn about the role of publicly available datasets and how to leverage challenges organized in the field.

Sub-Events

RC525A An Overview of Radiomics

Participants
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Advisor, Qlarity Imaging; Stockholder, Hologic, Inc; Shareholder, Quantitative Insights, Inc; Shareholder, QView Medical, Inc; Co-founder, Quantitative Insights, Inc; Royalties, Hologic, Inc; Royalties, General Electric Company; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies, LLC; Royalties, Mitsubishi Corporation; Royalties, Canon Medical Systems Corporation

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LEARNING OBJECTIVES

1) Appreciate the motivation and scientific premise of quantitative image analysis (radiomics). 2) Learn about the role of computer-extracted hand-engineered radiomics and deep learning in quantitative radiomics and machine learning. 3) Understand the role of quantitative radiomics in multi-omics cancer discovery studies and development of predictive models for precision medicine.

RC525B From Radiomics to Radiogenomics

Participants
Hugo Aerts, PhD, Boston, MA (*Presenter*) Stockholder, Sphera Inc

LEARNING OBJECTIVES

1) Learn about the motivation and methodology of A.I. technologies in Radiology. 2) Learn about the existing and future potential role of radiologic AI with other -omics data for precision medicine. 3) Learn about open-source informatics developments.

RC525C Challenges for Radiomics and Radiogenomics

Participants
Karen Drukker, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) To understand some of the challenges in radiomics and radiogenomics and the crucial role of statistics in the study design and evaluation. 2) To gain an understanding of the additional challenges brought along by the increasingly popular use of deep learning in radiomics. 3) To learn about the role of publicly available datasets and how to leverage challenges organized in the field.

SSK18

Physics (CT Protocols/Risk Reduction)

Wednesday, Dec. 4 10:30AM - 12:00PM Room: E353C

CT PH SQ

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

Participants
Frank N. Ranallo, PhD, Madison, WI (*Moderator*) Grant, General Electric Company
Tinsu Pan, PhD, Waukesha, WI (*Moderator*) Consultant, Bracco Group

Sub-Events

SSK18-01 Total Risk Index: A Mathematical Model for Decision Making Based on Clinical and Radiation Risk Assessment in CT

Wednesday, Dec. 4 10:30AM - 10:40AM Room: E353C

Participants
Francesco Ria, DMP, Durham, NC (*Presenter*) Nothing to Disclose
Taylor Smith, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Jocelyn Hoye, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Daniele Marin, MD, Durham, NC (*Abstract Co-Author*) Research support, General Electric Company
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company Research Grant, Siemens AG Advisory Board, medInt Holdings, LLC License agreement, 12 Sigma Technologies License agreement, Gammex, Inc

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PURPOSE

Radiological risk is a combination of radiation and clinical risk (likelihood of not delivering a proper diagnosis), which together may be characterized as a total risk index (TRI). While many strategies have been developed to ascertain radiation risk, there has been a paucity of studies assessing the clinical risk. This knowledge gap makes impossible to determine the total radiological procedure risk and, thus, to perform a comprehensive optimization. The purpose of this study was to develop a mathematical model to ascertain TRI and to identify the minimum TRI (mTRI) in a clinical CT population.

METHOD AND MATERIALS

This IRB approved study included 21 adults abdomen exams performed on a dual-source single energy CT at two different dose levels (84 CT series). Virtual liver lesions were inserted into projection data to simulate localized stage liver cancer (LSLC). The detectability index (d') was calculated in each series and converted to percentage of correct observer answers (AUC) in a two-alternative forced-choice model. The AUC was converted into the loss of 5-year relative survival rate (SEER, NCI), considering an upper bound on patient's risk for a misdiagnosis of LSLC (false positive+false negative). Concerning radiation risk, organ doses were estimated using a Monte Carlo method and the Risk Index was calculated and converted in 5-year relative survival rate for cancer. Finally, the two risks were weighted equally into a combined TRI curve per each patient as a function of CTDIvol. The analytical minimum of each TRI curve provided the patient mTRI.

RESULTS

The mTRI for LSLC patients that underwent an abdominal CT exhibited a rapid rise at low radiation dose due to enhanced clinical risk of under-dosed examinations. Increasing dose offered less risk with mortality per 100 patients between 2.1 and 6.5 (mean 4.5) at CTDIvol=5mGy; between 1.1 and 5.9 (mean 3.5) at CTDIvol=10mGy; and between 0.5 and 5.4 (mean 3.0) at CTDIvol=20 mGy.

CONCLUSION

The clinical risk seems to play a more dominant factor in designing optimum CT protocols. The TRI may provide an objective and quantifiable metric of the interplay of radiation and clinical risks during the optimization of the CT technique for individual patients.

CLINICAL RELEVANCE/APPLICATION

CT risk-based Optimization can be made possible by first quantifying both radiation and clinical risk using comparable units, then calculating an overall risk, and finally minimizing the total risk.

SSK18-02 Repeated/Rejected Events in CT: A Study Quantifying their Frequency and Impact on Patient Dose

Wednesday, Dec. 4 10:40AM - 10:50AM Room: E353C

Participants
Sean Rose, PhD, Madison, WI (*Presenter*) Nothing to Disclose
Ben Viggiano, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Timothy P. Szczykutowicz, PhD, Madison, WI (*Abstract Co-Author*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited

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PURPOSE

We have developed and validated an algorithm for automated detection of repeat/reject CT scans. Here we use the method to identify high repeat rate protocols at two sites and estimate their associated excess dose. We additionally determine reference standard repeat rates for each protocol.

METHOD AND MATERIALS

The algorithm estimated repeat/reject rates from high-volume protocols at CT scanners from two sites using dose monitoring data collected over 3 years. The sites included a rural and an academic hospital, sites A and B, respectively. We only considered repeats consisting of additional overlapping helical/axial scans in this study. Effective doses were calculated from all exams performed with the ten highest repeat-rate protocols at each site. Site-wide reference repeat rates were identified for each protocol by pooling exams performed with similar protocols (e.g. abdomen/pelvis protocols for all patient sizes) at each site and taking the minimum aggregate repeat rate between the two sites. Reference repeat rates were used to identify protocols for which targeted training has the largest potential to reduce repeat rates.

RESULTS

Overall repeat rates were the same for both sites, 1.4% [1.2,1.6] and 1.4% [1.3,1.5] (95% confidence intervals shown in brackets). Among the ten highest repeat rate protocols, the median percent increase in mean effective dose between normal and repeat-containing exams was 107.5% (interquartile range [89.9,130.2]) for site A and 64.6% (interquartile range [44.4,88.8]) for site B. More multiphasic protocols were used at Site B relative to Site A, making the relative dose increase smaller. Using the site-wide reference repeat rate (i.e. best institution practice), we calculated Site A and B could have reduced their number of repeat exams by 55 and 42 respectively over a three year period.

CONCLUSION

Overall repeat rates at the two sites were similar, but the ten highest repeat rate protocols differed. Comparison to site-wide reference repeat rates suggests that protocol-specific intervention may be effective in reducing repeat rates at both sites.

CLINICAL RELEVANCE/APPLICATION

Our informatics based repeat/reject methodology for CT can be used to quantify excess dose delivered due to operator error and identify best practice scanning within an institution.

SSK18-03 One Size Does Not Fit All: Factors Associated With Increased Frequency Of Radiation Overexposure Alerts Based On Fixed Alert Thresholds

Wednesday, Dec. 4 10:50AM - 11:00AM Room: E353C

Participants
Vladimir Valtchinov, PhD, Brookline, MA (*Abstract Co-Author*) Nothing to Disclose
Jenifer W. Siegelman, MD, MPH, Newton, MA (*Abstract Co-Author*) Employee, Takeda Pharmaceutical Company Limited
Bingxue K. Zhai, ARRT,MSc, Waban , MA (*Abstract Co-Author*) Nothing to Disclose
Ramin Khorasani, MD, Roxbury Crossing, MA (*Abstract Co-Author*) Nothing to Disclose
Aaron D. Sodickson, MD,PhD, Boston, MA (*Presenter*) Institutional research agreement, Siemens AG; Speaker, Siemens AG; Speaker, General Electric Company

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PURPOSE

To quantify the expected rate of CT radiation dose alerts for three body regions using accepted radiation benchmarks, and to assess key determinants of alert frequency.

METHOD AND MATERIALS

This IRB-approved retrospective cohort study evaluated 6 months of consecutive CT examinations performed within an academic medical system. CTDIvol x-ray tube output metrics were compared to the body-region-specific benchmark levels Achievable Doses (AD), Diagnostic Reference Levels (DRL), and Dose Notification Values (DNV), and simulated alerts were generated when benchmarks were exceeded. Frequency and proportion of events triggering alerts were calculated. A logistic regression model was fit for the outcome of simulated alert as a function of the independent predictors: scanner, body region, gender, weight, and age.

RESULTS

For 17,000 head, chest and abdomen exams, the proportion of events triggering alerts increased with weight for all scanners and body regions. Significant covariates were scanner, body region, patient weight, and age (all $p<0.0001$). Odds of alert generation for the AD, DRL, and DNV benchmarks increased by 3.3%, 3.0%, and 1.3% per pound, respectively, and by 0.8%, 1.1% and -2.7% per year of age (all $p < 0.0001$). Compared to the most highly optimized scanner, odds of alert generation varied by a factor of 595 for AD, 1126 for DRL, 13 for DNV.

CONCLUSION

Alert frequency was significantly correlated with weight, age, body region and scanner. Controllable factors include scanner functionality and associated protocol optimization. The patient factors driving alert frequency are predominantly weight, and to a lesser degree, age. Fixed dose threshold values can thus frequently produce false alerts in appropriately performed exams of large patients, while not triggering alerts in outlier scans of higher than expected dose in small patients.

CLINICAL RELEVANCE/APPLICATION

Factors influencing dose alert frequency were explored for a large cohort of CT scans in a multi-scanner environment. These have implications to the utility of fixed dose threshold alert values.

SSK18-04 How to Use Lead Apron to Reduce Excess Radiation Dose Caused by Over-Scan in Computed Tomography Using 40mm Collimation: An Anthropomorphic Phantom Study

Wednesday, Dec. 4 11:00AM - 11:10AM Room: E353C

Participants
Xinyu Li, Xian, China (*Presenter*) Nothing to Disclose
Jianying Li, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company
Yun Shen, PhD, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company Researcher, General Electric Company
Jianxin Guo, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Xijun Jiao, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Xianghui Zhang, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Peiyun Li, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Jian Yang, Xian, China (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

The typical over-scan range with 40mm collimation in helical scans was about 25x2mm resulting in dose penalty, but the use of lead apron may be used to reduce the dose penalty. The purpose of this study was to explore the optimal way of placing the lead apron to maximize dose reduction for the over-scans without negatively impact image quality with 40mm collimation.

METHOD AND MATERIALS

We used an anthropomorphic phantom containing a pig liver, kidney, meat and a femur head in a water box to evaluate image quality with the apron placed at different distances to the imaging boundary. A scout was taken first without lead apron to determine the desired imaging range and set up the automatic tube current modulation before putting on the lead apron. The helical scan groups were designed as follows: group 1, without apron as a reference and groups 2-22 with the apron first placed at the imaging boundary and in 0.5mm increment away from the it. The scan techniques were kept the same for all scans at 40mm collimation, 120kVp, 10-740mA for a noise index of 7HU. Images were reconstructed at 5mm slice thickness and the image nearest the imaging boundary was used for analysis and comparison. 10 regions of interest (ROI, 5mm*5mm in size) of different tissues in the images were selected to measure CT value. Measurements in group 1 (without apron) were as reference standards. The CT values of the 10 ROIs in each group from groups 2-22 were compared with group 1 using Paired t-test and the CT value difference (dCT(i)=CT(i)-CT(1)) for each ROI in matched location was calculated to evaluate objective imaging quality by a boxplot. Subjective image quality was also evaluated in terms of image noise and shading artifacts.

RESULTS

In the Paired t-test, the p values were continuously greater than 0.05 for groups 13-22 (apron 5.5-10mm from the boundary) with the average dCT values smaller than 3HU . There was no difference in subjective image quality between groups 13-22 and group 1.

CONCLUSION

Placing lead apron at least 5.5mm from the imaging boundary when using 40mm collimation is recommended, reducing the over-scan dose penalty by 78%.

CLINICAL RELEVANCE/APPLICATION

Lead apron may reduce the dose penalty for the over-scans without negatively impact image quality and placing lead apron at least 5.5mm from the imaging boundary in 40mm collimation is recommended.

SSK18-05 Effect of Gonad Shields on the Automatic Exposure Control in Computed Tomography: Influence on the Development of Standard Operating Procedures

Wednesday, Dec. 4 11:10AM - 11:20AM Room: E353C

Participants
Andrea Steuwe, Dusseldorf, Germany (*Presenter*) Nothing to Disclose
Yan Klosterkemper, Dusseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Christoph K. Thomas, MD, Dusseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Elisabeth Appel, MD, Dusseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Gerald Antoch, MD, Dusseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Johannes Boos, MD, Dusseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To analyze the influence of a lead gonad shield on the automatic exposure control (AEC) of three different computed tomography (CT) scanner models to develop in-house standard operating procedures (SOPs).

METHOD AND MATERIALS

An anthropomorphic male Alderson phantom was scanned thrice with the standard abdomen/pelvis protocol on three different CT scanners (Somatom Definition Edge (1), Somatom Definition Flash (2), Somatom Definition AS (3), all Siemens Healthineers, Germany) in cranio-caudal direction. Per scanner, the phantom was scanned (a) without shield, (b) with added shield after the scout (Mavig gonad shield, 1mm Pb) and (c) scout and scan with shield, covering the entire abdomen/pelvis. Subsequently, the scan range was shortened at the cranial side with the following distances to the shield: (d) 0cm (scan range adjacent to shield), (e) 1cm, (f) 2cm and (g) 3cm. Exposure [mAs] per reconstructed slice was determined and averaged over the three repetitions.

RESULTS

Compared to scans without shield (acquisition a), inclusion of the gonad shield on the scout resulted in increased x-ray exposure: For all scanners, exposure increased adjacent to the shield for approximately one detector width (up to 15%). Along the caudal part of the shield exposure increased by up to 85%. Modulation along the cranial part of the shield varied per scanner: Exposure increased for scanner 1 (+10%), stayed similar for scanner 2 and decreased for scanner 3 (-20%). For scans without gonad shield in the scan range (acquisitions d-g), exposure still increased adjacent to the shield (up to 15%). Placement of the shield after the scout (acquisition b) did not change exposure considerably for all evaluated scanners.

CONCLUSION

Our results indicate that the FOV range needs to be adapted to the scanner's detector width when using gonad shields with AEC, or ideally, placement of the shield needs to be performed after acquisition of the scout scan.

CLINICAL RELEVANCE/APPLICATION

Even for the same vendor, the influence of gonad shields on the AEC varies per scanner model and needs to be assessed prior to the development of scanner- and protocol-dependent SOPs.

SSK18-06 An Organ Dose Calculation Tool for Fetus at Various Ages Undergoing Computed Tomography

Wednesday, Dec. 4 11:20AM - 11:30AM Room: E353C

Participants
Choonsik Lee, PhD, Rockville, MD (*Presenter*) Nothing to Disclose
Les R. Folio, MPH,DO, Bethesda, MD (*Abstract Co-Author*) Institutional research agreement, Carestream Health, Inc

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PURPOSE

Pregnant patients may undergo CT in emergencies unrelated with pregnancy and potential risk to the developing fetus is of concern. It is critical to accurately estimate fetal organ doses in CT scans. We developed a fetal organ dose calculation tool using pregnancy-specific computational phantoms combined with Monte Carlo radiation transport techniques.

METHOD AND MATERIALS

We adopted a series of pregnancy computational phantoms developed at the University of Florida at the gestational ages of 8, 10, 15, 20, 25, 30, 35, and 38 weeks (Maynard et al. 2011). More than 30 organs and tissues and 20 skeletal sites are defined in each fetus model. We calculated fetal organ dose normalized by CTDIvol to derive organ dose conversion coefficients (mGy/mGy) for the eight fetuses for consequential slice locations ranging from the top to the bottom of the pregnancy phantoms with 1 cm slice thickness. Organ dose from helical scans were approximated by the summation of doses from multiple axial slices included in the given scan range of interest. We then compared dose conversion coefficients for major fetal organs in the abdominal-pelvis CT scan of pregnancy phantoms with the uterine dose of a non-pregnant adult female computational phantom.

RESULTS

A comprehensive library of organ conversion coefficients was established for the eight developing fetuses undergoing CT. They were implemented into an in-house graphical user interface-based computer program for convenient estimation of fetal organ doses by inputting CT technical parameters as well as the age of fetus. We found that the esophagus received the least dose whereas the kidneys received the greatest dose in all fetuses in AP scans of the pregnancy phantoms. We also found that when the uterine dose of a non-pregnant adult female phantom is used as a surrogate for fetal organ doses, root-mean-square-error ranged from 0.08 mGy (8 weeks) to 0.38 mGy (38 weeks). The uterine dose was up to 1.7-fold greater than the esophagus dose of the 38-week fetus model.

CONCLUSION

The calculation tool should be useful in cases requiring fetal organ dose in emergency CT scans as well as patient dose monitoring.

CLINICAL RELEVANCE/APPLICATION

The methods and tool we developed in this study should provide more accurate fetal organ dose estimations at various gestational ages, which should help radiologists and mothers to better understand the health impact of fetus undergoing CT.

SSK18-07 AEC- and Scan Time-Optimized Pediatric Body CT Protocols based on Size-Specific Dose Needs

Wednesday, Dec. 4 11:30AM - 11:40AM Room: E353C

Participants
Megan Lipford, PHD, Madison, WI (*Presenter*) Nothing to Disclose
Timothy P. Szczykutowicz, PhD, Madison, WI (*Abstract Co-Author*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited

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PURPOSE

We have developed a method for creating pediatric CT protocols. Currently, no methods exist for building a protocol that meets specific dose and scan time requirements for as a function of size/age.

METHOD AND MATERIALS

In our method, CT manuals and/or measurements define the maximum CTDIvol based on the tube limits and the range of available collimations, pitches, rotation times, etc. Then, using aggregated clinical data from 210 pediatric CT body exams, we characterized the dose and scan length required as a function of patient size (AP+Lat). With these data, we created a spreadsheet having an input of acquisition parameters and scanner specific speed and dosimetry values. Combining the clinical data with the scanner input data, the spreadsheet output a maximum patient size and scan time. We demonstrate the method by building protocols for the GE Revolution and Siemens Force. For each, we build two sets of protocols: one optimized for scan speed but with limited patient size dynamic range (i.e. size bins spanning a couple years), and one clinically robust protocol that can span large size ranges with a single protocol (i.e. size bins spanning 5-10 years).

RESULTS

The speed optimized sets of protocols resulted in 5 protocols for the Force and 4 for the Revolution in order to span newborn to teenager. The clinically robust set only used 2 protocols to span newborn to teenager. Scan times for the speed optimized sets had a minimum of 0.26 s, but at that scan speed could only image to a patient size of 310 mm AP+Lat (i.e. 2 years). The clinically robust set of protocols allowed a minimum scan time of 0.48 seconds for newborns but with a dose dynamic range up to 430 mm AP+Lat (i.e. 12 years). Our results also show the scan times between these premium models were similar, with no scanner taking longer than 2 seconds to scan a pediatric abdomen.

CONCLUSION

With this method of creating protocols, it is easy to predict how parameter adjustments affect the scan time (i.e. breath hold) and range of appropriate patient sizes (i.e. ages). In our demonstration, running a scanner as fast as possible required more changes in rotation time and pitch as a function of patient size.

CLINICAL RELEVANCE/APPLICATION

Before our work, no method existed for predicting if a protocol will actually allow for enough dose or a short enough scan time on a patient size and indication basis.

SSK18-08 Diagnostic Reference Levels and Achievable Doses for Computed Tomography for EUCLID (European Study on Clinical DRLs) Defined Clinical Indications: Data from a Multinational Dose Registry

Wednesday, Dec. 4 11:40AM - 11:50AM Room: E353C

Participants
Denise Oldenburg, MD, Essen, Germany (*Presenter*) Nothing to Disclose
Sophronia Yu, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Jason K. Luong, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Philip Chu, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Yifei Wang, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Axel Wetter, Essen, Germany (*Abstract Co-Author*) Nothing to Disclose
Rebecca Smith-Bindman, MD, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Radiation doses for Computed Tomography (CT) examinations between patients, institutions, and countries are highly variable. Diagnostic reference levels (DRLs), and achievable doses (ADs) are often created to help reduce unnecessary variation. The European Society of Radiology has identified common indications for CT named EUCLID (European Study on Clinical DRLs) in order to create benchmarks for these examination types. We generated DRLs and ADs for these examinations.

METHOD AND MATERIALS

Standardized data from > 2.3 million CT examinations in adults 18 years of age and older were collected between January 2016 and December 2018 from 155 institutions across 7 countries in a large, multinational CT Dose Registry. Two dose metrics were evaluated: CT-dose index (CTDIvol), and dose-length product (DLP).

RESULTS

AD (50% in dose distribution) and DRL (75% in dose distribution) are summarized as follows (CTDIvol (mGy)/ DLP (mGy-cm), sample size n): chronic sinusitis (15 and 21 / 250 and 373, n= 57070), stroke to detect and exclude hemorrhage (47 and 53/ 872 and 1076, n= 14040), cervical spine trauma (19 and 30/ 450 and 962, n= 111397), pulmonary embolism (10 and 15/ 372 and 558, n= 112784), coronary calcium scoring (4 and 7/ 66 and 102, n= 22579), coronary angiography (21 and 31/ 497 and 915, n= 3176), lung cancer first and follow-up (11 and 15/ 556 and 858, n= 7064), hepatocellular carcinoma (9 and 14/ 1304 and 2016, n= 4289), colic/abdominal pain (10 and 14/ 519 and 773, n= 64724), and appendicitis/routine abdomen (11 and 16/661 and 1059, n= 721263). Most CT scans for clinical indications showed large differences in radiation dose compared to routine CT scans, e.g. sinusitis scans were >60% lower in both CTDIvol and DLP compared to routine head CT scans. Further, there were large differences in the DRLs and ADs across facilities.

CONCLUSION

DRLs and ADs for the clinical indications of EUCLID were presented and showed differences to routine CT scans. Dose metrics from large multi-center studies can help create representative DRLs and ADs that can be used for dose optimization, institutional evaluation, and indication-specific dose-optimized protocols.

CLINICAL RELEVANCE/APPLICATION

DRLs and ADs for clinical indications are essential due to high variation of CT radiation doses and for dose optimization, institutional evaluation, and indication-specific dose-optimized protocols.

SSK18-09 Reference Dataset for Benchmarking Organ Doses Derived from Monte Carlo Simulations of CT Exams

Wednesday, Dec. 4 11:50AM - 12:00PM Room: E353C

Participants
Anthony Hardy, MS, Los Angeles, CA (*Presenter*) Nothing to Disclose
Maryam Bostani, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Erin Angel, PhD, Tustin, CA (*Abstract Co-Author*) Employee, Canon Medical Systems Corporation

Christopher H. Cagnon, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Abstract Co-Author*) Institutional research agreement, Siemens AG

PURPOSE

AAPM Report 195 contains reference datasets for the direct comparison of results between different Monte Carlo (MC) simulation tools but stops short of providing the necessary information for comparing organ doses. The purpose of this work was therefore to extend the efforts of AAPM Report 195 by providing a reference dataset for benchmarking absolute and normalized organ doses from MC simulations of CT exams.

METHOD AND MATERIALS

The reference dataset contains (1) scanner characteristics, (2) patient information, (3) exam specifications, and (4) organ dose results in tabular form. The scanner characteristics include descriptions of equivalent source spectrum, bowtie filtration profile, and scanner geometry information. Additionally, for MCNPX MC engines, normalization factors are provided to convert simulation results to units of absolute dose. The patient information was based on publicly available fetal dose models and includes de-identified image data; voxelized MC input files with fetus, uterus, and gestational sac identified; and patient size metrics in the form water equivalent diameter (Dw) distributions from the image data and from a simulated topogram. Exam characteristics include the scan length and imaging protocol specifications. For tube current modulation (TCM) simulations, an estimate of TCM is provided based on a validated method that accounts for patient attenuation and scanner tube current limitations. In this case, CTDIvol estimates were based on average tube current across the scan volume. Organ dose simulation results are given for each patient model and for TCM and fixed tube current (FTC) CT exam scenarios both in terms of absolute and CTDIvol-normalized fetal dose.

RESULTS

Results TCM and FTC simulations for absolute and normalized fetal dose are presented in tabular form with associated MC error estimates for benchmarking.

CONCLUSION

The reference dataset for MC benchmarking is now available. This will enable researchers to compare their simulations to a set of reference data.

CLINICAL RELEVANCE/APPLICATION

This dataset will for benchmarking dose management software results against MC simulations.

SSK19

Physics (Dark-Field/X-Ray Phase Contrast Imaging)

Wednesday, Dec. 4 10:30AM - 12:00PM Room: E353B

PH

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

FDA Discussions may include off-label uses.

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Sub-Events

SSK19-01 Fast Data Acquisition for a Human-Compatible Multi-Contrast Breast Imaging System

Wednesday, Dec. 4 10:30AM - 10:40AM Room: E353B

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PURPOSE

A major technical obstacle to bringing x-ray phase contrast and dark-field imaging to clinical use is the prolonged data acquisition time associated with the phase stepping procedure: the majority of the imaging time is spent accelerating-decelerating-stabilizing the x-ray grating instead of delivering the actual x-ray exposures. The purpose of this work was to introduce a fast data acquisition technique to a prototype multi-contrast breast imaging system so that the imaging time is identical to that of the clinical breast imaging procedure.

METHOD AND MATERIALS

The prototype system was constructed based on a Hologic Selenia Dimensions 3D Mammography system. During a multi-contrast image acquisition process, the diffraction grating traveled continuously along the direction parallel to the chest wall, and a train of 15 short x-ray pulses (42 ms each) was delivered by using the Zero-Degree Tomo mode (usually used for QC) offered by the Hologic system. Standard phase retrieval was applied to the 15 sub-images without spatial interpolation to avoid spatial resolution loss. The method was evaluated using both physical phantoms and a fresh mastectomy specimen (10 min post-surgery). For comparison, each object was also imaged by operating the same system under the conventional phase stepping mode.

RESULTS

The image acquisition time of the proposed method is 6 s and only limited by the scan time of the current version of the Zero-Degree Tomo mode. In comparison, conventional phase stepping took 106 s. Fringe visibility of both methods is 18±3%; spatial resolution of both methods is identical; mean glandular dose of both methods was matched at 1.9 mGy. No artifacts were observed in images produced by the proposed method.

CONCLUSION

The proposed continuous phase stepping acquisition method eliminated the overhead of imaging time imposed by the interleaved stepping motion in x-ray phase contrast imaging. A prototype multi-contrast breast imaging system equipped with this technique was developed; in this system, data acquisition, system geometry and radiation dose are all compatible with requirements of clinical breast imaging.

CLINICAL RELEVANCE/APPLICATION

The proposed fast phase stepping method eliminates the constraint on the imaging time of multi-contrast x-ray imaging, bringing this technology closer to clinical breast imaging applications.

SSK19-02 Scatter Artifact Reduction in Dark-Field X-Ray Imaging

Wednesday, Dec. 4 10:40AM - 10:50AM Room: E353B

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PURPOSE

Dark-field X-ray imaging is a new technology to visualize the alveolar structure of lung tissue, which relies on coherent small-angle x-ray scattering. Incoherent Compton scatter overlaying the dark-field signal impedes image formation and thus hampers diagnostic interpretation. The purpose of this work was to develop and validate an algorithm to eliminate the contribution of Compton scatter to the dark-field signal.

METHOD AND MATERIALS

A slot-scanning gratings-based chest dark-field system was used to acquire raw data of phantoms and 10 human patients. Correction for Compton scattering was performed in a two-step approach. First, a conventional x-ray transmission and a dark-field image were generated by standard so-called phase-retrieval, which was implemented as a weighted least-squares fit. The conventional image was the input for a kernel-based scatter estimation method, which accounts for the system geometry, the slot width, the attenuation by the grating assembly, and the detector efficiency. Second, estimates for scattered intensity were calculated for each slot position and were accounted for as additional incoherent background radiation during a second-pass phase-retrieval.

RESULTS

The dark-field signal level is physically limited to the range from 0 to 100%. Dark-field images without scatter correction show artificial dark-field signal in areas with a large scatter fraction. This can be primarily observed in image areas of the backbone, heart, and abdomen. The developed scatter correction greatly reduces this artificial signal and allows for a better quantitative measurement of the true dark-field signal generated by lung tissue. Typically, the correction of the dark-field signal by application of the scatter correction algorithms is in the order of 20%-40% in areas of the backbone, 10% in the area of the heart, and 10-20% in the abdomen.

CONCLUSION

Quantitative dark-field signal processing is possible if the developed Compton scatter correction is applied during image processing.

CLINICAL RELEVANCE/APPLICATION

In previous preclinical small-animal studies, dark-field X-ray radiography has demonstrated the potential to detect early stages of various lung diseases. By using the proposed scatter correction method, more accurate dark-field images are obtained.

SSK19-03 Detection of Monosodium Urate Crystals in X-Ray Dark-Field Radiography

Wednesday, Dec. 4 10:50AM - 11:00AM Room: E353B

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PURPOSE

To detect gout crystals in radiography by employing the X-ray dark-field signal caused by refractive index fluctuations of the amorphous crystal structure.

METHOD AND MATERIALS

Monosodium urate (MSU) crystals were injected into mouse legs post mortem to simulate gout crystal deposition and then imaged in a preclinical X-ray grating interferometer setup with a rotating molybdenum anode operated at 50 kVp acceleration voltage and a photon counting detector with an effective pixel size of 166µm. All animal procedures were performed with permission of the local regulatory authority. Every image acquisition provides the dark-field image together with the conventional attenuation image at the same time. In a reader study with 3 experienced radiologists, 7 image sets of dark-field and attenuation images have been evaluated first separately and then with both images available for the reader.

RESULTS

The contrast to noise ratio (CNR) of the MSU crystals in the dark-filed image is more than a factor of 5 higher than in the conventional radiography. All readers correctly identified all three cases with injected MSU crystals and rejected most of the images without crystal injection in the dark-field images (sensitivity = 100%, specificity = 92%) but could not give a reliable diagnose based on the conventional attenuation images (sensitivity = 11%, specificity = 92%). Sensitivity, specificity and confidence level have been maximized when attenuation and dark-field image where presented simultaneously to the reader (sensitivity = 100%, specificity = 100%, confidence level = high).

CONCLUSION

Our ex-vivo study demonstrates the potential of gout detection in radiography with a grating interferometer. The simultaneous accessibility of the conventional attenuation image and the dark-field image allowed a 100% specific and sensitive diagnose in a reader study with mouse legs.

CLINICAL RELEVANCE/APPLICATION

X-ray dark-field imaging enables the detection of MSU crystals in a radiographic projection and has the potential to supersede invasive joint puncture for gout diagnosis.

SSK19-04 Variation of Darkfield Chest X-Ray Signal Strength with Breathing State

Wednesday, Dec. 4 11:00AM - 11:10AM Room: E353B

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PURPOSE

To evaluate the lung signal strength of the first human dark-field chest X-rays with respect to the breathing state of the patient.

METHOD AND MATERIALS

We constructed a clinical prototype for grating-based dark-field chest radiography with a field of view of 37 x 37 cm², suitable for human chest imaging. It employs a scanning image acquisition procedure with an acquisition time of 7 s and a tube voltage of 70 kVp. The average effective dose for one posterior-anterior thorax radiograph is 0.04 mSv. So far, more than 60 patients have been examined in an IRB approved study in posterior-anterior orientation in two different respiratory states, viz. inspiration and expiration. From these images, the variation of the dark-field signal due to the micromorphological changes in the lung is assessed.

RESULTS

While the attenuation signal shows anatomical changes, the dark-field signal varies in strength due to underlying structural changes in the lung. In inspiration, the dark-field signal is quite homogeneous over the lung, which can be attributed to a homogeneous distribution of alveolar size and density. In expiration, the alveoli size is reduced and their packing density is increased, particularly in the lower parts of the lung. This leads to more air-tissue interfaces in the beam path, which cause small-angle scattering and thus produce a stronger dark-field signal. The variation strength naturally depends on patient cooperation, but mainly on his or her pulmonary health and ability to breathe. The difference in dark-field signal between the two breathing states allows to spatially identify regions that change micromorphologically and thus participate in the ventilation of the lung.

CONCLUSION

With this technique, it is possible to obtain spatial information about microstructural changes in the lung and thus the physiological activity of different lung regions between inspiration and expiration. The change in signal strength illustrates the origin of the dark-field signal and its sensitivity to the microstructure of the lung, promising a distinct diagnostic value of dark-field images for the assessment of lung diseases.

CLINICAL RELEVANCE/APPLICATION

The variation of dark-field signal with respect to respiration state is strong and thus motivates future investigations on its potential clinical benefit with regard to improved diagnosis and staging of lung diseases, including COPD.

SSK19-05 Grating-Based Spectral X-Ray Dark-Field Imaging for Correlation with Structural Size Properties

Wednesday, Dec. 4 11:10AM - 11:20AM Room: E353B

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PURPOSE

Previous small-animal studies have revealed a decrease in X-ray dark-field signal for various structural lung pathologies (i.e. emphysema, fibrosis), which typically are characterized by destruction or densification of alveolar structure. In our studies we have characterized correlations between the structure size of complex samples closely resembling human lung tissue and spectral X-ray dark-field imaging with a polychromatic X-ray source.

METHOD AND MATERIALS

At a setup for grating-based X-ray dark-field imaging with a multi-threshold photon-counting detector (Direct Conversion AB, Danderyd, Sweden), various types of closed-cell foams and hollow glass microspheres were measured. By separating the incoming X-ray photons at the detector into energy intervals, two distinct correlations lengths were sampled and the according energy-dependent X-ray dark-field signal was recorded. A connection between both energy intervals was achieved by determination of the quotient of the resulting X-ray dark-field signals. The structure size of sample materials was defined using micro computed tomography scans and the subsequent calculation of mean chord length, a medically-approved measure for alveolar structure size, which is known to be affected by several structural lung diseases.

RESULTS

For increasing mean chord lengths of the sample materials, an increase of the quotient of energy-dependent X-ray dark-field signals was found. Our findings reveal the possibility to differentiate between objects based on varying structural properties in a single X-ray dark-field scan with a spectral detector. For future clinical X-ray dark-field lung imaging, this implies an increase of diagnostic power as information about destruction or densification of lung tissue are directly accessible.

CONCLUSION

A differentiation of objects with various structural properties is shown to be possible based on the approach of mean chord length and the use of spectral X-ray dark-field imaging, which forms a connection between a medical measure for alveolar structure and X-ray dark-field imaging.

CLINICAL RELEVANCE/APPLICATION

The demonstrated accessibility of information about structural properties using spectral X-ray dark-field imaging potentially increases the diagnostic power of future X-ray dark-field lung imaging.

SSK19-06 Motion Artifact Reduction in Dark-Field X-Ray Imaging

Wednesday, Dec. 4 11:20AM - 11:30AM Room: E353B

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PURPOSE

Dark-field x-ray radiography is a new technology to visualize the alveolar structure of lung tissue. Dark-field images are generated from several x-ray exposures with a grating interferometer assembly in the beam. Motion between the exposures causes artifacts in the final dark-field image. The purpose of this work was to develop and validate an algorithm to reduce these motion artifacts.

METHOD AND MATERIALS

A slot-scanning grating interferometer was used to acquire dark-field images of 10 human study patients. Local illumination time was approximately 700 ms at total acquisition time of 7 seconds, which implies e.g. heart motion during exposure. In a first step, dark-field phase-retrieval processing based on a weighted least-squares fit was used to generate an x-ray transmission and a dark-field image. Motion artefact reduction processing relied on detection of motion-affected areas by analyzing the deviation of the weighted least-squares fit cost function from its expected value. For these areas, alternative dark-field images were generated by iteratively selecting a narrowed slot width and thus a shorter local illumination time. The selection criterion was to optimize the match of the cost function to its statistically expected value.

RESULTS

The dark-field signal level is physically limited to the range from 0 to 100%. Dark-field images generated with conventional processing revealed clearly visible motion artefacts, seen as horizontal stripes especially in the area of the heart, diaphragm, and aorta. The amplitude of these stripes reaches up to 50%. The newly developed processing achieved a substantial motion artifact reduction in dark-field images.

CONCLUSION

Local choice of a subset of exposures to generate a dark-field image can help to significantly reduce motion artefacts. Thus, the presented method enables a quantitative assessment of the dark-field signal strength in areas where lung tissue overlaps with moving objects like the heart.

CLINICAL RELEVANCE/APPLICATION

Motion artifact reduction is an important processing step if the dark-field image near moving objects like the heart is evaluated.

SSK19-07 Osteo-Articular X-Ray Phase Contrast Imaging Using Conventional Radiography Systems and a Random Modulator: Proof of Concepts on Human Fingers and Wrists

Wednesday, Dec. 4 11:30AM - 11:40AM Room: E353B

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PURPOSE

X-ray Phase Contrast Imaging (PCI) has been introduced a few decades ago at synchrotrons. It has demonstrated an increased contrast that allows the visualization of all tissues in a single modality with high resolution. Applications of PCI on laboratory or clinical set-up often encounter various limitations due to the optics it requires. In this work we present medical results of a PCI approach on a conventional device with solely the addition of a random beam intensity modulator. We present a preliminary comparison of results between standard radiography and PCI at 80% of the conventional radiograph radiation dose.

METHOD AND MATERIALS

Phantoms and anatomical pieces (human finger and hands) were imaged. Two different X-ray commercially available devices were used: a C-arm Siemens ARCADIS Avantic and a radiography table Primax Clisis Exel. The samples were imaged using both the standard radiography and the PCI approaches at 60 kvp and with clinical compatible doses. For the PCI acquisitions, a single thin random modulator was included upstream of the samples. Before imaging the samples, a first radiograph of the modulator was taken. Then, by numerically processing the couples of images taken with and without the sample, we are able to map the phase shifts induced by the samples.

RESULTS

The phase maps of the samples were obtained using the conventional device. The image quality from X-ray PCI visually permits the visualization of features invisible to conventional X-ray imaging techniques such as Styrofoam ball, cartilage thickness, micro calcifications, bone microstructures.

CONCLUSION

The study shows that, with a simple beam modulator, phase maps can be retrieved on conventional devices. Here, the experimental complexity of PCI is translated in to the numerical processing side. Despite not yet being implemented in routine, the PCI improved visualization capabilities demonstrated so far suggests that healthcare could significantly benefit from a widespread application of PCI. These preliminary results combined with more recent technical developments let foresee the availability of the proposed PCI method on conventional sources in a close future.

CLINICAL RELEVANCE/APPLICATION

This study presents the results of medical PCI using conventional X-ray device modified with an additional simple random modulator. The results reveal some advantages of PCI over standard radiograph.

SSK19-08 Dosimetry for Combined Dark-Field and Attenuation Chest X-Ray Imaging on Patients

Wednesday, Dec. 4 11:40AM - 11:50AM Room: E353B

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PURPOSE

To demonstrate that the applied effective dose for patient examinations at the first clinical X-ray dark-field chest radiography system is within a clinically acceptable dose range.

METHOD AND MATERIALS

A clinical setup for grating-based dark-field chest radiography was constructed which operates at an acceleration voltage of 70 kVp. The study was approved by the institutional review board and the national radiation protection agency. To obtain conversion coefficients relating effective dose to dose area product (DAP) at the dark-field system, thermoluminescent dosimeter (TLD) measurements were conducted using a phantom with approximately 200 TLDs, modeling the ICRP reference man with a body weight of 73.5 kg and a trunk length of 68 cm. The effective dose for the TLD measurements was calculated with weighting factors according to ICRP 103. For n = 53 patients, the DAP values for both posterior-anterior (pa) and lateral (lat) measurements were collected at the dark-field system and a conventional radiography system which is operated at 125 kVp. With the determined conversion coefficients, the respective effective dose was calculated.

RESULTS

The average effective dose for one measurement at the dark-field radiography system in pa orientation is determined to 44 μSv in the case of a typical patient as modeled by the anthropomorphic phantom. For the conventional system, an effective dose of 18 μSv was determined. For the examined patients, we obtain an average effective dose of pa: (40 ± 21) μSv (lat: (81 ± 34) μSv) at the dark-field system and pa: (13 ± 5) μSv (lat: (34 ± 31) μSv) for the conventional device. A strong variation in effective dose was observed, as patients of various weights and heights were imaged while targeting a fixed detector dose.

CONCLUSION

The effective dose at the clinical dark-field radiography system is about a factor of three higher compared to a conventional system. A potential diagnostic value provided by this novel contrast modality, which will be evaluated in further studies, could justify the higher dose.

CLINICAL RELEVANCE/APPLICATION

Dark-field chest radiography is compatible with clinical dose requirements, thus it qualifies as a potential mass screening tool for early detection of pulmonary disorders.

SSK19-09 Characterizing Cartilage Microarchitecture on Phase-Contrast X-Ray Computed Tomography - A Machine Learning Approach

Wednesday, Dec. 4 11:50AM - 12:00PM Room: E353B

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PURPOSE

Phase-contrast x-ray computed tomography (PCI-CT) has been shown to achieve soft-tissue contrast with micrometer scale resolution for cartilage imaging. In this study, we investigate the ability of deep learning with convolutional neural networks (CNNs) to characterize and classify between chondrocyte patterns in healthy and osteoarthritic cartilage.

METHOD AND MATERIALS

A total of 842 regions of interest (ROI) were annotated from five osteochondral cylinders (7 mm diameter, 3 osteoarthritic, 2 healthy) extracted from post-mortem human patellae. Specimens were subject to high-resolution (voxel size 8 µm3, 26 keV, synchrotron source) phase-contrast x-ray CT imaging. ROIs were defined for capturing chondrocyte patterns in the radial zone of the cartilage matrix. The deep learning task was performed using a pre-trained CaffeNet neural network. We obtained representations from each of the eight layers of this network serving as input features for supervised machine learning. Random sub-sampling cross-validation was utilized in optimizing a support vector machine with a radial basis function kernel for classifying healthy and osteoarthritic cartilage. Additionally, ROIs from the same subject were not used for training as well as testing. Classification performance was evaluated by Area Under the Curve (AUC) for Receiver Operator Characteristics (ROC) analysis. Furthermore, we compared the results obtained with traditional first and second-level (measures from gray-level co-occurrence matrices) statistical features.

RESULTS

An AUC=0.81 was achieved for differentiating between healthy and osteoarthritic cartilage, when features were extracted from the first fully connected CNN layer. Interestingly, the best classification performance was observed for features extracted from the last fully connected as well as the last convolutional layer (AUC=0.91 for both). For comparison, conventional first and second order statistical features performed poorly (best AUC=0.78, $p<0.05$, Wilcoxon signed-rank test).

CONCLUSION

Features from internal layers of pre-trained CNNs achieve high classification performance and can serve as benchmarks for cartilage characterization, as they significantly outperform traditional statistical features.

CLINICAL RELEVANCE/APPLICATION

Deep learning approaches for cartilage pattern characterization on phase-contrast CT imaging can contribute to the development of diagnostic imaging biomarkers for osteoarthritis.

PHS-WEA

Physics Wednesday Poster Discussions

Wednesday, Dec. 4 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants

Adel A. Mustafa, PhD, New Haven, CT (*Moderator*) Nothing to Disclose

Sub-Events

PH214-SD-WEA1 Scanned Projection Radiograph and Ultra-Low-Dose CT for Monitoring PICC Line Malposition

Station #1

Participants
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PURPOSE

Peripherally inserted central catheters (PICCs) are increasingly used for intravenous contrast injection in CT. However, safety concerns exist due to the possibility of PICC movement during injection. Scanning projection radiographs (SPRs) have been recommended by the Infusion Nursing Society to identify PICC tip position before and after power injection, which is sometimes challenging due to limited SPR image quality. The purpose of this study is to optimize the SPR technique and to compare results with those of an ultra-low-dose CT (ULD-CT) for monitoring PICC line malposition.

METHOD AND MATERIALS

An anthropomorphic chest phantom (Lungman, Kyoto Kagaku) with added plate was used to mimic an average-sized adult patient. A thin PICC line (3 French, PowerPICC SV, Bard) was attached within the plate with the tip close to the area of right atrium. SPR and ULD-CT images of the phantom were acquired with a 192-slice CT scanner (Force, Siemens). The SPRs were acquired at 70, 80, and 120 kV, and 100 kV with added tin filtration (100Sn), each at multiple dose levels (0.04, 0.09, 0.18 mGy CTDIvol equivalent) and 4 different kernels (Tr20, Tr60, Tx20, and Tx60). ULD-CT was acquired at 70 and 100Sn kV (0.09 mGy CTDIvol). For reference, a routine-dose CT was also performed at 120 kV and 5.0 mGy. Maximum intensity projection (MIP) images were created from CT images to view PICC position. Detectability of the PICC tip was visually compared among all SPRs and ULD-CT images.

RESULTS

The optimal kernel for the SPR images was Tr60, which provided the sharpest appearance of the PICC line. Lower tube potentials (70 and 80 kV) had enhanced contrast, which improved visibility of the PICC tip compared to higher tube potentials (120 and 100Sn). With a dose level as low as 0.09 mGy, ULD-CT images displayed in the MIP format provided sufficient image quality to visualize the PICC line, with additional 3D information to identify the PICC tip location compared to a SPR image.

CONCLUSION

SPRs with low tube potentials and sharp kernels can improve the visibility of a PICC line, while ULD-CT at an equivalent low dose level can provide 3D PICC localization information.

CLINICAL RELEVANCE/APPLICATION

PICC line malposition can be identified with an SPR scan using optimized tube potential and kernel. ULD-CT is an alternative method that may provide more accurate localization than SPRs.

PH215-SD-WEA2 Improvement of Nodule Classification Using Domain-Transformed Chest X-Ray Images

Station #2

Participants
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Grant, Canon Medical Systems Corporation
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PURPOSE

Training of convolutional neural networks generally requires a large dataset. However, collection of labeled clinical samples can be difficult. Although use of the pretrained networks with a large natural image dataset is considered effective, high level features may be better extracted using medical images. The purpose of this study is to improve classification of lung nodules in CT images using simulated samples generated by domain transformation from chest x-ray images with a generative adversarial network (GAN).

METHOD AND MATERIALS

Lung CT dataset used in this study consisted of 995 cases. For each nodule, a region of interest at the central slice was extracted. They were randomly split into training, validation, and test sets. The training set consisted of 278 primary cancers, 131 metastases, and 190 benign nodules, and validation and test sets each consisted of 91 primary cancers, 43 metastases, and 64 benign nodules. Simulated nodule images were generated using a cycle GAN, which was trained with unpaired nodules in CT and chest x-ray images. The network consisted of 2 sets of a generator based on the residual network and a discriminator with 5 convolutional layers. For CT images, 599 nodules in the training set were used, whereas for the plain images, 123 nodule images from the Japanese Society of Radiological Technology (JSRT) database were employed. After training, remaining 31 nodule images from the JSRT database were used as input data, and the output CT-like images by domain transformation were used as additional training data for classification network. Our baseline network for classification between benign and malignant nodules was a residual network. The network was trained with original images only, augmented samples by rotation and flipping, and mixed samples with the generated images.

RESULTS

The classification accuracies using the original data, augmented data, and simulated mix data were 62.6, 66.7, and 68.2%, respectively. The test AUC was slightly improved from 0.60 with the original data only to 0.67 with the augmented samples and 0.69 with the generated mix samples.

CONCLUSION

The proposed method can be useful for improving CNN training when the training samples are limited.

CLINICAL RELEVANCE/APPLICATION

Computerized classification system can assist radiologists in the diagnosis of lung cancer.

PH216-SD-WEA3 Novel Ultrahigh-Resolution CT Using a CMOS Detector Built on a Conventional Multislice CT Scanner's Detector

Station #3

Participants
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PURPOSE

We developed an ultrahigh-resolution (UHR) CT system constructed by adding a high-resolution CMOS detector with a 0.1-mm pixel pitch to a 16-row multislice (MSCT) scanner. The purpose of this study was to evaluate the performance of the UHR-CT compared with a 64-row MSCT.

METHOD AND MATERIALS

A dedicated handmade base was mounted on the detector of a 16-row MSCT, and the CMOS detector (1536 channels, 68 rows) was installed on it. To prevent the geometric unsharpness with the 0.8-mm focal spot of the MSCT, a contact geometry with a focal spot-to-detector distance of 635 mm was used. The rotation speed was 1.5 s/rot., and the dose level was set to CTDIw of 4 mGy. CT images were reconstructed by filtered back projection. Comparative images were obtained at the same radiation dose using a 64-row MSCT. Thin metal wire and 100-mm cylindrical water phantoms were scanned for measurements of the modulation transfer function (MTF) and noise power spectrum (NPS), respectively. The system performance functions (SPFs), based on the prewhitening theorem, were calculated from the results of MTF and NPS. In addition, foot and head phantoms were scanned, and the trabecular bone and inner ear structure were visually checked.

RESULTS

The 10% MTF value was 2.7 mm-1, which was notably higher than the 0.99 mm-1 of the 64-row MSCT. SPF was inferior to MSCT by 20%-30% at low frequencies. The relationship was reversed at more than 0.5 mm-1 and the superiority was continued to 3.0 mm-1, while MSCT's was limited to 1.0 mm-1. The UHR-CT clearly visualized fine trabecular bone structures and auditory ossicles, unlike MSCT.

CONCLUSION

The UHR-CT system, which enabled ultrahigh-resolution scan by simply attaching a CMOS detector to a conventional MSCT system, provided notably higher-resolution images compared with conventional MSCT. The feasibility of this type of UHR-CT was indicated through the investigation.

CLINICAL RELEVANCE/APPLICATION

Fine anatomical structures of bones and the inner ear, which have not been sufficiently visualized by conventional MSCT scanners, can be clearly visualized by this UHR-CT.

Participants PH260-SD-WEA4

Identification and Assessment of Scan Frequency and Cumulative Radiation Exposure in Repeated CT Scans: A Retrospective Cohort Study

Station #4

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PURPOSE

To identify and assess the scan frequency and cumulative radiation exposore in repeated CT scans on a large cohort of patient populations undergoing various protocols in an academic enterprise.

METHOD AND MATERIALS

This IRB-exempt study evaluated CT examinations performed in 2016, 2017, and 2018 by 30 scanners from two vendors with 14 models over three site hospitals in an academic enterprise. An in-house developed informatics system, called 'METIS', automatically collected and extracted scan information (protocol and dose) and patient demographics data from the PACS and electronic health record (EHR) systems. The scan frequency and cumulative effective dose (E) for each unique patient were then calculated. K-factors from the AAPM TG-96 were adopted. For young patients (age<18) with higher scan frequencies, scan interval and protocols adopted were further investigated.

RESULTS

300,000 CT studies on 120,000 patient (ages 0 - 70 and sizes 6 - 50 cm) with 270 different CT protocols were analyzed. Over 45% patient received repeated scans with scan frequencies ranging from 2 to 68 times. The types of protocols adopted by each patient ranged from 1 to 14 and E were found up to 1,283 mSv (38.9 ± 45.8 mSv). 358 young patients were identified receiving over 4 time repeated scans within past three years and E ranged from 4.4 to 442 mSv (48.5 ± 44.9 mSv) from 94 protocols. 52 young patients received over 5 scans (E: 10.5 - 442.4 mSv) in a single month and 30 young patients received over 10 times scan within a calendar year (E: 25 - 442.4 mSv).

CONCLUSION

This study offers a practical data-driven solution for automatically identifying and assessing CT repeated scans and cumulative radiation exposure using a large cohort of patient data. A large proportion of patients were identified to undergo repeated scans thus received substantial radiation exposure, which outweighs the potential risk, especially for those who are young. The findings in this study enable prospective optimization of clinical practice to maximize the imaging benefit while minimize patient safety across the healthcare enterprise.

CLINICAL RELEVANCE/APPLICATION

The radiation dose delivered to patients becomes a particular concern, especially in young patients. The level of radiation is even compounded by repeated follow-up CT examinations throughout their life.

PH260-SD-WEA5

Performance of a First Dark-Field Chest X-Ray System on Patients

Station #5

Awards

Trainee Research Prize - Resident

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PURPOSE

To demonstrate - for the first time - the successful implementation of dark-field chest radiography on patients and thus, to provide a novel imaging tool that generates structure-sensitive information for an improved diagnostic assessment of the lung's physical condition.

METHOD AND MATERIALS

The study was approved by the institutional ethics review board and the federal office for radiation protection. A prototype scanner, capable of acquiring dark-field and attenuation chest X-rays has been developed and installed on site for a first, great extent study on COPD patients. The system is assembled from medical X-ray components such as source, collimator, flat-panel detector and an interposed three-grating interferometer. Prior to the measurement, the field of view is adjusted to the patient in order to properly cover the region under investigation. Similar to conventional chest radiography, the patient stands upright and is advised to hold breath for the duration of the scan. Within the scope of the currently ongoing study, a total number of 500 participants will be involved whereof 65 have already been investigated. The proband collective includes patients without lung disorders for reference and such with mild to severe stages of COPD. By help of a questionnaire, computed tomography and spirometry, the individual severity of the disease is assessed.

RESULTS

The dark-field and attenuation images are obtained simultaneously in one 7 s scan at an average effective dose of 0.04 mSv. Thus, the acquisition is compatible with clinical requirements. We found that healthy patients exhibit a distinct and homogeneous signal over the entire pulmonary region. Here, intact alveolar structure with lots of air-tissue interfaces induces strong small-angle scattering, resulting in a pronounced image representation of the lungs. In contrast, a weak signal is obtained for COPD patients, where parenchyma degradation prevails.

CONCLUSION

These preliminary results indicate that dark-field radiography is capable of probing the lung's underlying microstructure, which remains inaccessible with currently deployed medical imaging methods while it is highly affected by disorders such as emphysema, fibrosis or lung cancer.

CLINICAL RELEVANCE/APPLICATION

Particularly with regard to early detection of COPD, we consider the technique's transfer to a human application as breakthrough and expect it to become an invaluable tool in clinical routine.

PH261-SD-WEA6 Multichannel Image Restoration for Quantitative MRI

Station #6

Participants
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PURPOSE

In quantitative MRI, one often applies curve fitting to a series of images acquired under different conditions. The quality of the fit is sensitive to the noise level. We propose a method to take advantage of the similarity of the underlying structure to do a better job of jointly denoising a set of images.

METHOD AND MATERIALS

The Bayesian least squares estimate with Gaussian scale mixture (BLS-GSM) method is based on a statistical model of the coefficients of a basis which allows improved denoising by considering neighboring coefficients jointly rather than thresholding each coefficient independently. In this work a 3D dual-tree wavelet transform was used as the basis for the BLS-GSM approach. In the context of MR parameter mapping experiments, 'neighboring' pixels can also include neighbors at the same spatial location, but acquired with different contrast. An MR parameter mapping dataset is commonly 4D (3D spatial + 'channels' corresponding to separate measurements). BLS-GSM was applied both with and without joint multichannel denoising (images with 3 different flip angles). For comparison, three other established denoising methods were applied to each channel independently: non-local means (NLM), wavelet shrinkage (BayesShrink) and total variation (TV) denoising. 1.4 mm isotropic spoiled GRE brain magnitude data with high SNR was used as a ground truth reference. Data was collected under informed consent on a 1.5 T scanner. Gaussian noise was added (for MRI, real and imaginary components each have Gaussian noise). Fairly high noise was used in the presented example for better visualization of differences. Peak signal to noise ratio (PSNR) values were used as a comparison metric. For NLM and TV denoising, manual optimization over hyperparameters was performed. Wavelet and BLS-GSM approaches required no tuning (only an estimate of the noise variance).

RESULTS

The BLS-GSM approach performed best with PSNR=33.66 and 34.51 when applied without and with joint multichannel denoising. NLM, Wavelet and TV gave PSNR values of 32.79, 30.80 and 31.64 respectively.

CONCLUSION

BLS-GSM denoising gave the best result and requires no manual tuning.

CLINICAL RELEVANCE/APPLICATION

A method of jointly denoising a series of images as acquired in quantitative MRI parameter mapping is presented. The goal is to enable improved fits for a range of quantitative MRI experiments.

PH135-ED-WEA7

Sonar to the Rescue: Curb Ionizing Radiation with Application of Contrast-Enhanced Ultrasound and Elastography/Controlled Attenuation Parameter Techniques

Station #7

Participants

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TEACHING POINTS

1. To provide a comprehensive approach to understanding the physical and clinical aspects of new ultrasound techniques: Contrast-enhanced Ultrasound (CEUS) and Elastography/Controlled Attenuation Parameter (CAP). 2. To understand how to adequately perform CEUS and Elastography/CAP. 3. To elucidate potential pitfalls and artifacts inherent to both CEUS and Elastography/CAP.

TABLE OF CONTENTS/OUTLINE

1) Highlight clinical indications for using CEUS and Elastography/CAP techniques: 1a) CEUS: Obviates need for iodinated and gadolinium-based contrast agents, for example, in MRI unsafe patients. 1b) Elastography/CAP: Inexpensive method to assess liver fibrosis and hepatic steatosis without liver biopsy. 2) Review relevant underlying physics: 2a) CEUS: Microbubble structure and physical characteristics that create the ultrasound image. 2b) Elastography/CAP: Physics of 2D shear wave elastography and CAP. 3) Performing the studies and recognition of common artifacts and pitfalls: 3a) Provide a pictorial step-by-step instructional guide for each technique. 4) Sample cases highlighting the clinical utility with interpretation of results: 4a) CEUS: Benign and malignant processes along with non-conventional uses. 4b) Elastography/CAP: Elastogram and CAP value analyses and report interpretation.

PHS-WEB

Physics Wednesday Poster Discussions

Wednesday, Dec. 4 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
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Sub-Events

PH211-SD-WEB1 Organ Dose Evaluations for Individual Patients in Chest-Abdomen-Pelvis CT Examinations Using Deep Learning-Based Automatic Segmentation

Station #1

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PURPOSE

Organ dose evaluations with dose distribution images obtained as Monte Carlo (MC) simulation results for individual patients undergoing CT examinations require region of interests (ROIs) delineating each imaged organ. However, it takes more time and effort to manually draw the ROIs. The aims of this study are to perform automatic organ segmentation with deep learning methods and to validate organ doses determined with the automatically segmented images for individual patients in routine chest-abdomen-pelvis (CAP) CT examinations.

METHOD AND MATERIALS

Automatic segmentation of lung, liver, and bladder was performed with U-net convolutional neural network which was trained with CT images of 50 patients (2,633 images for lung, 1,475 images for liver, and 484 images for bladder) and was tested on CT images of 5 patients. Performance of the automatic segmentation was evaluated on Dice coefficient overlap with the manual segmentation. Dose simulations were performed by inputting the voxelized models created from data set of the 5 patients, detailed descriptions of an Aquilion ONE CT scanner (Canon Medical Systems), and CT scan parameters into MC simulation software ImpactMC (Advanced Breast CT). Organ doses for lung, liver, and bladder were evaluated by setting each organ ROI from automatic and manual segmentation on the dose distribution images obtained as the simulation results. The organ doses determined with the automatically segmented images were also compared with those with the manually segmented images.

RESULTS

Trained U-Net had average dice coefficients of 0.82 for lung, 0.63 for liver, and 0.53 for bladder on the test set. Organ doses for these organs determined with the automatically segmented images agreed with those with the manually segmented images to within approximately 4% for lung, 7% for liver, and 6% for bladder.

CONCLUSION

Organ doses determined with the automatically segmented images obtained using trained U-net showed good agreement with those with the manually segmented images.

CLINICAL RELEVANCE/APPLICATION

Automatic organ segmentation with deep learning methods will be useful for real-time and accurate organ dose evaluations for individual patients in CAP CT examinations.

PH217-SD-WEB2 Quantitative Analysis of Hepatic Fibrosis and Adiposity Using Intravoxel Incoherent Motion and Magnetic Resonance Spectroscopy

Station #2

Participants
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PURPOSE

To investigate diffusion parameters in intravoxel incoherent motion (IVIM) analysis and determine relationships with proton magnetic resonance spectroscopy (1H-MRS) and hepatic fibrosis serum biomarkers.

METHOD AND MATERIALS

Thirty-seven subjects, 8 with a liver fat fraction (FF) > 5% and 29 normal (N) subjects, were studied retrospectively. A 3 T abdominal MRI examination, with an intravoxel incoherent motion (IVIM) sequence (multi-band factor=3, and SPAIR; 8 b-values: 0, 10, 20, 60, 150, 250, 500, and 800 s/mm2) and 1H-MRS (volume=(20 mm)3, TR=2000 ms, TE=20-35 ms, TM=10 ms) to quantify hepatic steatosis. Fasted serum was collected and blood tests included a complete blood count, metabolic, lipid, and liver panels. The fraction of fast-diffusion (f), fast-diffusion (Df), and slow-diffusion (Ds) were calculated from the IVIM images using nonlinear least-squares fitting. T2 corrected FF were fitted using AMARES in jMRUI. Two-sided t-tests were used to compare MRI data. Spearman correlation was applied to evaluate associations.

RESULTS

The f values were significantly higher in subjects with fatty liver compared to normals (0.25±0.08 vs 0.19±0.07, p=0.02). Neither Df or Ds were found to be significantly different between groups. The FF was significantly correlated with alanine aminotransferase (ALT,ρ=0.42,p=0.01), aspartate aminotransferase (AST,ρ=0.39,p=0.02), and low-density lipoprotein (LDL) cholesterol levels (ρ=0.36,p=0.03). ALT levels and Ds were significantly correlated (ρ=-0.39,p=0.03). A significant negative correlation was found between albumin levels and the f (r=-0.46, p=0.007). A multivariate linear model for the f with weight, alkaline phosphatase, and albumin levels as factors was cross-validated 3-fold with a residual sum-of-squares of 0.004, adjusted R2=0.352, and p=0.002.

CONCLUSION

Significant correlations with serum measures suggest the viability of a role for diffusion weighted imaging to assess structural changes in liver parenchyma. Future studies will continue to investigate the predictive power of these imaging biomarkers in relation to steatosis and fibrosis.

CLINICAL RELEVANCE/APPLICATION

As the incidence of fatty liver continues to rise, so too does the importance of accurate assessment of reversible fibrosis. Biopsy, an invasive method prone to sampling bias, remains the gold standard for diagnosis. This data illustrates the potential for IVIM imaging and MRS to non-invasively assess steatosis and fibrosis.

PH219-SD-WEB3 Dosimetric Validation of 3D Printed Quality Assurance Phantoms and Gynecologic Applicators for High Dose Rate Brachytherapy

Station #3

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CONCLUSION

3D printing applicators for patient specfic use is a viable way to deliver HDR brachytherapy. It is recommended that the material used in the 3D printer be validated dosimetrically prior to use as applicator material.

Background

High dose rate (HDR) brachytherapy is used for patients where a high dose to the tumor is desired but it is essential to spare dose to normal tissue. Due to variabilities in patient anatomy, often the available applicator does not match the ideal one. 3D printing could solve this problem; however, for these applicators to be used for treatments, a rigorous dosimetric analysis is required for both the material being used and the applicators themselves.

Evaluation

Three calibration cubes with different densities were designed and 3D printed with the catheter insert placed such that dose could be measured at a 5mm, 10mm, 15mm and 20mm distance from the source. Five cylinders with the same radii as those from Elekta Brachytherapy were printed with a channel in the center for the catheter. Oncentra Brachy software was used to create simple dose distribution plans for the 3D phantoms and cylinders and also for the Elekta cylinders. Gafchromic EBT3 film and Landauer NanoDots (OSLDs) were placed on the surfaces of the cube phantoms and cylinders and the plans were delivered. The NanoDots were read with a non-linear calibration on a Landauer Microstarii dosimeter and the film was analyzed in Matlab using a calibration curve made for the film batch with the brachytherapy source used.

Discussion

The measured values for the QA phantoms were consistent regardless of the amount of material used to fill the cubes. This is shown in figure 1 - a graph of nanodot measured versus expected dose readings for the three different cubes. This means that to save on material costs and printing time, a lattice technique can be used to print patient applicators. Further, the dose through the 3D printed cylinder applicators was more consistent with the expected measurements than the dose through the Elekta applicators. This is shown in figure 2 - a graph of film and OSLD measurements through the printed and Elekta cylinders. The film dose should be higher due to 0.5mm buildup in the nanodots.

PH218-SD-WEB4 A Data-Driven Approach to Setting Radiation Dose Notification Values for CT That Can Be Used in Dose Management Software Applications

Station #4

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PURPOSE

The purpose of this research is to propose a new data-driven method for setting radiation dose notification values that accounts for patient size

METHOD AND MATERIALS

Data were collected from CT exams of the chest, abdomen, and pelvis with contrast enhancement, which was performed from March 1, 2018 to February 28, 2019. Aquilion ONE and Aquilion ONE / ViSION (Both Canon Medical Systems, Tochigi) CT scanners were used. The CT-RDSR file (CTDIvol, DLP) of each cases were transferred to Workstation (Vitrea) and analyzed using a radiation dose management solution (Vitality XT, Canon Medical Systems). Based on single regression analysis data in the dose indices (CTDIvol, DLP) for body weight, the predicted upper limit (95%) for each body weight (20 to 120 kg, 1 kg interval) was calculated and a regression analysis was performed.

RESULTS

A total of 7,354 cases were collected with 3,323 and 4031 cases collected from the ONE and ONE/ViSION, respectively. For ONE scanner, the relationship between body weight and dose indices is described by the linear equation (CTDIvol: y=0.386x-4.628, DLP: y=34.15x-610.93), and a strong correlation (CTDIvol: γ=0.889, DLP: γ=0.924) was observed. Further, the regression equation of the upper limit predicted value (95%) to the weight was y=0.391x-0.312 for CTDIvol and y=34.52x-303.06 for DLP. Among the exams investigated, 111 (3.3% of total) and 122 (3.7% of total) cases exceeded the upper limits for CTDIvol and DLP, respectively. The relationship between body weight and dose indices was similarly linear in the ViSION, and a strong correlation (CTDIvol: γ=0.884, DLP: γ=0.918) was observed. In addition, the regression equation of the upper limit of prediction for body weight (95%) was y=0.476x-6.262 for CTDIvol and y = 40.68x-732.31 for DLP. Among the exams investigated for ViSION, 124 (3.1% of total) and 122 (3.0% of total) cases exceeded the upper limits for CTDIvol and DLP, respectively.

CONCLUSION

Based on regression analysis of patient weight and dose indices, we proposed a new method to set the upper limit for each weight for both CTDIvol and DLP. In this method, the notification value function is activated only when it is statistically significant (5%) from the past cases in each institution.

CLINICAL RELEVANCE/APPLICATION

Setting a notification value tailored to each patient's size allows sites to identify cases where the dose is clearly higher than usual while taking into account the patient size.

PH263-SD-WEB6 Assessment of Intraductal Carcinoma in Situ with Grating-Based Phase-Contrast Computed Tomography

Station #6

Participants
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PURPOSE

To investigate the potential of grating-based phase-contrast computed tomography (GBPC-CT) using clinical X-ray sources for tomographic margin assessment of intraductal carcinoma in situ (DCIS) samples.

METHOD AND MATERIALS

X-ray grating-based phase-contrast computed tomography is an emerging X-ray imaging method, which is based on X-ray refraction in contrast to conventional attenuation-based CT. Originating from large synchrotron research facilities, the technique has been successfully translated to clinical settings. GBPC-CT uses a three-grating interferometer in combination with a clinical X-ray source and detector. In addition to the conventional attenuation image, GBPC-CT provides an X-ray phase-contrast image related to the electron density and thus allowing for much higher soft-tissue contrast compared to the corresponding attenuation image. In this ex-vivo study, we used the high soft-tissue contrast property of GBPC-CT (40 kV, 60 mA) to investigate the extent of intraductal carcinoma in situ, which is commonly underestimated due to discontinuous growth and lack of microcalcifications. Specimen radiography has been established to reduce the rate of re-excision. However, the predictive value for margin assessment with conventional specimen radiography for DCIS is low. The ex-vivo study presented here included four samples containing DCIS and invasive carcinoma of non-specific type. The samples were of maximum 3 cm in diameter, excised of tumor-bearing areas, and fixed with 4% formaldehyde solution. Histopathologic workup was performed using standard protocols. Relevant tomographic phase-contrast and attenuation slices were matched with histology being the standard of reference.

RESULTS

The CT data was successfully matched with histology. The GBPC-CT data provided improved soft tissue contrast in comparison to attenuation-based images and more histological details are revealed in the same phase-contrast slices. Non-calcifying DCIS exceeding the invasive tumor could be correlated with areas of dilated bright ducts around the tumor.

CONCLUSION

The GBPC-CT results allowed for an improved depiction quality in contrast to corresponding attenuation-based images, the identification of diagnostically relevant tissue details, and a full three-dimensional sample margin assessment.

CLINICAL RELEVANCE/APPLICATION

Grating-based phase-contrast CT realized in a clinical setting will improve DCIS diagnosis.

PH264-SD-WEB7 Cumulative Radiation Risk for Multiple CT Examinations: A One-Year Survey For a Large Multi-Specialist Hospital

Station #7

Participants
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CONCLUSION

Dose tracking systems allow to quickly identify frequency of recurrent CT examinations among patients with high cumulative dose and to drive optimization actions to reduce the radiation risk.

Background

To investigate the highest cumulative radiation risks consequent to multiple CT examinations performed in a large multi-specialist hospital over the course of one year.

Evaluation

During the whole year 2018, a total of 61743 CT studies were executed on 11 different CT equipments. All the radiation dose structured reports (RDSR) were collected by a radiation dose monitoring system (Physico, EMME ESSE). For each scan, organ and effective doses were estimated by the software Virtual CT. A focused investigation of the diagnostic paths associated to high cumulative doses was performed for all the patients with cumulative DLP above 10000 mGy cm and effective doses above 100 mSv. For the same sample, radiation risks were calculated by means of the PCXMC software using the integrated tool based on the BEIR VII approach.

Discussion

33536 patients received more than one MDCT study, 4748 more than 5 studies and 634 more than 10. Cumulative DLP values above 10000 mGy cm (maximum 30750 mGy cm, corresponding to 27 examinations) were observed for 76 patients, whereas effective doses above 100 mSv (maximum 377 mSv) were associated to repeated examinations of 101 patients. Most of these were patients scanned for cancer or trauma. Estimated risks of exposure-induced cancer death (REID) were in the range 0.3 -1.4%. Since a large number of examinations are repeated head CT, high cumulative DLP values and/or high number of CT acquisitions are not always correlated to high risk values.

PH136-ED-WEB8 Triple-Rule-Out CT Angiography on 16cm Wide-Detector CT with Dual-Energy Spectral Mode: How to Obtain More (Information) with Less (Dose)

Station #8

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TEACHING POINTS

To illustrate limitations of conventional triple-rule-out CT Angiography (TRO-CTA);To illustrate advantages of 16cm wide-detector CT with dual-energy spectral imaging in TRO-CTA;To demonstrate strategies of applying dual-energy spectral imaging in TRO-CTA to obtain more information; with less contrast and radiation doses

TABLE OF CONTENTS/OUTLINE

Limitations of conventional TRO-CTA:1)High radiation and contrast doses2)Only anatomic information and often at suboptimal phases3)Often limited by high or unstable heart ratesAdvantages of wide-detector CT with dual-energy: 1)Various energy levels for balancing contrast and image noise2)Iodine maps for detecting lung perfusion defects3)High-pitch helical with 8cm detector for fast lung and 16cm axial for one heartbeat coronary imaging4)2nd-generation iterative reconstruction algorithm for noise control Optimization Strategies:1)High-pitch spectral CT for lungs in 1sec to include COPD patients at low radiation dose2)Proper low keV to improve enhancement at low contrast dose3)Iodine maps to detect perfusion defects for more accurate Pulmonary Embolism diagnosis4)Prospective-trigging axial scan for one heartbeat, low dose coronary imaging for all heart rate patients 5)Low kVp for aorta to reduce contrast dose requirement6)Iterative reconstructions to reduce image noise at low dose

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SSM23

Physics (Radiation Therapy/Outcome Modeling/Image Processing)

Wednesday, Dec. 4 3:00PM - 4:00PM Room: S102CD

PH RO

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

FDA Discussions may include off-label uses.

Participants
Carri Glide-Hurst, PHD, Detroit, MI (*Moderator*) Researcher, ViewRay, Inc; Research Consultant, Koninklijke Philips NV; Researcher, Koninklijke Philips NV; Researcher, Modus Medical Devices Inc; Equipment support, Medspira, LLC; Equipment support, QFix
Cem Altunbas, PhD, Aurora, CO (*Moderator*) Nothing to Disclose

Sub-Events

SSM23-01 Normalizing the Response of a Fixed Geometry EPID Using a Flattening Phantom on a Ring Gantry Linear Accelerator

Wednesday, Dec. 4 3:00PM - 3:10PM Room: S102CD

Participants
John Chapman, Baton Rouge, LA (*Presenter*) Research funded, Varian Medical Systems, Inc
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CONCLUSION

Based on our results, it is possible to characterize pixel variations by designing a phantom that flattens the beam at the EPID. In the near future, this phantom will be milled to validate the flatness of the beam at the level of the EPID. Finally, the EPID response under this flattening phantom can be directly used as the new "flood field" to correct the pixel response variations.

Background

Previous solutions that calibrated the variations of pixel response for the EPIDs on-board C-arm linacs used either a flat beam or a movable EPID panel. However, the Halcyon (Varian Medical Systems, Palo Alto, CA) is a ring gantry linac with a 6 MV flattening-filter-free (FFF) beam and an EPID rigidly fixed to the gantry. Therefore, this study introduces a strategy to design a beam flattening phantom, which is intended to calibrate the variations of pixel response while preserving the beam dosimetry features on EPID images derived from the Halcyon linac.

Evaluation

EPID images were acquired by irradiating a set of rectilinear solid water phantoms with various thicknesses (0-15 cm). Each solid water phantom was placed at the same position on the couch with a fixed source-to-couch distance (100 cm) and an open field set at the maximum size of 28 cm x 28 cm. Based on the EPID response as a function of solid water thickness, a quadratic form of the attenuation equation was fit with 2D parameter maps, a(x,y) and ß(x,y), which represent the first- and second- order attenuation of a poly-energetic beam. With the 2D attenuation coefficient maps and the ratio of ideal EPID response of the 6FFF beam to a flattened beam, a 2D phantom thickness map was derived.

Discussion

On the central-axis, the beam required 66% attenuation for the flattening phantom. The final flattening phantom design had an overall conical shape with a maximum thickness of 5.6 cm, making it economical and lightweight. Regression values for the linear fits used in our approach ranged between 94% and 95% with a maximum absolute fit error of 0.0083.

SSM23-02 Proton-Induced Acoustic Computed Tomography for Online Proton Beam Range Verification

Wednesday, Dec. 4 3:10PM - 3:20PM Room: S102CD

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PURPOSE

To localize the proton Bragg Peak by measuring the acoustic emissions generated by a pulsed proton spill from a clinical synchrocyclotron, ideally in real-time and noninvasively during patient treatment.

METHOD AND MATERIALS

A proton-induced acoustic computed tomography system based on 1MHz two-dimensional matrix array ultrasound probe with 256-elements, a 256-32ch switch and a parallel data acquisition system has been developed. The matrix array will now be placed in a water tank in front of the proton nozzle which enables rendering of the proton-induced acoustic images without mechanical scanning. The data acquisition will be synchronized by a trigger signal provided by the MEVION S250i Hyperscan proton therapy system. The digitized data will then be sent to the computer for real-time processing to generate proton-induced acoustic images with a full-field 3D filtered back-projection algorithm.

RESULTS

Hyperscan system has pulse width modulation from 0.5 to 20 us. On average, a full energy (230 MeV) pulse of 6.5 us produces 8 pC (~5x 10^7 protons) and deposits 3.2 cGy under Bragg peak. The total dose distribution of scanned proton pencil beams was simulated. The maximum spatial resolution of the proton-induced acoustic computed tomography was calculated to be about 1 mm, which is much better than the current range verification techniques proposed, for example, positron emission tomography and prompt gamma imaging. In addition, the proton-induced acoustic computed tomography system can obtain 50 frames of images per second without scanning, which means real-time in vivo images could be obtained during treatment to ensure the delivered dose distribution is as expected.

CONCLUSION

These results highlight the excellent prospect of the proton-induced acoustic computed tomography in clinical transformation providing the Bragg peak location, and monitoring proton dose distribution during radiation therapy.

CLINICAL RELEVANCE/APPLICATION

Proton-induced acoustic computed tomography provides real-time feedback with the possibility of adjustment during the treatment which reduces proton range uncertainty and improves the treatment output.

SSM23-03 Improving CBCT Quality to CT Level for Adaptive Radiation Therapy Using Deep-Learning with Generative Adversarial Network

Wednesday, Dec. 4 3:20PM - 3:30PM Room: S102CD

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PURPOSE

To apply a deep-learning based algorithm to improve CBCT image quality and HU accuracy for extended clinical applications, especially for adaptive radiotherapy for proton and photon treatments.

METHOD AND MATERIALS

Data from 150 pelvic patients with paired planning CT and CBCT were used in this study. All CT images were collected in GE LightSpeed VCT scanner and CBCT images were acquired with Varian Truebeam. A 2.5D pixel to pixel generative adversarial network (2.5D GAN) model with feature matching (FM) loss was trained to translate from a source domain (CBCT) to a target domain (dCBCT). Image pre-processing including denoising and suppressing non-uniformity by a non-local means method. Registration was applied to map the planning CT to CBCT using Velocity and worked as the ground-truth CT. A total of 10800 slices were used for training and validating the GAN-based model, while 1200 slices of CT and CBCT were used for testing. The obtained deep-learning based CBCT were compared to ground-truth CT in terms of mean absolute error (MAE) in Hounsfield Unit (HU) and peak signal-to-noise ratio (PSNR), and compared with other deep learning methods, including U-net, 2D GAN without FM, 2.5D GAN without FM, 2D GAN with FM.

RESULTS

A 10-fold cross-validation was used to evaluate the deep-learning algorithm. The mean MAE improved from 26.1±9.9 HU (CBCT vs. CT) to 8.1±1.3 HU (dCBCT vs. CT) for all 1200 test slices and the PSNR also increased from 16.7±10.2 (CBCT vs. CT) to 24.0±7.5 (dCBCT vs. CT). The experiments were performed on a GPU-optimized workstation with a single NVIDIA GeForce GTX Titan X (12GB, Maxwell architecture) and written in Python 3.5. After training the model, each slice took 11-12 ms to process and a 3D-volume of the dCBCT (80 slices) could be generated in less than one second.

CONCLUSION

We presented a deep-learning based algorithm to improve CBCT image quality close to the level of CT in a time efficient manner which opens up the possibility for online CBCT-based adaptive radiotherapy.

CLINICAL RELEVANCE/APPLICATION

The presented method is also promising as the improved quality CBCT scan can achieve close HU density to CT, thus have the potential to be used for adaptive planning.

SSM23-04 Evaluating the Complimentary Role of Pseudo-STIR in Assessment of Hyperintense Marrow Lesions as Compared to T2-STIR

Wednesday, Dec. 4 3:30PM - 3:40PM Room: S102CD

Participants
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PURPOSE

T2W weighted images contain inherent T1W weighted contrast. Pseudo-STIR images are generated by a simple post processing technique of subtracting T1W images from the T2W images. In this study we probe the diagnostic value of Pseudo-STIR to identify hyperintense marrow lesions in comparison with T2 STIR sequences.

METHOD AND MATERIALS

117 spine MR cases with sagittal T1FSE (n=85) or T1 FLAIR (n=32), T2W and STIR images from studies performed on 1.5T and 3.0T machines were extracted from PACS. The Pseudo-STIR images were created on an Osirix workstation by using the subtraction tool. The resulting 234 sets of STIR and Pseudo-STIR images were anonymized and blindly read by three independent Radiologists (R1, R2, R3 with 13 years, 16 years and 32 years of experience) with respect to the number of hyperintense lesions seen. The quality of study, and the confidence level of the observer in rating the lesions were also encoded. Accuracy for each Pseudo-STIR case was determined based on the observers' ability to match their independently reported count of the corresponding STIR Image.

RESULTS

The accuracy of the observers in reporting the count of hyper intense lesions in the Pseudo-STIR cases was reasonably good (R1: 69 %, R2: 78 %, R3: 64 %). The accuracy increased when the observers reported on cases where they assigned the highest image quality rating of three. All three reporters were more accurate while reporting cases that they gave the highest confidence rating of three (R1: 75 %, R2: 80 %, R3: 69%). It was observed that only two out of 117 cases (both T1 FLAIR derived Pseudo-STIR) were incorrectly marked by all three observers. Additionally, there was no significant bias in quality rating (at the highest rating of three) with respect to the Pseudo-STIR origin, with R1 (76% / 24 %), R2 (77 % / 23 %) and R3 (69 % / 31 %) scoring in line with the data distribution (73% / 27%). Finally, statistical testing for difference in accuracy based on Pseudo-STIR origin (T1FSE / T1 FLAIR), revealed no difference in each of the three observers.

CONCLUSION

These results point to the value offered by including STIR sequence in an MSK protocol. In the absence of a specific view plane, a Pseudo-STIR provides supporting evidence.

CLINICAL RELEVANCE/APPLICATION

In this study, we demonstrate potential complimentary value offered by a simple post processing technique especially in situations where the STIR sequence is not obtained prospectively

SSM23-05 Prediction of Cervical Nodal Metastasis Using Primary Head and Neck Cancer Tumor Deep Features Extracted from Dual-Energy CT Color Iodine Maps

Wednesday, Dec. 4 3:40PM - 3:50PM Room: S102CD

Participants
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PURPOSE

Establish whether convolutional neural networks (CNNs) pre-trained on everyday color images can be repurposed for prediction of lymphadenopathy based on primary tumor characteristics alone, using dual-energy CT color iodine maps.

METHOD AND MATERIALS

The dataset comprised 84 patients with head-and-neck squamous-cell-carcinoma. DICOM images of the central tumor slice (8 bits in each RGB channel) were converted to PNG format. The part of each image outside the tumor was made black. Images were cropped to the sizes appropriate for use with pre-trained CNNs. Three feature extraction methods (a method being defined by a CNN and a layer within it) were used: Alexnet 'fc6', Alexnet 'fc7', and Resnet18 'pool5'. This produced 4096, 4096, and 512 features, respectively. In all 3 cases, LASSO (variable selection and model building using L1 regularization) was used to choose a minimal set of features that are combined linearly to build a prediction model. The chosen λ parameter minimized the mean-squared-error (MSE). Performance metrics based on 4-fold cross validation were obtained. The reduced feature was fed to the t-distributed Stochastic Neighbor Embedding (t-SNE) algorithm to reduce dimensionality to 2 and illustrate the patients with positive and negative outcomes using a scatter plot.

RESULTS

LASSO chose 3 features for Alexnet 'fc6', 11 features for Alexnet 'fc7', and 7 features for Resnet18 'pool5'. Alexnet 'fc6' had accuracy = 0.76, sensitivity = 0.74, specificity = 0.79, and AUC = 0.86. We report the performance of the most parsimonious model (3 features) as it is least likely to suffer from over-fitting. The left figure shows how the λ parameter was chosen. The right figure shows the 2D representation of the cohort as obtained using the t-SNE algorithm. The hand-drawn line shows a separation accuracy consistent with what was reported.

CONCLUSION

To the best of our knowledge, this is the first demonstration that color iodine maps can be analyzed using pre-trained CNNs to for tumor characterization beyond what is currently done in clinical practice. The results need to be corroborated with external validation.

CLINICAL RELEVANCE/APPLICATION

This first successful demonstration of using iodine maps as color images to produce a quantitative biomarker using deep learning could lead to superior utilization of these maps.

SSM23-06 Imaging-Based Survival Prediction of Liver Cancer Patients Using Cox Proportional Hazard Models with Quantitative Texture and Shape Features

Wednesday, Dec. 4 3:50PM - 4:00PM Room: S102CD

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CONCLUSION

Our method can be applied to construct the imaging feature-based staging system which can predict the survival rate more accurately than the conventional TNM staging. *(This work was supported by Radiation Technology R&D program through the NRF of Korea (NRF-2017M2A2A7A02070427))*

Background

Prediction of survival period of liver cancer patients is an important task for treatment and therapy planning of patients. However, most of the current survival prediction depends on clinical information such as tumor size and metastasis. In this work, we propose a survival prediction system for liver cancer patients using quantitative imaging features including texture and shape features of tumors. In addition to the validation of the feasibility of imaging features for survival prediction, we analyze the key imaging features significantly affecting the survival of patients.

Evaluation

Our method was evaluated on a CT dataset acquired from 171 liver cancer patients with survival period recordings. All tumors were manually segmented by the clinical expert. From the tumor ROI images, the quantitative imaging features of 128-dimensions consisting of 119 texture features and 9 shape features. The Cox proportional hazard function was then fitted with those imaging features and survival periods. From the fitted Cox model, the features with the highest exponent weights were considered as key features for the survival. In experiments, the survival function was marginally fitted with the imaging-feature-based Cox model, which indicates the imaging features have a potential for survival prediction. In addition, the texture features including LBP and GLRLM low run features and the shape features including solidity and eccentricity were selected as the key features for the patient survival.

Discussion

The proposed method investigates the usefulness of quantitative imaging features instead of conventional patient information to predict time-variant survival in liver cancer patients. Throughout the Cox model fitting with imaging features, it was observed that the entropy-related texture features and size-related shape features have a significant effect on the prediction of the survival period.

ED013-TH

Physics Thursday Case of the Day

Thursday, Dec. 5 7:00AM - 11:59PM Room: Case of Day, Learning Center

AMA PRA Category 1 Credit ™: .50

Participants

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TEACHING POINTS

The physics case of the day questions and supplemental material will challenge the learner to combine their basic physics understanding with real clinical scenarios to explain a feature on an image.

Printed on: 10/29/20

RC621

Innovations in Medical Imaging Physics with Deep Learning

Thursday, Dec. 5 8:30AM - 10:00AM Room: E353B

AI PH

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

FDA Discussions may include off-label uses.

Participants

Guang-Hong Chen, PhD, Madison, WI (*Coordinator*) Research funded, General Electric Company
Lifeng Yu, PhD, Rochester, MN (*Coordinator*) Nothing to Disclose

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LEARNING OBJECTIVES

1) To cover machine learning demystified from a physicist's perspective. 2) Teach 'machine' to reduce image noise in CT. 3) Teach 'machine' to remove image artifacts in CT. 4) Teach 'machine' to reconstruct images.

ABSTRACT

In this presentation, we will share with audience on how we can leverage the power of deep learning computational framework to improve image quality in CT fields. We will cover four aspects in this presentation to help audience get some sense on machine learning, deep learning, artificial intelligence in medical CT.

Sub-Events

RC621A Applications of Deep Learning in CT Image Formation

Participants
Guang-Hong Chen, PhD, Madison, WI (*Presenter*) Research funded, General Electric Company

RC621B Applications of Deep Learning in MRI and PET/MRI Image Formation

Participants
Fang Liu, PhD, Madison, WI (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Present a technical overview of DL in medical imaging and discuss some recent DL applications that successfully translate new learning-based approaches into performance improvement in MR and PET/MR imaging workflow. 2) Draw tightly connections between fundamental DL concepts and technical challenges in medical imaging. 3) Cover rapid image acquisition and reconstruction to image post-processing such as image segmentation and synthesis in MR and PET/MR. 4) Discuss open problems in DL that are particularly relevant to medical imaging and the potential challenges and opportunities in this emerging field.

ABSTRACT

Medical imaging is a research field that remains lots of technical and clinical challenges. The recent development of Artificial Intelligence, particularly Deep Learning (DL), has demonstrated great potentials to resolve such challenges.

RC621C Applications of Deep Learning in CT Image Quality Evaluation

Participants
Lifeng Yu, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Review the state-of-the-art CT image quality evaluation methods and challenges. 2) Review the applications of deep learning-based methods in CT image quality evaluation.

RC622

Functional MR Imaging for Tumor Targeting in Radiotherapy

Thursday, Dec. 5 8:30AM - 10:00AM Room: E353A

MR PH RO

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

FDA Discussions may include off-label uses.

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

Sub-Events

RC622A State of the Art in Functional MR Imaging for Tumor Targeting

Participants
R. Jason Stafford, PhD, Houston, TX (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Identify some advanced and emerging MRI techniques which inform on tumor physiology and metabolism. 2) Explain the relevance of functional MR observations to basic underlying tumor physiology and biology. 3) Understand key limitations and tradeoffs of functional MR techniques for tumor assessment.

RC622B Clinical Need for Functional MR Imaging for Tumor Targeting in Radiation Therapy

Participants
Michelle M. Kim, MD, Ann Arbor, MI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the major limitations of anatomic imaging for tumor target delineation in radiation therapy. 2) Identify key physiologic and functional MRI techniques of value in radiation treatment planning. 3) Explain emerging concepts of radiation treatment-individualization using advanced MRI techniques. 4) Discuss the generalizability and application of advanced MRI techniques for radiation treatment planning.

RC622C Technical Challenges in the Integration of Functional MR Imaging for Tumor Targeting into Radiotherapy

Participants
Ning Wen, PHD, Detroit, MI (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

This presentation is going to review the technical challenges to integrate the functional MR Imaging into radiotherapy including the following aspects: 1) tumor characterization among different imaging modalities; 2) reproducibility of functional imaging across different institutions/scanners/protocols; 3) interpretation of imaging features extracted in the deep machine learning algorithms 4) precision to identify the boundary of the targets; 5) reliable imaging biomarkers to predict treatment response.

RC623

Optimization and Technology in Interventional Radiology

Thursday, Dec. 5 8:30AM - 10:00AM Room: S503AB

CT IR PH

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

FDA Discussions may include off-label uses.

Participants
Thaddeus A. Wilson, PhD, Madison, WI (*Coordinator*) Nothing to Disclose
William F. Sensakovic, PhD, Scottsdale, AZ (*Coordinator*) Founder, Telerad Physics Teaching, LLC

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LEARNING OBJECTIVES

1) Apply techniques to optimize dose in the interventional setting. 2) Identify opportunities where ionizing radiation can be replaced by ultrasound to guide interventional procedures. 3) To familiarize attendees with new CT interventional techniques that will open new fields of interventional procedures.

Sub-Events

RC623A Dose Optimization in the Interventional Suite

Participants
Robert G. Dixon, MD, Chapel Hill, NC (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Review the importance of dose optimization in the angiography suite. 2) Discuss basic concepts that will help to build a culture of safety at your institution. 3) Identify simple, practical steps that operators can take to protect patients, staff and themselves in the IR suite.

RC623B Using Ultrasound in Place of CT and Fluoroscopy in the Interventional Suite

Participants
Patrick Warren, MD, Columbus, OH (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Discuss skills, techniques, and pitfalls of invasive sonography. 2) Discuss basic skills involved in utilizing ultrasound guidance in lieu of CT fluoroscopy or conventional fluoroscopy during minimally invasive percutaneous procedures in order to minimize radiation exposure to patients and healthcare providers. 3) Incorporate these component skill sets into further life-long learning for expansion of competency and implementation into clinical interventional practice.

RC623C Advances in Interventional Use of CT

Participants
Frank Dong, PhD, Beachwood, OH (*Presenter*) Equipment support, Siemens AG; Software support, Siemens AG

LEARNING OBJECTIVES

1) To familiarize attendees with new CT interventional techniques that will open new fields of interventional procedures. 2) To describe the potential benefits of Cone Beam CT (CBCT) navigation to perform imaging guided tumor ablations. 3) To compare the radiation doses between CBCT used in interventional procedures and conventional CT.

Printed on: 10/29/20

RC625

Radiomics: Informatics Tools and Databases

Thursday, Dec. 5 8:30AM - 10:00AM Room: E352

BQ PH

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

Participants

Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

LEARNING OBJECTIVES

1) Understand the role of challenges in facilitating reproducible radiomics research. 2) Learn about past challenges and lessons learned. 3) Learn about best practices based on experiences from multisite challenges. 4) Review the meaning and importance of interoperability for quantitative image analysis tools. 5) Review specific use cases motivating interoperable communication of the analysis results. 6) Learn about the tools that support interoperable communication of the analysis results using the DICOM standard. 7) Understand the importance of open science methods to facilitate reproducible radiomics research. 8) Become familiar with publicly available sites where you can download existing radiomic data sets, request to upload new radiomic/radiogenomic data sets, and manage your research projects, and learn about data citations and new data-centric journals which help enable researchers to receive academic credit for releasing well-annotated data sets to the public.

Sub-Events

RC625A The Role of Challenges and Their Requirements

Participants
Jayashree Kalpathy-Cramer, MS, PhD, Portland, OR (*Presenter*) Research support, General Electric Company; Research support, F. Hoffmann-La Roche Ltd;

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LEARNING OBJECTIVES

1) Understand the role of challenges in facilitating reproducible radiomics research. 2) Learn about past challenges and lessons learned 3) Learn about best practices based on experiences from multisite challenges

RC625B Quantitative Image Analysis Tools: Communicating Quantitative Image Analysis Results

Participants
Andriy Fedorov, PhD, Cambridge, MA (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Review the meaning and importance of interoperability for quantitative image analysis tools. 2) Review specific use cases motivating interoperable communication of the analysis results. 3) Learn about the tools that support interoperable communication of the analysis results using the DICOM standard.

RC625C Public Databases for Radiomics Research: Current Status and Future Directions

Participants
Justin Kirby, Rockville, MD (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the importance of open science methods to facilitate reproducible radiomics research. 2) Become familiar with publicly available sites where you can download existing radiomic data sets, request to upload new radiomic/radiogenomic data sets, and manage your research projects. 3) Learn about data citations and new data-centric journals which help enable researchers to receive academic credit for releasing well-annotated data sets to the public.

ABSTRACT

Lack of reproducibility in scientific research, particularly in healthcare, has become an increasing issue in recent years. The National Institutes of Health (NIH) and many major publishers have since called for increased sharing of raw data sets so that new findings can be easily validated. This is especially important in the emerging field of radiomics where large data sets and huge numbers of image features lead to an increased risk of spurious correlations which are not driven by biology. A number of public tools and databases such as The Cancer Imaging Archive (TCIA) have since been created by governments and other organizations to help facilitate the sharing of data sets. Publishers have developed new 'data journals' and services specifically designed to encourage researchers to annotate and share their data sets. It is now up to the imaging research community to begin taking advantage of

these resources. Other disciplines such as genomics and proteomics are significantly leading imaging in the adoption of these new open science workflows. Engagement with NIH and other organizations providing open databases and related services is critical to enabling imaging researchers to successfully shift to a culture of data sharing and transparency.

Printed on: 10/29/20

SSQ18

Physics (Dual Energy/Spectral CT)

Thursday, Dec. 5 10:30AM - 12:00PM Room: E353A

CT PH

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

FDA Discussions may include off-label uses.

Participants
Jerome Z. Liang, PhD, Stony Brook, NY (*Moderator*) Nothing to Disclose
Xinming Liu, PhD, Houston, TX (*Moderator*) Nothing to Disclose

Sub-Events

SSQ18-01 Noise Suppression in Image-Domain Multi-Material Decomposition for Dual-Energy CT by Noise Propagation Analysis

Thursday, Dec. 5 10:30AM - 10:40AM Room: E353A

Participants
Yangkang Jiang, Hangzhou, China (*Presenter*) Nothing to Disclose
Yi Xue, Hangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Lei Xu, Hangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Pengfei Yang, Hangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Chen Luo, Hangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Tianye Niu, PhD, Hangzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Dual-energy CT (DECT) strengthens the material characterization and quantification due to its capability of material discrimination. The image-domain multi-material decomposition (MMD) via matrix inversion suffers from serious degradation of the signal-to-noise ratios (SNRs) of the decomposed images and thus the clinical application of DECT is limited. In this work, we propose a noise suppression algorithm based on the noise propagation for image-domain MMD.

METHOD AND MATERIALS

The noise in the decomposed images only distributes in two perpendicular directions. The noise perturbation is minimal along the principal axis and is thus suppressed along the principal axis by estimating the center of mass of the same-material pixel group. The proposed method is evaluated using the line-pair and contrast-rod slices of the Catphan©600 phantom and one patient data. We compared the proposed method with the direct inversion and the block-matching and three-dimensional (BM3D) filtration methods.

RESULTS

The results of Catphan©600 phantom and the patient show that the proposed method successfully suppresses the noise of the basis material images by one order of magnitude and preserves the spatial resolution of the decomposed images. Compared with the BM3D filtration method, the proposed method maintains the texture distribution of the decomposed images at the same SNR and the accuracy of the electron density measurement.

CONCLUSION

The algorithm achieves effective noise suppression compared with the BM3D filtration while maintaining the spatial distribution of the decomposed material images. It is thus attractive for advanced clinical applications using DECT.

CLINICAL RELEVANCE/APPLICATION

Improve the accuracy of dual-energy CT material decomposition and can be used for iodine removal in CTPA.

SSQ18-02 Implementation of Multi-Energy CT with Triple-Beam Dual-Source CT

Thursday, Dec. 5 10:40AM - 10:50AM Room: E353A

Awards
Trainee Research Prize - Fellow

Participants
Liqiang Ren, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Thomas Allmendinger, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Thomas G. Flohr, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Lifeng Yu, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To implement triple-beam energy-integrating-detector multi-energy CT (EID-MECT) on a dual-source (DS) CT scanner and compare its material decomposition (MD) performance with EID dual-energy CT (EID-DECT) and photon-counting-detector CT (PCD-CT) for two potential multi-contrast clinical tasks: biphasic liver imaging with iodine (I) and gadolinium (Gd), and small bowel imaging with iodine (I) and bismuth (Bi).

METHOD AND MATERIALS

The EID-MECT was implemented on a DSCT platform by mounting a z-axis split filter (0.05 mm Au, 0.6 mm Sn) on Tube A, which was operated at 120 or 140 kV. With Tube B operated at 70 or 80 kV, four triple-beam configurations were calibrated for MECT measurements: 70/Au120/Sn120, 70/Au140/Sn140, 80/Au120/Sn120, and 80/Au140/Sn140 kV. Mixed I/Gd samples were prepared, where the I/Gd enhancement values corresponded to late arterial/portal-venous phases, respectively, for biphasic liver imaging. Mixed I/Bi samples were prepared, where the I/Bi enhancement values corresponded to arterial/enteric enhancement, respectively, for small bowel imaging. Samples were placed in a 25-cm wide water phantom and scanned using the four configurations. The same phantom was scanned using twin-beam DECT (TB-DECT) (Au120/Sn120 kV), DS-DECT (80/Sn140 kV), and PCD-CT (80 kV: 25/35/50/55 keV for I/Gd; 140 kV: 25/50/75/90 keV for I/Bi), all at equivalent CTDIvol. Image-based MD was performed and mean (± std dev) material concentrations measured.

RESULTS

The optimal triple-beam configuration was 70/Au120/Sn120 and 70/Au140/Sn140 kV for I/Gd and I/Bi quantification, respectively. At equivalent radiation dose, noise in material concentration measurements was reduced for the triple-beam by 93%, 46%, and -2% for I/Gd quantification, and 62%, 24%, and 40% for I/Bi quantification, compared to TB-DECT, DS-DECT, and PCD-CT, respectively.

CONCLUSION

For the first time, the use of EIDs to perform MECT was experimentally demonstrated. Implemented with use of a Au/Sn split filter, three unique energy spectra were simultaneously measured using a DS system. Noise measured in material concentration was decreased relative to EID-DECT and comparable to or better than PCD-CT for two potential multi-contrast clinical tasks.

CLINICAL RELEVANCE/APPLICATION

With the triple-beam technique, the wide availability of DS-DECT in academic radiology departments can facilitate investigations of multi-contrast clinical tasks.

SSQ18-03 Multi-Contrast Imaging with Dual-Source (DS) Photon Counting Detector (PCD) CT and a Material Decomposition Technique Using Prior Knowledge Aware Iterative Denoising (MD-PKAID)

Thursday, Dec. 5 10:50AM - 11:00AM Room: E353A

Participants
Shengzhen Tao, Rochester, MN (*Presenter*) Nothing to Disclose
Kishore Rajendran, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shuai Leng, PHD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

Multi-energy data acquired on photon counting detector (PCD) suffer from considerable energy overlap due to imperfect detector response. This work aims to use dual source (DS)-PCD-CT to improve energy separation of multi-energy data, and a recently developed material decomposition method (MD-PKAID) to enable high fidelity simultaneous multi-contrast imaging of iodine (I), gadolinium (Gd), and bismuth (Bi).

METHOD AND MATERIALS

Head/body phantoms including solution vials containing I/Gd/Bi contrast agents of different concentrations were scanned on a single-source (SS) whole-body PCD-CT (chess mode with 4 thresholds = 25/50/75/90keV) and two times of clinical doses. The energy thresholds were chosen to capture the K edges of Gd/Bi. Energy bin images were reconstructed using a quantitative kernel (D30). An image-domain least-square material decomposition (MD-LS) was used to generate I/Gd/Bi specific images. Next, the same phantoms were scanned on DS-PCD-CT which was emulated by two consecutive scans with 80 kV / Sn140 kV for low/high energy tubes (Sn=tin filter). Total radiation dose of DS-PCD was 52.8/14.0 mGy for the head/body scans, similar to clinical exams. The energy thresholds were set as 25/50 keV for 80kV scan, and 25/90 keV for Sn140 kV scan. A recently developed material decomposition method (MD-PKAID) was applied, which used the energy threshold-low images as a prior image to denoise individual material-specific images. The root-mean-square-errors (RMSE) of material concentration relative to the true concentrations were measured for each material.

RESULTS

The improved energy separation offered by DS-PCD-CT, combined with MD-PKAID, was able to achieve excellent performance of multi-contrast imaging of I/Gd/Bi contrasts. The material concentration RMSEs for I/Gd/Bi were 0.26/0.11/0.21 mg/mL for head phantom, and 0.50/0.31/0.29 mg/mL for body phantom, in comparison to the RMSEs of 1.82/1.44/0.63 mg/mL (head) and 10.88/7.54/1.76 mg/mL (body) using SS-PCD with MD-LS.

CONCLUSION

The combination of DS approach and PCD technology, coupled with an iterative material decomposition algorithm, allowed simultaneous multi-contrast imaging using I/Gd/Bi with low (<0.50mg/mL) quantification error.

CLINICAL RELEVANCE/APPLICATION

DS-PCD-CT and a novel material decomposition algorithm may allow successful multi-contrast imaging, which may enable novel molecular imaging with nanoparticles and extend the frontier of clinical CT.

SSQ18-04 Evaluation of a Novel Multi-Energy CT Phantom with High-Precision Low Iodine and Calcium Concentration Inserts Using a Third Generation Dual-Source CT System

Thursday, Dec. 5 11:00AM - 11:10AM Room: E353A

Participants
Juan Carlos Ramirez-Giraldo, PhD, Cary, NC (*Presenter*) Employee, Siemens AG
Andrew Primak, PhD, Cleveland, OH (*Abstract Co-Author*) Employee, Siemens AG
Vladimir Varchena, MS, Norfolk, VA (*Abstract Co-Author*) Employee, CIRS
Till Schuermann, BS, Cary, NC (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate a novel multi-energy CT (MECT) phantom with multiple radiologically relevant inserts representing blood and water with contrast elements at low concentrations.

METHOD AND MATERIALS

A prototype of MECT phantom Model 662 (CIRS Inc, Norfolk, VA), with dimensions 33 x 27 x 25 cm was designed based on CIRS standard Electron Density Phantom Model 062 and comprised of the 5 cm thick target section in between two scatter 10 cm sections. It can be used in the "head" configuration Ø18 cm or full-size "body" configuration. The phantom is manufactured from Plastic Water-LR® and includes numerous material targets encapsulated inside the Ø1cm inserts made of PW-LR. Solid iodine inserts in water and blood included 0, 0.2, 0.5, 1.0, and 2.0, 5, 10 and 15mg/cc. Calcium inserts included 10, 20, 40, 60, 120 and 240 mg/cc concentrations. The phantom was scanned using dual-source CT (SOMATOM Force, Siemens) in the conventional SECT mode to assess linearity with kV ranging 70-150 (plus 100Sn and 150Sn). The iodine inserts were also evaluated with the MECT technique using kV pair combinations: 80/Sn150, 90/Sn150, and 100/Sn150 kV.

RESULTS

The HU values of all materials (including background 'water') in the phantom behaved as expected in the investigated kV range. The HU vs. concentration curves measured in the 'head' phantom showed excellent linearity with R2 values of 0.9990 (iodine in water), 0.9995 (iodine in blood) and 0.9998 (calcium in water). Iodine accuracy in the 'body' phantom varied from -0.5 to +0.2 mg/cc under all conditions except the highest iodine concentration (15 mg/cc) measured with 90/150Sn and 80/150Sn kV pairs where the absolute error increased to -0.8 and -1.1 mg/cc, respectively. With exception of the lowest concentrations <=0.5 mg/cc, percent errors were consistently below 10%. At lower concentrations, the 100/Sn150 kV had the highest accuracy. Iodine DE ratio values in the 'body' phantom were in excellent agreement with the previously published results (Krauss et al, Invest Radiol 2015).

CONCLUSION

The evaluated MECT phantom showed excellent characteristics in terms of concentration linearity, expected kV dependence of all clinically relevant materials, appropriate iodine DE ratio values, and enabled evaluation of low concentrations of materials.

CLINICAL RELEVANCE/APPLICATION

With MECT gaining more clinical attention, carefully designed phantoms are desired for assessing performance of state-of-the-art MECT systems.

SSQ18-05 K-Edge Subtraction Imaging with a Mono-Energetic Compact Synchrotron X-Ray Source

Thursday, Dec. 5 11:10AM - 11:20AM Room: E353A

Participants
Stephanie Kulpe, MSc, Garching, Germany (*Presenter*) Nothing to Disclose
Martin Dierolf, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Benedikt Gunther, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Madleen Busse, PhD, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
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Franz Pfeiffer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Daniela Pfeiffer, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

X-ray computed tomography (CT) is one of the most important diagnostic techniques in clinics. Yet, this method lacks the ability to differentiate similarly absorbing substances like commonly used iodine contrast agent and calcium, which is contained in calcifications, kidney stones and bones. K-edge subtraction (KES) imaging overcomes this limitation by subtracting two CT scans recorded at X-ray energies above and below the K-edge of the element in question. Thereby, reliable discrimination of contrast agent and calcium is achieved.

METHOD AND MATERIALS

KES benefits from monochromatic X-rays. Therefore, it has been mainly applied at synchrotron facilities. Here, we present the first proof-of-principle experiment of a filter-based KES CT performed at a compact synchrotron X-ray source based on inverse-Compton scattering, which provides a quasi-monochromatic X-ray beam of tunable energy in a laboratory setup. Two CT scans of an excised porcine kidney containing a kidney stone were performed. One scan was done with an iodine filter in the beam shifting the mean X-ray energy below the iodine K-edge energy, while the other one was performed with the full spectrum of the X-ray source.

RESULTS

KES CT allows for iodine contrast agent and calcium to be clearly separated, c.f. Figure 1. While both materials show almost the same absorption values in the unfiltered CT scans (Figure 1a), KES and inverse KES allow to discriminate the two materials (Figure 1c, d) due to the step increase in absorption of iodine between the X-ray energies employed for the two CTs.

CONCLUSION

The results show that KES CT is feasible at a compact inverse-Compton scattering X-ray source, which is going to provide benefits for contrast enhanced 3D imaging in a pre-clinical setting. KES CT allows for a discrimination of iodine and calcium, which will be of special interest in various clinical situations like kidney stones, atherosclerosis and bone imaging. We believe that KES at a compact synchrotron source can become an important tool in pre-clinical research and possible future clinical diagnostics.

CLINICAL RELEVANCE/APPLICATION

KES CT solves the clinically faced issue of the discrimination of iodine contrast agent and calcium, providing two CT volumes only showing one of the two materials, respectively.

SSQ18-06 The Potential Effects of Scout Scan Parameters on Image Quality and Radiation Dose in Chest CT on a 16cm Wide-Detector Dual-Energy CT

Thursday, Dec. 5 11:20AM - 11:30AM Room: E353A

Participants
Dandan Liu, Beijing, China (*Presenter*) Nothing to Disclose
Niu Yantao, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
Sen Lin Guo, Beijing , China (*Abstract Co-Author*) Nothing to Disclose
Zhang Yongxian, Beijing, China (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To explore the effects of scout scan parameters (tube position, tube voltage, mA) on image quality and radiation dose of chest CT scan under Smart mA and KV Assist modes on a chest phantom

METHOD AND MATERIALS

The CT scan was performed on a chest phantom by a 16cm wide-detector dual-energy CT (Revolution CT, GE Healthcare, Milwaukee) under Smart mA and KV Assist modes. During the scout scanning,the tube was positioned at 0°, 90 and 180°, separately corresponding to 5 different tube voltages (70, 80, 100, 120 and 140kV); 5-6 mA values were selected from a range of 10-110mA. Scan parameters were set as follows: KV Assist, Smart mA, detector width: 80mm, pitch: 0.992:1, rotation time: 0.5s/r, slice thickness: 5mm, NI: 10. The mA values atpulmonary apex, tracheal bifurcation, nipple, and right diaphragmatic dome were recorded. The CT dose index-volume (CTDIvol) in each scan was recorded as well. The radiation dose of breast in each scan was measured by the thermal leak detector (TLD). The regions of interest (ROIs) were placed at the tracheal bifurcation and right diaphragmatic dome to calculate the contrast-to-noise ratio (CNR).

RESULTS

Under Smart mA and KV Assist modes with tube positions at 90° and 180°, a tube voltage of 100kV was automatically selected for scanning. With the scanning parameters of 70kV and 10mA at the tube position of 0°, the automatically selected tube voltage was 100kV as well. For other scanning conditions, tube voltage was automatically selected as 80kV. At the tube position of 0°, the mean CTDIvol was 3.33mGy, the mean breast dose was 6.79mGy, and the mean CNR were 120.34 and 124.81 at a level of tracheal bifurcation and diaphragmatic dome, respectively . At the tube position of 90°, the above measurements were 4.87mGy, 8.42mGy, 168.00 and 144.33, respectively. At the tube location of 180°, measurements were 4.38mGy, 7.45mGy, 143.35 and 141.48, respectively.

CONCLUSION

In chest CT scout scan, the tube position has great influence on the radiation dose and particularly the organ dose of breast.

CLINICAL RELEVANCE/APPLICATION

A proper scan mode shall be selected according to the specific requirements of clinical examinations.

SSQ18-07 Assessment of Texture Feature Reproducibility in Dual-Energy Computed Tomography Virtual Monoenergetic Images

Thursday, Dec. 5 11:30AM - 11:40AM Room: E353A

Participants
Faraz Farhadi, Bethesda, VA (*Presenter*) Nothing to Disclose
Jayasai R. Rajagopal, BA, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Moozhan Nikpanah, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Michael Morris, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Paul Wakim, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Ziyue Xu, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Mohammad Hadi Bagheri, MD, Rockville, MD (*Abstract Co-Author*) Nothing to Disclose
William F. Pritchard JR, MD,PhD, Chevy Chase, MD (*Abstract Co-Author*) Research collaboration, Koninklijke Philips NV; Research collaboration, Biocompatibles International plc; Research collaboration, BTG International Ltd; Research collaboration, Siemens AG; Research collaboration, XACT Robotics; Research collaboration, W. L. Gore & Associates, Inc; Research collaboration, Celsion Corporation
Ashkan A. Malayeri, MD, Andover, MA (*Abstract Co-Author*) Nothing to Disclose
Babak Saboury, MD, MPH, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Elizabeth C. Jones, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To explore the reproducibility of radiomic texture features across virtual monenergitic images generated from dual-energy CT (DECT) acquisitions used in clinical practice and clinical trials at our institution.

METHOD AND MATERIALS

A phantom containing liver and lung texture modules was scanned in triplicate with a clinical dual source DECT scanner. Three fixed volumes of interest (VOIs) were drawn in mixed images (weighted images of low (90kV) and high (150kV) energy acquisitions) and monoenergetic images at 8 different energy levels (40,50,60,70,80,100,120,140 keV) to compare four Harlick texture features (energy, entropy, contrast, and homogeneity). Percentage difference of texture values from the mixed image was calculated for each VOI and keV level.

RESULTS

For VOIs placed in the lung portion of the phantom, texture value difference from mixed the image was on average 10% (range:1-17%) for energy, 4% (range:0.5-8%) for contrast, 3% (range:0.3-6%) for correlation, and 1% (range:0.1-2%) for homogeneity. In liver these values included 7% (range: 0.4-16%) for energy, 11% (range: 0.4-39%) for contrast, 10%(range: 2-29%) for correlation, and 2%(range: 0.3-6%) for homogeneity.

CONCLUSION

All four texture features reviewed showed variance across monoenergetic images of DECT.

CLINICAL RELEVANCE/APPLICATION

Defining imaging device characteristics and their effect on imaging features with an empirical manner is a critical step for utilization of radiomics in the precision medicine era.

SSQ18-09 Image-Domain Synthesis of Spectral CT Virtual Monoenergetic Images Using Stacked Deep Convolutional Neural Networks

Thursday, Dec. 5 11:50AM - 12:00PM Room: E353A

Participants
Hao Gong, PhD, Rochester,, MN (*Presenter*) Nothing to Disclose
Nathan Huber, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Kishore Rajendran, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shengzhen Tao, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
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PURPOSE

To develop a deep convolutional neural network (CNN) based technique to synthesize virtual monoenergetic images (VMIs) from spectral CT data and to compare results to conventional VMIs created from the same data.

METHOD AND MATERIALS

The developed technique consists of a VMI-synthesis CNN (CNNVMI) and a texture-synthesis CNN (CNNTEXT), with fully-customized architecture and loss functions. A two-stage training strategy was used. CNNVMI was trained using spectral CT polychromatic images and theoretical monoenergetic linear attenuation coefficients as inputs and labels, respectively. After CNNVMI training, the parameters were fixed, and CNNTEXT was stacked to the end of CNNVMI. CNNTEXT was trained to synthesize the image noise texture of a low noise image, using water phantom images as labels. CT images of an abdomen-sized water phantom with varying inserts were used to train and validate the CNNs. Additional porcine CT images were acquired to evaluate the generalizability of the CNNs for anatomical features. Images were acquired on a whole-body research photon-counting-detector (PCD) CT, using 140 kV and a two-threshold (25 and 65 keV) data acquisition mode. Phantom scans were acquired multiple times across three radiation dose levels (CTDIVOL: 23 mGy, 11.5 mGy, 5.75 mGy) and animal scans were acquired with 23 mGy. Results were compared with baseline images created using a conventional least-squares-based two-material decomposition.

RESULTS

Relative to baseline VMIs, CNN-synthesized VMIs demonstrated substantially lower noise and improved contrast resolution at all dose levels, especially for low-contrast inserts or tissues. Image details and noise texture were well maintained using the CNN synthesis compared to that of routine dose input images. The proposed CNNs accurately estimated the CT numbers of all inserts (mean absolute percent difference <5%), across all dose levels. Importantly, noise of the CNN VMIs was not substantially affected by the dose level of the input CT images (noise in water 12.6±0.14 HU across all dose levels).

CONCLUSION

The proposed CNN-based VMI synthesis provided high quality VMI images with accurate CT number, suppressed image noise, and improved contrast resolution.

CLINICAL RELEVANCE/APPLICATION

The clinical value of low keV VMIs could be dramatically increased by use of the described method to suppress image noise with maintaining CT number accuracy.

SSQ19

Physics (Deep Learning - Dose Reduction and Image Quality)

Thursday, Dec. 5 10:30AM - 12:00PM Room: E353B

AI CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Moderator*) Nothing to Disclose
Patrick J. La Riviere, PhD, Chicago, IL (*Moderator*) Research funded, Canon Medical Systems Corporation; Research funded, Accuray Incorporated; Research Consultant, MetriTrack, Inc

Sub-Events

SSQ19-01 Radiation Dose Reduction for CT Assessment of Urolithiasis Using Deep Learning Reconstruction Algorithm: A Prospective Intra-Individual Study

Thursday, Dec. 5 10:30AM - 10:40AM Room: E353B

Participants
Xiaohu Li, MD, Hefei, China (*Presenter*) Nothing to Disclose
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PURPOSE

To assess the performance of ASIR-V and Deep learning reconstruction algorithm(DL) in patients with urolithiasis at ultralow-dose CT

METHOD AND MATERIALS

13 patients scheduled for unenhanced abdominal CT for follow-up of urolithiasis were prospectively included. Routine dose acquisition was followed by two low-dose acquisitions at 60% and 90% reduced doses. All images were reconstructed with FBP, ASIR-V and DL. Urolithiasis detection rates, gall bladder, appendix and rectosigmoid evaluation and overall subjective image quality were evaluated by two observers.

RESULTS

52 stones were present in 13 patients. 65% stones were not detected on FBP at the lowest dose level, but this improved with DL to a sensitivity of 100%. ASIR-V resulted in a slight decrease in sensitivity at the lowest dose to 82 %, but out performed FBP. Evaluation of other structures with ASIR-V at 60% and with DL at 90% dose reductions was comparable to FBP at routine dose, but 80% and 90% dose reduction resulted in non-evaluable images.

CONCLUSION

CT radiation dose for urolithiasis detection can be safely reduced by 60(ASIR-V)-90(DL)% without affecting assessment of urolithiasis, possible extra-urinary tract pathology or overall image quality.

CLINICAL RELEVANCE/APPLICATION

The most frequent cause of acute flank pain is urolithiasis, which affects 3-5% of the population.Technical advancements like iterative reconstruction (IR) algorithms have resulted in substantial radiation dose reduc- tions. IR results in reduced noise, allowing acquisition ofim- ages at reduced radiation dose levels without intrinsically hampering image quality.

SSQ19-02 Radiation Dose Reduction in Chest CT at a Micro-Dose (mD) Level by Noise Simulation and Noise-Specific Anatomic Neural Network Convolution (NNC) Deep-Learning (DL) with K-Means Clustering

Thursday, Dec. 5 10:40AM - 10:50AM Room: E353B

Participants
Yuji Zhao, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Amin Zarshenas, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Toru Higaki, PhD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Canon Medical Systems Corporation; Research Grant, Hitachi, Ltd; Research Grant, Fujitsu Limited; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Eisai Co, Ltd;
Kenji Suzuki, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

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PURPOSE

Radiation dose reduction in chest CT is highly demanded since current radiation dose is high for lung cancer screening. Our purpose was to develop new noise-specific 3D NNC DL experts by means of K-means clustering with mDCT simulation to convert mDCT to 'virtual' high-dose (HD) CT where noise and artifacts are significantly reduced.

METHOD AND MATERIALS

We developed a mixture of noise-specific, anatomical NNC experts, employing volume-based neural network regression in a convolutional manner, with soft-gating layers to convert mDCT to HD-like CT. We trained 9 noise-specific, anatomical NNC models for 3 noise-specific clusters in 3 anatomic areas by means of K-means clustering. We trained our NNCs with simulated mDCT as input and corresponding HDCT (120 kVp, 92 mAs, 3.0 mSv) from our diagnostic CT database as 'teaching' images. Our mDCT simulation consisted of forward-projection of HDCT, addition of photons and electric noise to sinogram images, filtered back-projection of the noise component, and addition of the noise image to the original HDCT. Through training, our noise-specific, anatomical NNCs learned to convert lower-dose CT to HD-like CT, where noise and artifacts are substantially reduced; thus, termed 'virtual' HD (VHD) CT. To evaluate the performance, we collected mD (120 kVp, 5 mAs, 0.2 mSv) and full-dose (120 kVp, 50 mAs, 2.0 mSv) CT (Aquilion One, Toshiba, Japan) of 50 clinical cases including 30 cases with solid nodule and ground-glass (GG) nodule.

RESULTS

Our new VHD technology with clustering converted mDCT to 'virtual' HDCT and improved the image quality by reducing noise and artifacts substantially, while anatomic structures and pathological characteristics of both solid and GG nodules were well preserved. With our NNCs trained with simulated mDCT, contrast-to-noise-ratio (CNR) of mDCT of clinical cases was improved from 4.1±3.9 dB to 22.9±3.4 dB, which was also higher than that of 'reference-standard' full-dose CT (CNR: 13.4±5.1 dB).

CONCLUSION

Our noise-specific anatomical NNC models trained with simulated mDCT images was able to convert thin-slice mDCT of clinical cases to VHDCT that have higher image quality (in terms of CNR) than 'reference-standard' full-dose CT, achieving 90% dose reduction.

CLINICAL RELEVANCE/APPLICATION

Substantial reduction of radiation dose in CT by our new noise-specific VHD technology would potentially make mDCT screening possible, and it would be beneficial to screening population.

SSQ19-03 A Deep-Learning-Based Framework for Synthesizing Virtual CT Exams in the Image Domain

Thursday, Dec. 5 10:50AM - 11:00AM Room: E353B

Participants
Hao Gong, PhD, Rochester,, MN (*Presenter*) Nothing to Disclose
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Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
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PURPOSE

To develop a deep convolutional-neural-network (CNN) based framework to synthesize virtual patient CT exams having varying lesion characteristics and simulating varying radiation dose levels.

METHOD AND MATERIALS

The developed framework consists of a lesion-insertion CNN (CNNLesion) and a noise-insertion CNN (CNNNoise). Both CNNs were implemented with in-house-developed network architectures. CNNLesion inserts lesions into different locations of patient images by fusing multi-scaled features of patient lesion models with anatomical background. A cohort of lesion-free abdominal CT patient cases (n=10) was used to generate training data and validate CNNLesion. A previously-validated projection-based lesion insertion technique was used to generate reference images across 10 conditions: lesion sizes 5 - 11 mm, contrast levels 15 - 25 HU, and reconstruction types (filtered-backprojection and iterative reconstruction). CNNNoise used routine dose CT images and white noise as inputs to synthesize image noise magnitude and texture at lower dose levels. The architecture of CNNNoise approximates the underlying noise correlation in CT images. The loss function of CNNNoise consisted of a perceptual loss, a frequency-spectrum loss, and a diversity loss. Patient cases from the NIBIB/AAPM Low Dose CT Grand Challenge and water phantom scans were used to train and validate CNNNoise.

RESULTS

The CNNLesion-synthesized lesion-present images showed strong perceptual similarity compared to the reference images. The mean structural similarity index and the mean absolute CT number difference between the CNNLesion-inserted lesions and the reference were 0.983±0.004 and 1.9±0.3 HU, respectively. The CNNNoise-synthesized low-dose images had comparable noise texture to that of the reference images. The mean absolute percent difference of noise measured in the liver parenchyma was <3%. The noise power spectra measured from CNNNoise-synthesized water phantom scans were very close to those from real scans (mean absolute difference < 1.1 HU2cm2).

CONCLUSION

The developed deep CNN-based framework accurately and efficiently synthesized virtual patient CT exams with prescribed lesion characteristics and radiation dose levels.

CLINICAL RELEVANCE/APPLICATION

The developed CNN-based method can accurately and efficiently create patient cases with known pathology and dose to perform virtual clinical trials in CT for radiation dose and protocol optimization.

SSQ19-04 Nonlinear Analysis of Machine Learning in CT Image Formation

Thursday, Dec. 5 11:00AM - 11:10AM Room: E353B

Participants
Grace J. Gang, PHD, Baltimore, MD (*Presenter*) Nothing to Disclose
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PURPOSE

The proliferation of nonlinear machine learning algorithms poses significant challenges to image quality assessment. Performance characterization typically relies on qualitative 'beauty contests' or metrics like resolution and structural similarity which may not relate to diagnostic outcome. We propose a quantitative image quality metric for nonlinear algorithm analysis and present example applications in a neural network denoising algorithm in low dose CT imaging of the lung.

METHOD AND MATERIALS

We propose perturbation response analysis as a quantitative measure of image quality suitable for general nonlinear algorithms. Perturbation response is defined as the difference in the mean output between an image with a stimulus and an image without. Such analysis captures the various dependencies of the algorithms, including that on the stimulus itself. We performed the analysis for an example denoising algorithm based on a convolutional neural network. For stimuli inputs, we developed procedurally generated lesions to systematically sample ranges of clinically relevant features, including size, contrast, and speculation characteristics. The lesions were inserted into the projection data and propagated through the imaging chain.

RESULTS

The perturbation response for FBP reconstruction exhibits linear behavior. The denoising algorithm is effective in reducing noise in the image. However, perturbation response analysis reveals highly nonlinear behavior on the lesion stimuli. Spherical lesions of lower contrast may disappear completely (for contrast at ~0.001 mm-1) or appear at the right contrast but smaller in size (for contrast at ~0.005 mm-1). Lesions with thinner and shorter spiculations can appear with smooth boundaries. These results allow quantitative characterization that identify the range of lesion features that cannot be admitted or faithfully represented by the algorithm.

CONCLUSION

We applied perturbation response analysis in identifying the performance limits of an algorithm in terms of lesion contrast, size, and spiculation. This work provides a quantitative method for characterizing the performance of nonlinear algorithms in relation to clinically relevant features.

CLINICAL RELEVANCE/APPLICATION

This work provides an image quality analysis method that is generally applicable to nonlinear image processing. The analysis allows quantitative image quality assessment and can be used to guide algorithm development.

SSQ19-05 Quantitative Comparison of a Deep Learning-Based CT Reconstruction Algorithm (AiCE) to Other Reconstruction Techniques

Thursday, Dec. 5 11:10AM - 11:20AM Room: E353B

Participants
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Jonathan R. Dillman, MD, MSc, Cincinnati, OH (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Guerbet SA; Travel support, Koninklijke Philips NV; Research Grant, Canon Medical Systems Corporation; Research Grant, Bracco Group

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PURPOSE

To compare, in pediatric patients, a deep learning-based (DL) CT reconstruction algorithm (AiCE) to filtered back projection (FBP), statistical-based (AIDR3D), and model-based iterative (FIRST) reconstruction algorithms at different contrast levels and object sizes using quantitative image analysis.

METHOD AND MATERIALS

Patient raw image data acquired on a Genesis CT scanner (Canon Medical Systems) were reconstructed axially using FBP, AIDR3D, FIRST, and AiCE at 0.5mm and 3mm thicknesses. AiCE used a Deep Convolutional Neural Network (DCNN) in the regularization term of its iterative reconstruction algorithm. The DCNN was trained to differentiate signal from noise to reduce noise in the image. A non-prewhitening matched observer model with eye filter (d'NPWE) was used to characterize the signal-to-noise ratio (SNR) of objects of varying sizes (1-10mm) at three different CT contrast levels (-100, 100, & 350HU). To calculate d'NPWE, a Task Transfer Function for each reconstruction algorithm and contrast level was calculated using a water phantom with sensitometry inserts. A power spectrum was calculated by sampling noise characteristics from uniform regions of the patients' liver parenchyma.

Object signal differentiation due to reconstruction algorithm was estimated by calculating the area under the curve (AUC). AUC results for FBP, FIRST, and AiCE were normalized to AIDR3D, the routinely clinically employed reconstruction algorithm for this scanner.

RESULTS

Power spectrum magnitude for 3mm AiCE images were an average 58% lower (range: 45-70%) than 3mm AIDR3D images. Power spectrum frequency content of AiCE agrees to better than 28% with AIDR3D compared to 50% for FIRST. On average, AiCE 3mm images demonstrated greater distinction for all object sizes and contrast levels than all other algorithms. AiCE 0.5mm SNR agreed with 3mm AIDR3D to better than 0.4%.

CONCLUSION

Analysis demonstrates substantial improvement of object signal detection and noise magnitude using DL CT reconstruction (AiCE) leading to less noisy images with noise texture comparable with AIDR3D. Noise magnitude of AiCE 0.5mm images is comparable to AIDR 3mm images showing substantial dose reduction potential of AiCE.

CLINICAL RELEVANCE/APPLICATION

Deep learning-based CT reconstruction (AiCE) improves image signal detection of objects down to 1 mm in diameter at all contrast levels with the potential to substantially reduce dose without compromising image quality.

SSQ19-06 The Image Quality of the Newest Deep Learning Image Reconstruction on Chest CT

Thursday, Dec. 5 11:20AM - 11:30AM Room: E353B

Participants
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PURPOSE

To assess the image quality of the newest deep learning image reconstruction (DLIR) on chest CT in comparison with filtered back projection (FBP) and iterative reconstruction (IR).

METHOD AND MATERIALS

Thirty-six patients were evaluated retrospectively. All patients underwent routine contrast enhanced CTs (Revolution CT, GE Healthcare, WI) and images with 0.625-mm slice thickness were reconstructed using FBP, hybrid IR (ASiR-V), and DLIR (Truefidelity, GE Healthcare). The three settings of DLIR (low, medium, and high) and ASiR-V 60% were used. Regions of interest were placed at the axillary fat and the pectoralis major muscle, and the standard deviation (SD), the signal-to-noise ratio (SNR), and the contrast-to-noise ratio (CNR) were calculated objectively on the five image sets (FBP, ASiR-V, DLIR-low, DLIR-med, and DLIR-high). Two independent radiologists evaluated ASiR-V, DLIR-low, DLIR-med, and DLIR-high comparing with FBP on a 5-point scale ($1=\text{worst}<2<3<4<5=\text{best}$) in terms of noise, streak artifact, the visibility of lymph nodes, the clarity of small vessels in the chest wall, and overall image quality on mediastinum window setting (width 400 HU; level 60 HU). The objective parameters were analyzed statistically using one-way repeated measures ANOVA and the post hoc Tukey-Kramer test. The subjective scores were analyzed using the Wilcoxon signed-rank test with the Bonferroni correction.

RESULTS

DLIR-high significantly showed the least SD and the largest SNR and CNR among the reconstructions ($p<0.001$). The higher the DLIR setting, the lower the SD and the higher the SNR and CNR ($p < 0.01$). In the subjective analysis, DLIR-high showed the best score in terms of noise, streak artifact, and overall image quality among the reconstructions (significant in both readers' result: $p < 0.001$). The scores of DLIR-med and DLIR-high tended to be better in terms of lymph nodes and poor in terms of small vessels compared with ASiR-V (significant in 1 reader's result: $p <= 0.005$).

CONCLUSION

DLIR-high improved the objective parameters and the subjective image quality compared with ASiR-V by reducing noise and streak artifact on chest CT.

CLINICAL RELEVANCE/APPLICATION

With improved image quality, the DLIR may contribute to the diagnosis and the clinical practice on the chest CT.

SSQ19-07 Quantitative Comparison of Noise Texture between CT Images Reconstructed Using Filtered Back-Projection (FBP), Iterative Reconstruction, and Deep Learning Techniques

Thursday, Dec. 5 11:30AM - 11:40AM Room: E353B

Participants
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PURPOSE

To quantitatively compare noise texture via noise power spectra of computed tomography (CT) images reconstructed using filtered back-projection (FBP), iterative reconstruction (ASiR-V), and TrueFidelity (TF) deep learning image reconstruction (DLIR) at different dose levels.

METHOD AND MATERIALS

To measure the noise texture across image reconstruction algorithms, we calculated the normalized noise power spectra (nNPS) of uniform phantom images acquired at six dose levels (CTDIvol 2.5, 4.9, 7.4, 10.2, 12.6, 15.1mGy), and reconstructed using FBP, iterative reconstruction (ASiR-V, 100%), and deep learning (TrueFidelity DLIR, high). A 20cm water phantom was scanned on Revolution CT (GE Healthcare, five scans per condition), and images were reconstructed using the three algorithms above. From each scan, the difference-image was calculated between two 2.5mm-thick slices 2.5mm above and below the axial center. Then, the 2D NPS of the difference image was calculated, normalized to its own area, and radially averaged to yield the final 1-D normalized NPS (nNPS). To compare the nNPS, the average frequencies fa were calculated as first-order moments of nNPS normalized by the area under the curves. In addition, the root-mean squared of nNPS difference (RMSD) between nNPS of ASiR-V/TF and the corresponding nNPS of FBP was calculated.

RESULTS

nNPS of Images reconstructed with TF DLIR and FBP show a close match, with a slight shift towards lower frequencies occurring in TF images at CTDIvol of 2.5mGy. For all dose levels studied, fa of TF images was only 0.20 +/- 0.08lp/cm below that of FBP (a 6% difference), while fa of ASiR-V was 1.37+/- 0.01lp/cm below FBP (42% difference). RMSD_TF was 0.10+/-0.04mm2 and RMSD_ASiR-V was 1.14+/-0.01mm2.

CONCLUSION

Consistent with previous reports, normalized NPS of ASiR-V images is shifted towards lower spatial frequencies. The normalized NPS of TrueFidelity DLIR closely matches that of traditional high dose FBP images across a wide range of dose levels as quantified via RMSD and average frequency.

CLINICAL RELEVANCE/APPLICATION

Without the typical compromises in image texture occasioned by iterative methods even when the dose is reduced, deep learning image reconstruction (TrueFidelity, GE Healthcare) should help accelerate the adoption of low dose techniques into routine clinical practice.

SSQ19-08 Deep Learning-Based Metal Artifact Reduction in CT for Total Knee Arthroplasty

Thursday, Dec. 5 11:40AM - 11:50AM Room: E353B

Participants
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PURPOSE

To investigate the metal artifact reduction (MAR) performance of deep learning (DL)-based MAR technique in the evaluation of postoperative CT of total knee arthroplasty (TKA) patients

METHOD AND MATERIALS

The training dataset consisted of 640 image pairs obtained from 10 lower extremity CT scans without a metal prosthesis. Each image pair consists of a metal artifact-free image with a virtual metal shape embedded in the original image and a metal artifact image simulated through sinogram handling. Our DL network is a convolutional neural network (CNN) with encoder-decoder structure and skip connections. The summation of MSE and SSIM losses were implemented for parameter updating. For the test dataset, we used 10 lower extremity CT examinations from 10 patients who had a previous history of TKA (7 patients with unilateral TKA; 3 patients with bilateral TKA), and a total of 13 knee joints were used for analysis. To evaluate the metal artifacts quantitatively, the area, mean attenuation, and artifact index (AI) within the dark streak artifacts were calculated in the original, O-MAR, and DL-MAR images. For qualitative analysis, images were rated with a 5-point Likert scale regarding the degree of overall metal artifacts, conspicuity of bone cortex and trabeculae, and assessment of soft tissue around the prosthesis. Continuous variables were compared between different MAR protocols using the repeated measures ANOVA and qualitative grading results were analyzed by using the Friedman test.

RESULTS

The O-MAR showed a 24% reduction in metal artifact area, while the DL-MAR showed an area reduction of more than 99%, almost completely eliminating the dark streak artifact. In terms of mean attenuation and AI, DL-MAR also showed better performance than O-MAR ($P < 0.001$). In qualitative analysis, DL-MAR showed significantly lower overall metal artifacts ($P = 0.008$) and better bone delineation ($P = 0.020$) compared to O-MAR. However, there was no significant difference in the assessment of soft tissue between two MAR protocols ($P = 0.054$), and DL-MAR showed unusual blurring of periarticular soft tissue.

CONCLUSION

The DL-MAR technique has been successfully developed and shown comparable performance with conventional projection completion algorithm.

CLINICAL RELEVANCE/APPLICATION

The DL-MAR can effectively reduce severe metal artifacts caused by large TKA components, hence enabling its use in the diagnosis of postoperative complications of TKA.

SSQ19-09 Basic CT Physics Scaling Laws for Noise and CNR as a Function of Slice Thickness and Dose for a New Deep-Learning CT Image Reconstruction Method

Thursday, Dec. 5 11:50AM - 12:00PM Room: E353B

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC; Medical Advisory Board, medInt Holdings, LLC; Consultant, General Electric Company; Consultant, Takeda Pharmaceutical Company Limited
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PURPOSE

The relationships between noise, slice thickness, and dose in CT are well understood for filtered back projection. This work characterizes these relationships for an implementation of TrueFidelity, a new deep learning image reconstruction (DLIR) approach.

METHOD AND MATERIALS

We imaged an ACR phantom at 5 slice thicknesses: 0.625, 1.25, 2.5, 3.75, and 5 mm. We imaged at doses of 16, 8, and 4 mGy using 120 kV, 80 mm collimation, and 0.992:1 pitch. All measurements were repeated 5 times. Images were reconstructed using: filtered back projection (FBP), two levels of a statistical iterative reconstruction (ASiR-V), and three levels of a vendor's deep learning image reconstruction (DLIR) approach. The ASiR-V levels were chosen based on institution (20%) and vendor (50%) recommendations. We fit image noise and CNR as a function of dose and slice thickness. Confidence intervals for all fit parameters were determined.

RESULTS

FBP and ASIR-V 20%/50% had similar scaling exponents: for CNR as a function of slice thickness 0.47(0.43-0.51) and 0.46(0.43-0.50)/0.45(0.36-0.54) and for noise as a function of slice thickness -0.49(-0.50 -0.48) and -0.49(-0.52 -0.47)/-0.49(-0.59 -0.39) respectively. DLIR low/medium/high had exponents of 0.37(0.23-0.51)/0.37(0.20-0.53)/0.36(0.15-0.56) for CNR as a function of slice thickness and of -0.39(-0.51 -0.28)/-0.38(-0.51 -0.26)/-0.37(-0.51 -0.23) for noise as a function of slice thickness. For noise and CNR as a function of dose, all methods had similar scaling exponents across slice thickness. As a function of dose at 5 mm, the image noise exponents for FBP and ASIR-V 20%/50% were: -0.48(-0.66 -0.30) and -0.48(-0.65 -0.31)/-0.47(-0.65 -0.29). DLIR low/medium/high for noise as a function of dose at 5 mm had scaling exponents of -0.44(-0.72 -0.17)/-0.44(-0.88 0.00)/-0.42(-1.08 0.23).

CONCLUSION

The CNR and noise scaling laws for FBP were found to hold for all recon methods. TrueFidelity DLIR did tend to have smaller changes in CNR and noise as the slice thickness/dose was reduced. The performance of DLIR was predictable and better than FBP and ASiR-V at all slice thicknesses and doses.

CLINICAL RELEVANCE/APPLICATION

New deep-learning based CT reconstruction (TrueFidelity, GE Healthcare) follows the noise and CNR rules of FBP reconstruction. This new reconstruction approach can mitigate some of the noise penalty incurred by reducing slice thickness or dose.

PHS-THA

Physics Thursday Poster Discussions

Thursday, Dec. 5 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

Sub-Events

PH208-SD-THA1 Deep Learning-Based Liver Segmentation in Abdominal CT Images to Support Automatic Contouring in Radiotherapy Treatment Planning

Station #1

Participants
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PURPOSE

Liver segmentation is a prerequisite for measuring hepatic volume in liver transplantation, modeling of the liver anatomy in hepatic surgery planning, and contouring in radiotherapy treatment planning. The main challenges of liver segmentation are the appearance similarity of liver and surrounding stomach, heart, and spleen in 2D images and are the large shape variations of liver in 3D volume. In this study, we propose a deep learning-based liver segmentation method through the localization of the liver in abdomen using global context and the delineation of the liver in a bounding volume using shape-enhanced prior.

METHOD AND MATERIALS

Our dataset included 155 artery phase CT images obtained for radiation therapy from patients with liver cancer, which were divided into 75 subjects for training, 33 subjects for validation, and 47 subjects for test. The pixel spacing and slice thickness of the images varies from 0.65 to 0.79 mm and 3.0 to 7.0 mm. To localize the liver in the abdomen and exclude outliers, 2D segmentation networks based on axial, coronal, and sagittal FCNs are learned and a shape-enhanced prior is generated by the weighted fusion of three prediction maps. To correct the fine details of the liver in the bounding volume, 3D segmentation network based on 3D U-net is learned along with shape-enhanced prior.

RESULTS

Segmentation performance was evaluated as 91.2%, 94.3%, and 89.5% for the DSC in the 2.5D segmentation network, and proposed network with and without shape-enhanced prior, respectively. Experimental results showed that the 2.5D segmentation network excluded outliers near the liver and localized the liver in the abdomen. The proposed network corrected under-segmentation area of the 2.5D segmentation network considering the spatial local context and avoided over-segmentation into neighbor structures considering the shape-enhanced prior.

CONCLUSION

Our method improved segmentation accuracy by the localization of the liver in abdomen using global context and the delineation of the liver in a bounding volume using shape-enhanced prior. (This work was supported by Radiation Technology R&D program through the NRF of Korea(NRF-2017M2A2A7A02070427))

CLINICAL RELEVANCE/APPLICATION

Our method can be used for not only auto-contouring in radiotherapy treatment planning but also hepatic volume measurement in liver transplantation or liver anatomy modeling in hepatic surgery planning.

PH220-SD-THA2 Chronic Liver Disease Assessment Using Deep Learning on Shear Wave Elastography Image Sequences

Station #2

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PURPOSE

To compare the diagnostic performance of two popular Deep Learning schemes on Chronic Liver Disease having as input temporally stable Shear Wave Elastography (SWE) images.

METHOD AND MATERIALS

Clinical dataset includes 200 subjects (88 Healthy and 112 with Liver Biopsy validation CLD). Each subject had an Ultrasound (US) SWE liver examination performed on Aixplorer (Supersonic Imagine) US device. From each examination, 4 SWE images of the same liver area having 2 seconds time distance each were extracted. For each set of the 4 images, an RGB to Stiffness process was implemented according to Aixplorer's provided color-bar. For each stiffness-box, the Dyadic Wavelet Transform (DWT) "Atrous" algorithm was calculated. Then, the first stiffness-box and its corresponding DWT box are subtracted from each of the remaining three stiffness and DWT boxes to produce 6 image-boxes which are fed to a Fuzzy C-Means clustering algorithm to provide 2 clusters of high and low temporal stability. The low temporal stability areas were excluded from the first image and the resulting masked images along with the unmasked were fed to Alexnet and GoogLeNet Deep Learning schemes for comparison using transfer learning. The classification process was repeated 30 times to have a robust estimation of both networks' performance.

RESULTS

The difference of mean accuracies for the masked and unmasked images (ACCmasked -ACCunmasked) for Alexnet and GoogLeNet respectively were 0.13% (p-value = 0.62) and 1.92% (p-value < 0.01) for F01-F234, 0.27% (p-value = 0.54) and 4.12% (p-value < 0.01) for F0-F1234, and -1.27% (p-value < 0.01) and 2.27% (p-value < 0.01) for F01-F23-F4. Alexnet's range of accuracies in all classification schemes was 84% - 94.2% while GoogleNet's accuracies range was 80.8% - 91.6%.

CONCLUSION

Both Deep Learning schemes performed well in differentiating CLD fibrosis stages using the masked and unmasked images. Alexnet seems to perform better in both masked and unmasked images than GoogleNet but has no difference in performance between masked and unmasked images. GoogLeNet seems to perform better with the masked SWE images.

CLINICAL RELEVANCE/APPLICATION

This study compares the diagnostic performance of two popular deep learning schemes on CLD using SWE image sequences. This algorithm could be employed in a CAD system for CLD diagnosis.

PH222-SD-THA4 Size-Specific Analysis of Patient Doses From CT Localizer Radiographs

Station #4

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PURPOSE

The aim of this study was to estimate organ doses based on Monte Carlo (MC) simulations for individual patients in CT localizer radiograph and evaluate the organ doses for different patient size.

METHOD AND MATERIALS

In CT localizer radiographs, X-ray was irradiated from two directions of anterior-posterior (AP) and lateral (LAT). AP localizer protocols were set at the tube voltage of 120 kV, tube current of 30 mA, beam width of 2 mm. LAT localizer protocols were set at tube current of 50 mA, which corresponded to the default settings by the manufacturer. The length of CT localizer radiographs was adult chest-abdomen-pelvis region. Dose simulations of CT localizer radiographs were performed using MC simulation software ImpactMC (Advanced Breast CT). The voxelized models created from CT images of 24 patients (3 male and female underweight, normal weight, over weight, and obese patients which were classified based on patient's body mass index), and detailed descriptions of an Aquilion ONE CT scanner (Canon Medical Systems) were input into the software. The organ doses of thyroid, lung, esophagus, breast, liver, stomach, and bladder were estimated from the dose simulation results. The detectability of anatomical landmarks of lung and pelvic bone in each CT localizer radiograph was also subjectively evaluated.

RESULTS

The liver dose in AP direction was 0.59 mGy for underweight,0.49 mGy for normal weight, 0.36 mGy for overweight, and 0.35 mGy for obese patients. The patient doses for underweight patients in AP and LAT localizer protocols were higher than for obese patients because more X-rays in the protocols for underweight patients reached to the deeper organ position. Anatomical landmarks of lung and pelvic bone for all patients CT localizer radiographs could be detected. This makes it possible to determine the chest-abdomen-pelvis range.

CONCLUSION

Patient doses in CT localizer radiographs varied according to the patient size. Lung and pelvic bone on the CT localizer radiographs were detectable in all patient size. The doses for underweight patients in CT localizer radiographs could be reduced by at least one-third of doses for obese patients.

CLINICAL RELEVANCE/APPLICATION

The dose distributions and patient doses of the CT localizer radiograph were estimated. The exposure conditions of the CT localizer radiograph should be adjusted according to the patient size as well as the helical scan.

PH244-SD-THA5 Accuracy of Volumetric Trabecular Bone Mineral Density Assessment Using Dual-Source Dual-Energy CT: Phantom Study and Comparison with Quantitative CT

Station #5

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PURPOSE

To assess the accuracy of volumetric trabecular bone mineral density (BMD) assessment based on dedicated material decomposition using dual-source dual-energy computed tomography (DECT) in comparison to quantitative CT (QCT).

METHOD AND MATERIALS

Data from a validated anthropomorphic spine phantom consisting of three lumbar vertebra equivalents containing 50, 100 and 200 mg/cm³ calcium hydroxyapatite (HA) concentrations which had been scanned using third-generation dual-source DECT, QCT and dual x-ray absorptiometry (DXA) was analyzed. For volumetric BMD assessment based on DECT, dedicated postprocessing software using material decomposition was applied, which enables phantomless BMD assessment of the trabecular bone through semi-manual definition of the volume of interest (VOI). Scans of all modalities were repeated three times and measurements per vertebrae were also repeated three times, and averaged values were recorded. The accuracy of DECT and QCT for BMD assessment was compared and calculated BMD values were correlated with DXA, which served as the standard of reference.

RESULTS

Significantly higher correlations between actual and measured HA concentrations were found for DECT (r=0.98) compared to QCT (r=0.93, *p*<.001). Mean error for all measurements was -2.8 ± 3.3 mg/cm³ (DECT) and -8.3 ± 9.5 mg/cm³ (QCT) (*p*<.001). There was significantly higher correlation between BMD values of DECT and DXA (r=0.99) compared to BMD values of QCT and DXA (r=0.94, *p*<.001).

CONCLUSION

Phantomless DECT using dedicated material decomposition achieves substantially improved accuracy in measurement of volumetric trabecular BMD and significantly higher correlation with DXA in comparison to QCT.

CLINICAL RELEVANCE/APPLICATION

DECT yielded significantly higher accuracy for volumetric trabecular BMD assessment compared to QCT by application of material decomposition and furthermore may enable opportunistic osteoporosis screening on routinely performed DECT through phantomless BMD assessment as a potential clinical relevant advantage over established methods.

PH242-SD-THA6 Dose and Image Quality in Ultra Low-Dose CT for Urolithiasis: Added Value of Automatic Tube Current Modulation and Deep Learning Image Reconstruction

Station #6

Participants
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PURPOSE

To compare dose and image quality of a baseline low-dose CT vs an ultra-low dose CT (automatic tube current modulation, ATCM) in patients with suspected urinary stone disease and to assess the added value of Deep Learning Image Reconstruction

METHOD AND MATERIALS

CT examination was performed on 18 patients (10 baseline low-dose, 8 ultra-low-dose).Filtered back projection (FBP), Adaptive Statistical Iterative Reconstruction-V (ASIR-V) was used for both protocols and Deep Learning Image Reconstruction(TrueFidelity)was used for the ultra-low dose protocol only. Dose and stones information were collected for both protocols. Subjective image quality was assessed by two radiologists scoring noise, visibility of the stone and overall image quality. Objective image quality (contrast-to-noise ratio, CNR) was assessed for the ultra-low dose protocol only (ASIR-V and TrueFidelity).

RESULTS

The ultra-low dose protocol (ATCM) showed a 80% decrease in mean effective dose and improved visibility of the Urinary system . CNR was higher for TrueFidelity.

CONCLUSION

TrueFidelity improves the objective image quality, but not the subjective image quality for the chosen clinical task

CLINICAL RELEVANCE/APPLICATION

Urolithiasis is a worldwide problem with a high recurrence rate. Many patients will be affected by multiple stones throughout their lifetime. Among techniques available to reduce patient dose in the latest generation of CT scanners, automatic tube current modulation (ATCM) and Deep Learning Image Reconstruction have proved useful in clinical practice

PH243-SD-THA7 The Application of Monochromatic Images in Spectral CT for Reducing Metal Artifacts in Chest Biopsy Procedure

Station #7

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PURPOSE

To explore the value of using monochromatic images in dual-energy spectral CT for reducing metal artifacts in chest biopsy procedure.

METHOD AND MATERIALS

A total of 20 patients for CT-guided chest percutaneous biopsy were scanned using low dose dual-energy spectral CT imaging mode. After scanning, 9 sets of virtual monochromatic images with photon energies from 60-140keV in a 10keV increment were generated and analyzed on an AW4.6 workstation using the Gemstone Spectral Imaging (GSI) Viewer software. The degree of metal artifacts was evaluated using an artifact index (AI) and was calculated using the formula: AI=sqrt(SDadj - SDmuscle), where SDadj represents the standard deviation measurement in the area adjacent to the needle, and SDmuscle for the chest muscle. Higher AI values indicated worse quality. Two experienced radiologists also evaluated the subjective image quality independently and blindly using a 4-point scoring system including features like metal artifact, contrast resolution between needle and adjacent lesion tissue. Scores greater or equal to 2 were considered clinically acceptable.

RESULTS

The value of AI decreased with the increase of photon energy and plateaued after 120keV. The subjective evaluation indicated that the images at 120keV had the highest quality score. There was an excellent agreement in scores between the 2 observers (k=0.82) .

CONCLUSION

Low dose spectral CT imaging can significantly reduce the needle metal artifacts in chest CT biopsy to improve biopsy accuracy; and the 120keV is the optimal energy level to balance artifact reduction and contrast resolution.

CLINICAL RELEVANCE/APPLICATION

Spectral CT imaging may be used to improve chest CT biopsy accuracy with significantly reduced metal artifacts.

PH137-ED-THA8 Variable Skull Density Ratio for Transcranial MR-Guided Focused Ultrasound Thalamotomy: Is it Possible to Correlate Different Venders

Station #8

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TEACHING POINTS

The purpose of this exhibit is to summarize how to match skull density ratio (SDR), that show different value for each vender, by applying frequency filtering process. SDR is an index which shows how well ultrasound wave can pass through the skull for transcranial MR-guided focused ultrasound (TcMRgFUS) thalamotomy. Since skull with low SDR may be difficult to rise up the temperature of targeted tissue, it is one of the biggest obstacles in selecting the patients for treatment of TcMRgFUS thalamotomy. Although SDR is an important index to predict the temperature for the treatment of TcMRgFUS, it is varying not only in different venders, but also in different conditions of CT for the same patient. It is important to standardize the SDR which does not depend on each vender in TcMRgFUS thalamotomy.

TABLE OF CONTENTS/OUTLINE

Relationship between TcMRgFUS and SDR a. Thermal ablation by TcMRgFUS b. What is SDR? What is frequency filtering process a. How frequency filtering process works? b. Image change after processing SDR after frequency filtering process Future outlook

PHS-THB

Physics Thursday Poster Discussions

Thursday, Dec. 5 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
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Sub-Events

PH209-SD-THB1 Construction and Pre-Evaluation of an In-House Cylindrical Ionization Chamber Fabricated from Indigenous Materials

Station #1

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PURPOSE

The objectives of this study were to construct a very robust in-house cylindrical ionization chamber from locally available materials to minimise cost, and to assess the suitability of the constructed ionization chamber (IC) to be used for radiation metrologies appropriate with the detector in a clinical setting

METHOD AND MATERIALS

The entire body of the constructed IC was composed of Perspex (PMMA). Within the sensitive volume of the IC, the Perspex wall was made conductive by lining it with a piece of paper smeared with Graphite. The central electrode of the chamber was made of Alumimium rod, which formed part of strands of wires within a piece of scrapped Alumimium twisted cable obtained from the country's main electricity provider. The in-house IC was made waterproof by passing the triaxial cable connecting its various electrodes through a plastic tube which once served as a drainage tube of a urine bag. This connection was done such that the chamber was vented to the environment. The completed in-house IC was evaluated for: polarity effect, ion recombination, ion collection efficiency, stability, dose linearity, stem effect, leakage current, and angular, dose rate and energy dependences.

RESULTS

Although the pre-evaluation results confirmed that the in-house IC satisfied the stipulated international standards for ICs, there were the need to enhance stem effect and leakage current characteristics of the IC. The in-house IC was found to have an absorbed dose to water calibration coefficient of 4.475 x 107 Gy/C (uncertainty of 1.6%) for cobalt 60 through a cross calibration with a commercial 0.6 cc cylindrical IC with traceability to the Germany National Dosimetry Laboratory. Using a Jaffé diagram, the in-house IC was also found to have recombination correction factor of 1.0078 when operated at the calibration voltage of + 400 V. In terms of beam quality correction factors for megavoltage beams, the in-house IC was found to exhibit characteristics similar to those of Scanditronix-Wellhofer IC 70 Farmer type IC.

CONCLUSION

The use of the constructed in-house IC for beam output calibration in external beam radiotherapy is recommended.

CLINICAL RELEVANCE/APPLICATION

The study would be of interest to readers in the areas of reference dosimetry, design and construction of dosimeters. This study would also be of great significance to developing countries and other places with less endowed Radiotherapy Oncology institutions.

PH223-SD-THB2 Evaluation of Patient Radiation Dose Values Recorded During Fluoroscopically-Guided Neuro-Endovascular Procedures

Station #2

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PURPOSE

This study compares patient radiation doses between fluoroscopically-guided neuro-endovascular procedures. Peak skin dose is compared to dose area product and cumulative air kerma to determine correlations between these variables.

METHOD AND MATERIALS

The peak skin dose (PSD), cumulative air kerma (CAK), and dose area product (DAP) were retrospectively collected for 301 neuro-endovascular procedures from the Canon real-time Dose Tracking System (DTS). The procedures were categorized as cerebral angiography (207), aneurysm treatment (30), arteriovenous malformation (AVM) treatment (13), stenosis treatment (34), or thrombectomy (17). Cerebral angiographies were classified as diagnostic and the others interventional.

RESULTS

There was no significant difference in body mass index (BMI) of patients between procedure types. Cerebral angiography had a mean PSD (286 mGy) 3.4 times lower than the interventional procedures with individual procedure PSD's being: aneurysm treatment (1274 mGy), AVM treatment (1212 mGy), stenosis treatment (337 mGy), and thrombectomy (921 mGy). Eight interventional cases had a PSD above the 2000 mGy threshold for skin erythema: 5 aneurysm treatments, 2 AVM treatments, and 1 thrombectomy. The mean PSD, CAK, and DAP of the diagnostic procedures were significantly different from the interventional procedures ($p < 0.001$). However, the mean PSD and DAP of cerebral angiography, although lower, were not significantly different from stenosis treatment ($p = 0.117$ and $p = 0.139$). Regression analysis revealed a positive association, but with considerable dispersion of the data about the regression line between PSD and CAK ($R = 0.962$, mean absolute residuals = 88.8 mGy) and between PSD and DAP ($R = 0.869$, mean absolute residuals = 158.9 mGy) in the overall sample population.

CONCLUSION

Radiation exposure to patients during neuroendovascular procedures varies depending on the type of procedure. Cerebral angiography resulted in significantly lower radiation exposure than interventional procedures. PSD is important to assess the risk for skin injury and should be determined independently since, as seen from the magnitude of the residuals, it cannot be accurately estimated from CAK or DAP values.

CLINICAL RELEVANCE/APPLICATION

This presentation provides an insight into the magnitude of dose for neuroendovascular procedures which can place patients at risk for deterministic and stochastic radiation effects.

PH224-SD-THB3 A Brief Answer to the Concerns About Neutron Contamination in 18-MV Spatially Fractionated Radiation Therapy

Station #3

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PURPOSE

Despite the advantages of Spatially Fractionated Radiation Therapy (SFRT), there are concerns about photo-neutron production in 18-MV SFRT, especially when high-Z materials such as lead, cerrobend or brass are used for constructing the grid blocks. To have a better understanding about these concerns, the Monte Carlo (MC) calculations were carried out and the photo-neutron production was compared between two treatment modalities: 20-Gy single fraction SFRT and 40-Gy Conventional Fractionated Radiation Therapy (CFRT) in 20 fractions.

METHOD AND MATERIALS

The MCNPX 2.7.0 code was used to simulate photo-neutron production in the gantry head of an 18-MV LINAC (Varian 2100 CD). The tally f4 was used to estimate the total neutron fluence at the isocenter (Φn). SFRT plans were generated in different field sizes with a grid block on the LINAC tray. Each plan was calculated with a grid made of different materials (lead, cerrobend and brass). In the corresponding CFRT plans, same field sizes were used without a grid. Additionally, Neutron Equivalent Dose (NDE) to an 8 cm spherical tumor inside the liver of a MIRD anthropomorphic phantom was compared between CFRT and SFRT (brass grid only). In all MC calculations, the relative error was kept within 3%.

RESULTS

The values of Φn in the CFRT plans were found to be 4.56, 5.02, 5.18 and 5.11 (108 n/cm2) for 10 × 10, 15 × 15, 20 × 20 and 25 × 25 cm2 fields, respectively. In the corresponding SFRT plan using a brass grid, they were 1.2, 1.46, 1.68 and 1.81 (108 n/cm2). The Φn increased to 1.82, 2.37, 2.94 and 3.43 (108 n/cm2) when a lead grid was used instead. The Φn in SFRT with a cerrobend grid was 1.82, 2.31, 2.86 and 3.28 (108 n/cm2). The NDE to the tumor for the SFRT plan (brass grid) and CFRT plans was found to be 11.9 and 38.4 mSv, respectively.

CONCLUSION

In contrast with common concerns about 18-MV SFRT, this study showed that the neutron contamination during SFRT is less pronounced than CFRT. The Φn and NDE of SFRT are 33-74 % and 31% (brass grid) of CFRT. Brass is the preferred material for grid blocks due to its lower cross-section for (γ, n) reaction. This study will continue on the simulations of neutron dose to critical organs.

CLINICAL RELEVANCE/APPLICATION

(dealing with secondary neutron dose) Neutron contamination in 18 MV SFRT (GRID therapy) is less pronounced than conventional fractionated radiation therapy.

PH225-SD- Automated Segmentation of Cardiac Structures for Pre-Operative Training and Planning of Congenital

THB4 **Heart Surgery**

Station #4

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PURPOSE

To evaluate accuracies of automated 3D segmentation for the pre-operative training and planning of congenital heart surgery, via 3D U-Net with deep convolutional neural net (CNN).

METHOD AND MATERIALS

Pre-operative planning underwent for thirty-six patients with congenital heart disease, who were scanned by dual source mode of multi-detector CT (Somatom® Definition, Siemens) with submillimeter slice thickness. Myocardial structures including four chambers and lumen of vessels were manually segmented from enhanced CT images, under the supervision of an expert cardiac radiologist. Collected 36 pairs of CT images and 3D segmentation mask for myocardial structures were used to train 3D-Unet and 3-fold cross-validation were performed to evaluate the accuracy of the automatic segmentation method. Region of interest of congenital heart in CT images was standardized as 256 by 256 by 128 in 3D volume, and Dice similarity coefficient (DSC) was used to evaluate accuracy of the semantic segmentation method.

RESULTS

The automated semantic segmentation in 36 enrolled patients (Age 16.5±10.4 months, 19 male, and 17 female) showed considerable DSC accuracies (91.3% in 1st fold, 91.4% in 2nd fold, 92.5% in 3rd fold; 91.7% in average) compared to the ground truths via professional radiologist. In general, a manual segmentation task took around 7-9 hours. However, with the sematic segmentation which took around 10 sec, correction of automated segmentation result took around 1-2 hours for an expert radiographer.

CONCLUSION

The possible way to the full automation of myocardial structure segmentation, even for the congenital heart disease, was evaluated, which could be applied in real clinical workflow for more fast segmentation.

CLINICAL RELEVANCE/APPLICATION

Proposed automatic segmentation method of myocardial structures using 3D U-Net may help the radiologist's efforts for preoperative surgical planning and training, which could provide congenital heart disease patient more stable and effective surgical care.

PH245-SD-THB6 **The Impact of Radiation Dose on the Measurement Accuracy of Nodule Volume and Long Diameter Using Deep Learning-Based Computer-Aided Diagnostic System: A Phantom Study**

Station #6

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PURPOSE

To investigate the impact of radiation dose on the measurement accuracy of nodule volume and long diameter with a deep learning-based computer aided diagnostic system (DL-CAD) using an anthropomorphic chest phantom.

METHOD AND MATERIALS

An anthropomorphic chest phantom consisting of realistic pulmonary vessels (LUNGMAN, KYOTO KAGAKU, Kyoto, Japan) was used to simulate chest CT imaging. The chest phantom contains 8 spherical lung nodules of different diameters (6 mm, 8 mm, 10 mm, 12 mm) and densities (solid and ground glass nodules) and were scanned on a 256-slice CT (Revolution, GE Healthcare) with the following parameters:120 kVp, Noise Index=12, pre-ASIR-V was adjusted to 0%, 40%, 80% and 100% to modulate the tube current. Images were reconstructed with lung kernel and post-ASIR-V of 80%. Absolute percentage error (APE) of the diameter and volume of the lung nodules was used to describe the accuracy of measurement. The diameter APE was calculated as APEd =| Dm-Drs| / Drs×100, and the volume APE was calculated as APEv = | Vm-Vrs| / Vrs×100, where Dm, Drs represent the true and measured long diameter and Vm, Vrs represent the true and measured volume. One-way ANOVA and LSD-t test were used to compare APEd and APEv of nodules with different sizes and densities.

RESULTS

Effective radiation dose of different scans with 0%, 40%, 80%, 100% pre-ASIR-V were 9.68mSv, 3.78mSv, 0.82mSv and 0.23mSv respectively ($p<0.01$). For both nodule diameter and volume measurement, APEd and APEv for 0%, 40%, 80%, 100% pre-ASIR-V scans increased significantly ($p<0.05$) as the effective dose decreased, there was a significant difference between each scan for both APED and APEv ($p<0.05$) (Table 1 and Fig. 1-3).

CONCLUSION

The radiation dose impact the measurement accuracy of nodule volume and long diameter with DL-CAD.

CLINICAL RELEVANCE/APPLICATION

Radiation dose impact the measurement accuracy of volume and long diameter measurement accuracy with DL-CAD. Attention should be paid when DL-CAD was used to lung cancer screening or follow-up.

PH246-SD-THB7 Assessment of Texture Feature Reproducibility in Dual-Energy Computed Tomography Virtual Monoenergetic Images

Station #7

Participants
Faraz Farhadi, Bethesda, VA (*Presenter*) Nothing to Disclose
Jayasai R. Rajagopal, BA, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Moozhan Nikpanah, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
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Michael Morris, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Paul Wakim, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
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Ashkan A. Malayeri, MD, Andover, MA (*Abstract Co-Author*) Nothing to Disclose
Babak Saboury, MD, MPH, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Elizabeth C. Jones, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

To explore the reproducibility of radiomic texture features across virtual monenergitic images generated from dual-energy CT (DECT) acquisitions used in clinical practice and clinical trials at our institution.

METHOD AND MATERIALS

A phantom containing liver and lung texture modules was scanned in triplicate with a clinical dual source DECT scanner. Three fixed volumes of interest (VOIs) were drawn in mixed images (weighted images of low (90kV) and high (150kV) energy acquisitions) and monoenergetic images at 8 different energy levels (40,50,60,70,80,100,120,140 keV) to compare four Harlick texture features (energy, entropy, contrast, and homogeneity). Percentage difference of texture values from the mixed image was calculated for each VOI and keV level.

RESULTS

For VOIs placed in the lung portion of the phantom, texture value difference from mixed the image was on average 10% (range:1-17%) for energy, 4% (range:0.5-8%) for contrast, 3% (range:0.3-6%) for correlation, and 1% (range:0.1-2%) for homogeneity. In liver these values included 7% (range: 0.4-16%) for energy, 11% (range: 0.4-39%) for contrast, 10%(range: 2-29%) for correlation, and 2%(range: 0.3-6%) for homogeneity.

CONCLUSION

All four texture features reviewed showed variance across monoenergetic images of DECT.

CLINICAL RELEVANCE/APPLICATION

Defining imaging device characteristics and their effect on imaging features with an empirical manner is a critical step for utilization of radiomics in the precision medicine era.

PH138-ED-THB8 Know Your Dark Horse in Imaging: Acquisition and Physics Behind Dual-Energy CT and Its Application in Cardiac Imaging

Station #8

Participants
Bhavana Nagabhushana Reddy, MBBS, MD, Bengaluru, India (*Presenter*) Nothing to Disclose
Prashanth Reddy, MBBS,MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Bharath B. Das, MD, MBBS, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Suman T. Prabhakar, MBBS,MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose
Puneeth K. K N, MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Jainesh V. Dodia, MBBS,MD, Bangalore , India (*Abstract Co-Author*) Nothing to Disclose
Sanjaya Viswamitra, MD, Bangalore, India (*Abstract Co-Author*) Nothing to Disclose

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TEACHING POINTS

1. To educate the reader about the different acquisition techniques of dual energy CT.2. To describe the physics behind dual energy CT and understanding its basis on material decomposition 3. To discuss the applications of dual energy CT in cardiac imaging4. To be aware of pitfalls that could occur during dual energy CT.

TABLE OF CONTENTS/OUTLINE

108 CT coronary angiogram studies were done using dual energy CT performed in 2018-2019. Prospective review revealed various applications of DECT including in patients with suspected instent restenosis, high calcium score, stress and rest perfusion, assessment of myocardial infarction and viability will be discussed. We also discuss the various acquisition techniques in dual energy CT, physics behind it. Pitfalls which occur due to display Settings and Noise of Color-Coded Iodine maps, image noise on virtual monoenergetic images will also be discussed.

RC721

Innovations in MR and CT Perfusion

Thursday, Dec. 5 4:30PM - 6:00PM Room: S103AB

CT MR PH

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

FDA Discussions may include off-label uses.

Participants
Roland Bammer, PhD, Parkville, Australia (*Coordinator*) Founder, iSchemaView, Inc; Director, iSchemaView, Inc; Stockholder, iSchemaView, Inc; Founder,HobbitView, Inc; Director,HobbitView, Inc; Stockholder, HobbitView, Inc

LEARNING OBJECTIVES

1) A survivors guide for perfusion methodology. 2) Practical considerations of perfusion imaging and leakage measurements in tumors. 3) How to use and interpret perfusion imaging in cerebro-vascular disease.

Sub-Events

RC721A MR and CT Perfusion and Pharmacokinetic Imaging

Participants
Roland Bammer, PhD, Parkville, Australia (*Presenter*) Founder, iSchemaView, Inc; Director, iSchemaView, Inc; Stockholder, iSchemaView, Inc; Founder,HobbitView, Inc; Director,HobbitView, Inc; Stockholder, HobbitView, Inc

RC721B Evidence-Based Best Acquisition Protocols for DSC-MRI in Brain Tumors

Participants
Jerrold L. Boxerman, MD, PhD, Providence, RI (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Explain the DSC-MRI contrast mechanism and vessel size dependence of gradient-echo and spin-echo signal changes. 2) Identify the major protocol decisions for single-echo, gadolinium-based DSC-MRI. 3) Describe techniques for reducing contrast agent leakage effects in DSC-MRI. 4) Recommend an evidence-based best-practice protocol for DSC-MRI applications in neuro-oncology and clinical trials.

RC721C Perfusion Imaging in Cerebrovascular Disease

Participants
Shalini A. Amukotuwa, BMedSc,MBBS, Melbourne, Australia (*Presenter*) Spouse, Founder, iSchemaview

RC722

Functional MR Imaging for Normal Tissue Response Assessment in Radiotherapy

Thursday, Dec. 5 4:30PM - 6:00PM Room: S503AB

BQ MR PH RO

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

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

Sub-Events

RC722A State of the Art in Functional MR Imaging for Normal Tissue Assessment

Participants
Kiaran P. McGee, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Identify underlying biological processes associated with functional magnetic resonance imaging techniques. 2) List most commonly used functional imaging techniques in magnetic resonance imaging. 3) Explain the physics of various functional magnetic resonance imaging technique described in the presentation.

RC722B Clinical Need for Functional MR Imaging for Normal Tissue Assessment in Radiation Therapy

Participants
Clifton D. Fuller, MD,PhD, Houston, TX (*Presenter*) Research Consultant, Elekta AB Research Grant, Elekta AB Speaker, Elekta AB

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LEARNING OBJECTIVES

Discuss the relevant needs for normal tissue imaging after radiotherapy, using head and neck radiotherapy as a use case.Define opportunities for enhanced normal tissue imaging procedures for post-therapy toxicity and monitoring.

RC722C Technical Challenges in the Integration of Functional MR Imaging for Normal Tissue Assessment into Radiotherapy

Participants
Martha M. Matuszak, PhD, Ann Arbor, MI (*Presenter*) Research funded, Varian Medical Systems, Inc; Consultant, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Discuss the challenges in incorporating functional MR into treatment planning.

RC723

CT Radiation Dose Reduction: Techniques and Clinical Implementation

Thursday, Dec. 5 4:30PM - 6:00PM Room: S504AB

CT PH SQ

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

Participants
Lifeng Yu, PhD, Rochester, MN (*Coordinator*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Review techniques that are currently available for radiation dose reduction. 2) Understand general dose management and optimization strategies and how they are implemented in adult CT. 3) Understand strategies to optimize scanning protocols in pediatric CT.

ABSTRACT

This course will provide an overview of techniques and clincial implementations of radiation dose reduction in CT.

Sub-Events

RC723A Overview of Technology for Radiation Dose Reduction

Participants
Joseph W. Stayman, PhD, Baltimore, MD (*Presenter*) Research Grant, Canon Medical Systems Corporation; Research Grant, Carestream Health, Inc; Research Grant, Elekta AB; Research Grant, Fischer Medical; Research Grant, Medtronic plc; Research collaboration, Koninklijke Philips NV; Research collaboration, Varex Imaging Corporation; Research Grant, Siemens AG; Research Grant, General Electric Company;

LEARNING OBJECTIVES

1) Identify targets for radiation dose reductions in x-ray CT. 2) Gain an understanding of dose reduction strategies based on innovations in hardware design and development. 3) Gain an understanding of dose reduction strategies based on data processing chain improvements including iterative reconstruction methods. 4) Understand some of the trade-offs in dose reduction as well as limitations on dose reduction.

RC723B Dose Optimization Strategy and Clinical Implementation in Adult CT

Participants
Lifeng Yu, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Introduce dose management and optimization strategies in adult CT. 2) Describe how dose reduction techniques are clinical implemented in adult CT, including neuro, chest, abdominal, cardiovascular, and MSK.

RC723C Dose Reduction and Protocol Optimization in Pediatric CT

Participants
Robert MacDougall, PhD, Boston, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Recognize the important of clinical indication on CT protocol design. 2) Describe the different commercial implementations of kV and mA modulation algorithms and understand methods of standardizing image quality across platforms. 3) Understand the effect of reconstruction algorithms on acquisition parameter selection in pediatric CT.

Printed on: 10/29/20

RC725

Radiomics: Oncologic Applications

Thursday, Dec. 5 4:30PM - 6:00PM Room: N226

BQ PH

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

Participants
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

LEARNING OBJECTIVES

1) Provide an overview of imaging genomics fields (radiogenomics and radiomics). 2) Survey progress made to date in imaging genomics of breast and liver cancer. 3) Understand and appreciate the context for 'real world' applications of imaging genomics in breast and hepatic malignancies. 4) Apply radiomics and imaging genomics in brain tumors. 5) Describe the use of MRI as a biomarker for underlying genomic composition. 6) Define role of MRI in personalized medicine for target discovery of therapeutic targets. 7) Explain the use of MRI in drug development and clinical trials. 8) Assess the research available in imaging genomics. 9) Describe the integration of radiomics and imaging genomics into big data platforms.

Sub-Events

RC725A Breast Cancer with PET-CT

Participants
Richard L. Wahl, MD, Saint Louis, MO (*Presenter*) Research Consultant, Nihon Medi-Physics Co, Ltd Contract, WhiteRabbit.AI Inc

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RC725B Radiogenomics of Hepatic Malignancies

Participants
Neema Jamshidi, MD, PhD, Santa Monica, CA (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Provide an overview of imaging genomics fields (radiogenomics and radiomics). 2) Survey progress made to date in imaging genomics of liver cancer. 3) Understand and appreciate the context for 'real world' applications of imaging genomics in hepatic malignancies.

RC725C Brain Cancer: Radiomics, Radiogenomics, and Big Data

Participants
Rivka R. Colen, MD, Houston, TX (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Define the field of radiomics and imaging genomics. 2) Apply radiomics and imaging genomics in brain tumors. 3) Describe the use of MRI as a biomarker for underlying genomic composition. 4) Define role of MRI in personalized medicine for target discovery of therapeutic targets. 5) Explain the use of MRI in drug development and clinical trials. 6) Assess the research available in imaging genomics. 7) Describe the integration of radiomics and imaging genomics into big data platforms.

ABSTRACT

This objective of this course is to introduce the recently emerged field of radiomics and imaging genomics (radiogenomics) in brain tumors, specifically glioblastoma (GBM) and brain metastasis. Emphasis will be on radiomics with regards to the high-dimensional, high-throughput feature extraction of imaging features from medical images, specifically MRI; the second emphasis will be on the use of imaging in relation to underlying tumor genomics, how to use MRI as a biomarker, surrogate and correlate of tumor genomics as well as the use of MRI as a genomic target discovery tool and its application in therapeutic discovery and drug development. The role of radiomics and imaging genomics in the era of big data and how we can leverage the imaging-omic data will also be discussed.

RC825

Radiomics: From Image to Radiomics

Friday, Dec. 6 8:30AM - 10:00AM Room: E350

BQ PH

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

Participants
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

LEARNING OBJECTIVES

1) Learn about the role of image annotations in radiology and their relevance to enabling interoperability and for communicating results and value for machine learning and decision support. 2) Become acquainted with important standards and tools that support the creation, management, and use of image annotations. 3) See case examples of image annotations in practice to enable developing applications that help the practice of radiology. 4) Understand the categories of, and the specific radiomic image features that can be computed from images. 5) Understand the effect and implications of image acquisition and reconstruction on radiomic image features. 6) Learn about workflows that drive the creation of predictive models from radiomic image features. 7) Understand the methods for and the potential value of correlating radiological images with genomic data for research and clinical care. 8) Learn how to access genomic and imaging data from databases such as The Cancer Genome Atlas (TCGA) and The Cancer Imaging Archive (TCIA) databases, respectively. 9) Learn about methods and tools for annotating regions within images and link them with semantic and computational features.10) Learn about methods and tools for analyzing molecular data, generating molecular features and associating them with imaging features. 11) Learn how deep learning can revolutionize interpretation of medical images.

Sub-Events

RC825A Image Annotation and Semantic Labeling

Participants
Daniel L. Rubin, MD, Stanford, CA (*Presenter*) Consultant, F. Hoffmann-La Roche Ltd

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LEARNING OBJECTIVES

1) To learn about the role of image annotations in radiology and their relevance to enabling interoperability and for communicating results and value for machine learning and decision support. 2) To become acquainted with important standards and tools that support the creation, management, and use of image annotations. 3) To see case examples of image annotations in practice to enable developing applications that help the practice of radiology.

RC825B Image feature Computation and Considerations

Participants
Sandy Napel, PhD, Stanford, CA (*Presenter*) Medical Advisory Board, Fovia, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

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LEARNING OBJECTIVES

1) To understand the categories of, and the specific radiomic image features that can be computed from images. 2) To understand the effect and implications of image acquisition and reconstruction on radiomic image features. 3) To learn about workflows that drive the creation of predictive models from radiomic image features.

RC825C Correlating Image features with Multi-Omics Data

Participants
Olivier Gevaert, PhD, Stanford, CA (*Presenter*) Nothing to Disclose

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LEARNING OBJECTIVES

1) Understand the methods for and the potential value of correlating radiological images with genomic data for research and clinical care. 2) Learn how to access genomic and imaging data from databases such as The Cancer Genome Atlas (TCGA) and The Cancer Imaging Archive (TCIA) databases, respectively. 3) Learn about methods and tools for annotating regions within images and link them with semantic and computational features. 4) Learn about methods and tools for analyzing molecular data, generating

molecular features and associating them with imaging features. 5) Introduction into how deep learning can revolutionize interpretation of medical images: challenges and opportunities.

ABSTRACT

Radiogenomics is an emerging field that integrates medical images and genomic data for the purposes of improved clinical decision making and advancing discovery of critical disease processes. In cancer, both imaging and genomic data are becoming publicly available through The Cancer Imaging Archive (TCIA) and The Cancer Genome Atlas (TCGA) databases, respectively. The TCIA/TCGA provide examples of matched molecular and image data for five cancer types, namely breast, lung, brain, prostate and kidney. The data in TCGA includes various omics data such as gene expression, microRNA expression, DNA methylation and mutation data. Quantitative image analysis from MRI, CT and/or PET images in TCIA has now become widespread and these image features represent concepts such as tumor volume, shape, edge sharpness, voxel-value histogram statistics, image textures, and specialized features developed for particular acquisition modes. Similarly, images are being annotated with semantic descriptors by radiologists using controlled terminologies to record the visual characteristics of the diseases. The availability of these linked imaging-genomic data provides exciting new opportunities to recognize imaging phenotypes that emerge from molecular characteristics of disease and that can potentially serve as biomarkers of disease and its response to treatment. They also provide an opportunity to discover key molecular processes associated with distinct image features, within one cancer type and across different cancer types. More recently, deep learning approaches have become very popular to analyze medical images. Deep learning has the advantage that no features have to be engineered beforehand, and everything is learned from the image. This workshop will describe datasets and tools that enable research at the intersection of imaging and genomics, and focus on the opportunities and challenges to develop future applications that leverage this knowledge for diagnostic decision support and treatment planning.

SST09

Physics (CT - Artifact Reduction)

Friday, Dec. 6 10:30AM - 12:00PM Room: E351

CT PH

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

FDA Discussions may include off-label uses.

Participants

Xiaochuan Pan, PhD, Chicago, IL (*Moderator*) Founder, XP Imaging, LLC; Shareholder, XP Imaging, LLC; Founder, XPIM, LLC; Shareholder, XPIM, LLC; Founder, Clarix Imaging Corp; Shareholder, Clarix Imaging Corp
Shuai Leng, PHD, Rochester, MN (*Moderator*) Nothing to Disclose

Sub-Events

SST09-01 A Deep Learning-Based Dual-Domain Model for Reducing Metal Artifacts in Clinical CT Images

Friday, Dec. 6 10:30AM - 10:40AM Room: E351

Participants
Yuanyuan Lyu, Zushou, China (*Abstract Co-Author*) Z2AI Corporation
Wei-An Lin, College Park, MD (*Abstract Co-Author*) Nothing to Disclose
Haofu Liao, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Jingjing Lu, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Lei Wang, Beijing, China (*Abstract Co-Author*) Nothing to Disclose
S. Kevin Zhou, Princeton, NJ (*Presenter*) Employee, Siemens AG

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CONCLUSION

Our proposed deep learning model yields better metal artifact reduction performance than other state-of-the-art methods and can be applied in the real word.

Background

Metallic implants cause severe streak and beam hardening artifacts in CT scans. Traditional methods, like linear interpolation (LI) and NMAR, inpaint affected sinogram to reduce artifact, but induce secondary artifacts or suffer from false tissue segmentation. Recently, deep learning based method, cGan-CT, tries to reduce artifacts in image domain but the effect is limited. Here, we propose a Dual-Domain Network (DuDoNet) and demonstrate its application to clinical data.

Evaluation

DuDoNet consists of a sinogram enhancement network (SE-Net), a differentiable Radon inversion layer (RIL) and an image enhancement network (IE-Net). The SE-Net learns to restore sinogram data via a mask pyramid U-Net. RIL reconstructs images from sinograms and allows joint learning of the two networks. The IE-Net further refines the images by a U-Net with residual learning. The learning of DuDoNet, which takes metal affected sinograms and corresponding metal traces as inputs, is supervised with clean sinograms and images. We synthesize 360,000 training and 2,000 validation samples based on DeepLesion. In synthesized data, DuDoNet restores the most details among all methods, with a PSNR of 32.29dB and a SSIM of 0.959. Our model successfully reduces the streak and shadowing artifacts and alleviates drawbacks of single domain methods. Then, DuDoNet trained on simulated data is applied to a total of 100 clinical images from DeepLesion and SpineWeb. Visual comparison shows that DuDoNet effectively suppresses the secondary artifacts and avoids false structural segmentation problem in prior based methods. Blinded qualitative evaluation by radiologists shows DuDoNet achieves the best performance (rank: 3.13) and significantly outperforms LI, NMAR, cGan-CT ($p<0.028$).

Discussion

In DuDoNet, SE-Net first recovers inconsistent sinograms and IE-Net further reduces secondary artifacts. Our model effectively reduces metal artifacts in both simulated and clinical scans and achieves better image quality than other single domain approaches.

SST09-02 Reduction of Artifacts from High-Density Moving Objects in C-arm CBCT Using a Deep Learning-Based Segmentation Approach

Friday, Dec. 6 10:40AM - 10:50AM Room: E351

Participants
Daniel Gomez-Cardona, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Shuai Leng, PHD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Christopher P. Favazza, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Beth A. Schueler, PhD, Zumbrota, MN (*Abstract Co-Author*) Nothing to Disclose
Kenneth A. Fetterly, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

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PURPOSE

Moving, high-density objects in the heart, including catheters and pacemaker leads, cause substantial artifacts in cone beam CT (CBCT) images. The purpose of this work was to exploit a deep learning method to efficiently segment and remove these objects from projection rotational angiography (RA) images, thereby reducing artifacts in cardiovascular CBCT images.

METHOD AND MATERIALS

Segmentation of the high-density objects from the RA images was performed using a deep convolutional neural network with an encoder-decoder architecture based on the VGG-16 network. Synthetic training (3,000) and validation (2,000) images were created by adding augmented RA images of a pigtail catheter to RA images of an anthropomorphic phantom acquired with a clinical angiography system. The model trained with the synthetic images was then used as a starting point to learn to label pacemaker leads and different type of catheters in two real patient data sets. The new image set consisted of 450 and 50 RA images in total for training and validation, respectively. Data was augmented by reflection, translation, size scaling, rotation, and noise addition in both image sets. To remove high-density object artifacts, the segmented image pixels were inpainted by solving the Dirichlet boundary value problem. Correlated Poisson noise was then added to the inpainted pixels to match image texture. The original and modified RA images were reconstructed using filtered back-projection to create CBCT images.

RESULTS

Training for the synthetic and patient images took 25 and 2 hours, respectively. A Sørenson-Dice coefficient of 80.8% and 75.6% was obtained for each set, respectively. These values are partly explained by the model output which extended modestly beyond the edges of the ground truth representation of the objects. Visual inspection of the resultant patient CBCT images demonstrated that artifacts associated with moving catheters and pacemaker leads were nearly completely resolved without introduction of other image defects.

CONCLUSION

A deep learning method to segment catheters and pacemaker leads in projection RA images of the heart was implemented and used to mitigate associated artifacts in CBCT images of the heart.

CLINICAL RELEVANCE/APPLICATION

This work demonstrates a deep learning segmentation method to mitigate the artifacts caused by moving high-density objects in the heart, thereby providing substantially improved CBCT images.

SST09-03 Dental Artifact Reduction Using a Three-Stage Projection-Based Metal Artifact Reduction Algorithm for Spectral Imaging: A Phantom Study

Friday, Dec. 6 10:50AM - 11:00AM Room: E351

Participants
Nikesh Muthukrishnan, Montreal, QC (*Presenter*) Nothing to Disclose
Elizabeth Nett, Waukesha, WI (*Abstract Co-Author*) Employee, General Electric Company
Sahir Bhatnagar, PhD, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Deborah R. Shatzkes, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
C. Douglas Phillips, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Griselda T. Romero Sanchez, MD, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Rajiv Gupta, PhD, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Reza Forghani, MD,PhD, Cote Saint-Luc, QC (*Abstract Co-Author*) Researcher, General Electric Company; Institutional research collaboration, General Electric Company; Consultant, General Electric Company; Speaker, General Electric Company ; Founder, 4intelligent Inc; Stockholder, 4intelligent Inc; Stockholder, Real-Time Medical, Inc

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PURPOSE

Dental artifact remains a significant challenge on neck computed tomography. The purpose of this study is to evaluate a novel three-stage projection-based metal artifact reduction (GSI MAR) algorithm for reducing dental artifact using a phantom. The study evaluates the effectiveness of the MAR algorithm on dual energy acquisitions, the impact of radiation dose and the impact of MAR on multiple iodine concentrations.

METHOD AND MATERIALS

Two dental amalgams were inserted in a phantom next to five varying iodine concentrations to simulate the effects of artifact on enhancing tissues. Scans were acquired at five different doses and reconstructed without or with GSI MAR. Quantitative analysis was performed using standard deviation (SD), signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of strategically located regions of interest (ROI). The impact across 40 keV to 140 keV virtual monochromatic image (VMI) were evaluated. Qualitative analysis was performed by two external radiologists, estimating artifact reduction, anatomical and contrast improvement. Lastly, material decomposition maps were used for estimating iodine content.

RESULTS

Quantitative results indicated that the GSI MAR significantly lowered noise at all energy levels. Noise reduction percentage was highest at 70.72 % in the 135 keV VMI and the lowest at 58.70% in the 40 keV VMI. Iodine conspicuity was highest at low energy levels. A 348.58 % CNR and 294.35 % SNR increase was calculated at 40 keV VMI and a 18.5 % CNR and 14.25 % SNR increase in the 140 keV VMI. GSI-MAR improved the iodine estimation error from 146.95% to 62.82%. Subjective analysis indicated that the MAR provided higher quality acquisitions with an average artifact reduction between 51-75%.

CONCLUSION

Quantitative analysis of GSI MAR indicated an improvement of image quality across all energy levels. Lowest noise was found at higher energy levels and highest CNR and SNR was found at lower energy levels. Furthermore, subjective review indicated that MAR reconstructions provided higher quality images. Finally, GSI MAR was found to improve iodine concentration estimation.

CLINICAL RELEVANCE/APPLICATION

Dental artifact remains a significant challenge on neck computed tomography. This study evaluates the effectiveness of a novel metal artifact reduction algorithm.

SST09-04 CT Image Quality for Five Different Metal Artifact Reduction Algorithms

Friday, Dec. 6 11:00AM - 11:10AM Room: E351

Participants
Mercy Victoria Kataike, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
Matt Whitaker, Salem, NY (*Abstract Co-Author*) Employee, Image Owl, Inc
Hilde K. Andersen, MSc, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
Caroline Stokke, PhD, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
Anne C. Martinsen, Oslo, Norway (*Presenter*) Nothing to Disclose

PURPOSE

To evaluate the effectiveness of five CT Metal Artifact Reduction (MAR) Algorithms from four vendors in improving the image quality using a novel phantom for Metal Artifact Analysis.

METHOD AND MATERIALS

A Catphan 605 phantom with extension ring was scanned with different inserts (Hard Steel, Titanium, and Water) on 5 CT scanners reconstructed with and without MAR algorithms. The MAR algorithms used; GSI MAR (GE Revolution CT), Smart MAR (GE Revolution Frontier), O-MAR (Philips Ingenuity CT), iMAR (Siemens Somatom Drive) and SEMAR (Toshiba Aquilion One Genesis). Phantom was scanned at 120kV and at 120 kVp equivalent for GSI MAR and iMAR. Image quality was assessed by obtaining Contrast to Noise Ratio (CNR), Metal Artifact Analysis and Noise Power Spectrum (NPS). The parameters were obtained from ImageOwl Catphan QA software and Matlab.

RESULTS

For Titanium, Smart MAR, iMAR and SEMAR images had more noise than the images without MAR algorithms, while GSI MAR and O-MAR images had less noise than the images without MAR. MAR images had a lower CNR than the corresponding images without MAR, except GSI MAR images which had higher CNR than the images without MAR. For water, there was no difference in CNR for images with and without MAR, except iMAR and SEMAR. Metal Artifact Analysis showed artifact reduction around the insert and at a distance from the insert for all MAR algorithms in like manner. For titanium, GSI MAR showed the largest artifact reduction (87%, 73% respectively) followed by Smart MAR, SEMAR, O-MAR and iMAR. For hard steel, Smart MAR showed the largest artifact reduction (92%, 82%) followed by GSI MAR, SEMAR, iMAR, and O-MAR.There was no difference in NPS with and without MAR.

CONCLUSION

GSI MAR showed the most consistent performance under different conditions. Different MAR algorithms compensate differently for metal artifacts under different conditions. Thus, it is important to know the effects of the algorithms on image quality. Images obtained with MAR algorithms should be compared with those without MAR algorithms.

CLINICAL RELEVANCE/APPLICATION

Different MAR algorithms compensate for metal artifacts differently under different conditions. Thus, it is important to know the effects of the algorithms on image quality.

SST09-05 Image Quality Assessment of Metal Artefact Reduction in CT Using a Novel Abdominal Phantom

Friday, Dec. 6 11:10AM - 11:20AM Room: E351

Participants
Mercy Afadzi, PhD, Olso, Norway (*Presenter*) Nothing to Disclose
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PURPOSE

To evaluate a novel anthropomorphic abdominal phantom specially designed for qualitative and quantitative metal artefact assessment in CT for two different metal artefact reduction technologies.

METHOD AND MATERIALS

A anthropomorphic abdominal phantom with different inserts (bone with metal, low contrast, spatial resolution and homogeneity) was used in this study. Titanium, Hard and stainless steel inserts were placed in the center of the bone insert. All scans were performed on a GE Revolution CT at 15 and 20 mGy CTDIvol, 40 mm collimation, 120 kVp (+/- HiRes) and spectral imaging (GSI). Images were reconstructed with standard kernel, 2.5 mm slices, ASIR-V 50% and +/- MAR. Four observers evaluated lesion conspicuity and scored artefacts on a 4-point scale for all reconstructions. HU uniformity, coefficient of variation, reduction in noise streaks (range and standard deviations (SD)), noise power spectrum (NPS) and modulation transfer function (MTF) were evaluated for all reconstructions.

RESULTS

Preliminary quantitative and qualitative results showed that both single energy MAR (SMAR) and GSI MAR (GSIMAR) reduced streaks artefacts surrounding (2123-7019 vs 1267-5993 HU) and at a distance (196-251 vs 78-83 HU). Lesion conspicuity was not affected by MAR. HU uniformity and SD around the metals (223.08-438.76 vs 105.02-260.75 HU) and the bone insert (SD: 71.48 -143.17 vs 39.59 - 69.97 HU) were improved by the use of both SMAR and GSIMAR. These improvements were independent of dose. The use of only HiRes without MAR did not reduce streaks artefact, noise or HU uniformity. MAR hardly affected the MTF@50%. NPS profile was not affected by MAR.

CONCLUSION

Both SMAR and GSIMAR reduced metal artefact and improved image quality. Anthropomorphic phantom designed for qualitative and quantitative image quality analysis evaluation of metal artefact reduction should be used to assess image quality and lesion detection when MAR is introduced in daily routine to ensure that pathology is not missing after MAR has been applied.

CLINICAL RELEVANCE/APPLICATION

New anthropomorphic phantom specially designed for quantitative and qualitative assessment of metal artefact reduction in CT is important to ensure that pathology is not missing when MAR is applied.

SST09-06 Reduction of Cone-Beam Artifacts in Axial CT Systems with Large Detector Coverage

Friday, Dec. 6 11:20AM - 11:30AM Room: E351

Participants
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PURPOSE

We report cone-beam artifact reduction on axial scans with a 16cm coverage CT system using a recursive application of 3D filtered backprojection (FBP).

METHOD AND MATERIALS

Axial CT for voxels outside the acquisition plane does not satisfy a fundamental completeness condition, which leads to cone-beam artifacts. This is particularly evident in systems with large detectors. Previously published re-projection based recursive application of FBP was used to improve image quality in large pitch helical scans. We revisit this approach, apply it to the axial 3D FBP reconstruction and explain the effectiveness of the algorithm using a new argument based on the minimization of Bregman distances. The theoretical result is tested with analytic simulations and clinical data sets, reused from the previous clinical trials.

RESULTS

Recursive FBP algorithm reduced the low frequency artifacts in simulations effectively, returning images which are approaching the analytic ground-truth with every repeated recursive step. In clinical data, cone beam artifacts were considerably reduced with a more pragmatic combination of image processing and one recursive FBP application.

CONCLUSION

Bregman distance minimization algorithm leads to a previously known recursive 3D FBP algorithm, which proves to be effective for axial scans on systems with large detector coverage, offering a strong, new theoretical foundation for this algorithm. A pragmatic combination of recursive FBP with image processing returns high quality results from single-shot axial scans with improved bone clarity and more accurate CT numbers in the soft tissue.

CLINICAL RELEVANCE/APPLICATION

Cardiac scans can be performed within a single heartbeat using an axial CT with 0.25s rotation time and 16cm detector coverage. Tilted single shot axial head scanning ensures an efficient protection against excessive x-ray dose delivered to the eye lenses. Efficient reduction of cone-beam artifacts for both of these protocols is necessary.

SST09-07 Reduction of Artifact Caused by Embolization Coil Implant in Spectral CT Examination by Means of Virtual Monochromatic Imaging (VMI) and Monochromatic Imaging Combined with Metal Artifact Reduction Software (MARs)

Friday, Dec. 6 11:30AM - 11:40AM Room: E351

Participants
Zhipeng Yao, Beijing, China (*Presenter*) Nothing to Disclose
Yahui Peng, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate the reduction of artifact from embolization coil implant using VMI and VMI combined with MARs in spectral CT.

METHOD AND MATERIALS

Embolization coil implant was placed in an intermediate tube of the Quantitative Standard Pulsating Phantom (QSP) that contained an Iodine solution of 7 mgI/ml (CT value = 160HU at 120 kVp, representing the portal vein attenuation in the portal vein phase). Subsequently, 20 ml of sodium chloride solution was contained in eight tubes and inserted into the QSP. Two spectral CT scan protocols were used for image acquisition: conventional CT scan with tube voltage of 120 kVp(Group A); Spectral Imaging scan (Group B). A conventional image (CI) and virtual monochromatic images (70 - 140 keV, of 10 keV interval) with and without MARs were reconstructed, respectively. In each of the images, a measurement region of interest (ROI) was placed around the tube , including all pixels contaminated by the metal artifact but excluding the pixels inside the tube(ROItube). Besides, a background ROI was placed above the tube not influenced by the artifact,from where mean CT number(NCT) and standard deviation (SD) were measured. ΔCT was defined as the absolute value of NCT in hyperdense or hypodense artifact minus NCT in background ROI.

RESULTS

VMIMARs showed a significant decrease of hyperdense artifact ($p<0.05$)and hypodense artifact($p<0.05$)in term of lower ΔCT as compared to 120kVp imaging. With increasing of KeV , ΔCT and SD of artifact were decreasing in VMIMARs.In addition, noise image in VMIMARs exhibited a decreasing trend with increasing keV level. Whereas VMI only showed a significant decrease of hyperdense artifact ($p<0.05$). VMIMARs at 70 keV -140keV could show a better effect on the reduction of metal artifact as compared VMI at 140keV($p<0.05$).

CONCLUSION

Compared with conventional CT scanning, VMIMARs by using spectral CT could significantly reduce metal artifacts caused by embolization coil implants and provide better image noise.

CLINICAL RELEVANCE/APPLICATION

When using spectral CT for patients underwent Gastric coronary vein embolization(GCVE) produre, VMIMARs could significantly reduce metal artifacts caused by embolization coil implants in portal vein phase.

SST09-08 Ability of a Single Adaptive Iterative Metal Artifact Reduction Algorithm to Improve CT Image Quality in Patients with Multiple Metal Implants

Friday, Dec. 6 11:40AM - 11:50AM Room: E351

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PURPOSE

To compare performance of a single, adaptive iterative metal artifact reduction (AiMAR) algorithm applied to an entire patient's CT exam to 7 anatomically specific iMAR presets, in patients with multiple metal implants.

METHOD AND MATERIALS

In 30 patients with 72 types of implants, CT images were reconstructed with different strength settings of a single AiMAR algorithm and 2 - 3 iMAR presets (selected for body part/implant). The AiMAR algorithm enables real-time image-based measurements to adapt the degree and level of artifact reduction. In separate sessions, 2 trained radiologists evaluated artifacts (0 - 5), visualization of critical anatomic structures (1 - 5) and diagnostic confidence (1 - 5) in the region of each implant, also assigning an overall 'whole body' image quality score (1 - 5), considering all evaluated regions, with lower values for all scales being better. The optimal AiMAR strength was determined by comparing whole body image quality scores with individual iMAR presets in each body region. Significance was tested by Wilcoxon Signed rank test for paired samples.

RESULTS

Optimized results using AiMAR were achieved using strength settings 4 and 5 for head&neck, thoracic and extremity areas (dental, neuro, cervical spine,shoulder, thoracic spine, cardiac,arms/elbow, legs/knee). For abdomen/pelvis (hip, lumbar spine), preferred AiMAR strengths varied between 2 - 5, with the lower strengths providing higher diagnostic confidence and the higher strengths providing better artifact reduction. AiMAR strength 5 setting was preferred over lower strengths ($p<0.05$) when evaluating whole body image quality scores. For every body region, AiMAR strength 4 and 5 settings demonstrated widely overlapping ($p>0.05$) diagnostic confidence, visualization and artifact performance with the dedicated anatomically specific iMAR presets (figure).

CONCLUSION

In patients with multiple metal implants, a strength based adaptive implementation of artifact reduction (AiMAR) permits a single reconstruction of the entire body that provides a diagnostic quality anatomic evaluation and metal artifact reduction of similar quality compared to multiple reconstructions using separate body part specific iMAR presets.

CLINICAL RELEVANCE/APPLICATION

AiMAR can dramatically improve clinical workflow by minimizing the need for body-part specific iMAR reconstructions without compromising image quality, diagnostic confidence or artifact reduction.

SST09-09 Reproducibility and Validity of Approaches for Artifact Quantification in CT Imaging

Friday, Dec. 6 11:50AM - 12:00PM Room: E351

Participants
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PURPOSE

To objectify metal artifact reduction, numerous methods and approaches have been suggested. We aimed to compare results of such methods to visual perception of artifacts in order to establish a standard for artifact quantification in CT imaging.

METHOD AND MATERIALS

Two titanium rods (5 and 10mm) were examined with 25 different scanning and image reconstruction parameters to obtain a reference database of different types and extents of artifacts. 4 radiologists separately evaluated every image against each other (2-pair forced choice) using an in-house developed software. Rating was repeated two times (2400 comparisons = 2 times x 4 readers x 300 comparisons). Rankings were combined to obtain a reference ranking reaching from best to worst image. Proposed approaches for artifact quantification have been identified in literature, including manual measurement of artifact attenuation, standard deviation and noise as well as sophisticated algorithm-based approaches within the image- and frequency-domain (ImgD and FreqD, respectively). Two radiologists conducted manual measurements twice while the aforementioned algorithms were developed within the Matlab-Environment allowing for automated image analysis. The reference ranking was compared to all aforementioned methods for artifact quantification to identify suited and less-suited approaches. Besides visual analysis, Kappa-statistics were used to evaluate agreement between quantitative methods and visual perception. Intraclass correlation coefficients (ICC) indicated intra- and interreader agreement.

RESULTS

Intra- and Interreader agreement of visual artifact perception were excellent (ICC 0.85-0.92). No quantitative method was able to represent the exact ranking of visually perceived artifacts; however, ICC for manual measurements were low (ICC 0,25-0,97). The methods that showed best correspondence and reproducibility were ImgD and FreqD-based.

CONCLUSION

Artifact quantification in CT is challenging. Manual measurements show a limited reproducibility. We propose two methods that quantify artifacts in the image- and frequency-domain and that correspond closely to visual artifact perception.

CLINICAL RELEVANCE/APPLICATION

Automated measurements of artifact extent should be preferred over manual measurements as they correspond close to visual perception while the latter show a limited reproducibility.

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