103rd Scientific Assembly and Annual Meeting

November 26 to December 1
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PH001-EB-X

Smoke and Mirrors: A Review of the Top Artifacts on CT, MR, Ultrasound, and Molecular Imaging That Residents Should Know

All Day Room: NA Hardcopy Backboard

Awards
Certificate of Merit
Identified for RadioGraphics

Participants
Benjamin L. Triche, MD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
John T. Nelson JR, MD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Noah S. McGill, MD, Birmingham, AL (*Presenter*) Nothing to Disclose
Kristin K. Porter, MD,PhD, Birmingham, AL (*Abstract Co-Author*) Stockholder, Pfizer Inc
Rupan Sanyal, MD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Franklin N. Tessler, MD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Jonathan E. McConathy, MD, PhD, Birmingham, AL (*Abstract Co-Author*) Research Consultant, Eli Lilly and Company Research Consultant, Blue Earth Diagnostics Ltd Research Consultant, Siemens AG Research Consultant, General Electric Company
David M. Gauntt, PhD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Michael V. Yester, PhD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Satinder P. Singh, MD, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

btriche@uabmc.edu

TEACHING POINTS

The purpose for this exhibit is to: 1. Recognize common artifacts in CT, MR, Ultrasound, and Molecular Imaging. 2. Understand the physical principles that result in these artifacts and comprehend the implications for image interpretation. 3. Explain how to resolve or accentuate them to improve diagnostic quality and accuracy.

TABLE OF CONTENTS/OUTLINE

A description, the etiology, and the resolution/usefulness for each artifact will be discussed. Below is the outline of the artifacts from each modality: CT Beam Hardening Volume Averaging Photon Starvation Metal Motion Undersampling (aliasing) Truncation artifact Stair Step Ring artifact Windmill MR Bounce Point Zipper Motion/Pulsation/Ghost Susceptibility Chemical shift Wraparound Truncation Magic Angle Fat Saturation Failure Dielectric Effect US Reverberation Comet tail/Ring-down Mirror image Acoustic shadowing Increased through-transmission Twinkle Incorrect dynamic range setting Partial volume averaging Aliasing (color and spectral Doppler) Faulty angle correction (spectral Doppler) Molecular Imaging Star pattern Off peak Ring/Nonuniformity Nonlinearity PMT malfunction Metallic objects/Contrast material Contamination Truncation Attenuation Correction- Data Entry Error Patient Preparation

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PH003-EB-X

Management of Radiation exposure in Fluoroscopy Systems with an Over-the table X-ray Tube for Upper Gastrointestinal (Barium Meal) Examination

All Day Room: NA Hardcopy Backboard

Participants
Chiharu Hoshi, Sendai, Japan (*Presenter*) Nothing to Disclose
Koichi Chida, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshisada Kaneko, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Daisuke Shibuya, MD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Shigeru Hisamichi, MD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

-To emphasize the necessity of clarifying the radiation dose of over-the-table X-ray tube systems used for upper gastrointestinal examinations (UGEs). -To understand the importance of managing radiography and fluoroscopy radiation doses of X-ray systems used for UGEs.

TABLE OF CONTENTS/OUTLINE

Radiation dose measurement of numerous X-ray systems used for UGE The entrance doses for X-ray systems were compared, and reasons underlying high radiation doses were evaluated. We estimated the radiation dose received by patients during UGE using phantom dose measurements, based on standard procedures (2 min fluoroscopy, 8 radiograms). *Optimizing the radiation for UGEs* The relationship between image quality and radiation dose was evaluated. OUTLINE: Previous reports have evaluated the image quality and diagnostic ability of UGEs; however, there are no detailed data on radiation exposure in fluoroscopic systems used for UGEs. In our study, while no significant differences were found between entrance doses for any systems examined, there was a trend for higher doses in some systems. In addition, the maximum-minimum dose differences in the X-ray systems were large. As UGEs are the second most common X-ray examinations performed in Japan following chest X-rays, establishing diagnostic reference levels for these examinations is important.

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PH005-EB-X

The Physics of Diffusion MRI and its Applications in Oncology

All Day Room: NA Hardcopy Backboard

Awards
Cum Laude
Identified for RadioGraphics

Participants
Matthew Marzetti, MSc, Dundee, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Brooke Lawson, MD, Dundee, United Kingdom (*Presenter*) Nothing to Disclose
Shelley Henderson, PhD , Dundee, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Stephen J. Gandy, PhD, London, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Tracy Brunton, Dundee, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
James Muir, Dundee, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Prasad Guntur Ramkumar, MRCP, FRCR, Dundee, United Kingdom (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

matthewmarzetti@nhs.net

TEACHING POINTS

Diffusion weighted imaging (DWI) generates contrast based on the differences in motion of water molecules within the tissue. DWI is an established imaging technique providing information regarding tissue structure and pathology without the need for external contrast agents. This exhibit will explain the physical principles of diffusion weighted imaging and diffusion tensor imaging, including the properties of the b-value and its effect on images. The clinical utility and relevance of diffusion weighted images and Apparent Diffusion Coefficient (ADC) maps in oncology imaging, for both diagnosis and monitoring, will be reviewed. The clinical use of diffusion imaging in conjunction with other techniques to aid in the diagnosis of complex cases will be discussed.

TABLE OF CONTENTS/OUTLINE

Outline of the physics of b-values, diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) maps; quality assurance measures for DWI; repeatability of DWI and clinical implications for monitoring change over time; imaging review of basic oncology applications (neuro, breast, liver, prostate, haematological; diagnosis/classification/treatment monitoring, both as a standalone technique and combined with other imaging techniques); advanced applications of DWI (whole body myeloma diagnosis and treatment monitoring; brain tractography; breast DTI)

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PH100-ED-X

Approaching Motion on MR Imaging

All Day Room: NA Digital Education Exhibit

Participants
Johannes K. Richter, MD, Bern, Switzerland (*Presenter*) Nothing to Disclose
Alan Peters, MD, Bern, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Johannes T. Heverhagen, MD, PhD, Bern, Switzerland (*Abstract Co-Author*) Research Grant, Bracco Group; Research Grant, Guerbet SA; Research Grant, Siemens AG; Speaker, Bayer AG
Rainer J. Egli, MD,PhD, Bern, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Paolo Lombardo, Turin, Italy (*Abstract Co-Author*) Nothing to Disclose
Reto D. Merges, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Jeremias Klaus, MMed , Bern, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Philippe Vollmar, MD, Bern, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Sebastian Sixt, Bad Krozingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Martin H. Maurer, MD, Bern, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Hendrik Von Tengg-Kobligk, MD, Bern, Switzerland (*Abstract Co-Author*) Research Grant, W. L. Gore & Associates, Inc
Val M. Runge, MD, Bern, Switzerland (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

johannes.richter@insel.ch

TEACHING POINTS

(1) To present and discuss the clinically relevant techniques addressing the issue of motion in MR imaging focusing mainly on the abdomen (Blade, TWIST VIBE, radial VIBE, GRASP).(2) To provide relevant background knowledge on parallel imaging and compressed sensing and show its benefits in daily routine, in cardiac imaging and beyond.(3) To provide guidance to the radiologist as to the implementation of the above mentioned techniques, with the intent to enable faster and improved clinical scan results.

TABLE OF CONTENTS/OUTLINE

The exhibit uses primarily patient images to convey the benefits of dedicated MR sequences for motion artifact reduction when compared to more conventional scans in day-to-day clinical routine. Following the introduction to the basic appearance of motion artifacts (ghosting and smearing), conventional approaches of reduction (triggering, gating, and navigator echoes) and the relevant advanced techniques (i.e. BLADE, TWIST VIBE, Radial VIBE, CAIPIRINHA-VIBE and GRASP) will be illustrated. Imaging examples include a 19 sec breath-hold CAIPIRINHA-VIBE vs. a 2 min non-breath-hold radial VIBE and a 4.8 sec breath-hold Dixon VIBE vs. non-breath-hold radial VIBE images (2 min vs. 21 sec - with differing degree of streak artifacts). The concepts of parallel imaging and compressed sensing will be explained and illustrated.

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PH101-ED-X

Potential Exposure Dose Reductions During Digital Breast Tomosynthesis Using a Novel Compressive Sensing Algorithm

All Day Room: NA Digital Education Exhibit

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

For information about this presentation, contact:

gomi@kitasato-u.ac.jp

TEACHING POINTS

1) To use conventional [filtered back projection (FBP) and iterative reconstruction (IR)] and novel compressive sensing (CS) algorithms for identifying indications of digital breast tomosynthesis (DBT) at various exposure doses. 2) To compare FBP, IR, CS, and radiography. 3) To select an appropriate algorithm and exposure dose for microcalcification and lesion detection.

TABLE OF CONTENTS/OUTLINE

1. Overview of FBP, IR [simultaneous iterative reconstruction techniques (SIRT) and maximum likelihood expectation maximization (MLEM)], and CS algorithms for DBT and radiography 2. Diagnostic imaging properties Efficacy with respect to the normal structure and lesion detection 3. Parameter review Full width at half-maximum (FWHM) Signal difference-to-noise ratio (SDNR) Average glandular dose (AGD) 4. Clinical relevance Outline: CS algorithm for DBT can preserve the resolution and contrast visibility after appropriately selecting the reduced exposure dose. Hence, CS algorithm for DBT, rather than conventional algorithms and radiography, should be further evaluated. Furthermore, the exposure dose could possibly be decreased by half with CS algorithm for DBT. Understanding the potential of CS algorithm for DBT in selecting exposure dose may improve the diagnostic accuracy of this algorithm in clinical applications.

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PH102-ED-X

3D Printing of a Tissue Realistic Anthropomorphic Abdominal Phantom

All Day Room: NA Digital Education Exhibit

Awards
Certificate of Merit

Participants
Vahid Anwari, BSC, Toronto, ON (*Presenter*) Nothing to Disclose
Ali Ursani, MENG, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Shailaja Sajja, MS, Toronto, ON (*Abstract Co-Author*) Research funded, Carestream Health, Inc
Ashley A. Lai, BSC,RT, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Karina Rego, BSC, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Narinder S. Paul, MD, Toronto, ON (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation; Research Grant, Carestream Health, Inc

For information about this presentation, contact:

vahid.anwari@uhn.ca

TEACHING POINTS

1) To appreciate the novel applications of 3d printing in medical imaging. 2) To review the steps in 3d printing of phantoms for medical imaging. 3) To present the roles of the interdisciplinary team in 3d printing. 4) To define metrics and processes for successful design, printing and construction of a 3d tissue realistic anthropomorphic abdominal phantom.

TABLE OF CONTENTS/OUTLINE

1) A review of current and potential future applications for 3d printing in medical imaging. 2) Introduction to the steps involved in 3d printing: • Image acquisition • Image post-processing • 3-d printing 3) Essentials of interdisciplinary involvement for a comprehensive 3d printing program. 4) 4 categories of 3d printed models for medical imaging: • Educational Models: Patients as Partners in their Care: To educate patients about their disease and treatment options • Surgical procedure aiding models: Improve Quality of care during Interventional and Surgical procedures • Radiation dose monitoring models: Optimize exposure parameters and Radiation Dose. • Tissue realistic anthropomorphic phantoms: Optimize diagnostic and interventional procedures 5) Case study: 3d printing of tissue realistic abdominal organs: An iterative learning and development process.

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PH105-ED-X

Can Ultra-high-resolution CT that Achieves Reduction in the Partial Volume Effect Reduce the Amount of Contrast Medium Required?

All Day Room: NA Digital Education Exhibit

Participants
Toshihiro Ishihara, RT, cyuo-ku, Japan (*Presenter*) Nothing to Disclose
Hirobumi Nagasawa, RT, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
So Tsushima, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Tomohiko Aso, RT, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

To understand the characteristics of ultra-high-resolution computed tomography (CT) and multi-detector CT (MDCT). To understand the characteristics of the partial volume effect in ultra-high-resolution CT and MDCT. To understand the usefulness of ultra-high-resolution CT based on the sensitivity characteristics and CT values of iodine-based contrast agents relating to the partial volume effect.

TABLE OF CONTENTS/OUTLINE

To show the difference in resolution characteristics between ultra-high-resolution CT and MDCT. To investigate the modulation transfer function (MTF) and CT value characteristics normalized by line spread function (LSF). To simulate the decrease in the amount of contrast agent required based on the CT value characteristics, by verifying the partial volume effect from the model vessel diameter. To verify the security of CT values, to verify differences in equipment and effective tube voltage characteristics, and to confirm the basic data for clinical application. However, with MTF that normalizes the peak CT value of LSF, the sensitivity of CT values is not expressed in absolute terms. LSF in ultra-high-resolution CT (Aquilion Precision; Toshiba, Ootawara, Japan) represents a partial volume-suppressing effect and can improve the sensitivity of iodine-based contrast agents as CT sensitivity improves.

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PH107-ED-X

High-quality 2D and 3D Angiography CT Imaging of Pancreato-Biliary Diseases with Low Tube Voltage, Small Focal Spot and Iterative Model Reconstruction Techniques

All Day Room: NA Digital Education Exhibit

Participants
Masafumi Uchida, MD, PhD, Kurume, Japan (*Presenter*) Nothing to Disclose
Asako Kuhara, Kurume, Japan (*Abstract Co-Author*) Nothing to Disclose
Akiko Sumi, MD, Kurume, Japan (*Abstract Co-Author*) Nothing to Disclose
Hidefumi Kuroki, RT, Kurume, Japan (*Abstract Co-Author*) Nothing to Disclose
Shinichi Tokuyasu, RT,MS, Minato-ku, Japan (*Abstract Co-Author*) Employee, Koninklijke Philips NV

For information about this presentation, contact:

krumf@med.kurume-u.ac.jp

TEACHING POINTS

High-quality 2D and 3D angiography CT image is a promising tool for evaluating in patients with pancreato-biliary diseases. To evaluate the high-quality 2D and 3D angiography CT images of the abdominal viscera with low tube voltage, small focal spot and iterative model reconstruction technique (IMR).

TABLE OF CONTENTS/OUTLINE

1. The new image technique for the new high-quality 2D and 3D angiography CT imaging with low tube voltage, small focal spot and iterative model reconstruction techniques. 2. The protocol used for high-quality CT imaging of the abdominal viscera. 3. Diagnostic imaging using high-quality CT angiography. 4. A review of the imaging findings of high-quality 3D CT angiography of the abdominal viscera. 5. Comparison of 2D and 3D Angiography images with respect to their clinical utility.

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PH108-ED-X

A Radiation Protection & Diagnostic Radiology eLearning Module Developed to Improve Healthcare Professionals Knowledge

All Day Room: NA Digital Education Exhibit

Participants
Amy Clayton, FRCR,MBBCh, Cardiff, United Kingdom (*Presenter*) Nothing to Disclose
Kate Gower Thomas, Cardiff, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Julie Rogers, Cardiff, United Kingdom (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

amy.clayton@wales.nhs.uk

TEACHING POINTS

The learner, by completing the module will develop a baseline knowledge and understanding of important aspects of ionising radiation safety, doses and the law. It also includes patient and staff protection; patient preparation; general diagnostic examinations including PET, CT, MRI and fluoroscopy; patient care (eg during pregnancy), plus drugs and contrast agent use. The eLearning module is an educational tool accessible via the internet; formulated to address the fundamental lack of radiation/radiology knowledge amongst our healthcare professionals and medical students. The learner will experience an effective, successful learning platform that has responded to the above needs and has been shown to modify practice. Access for use within your own hospitals/medical schools is freely available.

TABLE OF CONTENTS/OUTLINE

Review of the eLearning module: Ionising radiation safety. Ionising radiation doses and the law. Patient and staff protection. Patient preparation. General diagnostic examinations including PET, CT and fluoroscopy; MRI and US Patient care (eg during pregnancy. Drugs and contrast agents. Evaluating knowledge through testing. Evaluating the module through feedback.

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PH109-ED-X

Optimization of Radiation Dose and Image Quality in Abdomen CT using Pre-set and Post-recon ASIR-V Tips: What the Radiologists Should Know

All Day Room: NA Digital Education Exhibit

Participants
Yaru Chai, MD, Zhengzhou, China (*Presenter*) Nothing to Disclose
Jianbo Gao, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Jingjing Xing, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Ping Hou, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose
Peijie Lu, MD, Zhengzhou, China (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

To introduce the principle of ASIR-V and compared with ASIR, MBIR To illustrate the application of Pre-set and Post-recon ASIR-V To demonstrate the effect of Pre-set and Post-recon ASIR-V on image quality and radiation dose by presenting graphs and images

TABLE OF CONTENTS/OUTLINE

1.Principle ASIR: partial iterative reconstruction(IR); models(noise, object); clinical application, dose reduction?, noise decreasement? MBIR: full IR; models(noise, object, physics, optics); long processing time, dose reduction???, noise decreasement??? ASIR-V: nearly full IR between ASIR and MBIR; models(noise, object, physics); short processing time, dose reduction??, noise decreasement?? 2.Application methods Preset: set in scanning protocol and can reduce dose automatically by decreasing mAs Post-recon: set with different percent after scan with the same scanning protocol 3.The effect on image quality and radiation dose Preset: dose decrease continuously with ASIR-V percent increase; image noise and CT number remain basically stable with ASIR-V; subjective quality is best at 40% ASIR-V, and unacceptable over 60% Post-recon: dose is constant with ASIR-V percent increase; image noise decrease continuously with ASIR-V and CT number remain unchanged; subjective quality is best at 60% ASIR-V and unacceptable over 80%

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PH110-ED-X

Real-time Management of Patient Radiation Dose during Interventional Radiology

All Day Room: NA Digital Education Exhibit

FDA Discussions may include off-label uses.

Participants
Koichi Chida, PhD, Sendai, Japan (*Presenter*) Nothing to Disclose
Yohei Inaba, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Mamoru Kato, PhD, Akita, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiaki Morishima, BSC, RT, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Masaaki Nakamura, MSc, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Masayuki Zuguchi, MD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

-To understand the importance of evaluating the patient's maximum skin dose (MSD) in real-time, to reduce the risk of radiation injury in interventional radiology (IR). -To understand the method by which the MSD can be measured in real-time during IR. -To demonstrate the feasibility of a real-time patient dosimeter in a clinical setting. -To contribute towards utilizing a diagnostic reference level (DRL) for IR.

TABLE OF CONTENTS/OUTLINE

Advantages/limitations of real-time patient dose-measuring devices Skin dose monitor, patient skin dosimeter, MOSFET dosimeter, *etc.,* were evaluated. A number of patients were studied using the new real-time dosimeter. Real-time dosimeter measurements were compared with those from a reference dosimeter. *Necessity of real-time evaluation of the MSD* OUTLINE: Real-time monitoring of patient radiation doses is essential to avoid radiation injuries such as skin ulceration. However, there is currently no effective real-time patient dosimeter available for use in IR. Novel real-time dosimeter can accurately measure skin doses in a clinical setting. The sensor and cable of the new dosimeter also do not interfere with the IR procedure. Therefore, the new dosimeter will be an effective tool for real-time measurement of patient dose during IR. This dosimeter will also be of use in establishing the DRL in IR.

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PH111-ED-X

Thimble Ionization Chamber and Solid-State Detector: Which is Better for Measuring Equilibrium Dose in Computed Tomography?

All Day Room: NA Digital Education Exhibit

Participants
Kosuke Matsubara, PhD, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Yasutaka Takei, PhD, Kurashiki, Japan (*Abstract Co-Author*) Nothing to Disclose
Shouichi Suzuki, PhD, Toyoake, Japan (*Abstract Co-Author*) Nothing to Disclose
Kimiya Noto, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Thunyarat -. Chusin, Phitsanulok, Thailand (*Abstract Co-Author*) Nothing to Disclose
Rena Okubo, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

matsuk@mhs.mp.kanazawa-u.ac.jp

TEACHING POINTS

The teaching points of this exhibit are: (1) The use of a 10-cm pencil-type ionization chamber causes underestimation of the equilibrium dose. (2) A solid-state detector has a higher energy dependency than a thimble ionizing chamber. (3) Equilibrium doses obtained are different between the thimble ionization chamber and the solid-state detector depending on various conditions.

TABLE OF CONTENTS/OUTLINE

1. Dosimeters used for measuring equilibrium dose A 0.6-cm3 thimble ionization chamber A solid-state detector 2. Equilibrium dose and computed tomography dose index 3. Comparison of energy dependency 4. Comparison of accumulated dose 5. Effect of volume and active length of thimble ionization chamber Dose profile in free-air Accumulated dose 6. Discussion 7. Summary

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PH112-ED-X

Unboxing Contrast Enhanced MRI Perfusion Techniques and Their Analysis Models: A Primer for Technicians and a Reminder for Radiologists

All Day Room: NA Digital Education Exhibit

Awards
Certificate of Merit

Participants
Teodoro Martin, MD, Jaen, Spain (*Presenter*) Nothing to Disclose
Antonio Luna, MD, Jaen, Spain (*Abstract Co-Author*) Consultant, Bracco Group; Speaker, General Electric Company; Speaker, Toshiba Medical Systems Corporation
Lidia Alcala Mata, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Javier Sanchez, MD, PhD, Madrid, Spain (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

t.martin.f@htime.org

TEACHING POINTS

1. Describe the technical adjustments necessary to perform T1 Dynamic Contrast Enhanced (DCE) and T2* Dynamic Susceptibility Contrast (DSC) studies at different anatomical regions. 2. Detail from an educational point of view the different analysis models for DCE and DSC studies as well as the biological meaning of the parameters and time intensity curves (TIC) derived from each one. 3. Review the advantages, limitations, pitfalls and differences between both techniques in several clinical scenarios.

TABLE OF CONTENTS/OUTLINE

1. Introduction 2. Technical basis and adjustments for performing DCE and DSC. a. DCE sequence design and physical basis. b. DSC sequence design and physical basis. 3. Signal intensity analysis models, TIC and parameters derived. a. DCE monocompartmental model (wash in, wash out, maximum relative enhancement, area under the curve) b. DCE bicompartmental model and permeability studies (AIF, Ktrans, Kep, Ve). c. DSC analysis (Time to peak, mean transit time, cerebral blood volume, cerebral blood flow) 4. Technical review in clinical practice of both approaches. a. When, where and why use DCE instead of DSC (or vice versa)? Advantages, limitations and pitfalls. b. Central nervous system and head&neck assessment. c. Breast and Thoracic imaging d. Abdominopelvic viscera evaluation e. MSK and spine.

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PH113-ED-X

How Deep Should We Go with Deep Learning in Medical Image Analysis?

All Day Room: NA Digital Education Exhibit

Participants
Nima Tajbakhsh, PhD, Chicago, IL (*Abstract Co-Author*) Employee, CureMetrix, Inc
Amin Zarshenas, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Kenji Suzuki, PhD, Chicago, IL (*Presenter*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

ksuzuki@iit.edu

TEACHING POINTS

1) To learn the history of machine learning (ML) in computer vision. 2) To understand the basic principles of deep learning. 3) To learn major deep learning models. 4) To study the effects of the depth of deep learning on the performance. 5) To understand the applications that require 'deeper' deep learning.

TABLE OF CONTENTS/OUTLINE

A. History of Machine Learning in Computer Vision - Classes of object/feature-based machine learning and image/pixel-based machine learning - Introduction of deep learning in the computer vision field B. Major Deep Learning Models - Convolutional neural networks (AlexNet, LeNet) - Deep belief network - Deep Boltzmann machine C. Basic Principles of Deep Learning - Backpropagation - Convolutional layers and pooling layers - Regularization (drop-out, weight decay, stochastic pooling) - Fully-connected layers and soft-max layer D. Effects of the Depth on the Performance - Lung nodule detection and classification studies - Polyp detection study E. Interpretation of Deep Learning Models - Deep convolutional neural networks for higher-level representation of objects - Applications that require deeper architectures F. Current applications of deep learning in medical imaging - Classification of lesions with deep learning - Segmentation of organs with deep learning

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PH114-ED-X

CSF Flow Artifacts: The Radiologist's Frenemy

All Day Room: NA Digital Education Exhibit

Participants
Vivek B. Pai, MBBS,MD, Mumbai, India (*Presenter*) Nothing to Disclose
Richa Kothari, MBBS,MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Chintan R. Trivedi, MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Kanchan Gupta, MD, Bengaluru, India (*Abstract Co-Author*) Nothing to Disclose
Anupkumar D. Agarwal, MBBS,MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Pradip Singh, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Hemanth Sudarsanam, MBBS, MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Nilay J. Shah, MBBS, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Pujanwita S. Das Majumder, MBBS,MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Tapas K. Manvar, MBBS, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Sanaa H. Nadkarni, MBBS, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Bhujang U. Pai, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Ajinkya Redij, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Kapil Joshi, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Vijay Kumar, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Shamika S. Wagh, DMRD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Maulik D. Bhalsod, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Shivam Kotak, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

drvivek.pai@sevenhillshospital.com

TEACHING POINTS

To revisit the physiology of cerebrospinal fluid (CSF). To discuss the Magnetic Resonance (MR) artifacts related to CSF circulation and methods of rectification. To differentiate these artifacts from true pathologies. To understand their benefits in diagnosing certain conditions.

TABLE OF CONTENTS/OUTLINE

Ghost artifacts were commonly encountered. Other artifacts identified were attributed to time-of-flight effects leading either to signal loss or flow enhancement. Flow voids due to CSF turbulence were also encountered. Imaging with sequences such as true FISP and GRE helped eliminate these artifacts. Changing the direction of phase encoding and use of short TE sequences also helped in minimizing ghosting and turbulence dephasing respectively. Pathologies these artifacts masquerade include colloid cysts, subarachnoid hemorrhage, aneurysms and spinal arteriovenous malformations. However, their benefits include the supportive diagnosis of normal pressure hydrocephalus, identification of spinal canal stenosis and distinguishing spinal arachnoid cysts from webs or cord herniations. CSF flow related artifacts are not given due credence, as compared to its contemporaries in MR literature. Though they have some benefits, these artifacts may lead to misinterpretation. This exhibit focuses on helping the trainee understand these artifacts.

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PH115-ED-X

Technological Factors for Realizing State-of-the-art Ultra-high-resolution CT and Its Clinical Impact: What the Radiologist and Radiological Technologist Needs to Know

All Day Room: NA Digital Education Exhibit

Participants
Toshiya Kariyasu, Tokyo, Japan (*Presenter*) Nothing to Disclose
Haruhiko Machida, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Takuya Adachi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Keita Fukushima, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuta Shimizu, MItaka-shi, Japan (*Abstract Co-Author*) Nothing to Disclose
Wataru Yamamura, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Masamichi Koyanagi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Akihito Nakanishi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Kenichi Yokoyama, MD, Mitaka-Shi, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshiaki Nitatori, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
takahiro arai, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiromi Enomoto, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Koji Yamashita, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

To describe the basic characteristics and clinical significance of ultra-high-resolution CT (UHRCT) To illustrate technological factors for realizing UHRCT and present phantom experiment results related to these factors To demonstrate the clinical impact of UHRCT by presenting various clinical images

TABLE OF CONTENTS/OUTLINE

Basic characteristics and clinical significance of UHRCT Reduction of partial volume effects/isotropic imaging Improved depiction of fine structures/tissues/lesions Improved quality of 3D images Accurate CT values (sensitive detection of subtle fat) Technological factors for realizing UHRCT and phantom experiment results related to these factors X-ray tube focus size Detector size/number Matrix size Reconstruction kernel Reconstruction algorithm: interpolation/iterative reconstruction Clinical impact of UHRCT *Improved depiction* Temporal bone Pulmonary ground-glass nodules Subtle bone fractures Transmural extension of malignancies (gastric/colon cancer) CT angiography (small peripheral vessels): perforating brain arteries, vertebral artery dissection, stented/calcified coronary arteries, peripheral feeders to HCC/extravasation *Improved quality of 3D images (virtual bronchoscopy) Sensitive detection of subtle fat for adrenal adenomas/lipid-rich coronary plaques*

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PH116-ED-X

Deep Learning in Medical Image Analysis: What's Next?

All Day Room: NA Digital Education Exhibit

Awards
Magna Cum Laude

Participants
Ivana Isgum, PhD, Utrecht, Netherlands (*Presenter*) Research Grant, Pie Medical Imaging BV; Research Grant, 3mensio Medical Imaging BV; Research Grant, Koninklijke Philips NV; ;
Jelmer M. Wolterink, MSc, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Bob De Vos, MSc, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Nikolas Lessmann, MSc, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Majd Zreik, MSc, Utrecht, Netherlands (*Abstract Co-Author*) My wife works for Philips HealthTech, Philips quality management systems
Robbert W. van Hamersvelt, MD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Tim Leiner, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Speakers Bureau, Koninklijke Philips NV; Research Grant, Bayer AG;

For information about this presentation, contact:

i.isgum@umcutrecht.nl

TEACHING POINTS

- To provide an overview of state-of-the-art supervised deep learning methods in medical image analysis - To show the potential of unsupervised and semi-supervised deep learning methods in medical image analysis - To show the potential and current limitations of deep learning methods for direct quantification, diagnosis and prognosis

TABLE OF CONTENTS/OUTLINE

Deep learning is currently the most active research area in medical image analysis, because it has shown the ability to perform a myriad of tasks at the level of radiologists. Current deep learning methods are primarily supervised and focus on segmentation and detection. However, deep learning has great potential to perform quantification, diagnosis, and prognosis directly, circumventing the need for intermediate segmentation or detection. Moreover, current deep learning developments facilitate unsupervised learning alleviating the need for large sets of annotated training data. We will describe these developments and show how radiologists can apply deep learning in medical image analysis in clinical practice. In this exhibit we will discuss: - The basics of deep learning for detection and segmentation tasks - Differences between supervised, semi-supervised and unsupervised deep learning - Possibilities of deep learning in direct image-based quantification, diagnosis and prognosis

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PH118-ED-X

Monochromatic Images in Spectral CT: The New Technology of CT Imaging in CT Angiography

All Day Room: NA Digital Education Exhibit

Participants
Xiaoxia Chen, MMed, Xianyang City, China (*Presenter*) Nothing to Disclose
Yang Xiao, PhD,PhD, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Dong Han, MD, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Yong Yu, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Zhang Xirong, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Chuangbo Yang, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Qi Yang, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

1183729657@qq.com

TEACHING POINTS

1)To point out the short comings of conventional CT angiography (CTA) 2)To describe the principle of monochromatic image with spectral CT and the influence of different energy level on the contrast agent in the blood vessel 3)To introduce the application of monochromatic image in CT angiography

TABLE OF CONTENTS/OUTLINE

1)The short comings of conventional CTA -Difficult to reveal small blood vessels -Potential risk of high contrast dose induced nephropathy -Difficult for the venous imaging. -Average effect of polychromatic images for reduced contrast resolution 2)Spectral CT -Generating 101 sets of monochromatic images through material density image, flexible to select different energies -Different monochromatic images have different characteristics: lower energy level increases the attenuation of iodine contrast and improves the contrast between vessels and surrounding tissues 3)The use of monochromatic images in CTA -To reveal small blood vessels or low enhanced lesions with low energy (40-60keV) monochromatic images -To reduce contrast dose and flow rate. -To provide better images for veins with optimal energy level images -To have better contrast between vessels or lesions and surrounding tissues with monochromatic images

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PH119-ED-X

Neuroimaging Problem Solving on MRI with Dynamic Susceptibility Contrast Perfusion Weighted Imaging, Proton Magnetic Resonance Spectroscopy, and Diffusion Weighted Imaging: Basic Physics and Clinical Applications for Residents and Fellows

All Day Room: NA Digital Education Exhibit

Participants
Alex Chan, DO, Newark, DE (*Presenter*) Nothing to Disclose
Arpit Gandhi, MD, Bear, DE (*Abstract Co-Author*) Nothing to Disclose
Shoheb A. Farooqui, MD, Newark, DE (*Abstract Co-Author*) Nothing to Disclose
Parham Moftakhar, MD, San Francisco, CA (*Abstract Co-Author*) Nothing to Disclose
Alberto C. Iaia, MD, Wilmington, DE (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

alchan@christianacare.org

TEACHING POINTS

Main teaching points include:1. MRI is a powerful neuroimaging modality that not only provides exquisite anatomic detail, but also, hemodynamic, biochemical, and physiological information can be extracted making MRI a multifaceted problem solving tool. 2. Dynamic Susceptibility Contrast (DSC) imaging uses non-diffusible intravascular contrast and bolus tracking to extract hemodynamic parameters, such as cerebral blood volume, cerebral blood flow, and mean transit time. 3. Proton MR Spectroscopy (H1-MRS) exploits chemical shift (CS) phenomenon and voxel localization techniques to provide biochemical information. 4. Diffusion Weighted Imaging (DWI) uses bipolar gradients and fast imaging acquisition techniques to measure the random microscopic movement of water in pathologic conditions.

TABLE OF CONTENTS/OUTLINE

1. DSC:a. Basic bolus trackingb. Susceptibility induced signal drop c. Extraction of hemodynamic parametersd. Recirculation and T1 leakage2. H1-MRS:a. Chemical shiftb. Voxel localizationc. Suppression techniques and sequence parameters3. DWI:a. Motion of water in normal and pathologic statesb. Diffusion gradients and b-value c. Source and trace imagesd. Calculated ADC map4. Clinical Examples:a. Tumor vs metastatic diseaseb. CBV and tumor gradec. Pseudoprogression vs recurrent tumor

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PH120-ED-X

Monte Carlo Based Platform for Personalized Pediatric Dosimetry in Nuclear Medicine Applications

All Day Room: NA Digital Education Exhibit

Participants
Panagiotis Papadimitroulas, Athens, Greece (*Abstract Co-Author*) Nothing to Disclose
Yannis Kopsinis, DIPLENG,PhD, Edinburgh, United Kingdom (*Abstract Co-Author*) Nothing to Disclose
Dimitrios Karnabatidis, MD, PhD, Patra, Greece (*Abstract Co-Author*) Consultant, C. R. Bard, Inc Research funded, C. R. Bard, Inc
George Kagadis, PhD, Patras, Greece (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

gkagad@gmail.com

TEACHING POINTS

The purpose of this exhibit is to: • Describe the essential principles of S-values calculation for dosimetry assessment (source target organ). • Present a novel dosimetry approach (Specific Absorbed Dose Rate - SADRs), considering the whole-body biodistribution of the radiopharmaceuticals. • Study Monte Carlo simulations for absorbed dose calculation, incorporating patient specific biodistributions with anthropomorphic computational models. • Create a dataset of dosimetry parameters, for the definition of absorbed dose per organ. Describe a platform, for personalized dosimetry in pediatric applications based on patient specific characteristics (gender, age, height, weight).

TABLE OF CONTENTS/OUTLINE

• Dosimetry parameters definition (energy deposition, S-values, SADRs) • Monte Carlo simulation procedure (GATE MC toolkit, Dose-Actors concept) • Anthropomorphic computational models (XCAT, pediatric population, clinical based phantoms - CT data) • Use of clinical data for radiopharmaceutical biodistributions extraction (SPECT/PET) • Creation of a database of calculated dose parameters • Personalized platform for pediatric dosimetry in NM applications (dose/organ) Concept of the ERROR project (https://error.upatras.gr/).

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PH121-ED-X

From Chernobyl to Radiology Physics: A Lesson to Remember

All Day Room: NA Digital Education Exhibit

Participants
Tetiana Glushko, MD, Darby, PA (*Presenter*) Nothing to Disclose
Sergiy Kushchayev, MD, Darby, PA (*Abstract Co-Author*) Nothing to Disclose
Aliaksei Salei, MD, Darby, PA (*Abstract Co-Author*) Nothing to Disclose
Dmitry Trifanov, MD, Darby, PA (*Abstract Co-Author*) Nothing to Disclose
Oleg Teytelboym, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

taglushko@gmail.com

TEACHING POINTS

- Important mistakes and contributing factors leading to more severe consequences of Chernobyl catastrophe compared to Fukushima. Readers will also fly through historical events and representative photos of the Chernobyl disaster - Radiation effects and comparable doses - Isotope compositions released after Chernobyl and types of isotopes used in radiology - Important measures of radiation safety and protection

TABLE OF CONTENTS/OUTLINE

This educational exhibit will reveal historical events leading to Chernobyl catastrophe and will illustrate important physics parallels which radiologists need to know in their working environment. This will include: - Units of measure for radioactivity - Factors contributed to Chernobyl explosion versus important mechanisms for protection of an X-ray tube from overheating. - Radiation effects (stochastic and deterministic): radiation doses and their effects, increased incidence of cancer after the explosion (children vs. adults). Comparable doses used in Diagnostic radiology. - Composition of isotopes released into the environment after Chernobyl and their effects: alpha, beta and gamma radiation. Important alpha, beta and gamma emitters used in Radiology. - Acute radiation sickness, skin lesions, cataracts, reproductive problems with associated dose threshold. - Radiation safety and protection.

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PH122-ED-X

Clinical Applications of Digital Tomosynthesis: When and How Useful?

All Day Room: NA Digital Education Exhibit

Participants
Huizhi Cao, PhD, Beijing, China (*Presenter*) Nothing to Disclose

TEACHING POINTS

1. To understand the technical concept of low dose digital tomosynthesis and its implementation 2. To understand which type of lesion can be evaluated under digital tomosynthesis 3. To recognize the limitations and benefits of digital tomosynthesis in radiation exposure and image acquisition.

TABLE OF CONTENTS/OUTLINE

1.Background and physics of digital tomosynthesis 2. Clinical application of digital tomosynthesis in improving detection of pulmonary nodules, sinonasal mucosal thickening, and bone fractures and delineation of complex anatomic structures such as the ostiomeatal unit, atlantoaxial joint, carpal and tarsal bones, and pancreatobiliary and gastrointestinal tracts. 3. Benefits and limitation of tomosynthesis.

SPPH01

AAPM Medical Physics Tutorial Session 1

Saturday, Nov. 25 12:00PM - 2:00PM Room: E351

BR PH

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

FDA Discussions may include off-label uses.

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

LEARNING OBJECTIVES

1) Present a cohernet set of talks covering major women's imaging practices and technology with a look both at current practice as well as state of the art. 2) Present the information in a forum that includes a diverse audience of students, physicians, physicists and other imaging professionals. 3) Eventually translate this information if appropriate to enduring materials such as those found in the RSNA Radiographics journal under the Physics Tutorial series.

Sub-Events

SPPH01A Digital Breast Tomosynthesis

Participants
Andrew D. Maidment, PhD, Philadelphia, PA (*Presenter*) Research support, Hologic, Inc; Research support, Barco nv; Research support, Analogic Corporation; Spouse, Employee, Real-Time Tomography, LLC; Spouse, Stockholder, Real-Time Tomography, LLC; Scientific Advisory Board, Real-Time Tomography, LLC; Scientific Advisory Board, Gamma Medica, Inc

For information about this presentation, contact:

Andrew.Maidment@uphs.upenn.edu

LEARNING OBJECTIVES

1) Understand the fundamental principles behind tomosynthesis. 2) Analyze the differences between tomosynthesis, projection imaging, and computed tomography. 3) Explore the determinants of image quality. 4) Explain the factors that affect radiation dose. 5) Examine future trends in tomosynthesis.

ABSTRACT

Digital Breast Tomosynthesis (DBT) is rapidly becoming the standard of care for breast cancer screening and diagnosis. DBT is a form of computed tomography, in which a limited set of projection images are acquired over a small angular range and reconstructed into tomographic data. It is equally valid to treat DBT as the digital equivalent of classical tomography. DBT shares many common features with classical tomography, including the radiographic appearance, dose, and image quality considerations. In this lecture, we will contrast DBT to projection radiography, linear tomography, and CT in order to gain a better understanding of DBT as it is practiced today, and forecast how it might evolve in the future.

Active Handout:Andrew D.A. Maidment

http://abstract.rsna.org/uploads/2017/17001138/Active SPPH01A.pdf

SPPH01B CT Breast Imaging

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

LEARNING OBJECTIVES

1) To demonstrate the pendent geometry and scanner design for cone beam breast CT. 2) Show mathematical metrics comparing breast CT images with mammography and breast tomosynthesis. 3) Show observer performance comparisons, both computer and human, comparing breast CT with projection imaging of the breast.

SPPH01C TMIST Update

Participants
Martin J. Yaffe, PhD, Toronto, ON (*Presenter*) Research collaboration, General Electric Company; Founder, VOLPARA Technologies; Shareholder, VOLPARA Technologies; Co-founder, Mammographic Physics Inc

For information about this presentation, contact:

martin.yaffe@sri.utoronto.ca

LEARNING OBJECTIVES

1) The primary and secondary goals of the TMIST Trial. 2) How TMIST will be conducted. 3) The design of the Physics QC Program.

4) The specific QC tests, standards and approaches to problems.

SPPH01D Stereotactic Breast Biopsy

Participants
Ingrid Reiser, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

ireiser@uchicago.edu

LEARNING OBJECTIVES

1) Understand the clinical role of stereotactic breast biopsy. 2) Understand the physical principle of conventional two-view stereotactic breast biopsy systems. 3) Understand the advantages and drawbacks of different system configurations. 4) Understand the principles of tomosynthesis-guided breast biopsy.

ABSTRACT

Breast core needle biopsy is a minimally invasive procedure used in the diagnosis of breast lesions. It is an established diagnostic breast imaging procedure, which can be performed in an outpatient setting and results in minimal trauma and no disfiguration of the breast, in comparison with open surgical biopsy. Stereotactic breast biopsy is mostly performed to assess lesions associated with microcalcifications, that are not visible on ultrasound. This tutorial describes the current clinical use of stereotactic breast biopsy, reviews conventional clinical systems and system configurations. It also describes the principles of tomosynthesis-guided breast biopsy.

SPPH02

AAPM Medical Physics Tutorial Session 2

Saturday, Nov. 25 2:15PM - 4:15PM Room: E351

BR PH

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

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

LEARNING OBJECTIVES

1) Present a cohernet set of talks covering major women's imaging practices and technology with a look both at current practice as well as state of the art. 2) Present the information in a forum that includes a diverse audience of students, physicians, physicists and other imaging professionals. 3) Eventually translate this information if appropriate to enduring materials such as those found in the RSNA Radiographics journal under the Physics Tutorial series.

Sub-Events

SPPH02A Ultrasound Breast Imaging

Participants
Wendie A. Berg, MD, PhD, Pittsburgh, PA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

wendieberg@gmail.com

LEARNING OBJECTIVES

1) Review technical aspects of breast ultrasound including harmonic imaging. 2) Discuss clinical uses of breast ultrasound in diagnostic breast imaging including evaluation of lumps, nipple discharge, and pain. 3) Consider approaches to use of ultrasound to screen for breast cancer, including whole breast ultrasound.

SPPH02B MRI Breast Imaging

Participants
Donna M. Reeve, MS, Houston, TX (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

dmreeve@mdanderson.org

LEARNING OBJECTIVES

1) Understand breast MR imaging objectives, challenges and technical requirements. 2) Review breast MRI protocols, acquisition criteria and protocol optimization. 3) Describe common image quality problems, including artifacts.

SPPH02C Contrast Enhanced Mammography

Participants
John M. Lewin, MD, Denver, CO (*Presenter*) Consultant, Hologic, Inc; Consultant, Novian Health Inc

For information about this presentation, contact:

lewinjz@gmail.com

LEARNING OBJECTIVES

1) Explain the rationale behind the use of dual-energy subtraction for contrast-enhanced mammography. 2) Explain the physical principles underlying dual-energy subtraction for contrast-enhanced mammography and how to obtain optimal images. 3) Discuss the clinical studies comparing contrast-enhanced mammography to MRI and other modalities.

ABSTRACT

Contrast-enhanced digital/spectral mammography (CEDM, CESM) is an FDA approved, clinically utilized modality for breast cancer detection. The technique utilizes an intravenous injection of a standard FDA approved iodinated contrast agent combined with dual-energy subtraction mammography. The dual-energy subtraction greatly increases the visibility of the contrast agent by subtracting out the 'structured noise' of the image (i.e., the equalizing the density of the fibroglandular tissue and the fat). CEDM/CESM has been shown to have diagnostic performance superior to standard digital mammography and approximately equal in performance to contrast-enhanced breast MRI when tested on subjects with a known breast cancer. Other small studies have shown usefulness for diagnostic (problem solving) applications and evaluating treatment effect in neoadjuvant chemotherapy. Studies testing the technique for other applications, such as high-risk screening, are in progress.

SPPH02D Molecular Breast Imaging

Participants
Michael K. O'Connor, PhD, Rochester, MN (*Presenter*) Royalties, Gamma Medica, Inc

For information about this presentation, contact:

mkoconnor@mayo.edu

LEARNING OBJECTIVES

1) Understand the technical aspects of molecular breast imaging. 2) Compare the strengths and weakness of molecular breast imaging with other breast imaging modalities. 3) Understand the potential applications for molecular breast imaging in the diagnostic and screening environments.

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SSA20

Physics (CT: Photon Counting and Spectral CT)

Sunday, Nov. 26 10:45AM - 12:15PM Room: S403B

CT PH

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

FDA Discussions may include off-label uses.

Participants
Katsuyuki Taguchi, PhD, Baltimore, MD (*Moderator*) Research Grant, Siemens AG; Consultant, JOB Corporation
Guang-Hong Chen, PhD, Madison, WI (*Moderator*) Research funded, General Electric Company Research funded, Siemens AG

Sub-Events

SSA20-01 Multi-Material Decomposition of Iodine Mixed with Potential High-Z Contrast Agents in Energy Discriminating Photon Counting Computed Tomography

Sunday, Nov. 26 10:45AM - 10:55AM Room: S403B

Participants
Ralf Gutjahr, Munich, Germany (*Presenter*) Grant, Siemens AG
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Martin U. Sedlmair, MS, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Hubertus Pietsch, PhD, Berlin, Germany (*Abstract Co-Author*) Employee, Bayer AG
Bernhard Krauss, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens Healthcare GmbH; ;
Tristan Nowak, Forchheim, Germany (*Abstract Co-Author*) Grant, Siemens AG

For information about this presentation, contact:

ralf.gutjahr@tum.de

PURPOSE

To evaluate the quality of a quantitative image-based multi-material decomposition algorithm on mixtures of potential CT contrast agents (CA) for Photon Counting Detector CT (PCD-CT) technology.

METHOD AND MATERIALS

CT-images were obtained using a PCD-CT research scanner (SOMATOM CounT, Siemens Healthcare GmbH, Forchheim). Three tube voltages were applied: 100, 120, and 140 kV using 160, 120, and 80 mAs, respectively. All CT images were acquired using four energy thresholds: 25, 45, 65, and 80 keV. Three mixtures of aqueous solutions of iodine and a high-Z CA, either Gadolinium (Gd), Hafnium (Hf) or Tungsten (W), were investigated. They were placed into vials arranged around the center of a cylindrical 20 cm wide water-equivalent phantom. Both a two and a three material decomposition, including water as a third base material, were applied to the reconstructed energy threshold images. Identical measurements were repeated 15 times to determine average concentrations and the systematic deviation. The statistical errors were assessed by the evaluation of the dose normalized standard deviations of the measured concentrations.

RESULTS

When decomposing into two base materials the measured concentrations deviated from the known values from -0.5 mg/mL to 0.5 mg/mL. The overall best performance was observed for the differentiation of I and Hf using the 140 kV x-ray spectrum and the given energy thresholds (0.1 mg/mL and 0.0 mg/mL deviation for I and Hf, respectively). By adding water as a third base material, the systematic deviations increased to a range from -2.7 mg/mL to 1.8 mg/mL. Separation into I, water and either Gd or Hf provided more accurate results due to their better energy separation when compared to I, water and W, where especially water and W showed similar attenuation over all selected energies.

CONCLUSION

For the selected x-ray spectra and energy thresholds, the two-material decompositions provided good results with absolute deviations from the known concentrations under 0.5 mg/mL. By adding water as a third base material the accuracy of the decomposition decreased, especially with tungsten at 100 kV due to its similar spectral characteristics to water at this configuration.

CLINICAL RELEVANCE/APPLICATION

To separate and quantify mixed CA solutions using image data from a single PCD-CT scan

SSA20-02 Differentiation between Blood and Iodine in a Bovine Brain: Initial Experience with Spectral Photon-Counting CT

Sunday, Nov. 26 10:55AM - 11:05AM Room: S403B

Participants

Isabelle Riederer, MD, Munich, Germany (*Presenter*) Nothing to Disclose
Daniel Bar-Ness, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Franz Pfeiffer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Philippe C. Douek, MD, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Peter B. Noel, PhD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Daniela Muenzel, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Sebastian Ehn, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Salim Si-Mohamed, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Alexander A. Fingerle, MD, Munchen, Germany (*Abstract Co-Author*) Nothing to Disclose
Ernst J. Rummeny, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

isabelle.riederer@tum.de

PURPOSE

To evaluate the potential of the Spectral Photon-Counting CT (SPCCT) for the differentiation between blood and iodine in a bovine brain.

METHOD AND MATERIALS

First, in vitro experiment using tubes with blood and different concentrations of iodine-based contrast material were scanned with a preclinical SPCCT system to obtain spectral and conventional data. Second, tubes with (a) blood and (b) iodine-based contrast material were positioned within a bovine brain. Iodine maps and virtual non-contrast images were generated using the multibin spectral information to perform material decomposition. Region of interest (ROI) analysis were performed within the tubes to quantitatively determine the absolute content of iodine.

RESULTS

In the conventional CT images, ROI analysis showed similar HU density values for the tube with blood and iodine (59.9 +/- 1.8 versus 59.2. +/- 1.5). Iodine maps enabled clear differentiation between blood and iodine in vitro as well as in the bovine brain. Quantitative measurements of the tubes with different iodine concentrations matched well with those of actual prepared mixtures.

CONCLUSION

Spectral Photon-Counting CT enables differentiation between blood and iodine in vitro and within a bovine brain, and quantification of different iodine concentrations is feasible.

CLINICAL RELEVANCE/APPLICATION

Spectral Photon-Counting CT providing iodine maps and virtual non-contrast images allows for material decomposition and reliable quantification of different iodine concentrations.

SSA20-03 Gold Nanoparticle-Based Contrast-Enhanced CT in a Large Animal Model of Renal Artery Stenosis Using a Whole Body Photon-Counting CT System

Sunday, Nov. 26 11:05AM - 11:15AM Room: S403B

Participants
Kishore Rajendran, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Xiang Zhu, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Lilach Lerman, Rochester, MN (*Abstract Co-Author*) Research grant, Recombinetics Inc. Consulting, Novartis Consulting, AstraZeneca Consulting, CohBar Inc.
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

rajendran.kishore@mayo.edu

PURPOSE

To evaluate, in phantoms and in a swine model of renal artery stenosis (RAS), the performance of a photon-counting CT (PCCT) system for quantification of targeted-gold nanoparticles (AuNPs).

METHOD AND MATERIALS

We used a whole-body PCCT system (Siemens Healthcare, Germany) to image phantoms and a swine with induced RAS. AuNPs (bare size = 20 nm) were synthesized using gold chloride solution (10% HAuCl4.3H20) and 5% sodium citrate dihydrate. Collagen-1 antibody conjugated PEG-coated AuNPs (45 nm) were made to target tissue fibrosis. RAS was induced in a pig by placing a local-irritant coil in the main renal artery for 6 weeks. A 20 cm water phantom with iodine (4, 8, 10 mg/mL) and AuNPs (2, 4, 6 mg/mL) solutions was scanned to assess material quantification accuracy. Renal artery angiography of the pig was performed to assess the degree of stenosis using iodinated contrast (Omnipaque, GE Healthcare Inc.), followed by PCCT scans (T = 0: no AuNPs, and T=1: 20 mL intra-renal injection of 20mg/mL AuNPs). All scans were performed at 120 kVp, 550mAs (CTDIvol = 47.8 mGy) with energy thresholds 25, 48, 65 and 75 keV. Images were reconstructed using filtered backprojection and a quantitative, medium-smooth kernel (D30). Prototype software (eXamine, Siemens Healthcare, Germany) was used for material quantification of targeted-AuNPs and residual iodine from renal angiography.

RESULTS

Regression analysis revealed a close linear relationship (R2 =0.95) between the measured and true AuNP densities in the phantom. AuNPs at 2, 4 and 6 mg/mL were estimated at 2.2, 3.5 and 6.3 mg/mL respectively. In the swine images, ROI analysis showed a CT number enhancement of approximately 76 HU within the injected stenotic kidney cortex and medulla, while a circular ROI in the paraspinal muscle showed a mean CT number of 60 HU.

CONCLUSION

We evaluated the performance of PCCT and material quantification for multi-contrast imaging, specifically, measuring CT number enhancement induced by low concentrations of AuNPs. We have demonstrated for the first time in vivo imaging of AuNPs in a large animal model using a whole-body PCCT system, albeit the signal magnitude at the current level of development is challenging.

CLINICAL RELEVANCE/APPLICATION

Gold nanoparticles can be tailored for molecular imaging, targeting certain tissue-types and organs thereby enabling novel applications of PCCT in diagnosis and treatment assessment.

SSA20-04 Spectral Ultra-High Resolution Coronary Stent Imaging with Photon-Counting CT: Initial Experience

Sunday, Nov. 26 11:15AM - 11:25AM Room: S403B

Participants
Rolf Symons, MD, Bethesda, MD (*Presenter*) Nothing to Disclose
John Roosen, MD, Bonheiden, Belgium (*Abstract Co-Author*) Nothing to Disclose
Yves de Bruecker, MD, Keerbergen, Belgium (*Abstract Co-Author*) Nothing to Disclose
Tyler E. Cork, MS, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Steffen Kappler, DIPLPHYS, Forchheim, Germany (*Abstract Co-Author*) Researcher, Siemens AG
Stefan Ulzheimer, PhD, Nurnberg, Germany (*Abstract Co-Author*) Employee, Siemens AG
Veit Sandfort, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Jan G. Bogaert, MD, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research agreement, Siemens AG; Research support, Siemens AG; Research agreement, Carestream Health, Inc; Research support, Carestream Health, Inc
Amir Pourmorteza, PhD, Atlanta, GA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

rolfsymons@hotmail.com

PURPOSE

To evaluate the performance of an ultra-high resolution (UHR) spectral photon-counting detector (PCD) computed tomography (CT) system for coronary stent imaging and to compare the results to conventional energy-integrating detector (EID) CT.

METHOD AND MATERIALS

Coronary stents with different diameters (2.0-4.0 mm) were examined inside a coronary artery phantom consisting of plastic tubes filled with iodine-based contrast material diluted to approximate clinical concentrations (450 HU). EID images were acquired using 2nd and 3rd generation dual-source CT systems (SOMATOM Flash and SOMATOM Force, Siemens Healthcare) at 0.60 mm isotropic voxel size. Radiation-dose matched PCD images were acquired using a prototype ultra-high resolution PCD system (Siemens Healthcare) at standard 0.50 mm and ultra-high 0.25 mm isotropic resolution. Images were reconstructed using optimized convolution kernels. Image quality of EID versus PCD for stent diameter visualization was compared using one-way analysis of variance and Wilcoxon signed-rank test. Paired t-test was used to compare the accuracy of spectral PCD iodine quantification in the presence or absence of the highly attenuating stents.

RESULTS

UHR PCD images significantly improved stent lumen visualization (78.2±9.6%) over EID Flash, EID Force, and standard resolution PCD images (52.5±12.6%, 56.8±12.5%, and 60.3±12.3%, respectively, all $P<0.01$). Stent lumen visualization improved with larger stent sizes for all image series ($P<0.05$ Pearson correlation). Spectral PCD iodine imaging enabled visualization of the coronary artery lumen without interference from the coronary stent or plastic tube. PCD iodine quantification was similar in the presence or absence of the coronary stents (23.0±1.7 mM vs 22.9±0.9 mM, $P=0.81$), suggesting robustness of material decomposition to beam hardening artifacts.

CONCLUSION

Ultra-high resolution PCD CT may significantly improve coronary stent lumen visualization over conventional CT due to reduced blooming artifacts with the added advantage of providing spectral information that may be used for material decomposition.

CLINICAL RELEVANCE/APPLICATION

Improved coronary stent lumen visualization with ultra-high resolution PCD CT may allow for improved non-invasive diagnosis of stent malapposition and in-stent restenosis.

SSA20-05 Image based Material Decomposition with Material Map De-noising using Photon Counting Computed Tomography (PCCT)

Sunday, Nov. 26 11:25AM - 11:35AM Room: S403B

Participants
Dilbar Abdurakhimova, MA, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Joshua D. Trzasko, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Wei Zhou, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Hao Gong, PhD, Rochester,, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shengzhen Tao, Rochester, MN (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

Leng.Shuai@mayo.edu

PURPOSE

To develop and validate a new image based material decomposition method using non-local means (NLM) and alternating direction method of multipliers (ADMM).

METHOD AND MATERIALS

Image based material decomposition was formulated as minimization of an objective function consisting of a data fidelity and a NLM-based regularization term. The optimization problem was solved with ADMM. The method was evaluated using simulations, phantom and animal studies. Vials containing various concentrations of iron chloride and sodium chloride solutions were used in simulations. For phantom studies, vials containing calcium chloride and iohexol solutions were placed in a 20 cm water phantom and scanned on a whole-body PCCT scanner (CounT, Siemens Healthcare). Material decomposition was performed using denoised images and results were compared to the reference concentrations. In addition, a female swine was scanned on the PCCT scanner with 140 kV, 4 energy thresholds (25, 45, 65, 85 keV), 140mAs, 32x0.5 mm collimation and 15.5 mGy CTDIvol (matched to clinical dose level). Performance of the proposed method was compared to a least squares (LS) based decomposition method using original and denoised images.

RESULTS

A linear relationship was observed between measured and reference concentrations (R2>=0.93) using the proposed method. Compared to the LS method (with and without denoising), it showed more uniform appearance and less noise in all three studies. In simulations, the proposed method had 90, 91, and 91% reduction of root mean square errors (RMSE) in the Fe, Na and water concentration measurements compared to the LS method, and 27, 31 and 29% reduction compared to the LS method with denoising. In the phantom study, the RMSE in the Ca, I and water concentrations were reduced by 90, 89 and 78%, and 17, 14, and 4% of LS without and with denoising, respectively.

CONCLUSION

Simulation and phantom studies quantitatively demonstrated that the proposed method provided accurate material specific images with low image noise. The advantage of the proposed method was further confirmed in the in-vivo swine study, where the patchy appearance of LS method with denoising in the material specific images was decreased with proposed method.

CLINICAL RELEVANCE/APPLICATION

The proposed method provides accurate and low noise material specific images using PCCT multi-energy imaging at clinical dose levels.

SSA20-06 Efficient and Accurate Spectral Distortion Compensation for Photon Counting CT via Low-Rank Approximation-Based X-Ray Transmittance Modeling

Sunday, Nov. 26 11:35AM - 11:45AM Room: S403B

Participants
Okkyun Lee, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Steffen Kappler, DIPLPHYS, Forchheim, Germany (*Abstract Co-Author*) Researcher, Siemens AG
Christoph Polster, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Katsuyuki Taguchi, PhD, Baltimore, MD (*Presenter*) Research Grant, Siemens AG; Consultant, JOB Corporation

PURPOSE

Photon counting detectors (PCDs) provide spectral sensitivity with energy windows; however, the measured spectrum is distorted due to charge sharing and fluorescent x-ray emission. These spectral distortions can be compensated for to improve material decomposition accuracy. Thus, the aim of this study was to develop a method that is more computationally efficient than maximum likelihood (ML) estimator, while it is also as accurate and precise as ML is.

METHOD AND MATERIALS

We have developed a method that works on each of sinogram point independently and efficiently. The spectral distortion model was incorporated as the imaging chain, which related the incident x-ray spectrum to the attenuation due to the object (which is called "x-ray transmittance") to the output of PCD. The non-linear x-ray transmittance was modeled by a set of energy-dependent basis curves via the low-rank approximation, and the coefficients of the basis curves, which were linearly related to the PCD output, were efficiently estimated by solving the linear minimization problem. Thorough and systematic computer simulations were performed to assess the performance of the proposed method.

RESULTS

We have performed two types of computer simulations with two objects. The first object consisted of soft tissue and bone, whereas the second object added gadolinium to the first object. Many combinations of different thicknesses of multiple materials were examined. The computational efficiency of the proposed method was found to be orders of magnitude faster than ML with non-negativity constraint (ML+) (0.22 min versus 1,056.8 min). The bias of the proposed method was smaller than the ML and ML+. The noise of the proposed method was comparable to Cramer Rao lower bound (CRLB) and slightly larger than that of ML+. The reconstructed K-edge images showed streaking artifacts due to the bias with ML+, whereas accurate results with the proposed method.

CONCLUSION

We have developed a method, which is computationally efficient, can compensate for the spectral distortion more effectively than ML or ML+, and has noise level that is comparable to CRLB.

CLINICAL RELEVANCE/APPLICATION

Efficient and effective spectral distortion compensation is the key to the direct characterization of tissues and lesions, which is expected to be an important feature of PCD-CT.

SSA20-07 First Evaluation of New Photon Counting Technology for Cardiac CT

Sunday, Nov. 26 11:45AM - 11:55AM Room: S403B

Participants
Fredrik Gronberg, MSc, Stockholm, Sweden (*Abstract Co-Author*) Shareholder, Prismatic Sensors AB; Research Consultant, Prismatic Sensors AB
Martin Sjolin, DPhil,MSc, Stockholm, Sweden (*Abstract Co-Author*) Co-founder, Prismatic Sensors AB; Employee, Prismatic Sensors AB
Staffan Holmin, MD,PhD, Stockholm, Sweden (*Presenter*) Medical advisor for Prismatic Senosrs AB
Johan Lundberg, MD,PhD, Stockholm, Sweden (*Abstract Co-Author*) Financial Interest, Smartwise AB
Mats Persson, Stanford, CA (*Abstract Co-Author*) Stockholder, Prismatic Sensors AB; Former Employee, Prismatic Sensors AB
Moa Yveborg, PhD, Stockholm, Sweden (*Abstract Co-Author*) Stockholder, Prismatic Sensors AB
Mats Danielsson, PhD, Stockholm, Sweden (*Abstract Co-Author*) Stockholder, Prismatic Sensors AB; President, Prismatic Sensors AB; Stockholder, Innovicum AB; President, Innovicum AB; Stockholder, Biovica International AB; Board Member, Biovica International AB; Research collaboration, General Electric Company

For information about this presentation, contact:

gronberg@mi.physics.kth.se

PURPOSE

We are developing a novel photon-counting detector with 8 energy bins and 0.2x0.3mm^2 pixels at the isocentre for high-resolution clinical computed tomography (CT) imaging. We present the first images of excised human hearts that were scanned using our detector technology, showing improved visibility of arterial plaque and iodine compared to the current state of the art. In addition, we demonstrate the feasibility of projection-based, three-material basis decomposition for cardiac CT based on measurements acquired with the new detector technology.

METHOD AND MATERIALS

Post-mortem human hearts from five individuals were staged and imaged using a spectrally resolved photon counting detector made of crystalline Silicon. The hearts were sliced axially and then mounted in a 3D-printed model to preserve the anatomical structure and facilitate imaging despite different scanning orientations. Coronary arteries that were cut were closed with 6-0 sutures and the lumen filled with gelatine containing iodine to obtain relevant Hounsfield Unit contrast. Reconstructed CT images from the photon counting system were compared to those acquired using three state-of-the-art clinical CT scanners at the Karolinska University Hospital. We compared the visibility and separation of arterial plaque and iodine. In addition, we performed projection-based three-material basis material decomposition using recent developments in forward-model calibration - not currently possible with dual-energy clinical CT systems.

RESULTS

The results demonstrate improved spatial and spectral resolution, compared to state-of-the-art. Specifically, we demonstrate increased visibility and separation of arterial plaque and iodine. In addition, unbiased iodine basis material images are presented.

CONCLUSION

Several excised human hearts have successfully been imaged using a novel photon-counting spectrally resolved detector with sub-millimetre spatial resolution. Compared to current state of the art, reconstructed CT images demonstrate improved spatial and spectral resolution, which may improve CT applications such as cardiac imaging.

CLINICAL RELEVANCE/APPLICATION

High-resolution CT with enhanced spectral capability may benefit cardiac imaging by improving quantitation in calcium scoring due to reduction of blooming artefacts, visualization in coronary CT angiography, and perfusion analysis due to improved detection of iodine and unbiased material-specific imaging.

SSA20-08 Anisotropic Denoising for Material Decomposition from Spectral Photon-Counting CT: Application to Human Blood Iron Level Estimation

Sunday, Nov. 26 11:55AM - 12:05PM Room: S403B

Awards
Trainee Research Prize - Fellow

Participants
Adam P. Harrison, PhD, Bethesda, MD (*Presenter*) Nothing to Disclose
Rolf Symons, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Daniel J. Mollura, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research agreement, Siemens AG; Research support, Siemens AG; Research agreement, Carestream Health, Inc; Research support, Carestream Health, Inc
Amir Pourmorteza, PhD, Atlanta, GA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

adam.p.harrison@gmail.com

PURPOSE

To develop a radiation dose-efficient image-based material decomposition technique for spectral photon-counting CT (PCCT) data and to investigate estimating human blood iron concentration from contrast-enhanced (CE) scans.

METHOD AND MATERIALS

We adapt the well-known anisotropic denoising (AD) approach for simultaneous denoising and decomposition of spectral PCCT images. Unlike the standard pixel-by-pixel approach, AD regularizes the solution using similarity weights between neighboring pixels.

We tailor AD for PCCT in two ways. First, to ensure accuracy, we employ a *guided* similarity calculation, using the image created from all detected photons, regardless of their spectral bin, to calculate weights. We assume the all-photon image contains all the edge information of the spectral bins but is less noisy. Second, we incorporate the linear generative model directly into the anisotropic equation, simultaneously estimating concentration maps of all pixels from spectral bins. AD only requires a large and sparse linear system to solve, with one parameter for the filter weight.

RESULTS

We test AD on 4-energy threshold spectral PCCT scans of a human subject pre- and post-contrast. The decomposition method was calibrated using vials of known concentrations of iodine and Fe solutions placed under the patient. The vials were also used to calculate the precision and bias of AD. The blood iron content of the CE scan was estimated and compared to that of the pre-contrast scan. Within the vials, AD estimates remain stable while reducing noise SD by 56% and 54% for iron and iodine, respectively. This suggests over 4x decrease in radiation. Aortic iron concentration measured from AD had small bias, but with a noise reduction of 67.8%. The small bias (-5%) in CE Fe content may be attributed to the blood volume increase after injection.

CONCLUSION

The dose-efficient AD decomposition method shows improved precision over the standard approach in estimating blood-iron concentration. Future work will include additional human studies to determine the optimal tradeoff between precision and algorithmic bias.

CLINICAL RELEVANCE/APPLICATION

This algorithm can provide higher quality concentration maps from spectral photon-counting CT, improving estimation of blood-iron content in addition to iodine concentration.

SSA20-09 Applied Quantitative Multi-Material Decomposition Using Photon Counting Detector CT (PDC-CT) Image Data

Sunday, Nov. 26 12:05PM - 12:15PM Room: S403B

Participants
Ralf Gutjahr, Munich, Germany (*Presenter*) Grant, Siemens AG
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Martin U. Sedlmair, MS, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Thomas G. Flohr, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Hubertus Pietsch, PhD, Berlin, Germany (*Abstract Co-Author*) Employee, Bayer AG
Bernhard Krauss, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens Healthcare GmbH; ;
Tristan Nowak, Forchheim, Germany (*Abstract Co-Author*) Grant, Siemens AG

For information about this presentation, contact:

Ralf.Gutjahr@tum.de

PURPOSE

To apply and evaluate an image based decomposition algorithm on three and four materials using single scan multi-energy projection data acquired by a research photon counting detector CT (PCD-CT) system.

METHOD AND MATERIALS

Six solutions of contrast agents (CAs) in concentrations of 5 and 10 mg/mL were investigated: zirconium (Zr), iodine (I), gadolinium (Gd), dysprosium (Dy), hafnium (Hf), and tungsten (W). The K-edges of all materials lay in the energy range for clinical CT. Multi-energy CT-images were obtained from eight different combinations of sets of three CAs. The solutions, each filled into a 2 cm wide vial, were arranged in an equiangular fashion inside a 20 cm diameter water-equivalent phantom. All CT-images were acquired using a PCD-CT research system (SOMATOM CounT, Siemens Healthcare GmbH, Forchheim) with tube voltages of 100, 120, or 140 kV and respective tube current-time-products of 160, 120, 80 mAs. Four energy thresholds were applied: 25, 45, 65, and 80 keV. The reconstructed energy-threshold images were decomposed into concentration images of three or four materials. For the first case, the respective materials of the investigated set of CAs were chosen as base materials, for the second case, water was additionally included as a base material. The resulting accuracies were determined by comparing the extracted concentration values to the corresponding known values.

RESULTS

The CAs could be differentiated and quantified in all investigated cases. The mean deviations of the measured concentrations were 8% for 100 kV, 3% for 120 kV, and 9% for 140 kV. The two different concentrations provided linear proportionality in CT-values. CAs with similar x-ray attenuation characteristics showed resembling enhancements throughout the single spectral images and showed greater deviations from the anticipated concentration values (up to -34% for separation of I, Hf, W, and water at 120 kV).

CONCLUSION

An image-based multi-material decomposition algorithm was applied on CT-data of a PCD-CT research system. The measured concentrations of different CAs showed good correspondence to their known concentrations. The quality of the material separations depend on the selected base materials, the number of base materials, the applied x-ray tube voltage and the selected energy thresholds.

CLINICAL RELEVANCE/APPLICATION

To demonstrate feasibility of applying and separating multiple contrast agents within a single PCD-CT scan.

SSA21

Physics (CT: New Techniques)

Sunday, Nov. 26 10:45AM - 12:15PM Room: S404AB

CT PH

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

FDA Discussions may include off-label uses.

Participants
Cynthia H. McCollough, PhD, Rochester, MN (*Moderator*) Research Grant, Siemens AG
Ke Li, PhD, Madison, WI (*Moderator*) Nothing to Disclose

Sub-Events

SSA21-01 Potential Application of Photon Counting Detector CT in Intracranial Hemorrhage Detection

Sunday, Nov. 26 10:45AM - 10:55AM Room: S404AB

Awards
Trainee Research Prize - Medical Student

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

PURPOSE

Detection and monitoring of intracranial hemorrhage (ICH) is crucial for the management and treatment of acute strokes. When endovascular stroke therapy is performed in the angiography suite, there is often a need for intraoperative ICH imaging, which currently is performed using C-arm CBCT with a flat panel detector (FPD). However, the performance of CBCT for detecting low contrast ICH may be severely limited. The purpose of this work was to study the potential of a photon counting detector (PCD)-based CT system for reliable ICH imaging.

METHOD AND MATERIALS

The PCD-CT system used a CdTe-based PCD with 100 µm pixel size, 50 cm transverse coverage, 150 fps maximal readout speed, >75% MTF@ 2 lp/mm, >50% DQE(f) @2 lp/mm, and negligible lag. Other major components of the PCD-CT include a rotating-anode diagnostic tube, 0.2 mm Cu beam filter, and a bowtie filter. The maximal field of view of the system is 41 cm. An anthropomorphic head phantom with a simulated ICH (diameter=0.8 cm, nominal contrast=10 HU) in the right hemisphere and contrast-enhanced cerebral arteries in the left hemisphere was imaged using both the PCD-CT and a state-of-the-art MDCT. The tube potential (80 kV), radiation dose (CTDIvol=17 mGy), slice thickness (5 mm), image pixel size (0.4 mm), and image display W/L were matched between the two CT systems. Images of the phantom were evaluated quantitatively using the CNR of the ICH and subjectively in terms of brain tissue-CSF differentiation, image sharpness, and noise texture.

RESULTS

The small, low contrast ICH was clearly visible in the PCD-CT image. The measured CNR of the ICH was 3.1 for PCD-CT and 2.9 for MDCT. The PCD-CT reconstructions demonstrated a much finer noise texture compared with the MDCT images, and edges of the ICH and small vessels were sharper in PCD-CT. The boundary between brain tissue and CSF was well defined by PCD-CT.

CONCLUSION

The feasibility of intracranial hemorrhage detection using PCD-CT was demonstrated. Initial phantom studies demonstrate that image quality and detection performance for low contrast ICH using the PCD-CT can match clinical MDCT.

CLINICAL RELEVANCE/APPLICATION

The presented PCD-CT system has the potential to address the limited low contrast sensitivity of FPD-based CBCT in assessing the risk of ICH prior to and during endovascular stroke therapy.

SSA21-02 Impact of Tube Voltage (kV) Selection on Spectral-Based Coronary CTA Calcium Plaque Removal for Photon Counting Detector CT (PCD-CT)

Sunday, Nov. 26 10:55AM - 11:05AM Room: S404AB

Participants
Bernhard Schmidt, PhD, Forchheim, Germany (*Presenter*) Employee, Siemens AG
Katharine Grant, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Thomas Allmendinger, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG

Ralf Gutjahr, Munich, Germany (*Abstract Co-Author*) Grant, Siemens AG
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Thomas G. Flohr, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Bernhard Krauss, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens Healthcare GmbH; ;

PURPOSE

Previous studies demonstrated the feasibility of removing calcified plaques from coronary CT angiograms (CTA) using spectral data. For PCD-CT, higher kV increases spectral performance, whereas lower kV improves iodine visualization in coronary vessels. Our aim was to evaluate the influence of kV selection on vessel iodine contrast, noise and quality of spectral-based calcified plaque removal.

METHOD AND MATERIALS

Four anthropomorphic vessel phantoms simulating coronary arteries (Ø 4 mm) with different combinations of iodine enhancement (500 and 800 HU at 120 kV) and three degrees of calcified stenosis (25, 50 and 75%) & calcium densities (400 and 800 mgHA/cm³) were used in this study. To simulate patient attenuation, an anthropomorphic chest phantom was used. CT images were acquired using a PCD-CT research scanner (SOMATOM CounT, Siemens, Germany). For various dose levels (CTDIvol: 8 to 32 mGy) and four tube voltages (80 to 140 kV), high and low energy bin images were obtained. Images were processed using a modified three material decomposition to separate the data into calcium, soft tissue, and iodine maps. Mixed images, images without coronary calcium and calcium-only images were generated. Iodine enhancement (CT values) and noise (STDEV) were recorded. Quality of the calcium removal was evaluated quantitatively and visually.

RESULTS

For the same dose level, tube voltage minimally influenced image noise. However, for all dose levels, lower tube voltage did result in higher iodine CT values. For example, lumen contrast was 682 HU, 763 HU and 898 HU at 140 kV, 120 kV and 100 kV, respectively. Plaque removal performed better for higher concentrations of iodine and higher densities of calcium. 120 kV and 140 kV led to similar calcium removal quality, whereas the plaque surface appeared fringed at 80 kV and 100 kV due to reduced spectral separation.

CONCLUSION

Removal of calcified plaques using spectral information is feasible irrespective of the selected tube voltage for PCT-CT. However, a substantial improvement in plaque removal quality was observed at 120 and 140 kV. Of these, 120 kV revealed increased vessel contrast.

CLINICAL RELEVANCE/APPLICATION

Reliable removal of calcified plaque in coronary CTA imaging may allow for reduced exam series and more accurate diagnoses.

SSA21-03 Potential of Photon Counting Technique for Next-Generation Type X-Ray Diagnostic System: To Provide New Medical Image Concerning Effective Atomic Numbers Using Plain X-Ray

Sunday, Nov. 26 11:05AM - 11:15AM Room: S404AB

Participants
Natsumi Kimoto, Tokushima, Japan (*Presenter*) Nothing to Disclose
Hiroaki Hayashi, PhD, Tokushima, Japan (*Abstract Co-Author*) Equipment support, Nagase Landauer, Ltd; Research collaboration, Nagase Landauer, Ltd; Equipment support, JOB Corporation; Research collaboration, JOB Corporation;
Takashi Asahara, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Emi Tomita, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Sota Goto, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiki Mihara, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuki Kanazawa, PhD, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Tsutomu Yamakawa, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Shuichiro Yamamoto, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Masashi Yamasaki, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Masahiro Okada, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Daisuke Hashimoto, Osaka, Japan (*Abstract Co-Author*) Employee, R&D Direct

For information about this presentation, contact:

natsumi.kimoto.0717@gmail.com

TEACHING POINTS

1) Photon counting technique enables the production of a diagnostic X-ray image in which the effective atomic number can be precisely determined. 2) The beam hardening effect should be corrected in order to achieve precise analysis even when a part of the X-ray spectrum is analyzed.

TABLE OF CONTENTS/OUTLINE

1) Aim We aim to propose a novel material identification method based on a photon counting technique. In this system, X-ray spectrum penetrating an object is measured pixel by pixel. Each pixel has the potential to derive material composition of an object. 2) Materials and Methods We proposed a novel method. By dividing the X-ray spectrum into two energy bins, and attenuation factors of the object were calculated. In addition, we proposed a beam hardening correction procedure, which can be applied to two energy bins. The following studies were performed; 1) theory construction, 2) verification experiment using single-probe-type CdTe detector, 3) Monte-Carlo simulation, and 4) demonstration of obtaining a two dimensional X-ray image using a test imaging system. 3) Result and Discussion Our method can determine effective atomic number with an accuracy of +/-0.1 Z under actual clinical conditions during plain X-ray diagnosis. In addition to the traditional X-ray image, effective atomic number image enables precise diagnosis.

PDF UPLOAD

https://abstract.rsna.org/uploads/2017/17004368/17004368_fnrr.pdf

SSA21-04 Assessment of Spatial Resolution in Coronary Stents using Photon-Counting CT Detector: An In-vitro Study

Sunday, Nov. 26 11:15AM - 11:25AM Room: S404AB

Participants
Manoj Mannil, Zurich, Switzerland (*Presenter*) Nothing to Disclose
Tilman Hickethier, MD, Cologne, Germany (*Abstract Co-Author*) Nothing to Disclose
Jochen von Spiczak, MD,MSc, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Matthias Baer, DiplPhys, Erlangen, Germany (*Abstract Co-Author*) Nothing to Disclose
Bernhard Schmidt, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Thomas G. Flohr, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
David C. Maintz, MD, Koln, Germany (*Abstract Co-Author*) Nothing to Disclose
Hatem Alkadhi, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate computed tomography (CT) imaging characteristics of coronary stents using a novel photon counting detector (PCD) in comparison with a conventional energy-integrating detector (EID).

METHOD AND MATERIALS

In this in-vitro study, 18 different coronary stents were expanded in plastic tubes of 3 mm diameter, were filled with diluted contrast agent (300mg/ml) and were sealed. Stents were placed in an oil-filled custom phantom calibrated to an attenuation of -100HU for resembling pericardial fat. The phantom was positioned in the gantry at 2 different angles at 0° and 90° relative to the z-axis and were imaged in a 128-section research dual-source PCD-CT scanner. Detector subsystem "A" used a standard EID, while detector subsystem "B" used a PCD allowing high resolution scanning at two energy thresholds. Images were obtained at identical tube voltage and tube current and were reconstructed using the identical sharp-tissue convolution kernel (B46f). Two independent, blinded readers evaluated in-stent visibility, measured noise, intraluminal stent diameter, and in-stent attenuation for each detector subsystem. Differences in noise, intraluminal stent diameter, and in-stent attenuation where tested using a paired t-test; differences in subjective in-stent visibility were evaluated using a Wilcoxon signed-rank test.

RESULTS

Subjective in-stent visibility was superior in coronary stent images obtained from PCD, compared to EID ($p<0.001$). The mean intraluminal stent diameter was 22.9% greater in PCD (0.85 ±0.24 mm) compared to EID image acquisition (0.66 ±0.21 mm; $p<0.001$). Average noise was significantly lower ($p<0.001$) for PCD (5±0.2 HU) compared to EID (8.3±0.2 HU). In-stent attenuation values were significantly lower for PCD (125.8±77.6 HU) compared to EID (193.5±140.9 HU) ($p=0.001$).

CONCLUSION

Use of PCD in CT imaging of coronary artery stents yields superior spatial resolution compared to CT scanners equipped with conventional EID at a matched dose.

CLINICAL RELEVANCE/APPLICATION

PCD-CT imaging has superior spatial resolution compared to images obtained with a conventional EID-CT at a matched dose, which improves the in-stent lumen visualization of coronary artery stents.

SSA21-05 Image Quality Assessment and Dose-Efficiency of Quarter-Millimeter Photon-Counting CT of Humans: First In Vivo Experience

Sunday, Nov. 26 11:25AM - 11:35AM Room: S404AB

Participants
Amir Pourmorteza, PhD, Atlanta, GA (*Presenter*) Nothing to Disclose
Rolf Symons, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Friederike Schock, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Andre Henning, MENG,MSc, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Steffen Kappler, DIPLPHYS, Forchheim, Germany (*Abstract Co-Author*) Researcher, Siemens AG
Stefan Ulzheimer, PhD, Nurnberg, Germany (*Abstract Co-Author*) Employee, Siemens AG
David A. Bluemke, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Research agreement, Siemens AG; Research support, Siemens AG; Research agreement, Carestream Health, Inc; Research support, Carestream Health, Inc

For information about this presentation, contact:

amir.pourmorteza@nih.gov

PURPOSE

Current methods of UHR acquisition rely on a the highly dose-inefficient UHR comb that blocks ½ to ¾ of the surface of the detector in order to increase spatial resolution. We investigated the image quality of 0.25mm, ultra-high resolution (UHR) photon-counting detector CT (PCD-CT) acquisition and reconstructions in human subjects. PCDs directly convert x-ray photons into electric pulses and their pixels can be made very small because PCDs do not include scintillating crystals and therefore do not suffer from their physical limitations.

METHOD AND MATERIALS

8 volunteers received brain and lung scans in spiral standard resolution (SR) and axial UHR modes on a whole-body prototype PCD-CT scanner; lungs: 140 kVp, 110 mAs, brain: 120 kVp, 370 mAs. Filtered backprojection reconstructions were made at 0.5 mm isotropic voxel size for SR and UHR data and 0.25 mm isotropic size for UHR data. Noise power spectrum was measured in a 20-cm water-equivalent phantom; image standard deviation was measured in large uniform ROIs in the volunteers. Image resolution was measured in the line pair section of the Catphan CT phantom. HU accuracy was measured in a water phantom with 25 inserts of materials of known concentrations.

RESULTS

UHR acquisition reconstructed at 0.25 mm improved image resolution from 9 to 19 LP/cm, with 70% noise increase compared to dose-matched SR acquisition. Interestingly, UHR acquisitions reconstructed at 0.5 mm resolution showed 20% less noise compared to SR images at 0.5 mm, confirmed both in phantom and human measurements. This can be attributed to the reduced noise aliasing due to higher sampling rate of noise in UHR acquisitions. There was no significant bias in the HU values measured in SR and UHR: confidence interval= [-4.6 4.8] HU.

CONCLUSION

0.25-mm PCD acquisition has two advantages: 1- ultrahigh resolution images at acceptable dose levels compared to UHR comb scans (2.8x vs 16x). 2- lower-noise images (20%) when reconstructed at SR voxel sizes, leading to potentially 36% reduction in radiation dose while maintaining image quality.

CLINICAL RELEVANCE/APPLICATION

Ultrahigh-resolution PCD CT markedly improves spatial resolution (19 LP/cm); at standard (0.5 mm) resolution, radiation dose of PCD CT would decrease by 36% compared to conventional detectors.

SSA21-06 Feasibility of Auto-ECG-Gating Technique of 256 Row CT Coronary Angiography in Patients without Heart Rate Control

Sunday, Nov. 26 11:35AM - 11:45AM Room: S404AB

Participants
Fang Wang, Yinchuan, China (*Presenter*) Nothing to Disclose
Lili Yang, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose
Jie Ding, Yin Chuan, China (*Abstract Co-Author*) Nothing to Disclose
Ruoshui Ha, BA, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose
Yongbin Gao, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

xiaoxiao_8236@sina.com

PURPOSE

To investigate the feasibility of CT coronary angiography (CCTA) in patients without heart rate control by optimizing the acquisition phase with auto-ECG-gating technology on a 256-row detector CT.

METHOD AND MATERIALS

Total 200 patients with suspected coronary artery disease were enrolled and underwent CCTA with auto-ECG-gating on a 256 row wide detector CT (Revolution CT). Patients were divided into four groups according to the real-time heart rate (HR), group A (50 patients): HR<= 69 bpm; group B (50 patients): HR 70 to 80 bpm; group C (50 patients): HR 81 to 90 bpm; group D: HR>= 91 bpm. The image quality and diagnostic interpretability were accessed by two experienced radiologists blindly with likert 4-point score. The images quality score, diagnostic interpretability and radiation dose were compared with one-way ANOVA or rank sum test among 4 groups.

RESULTS

There were no significant difference of age, sex, and body mass index among four groups, and there was significant difference of image quality score among 4 groups (all $P<0.05$). Total 800 coronary arteries and 2575 segments were assessed. There were no significant differences of diagnostic interpretability among four groups derived from the segment, coronary artery and patients ($P>0.05$). The effective radiation dose in A-D groups were (1.05±0.48)mSv,(2.41±1.20)mSv,(1.27±0.55)mSv, (2.66±1.12)mSv($F=29.22$,$P< 0.001$) respectively.

CONCLUSION

It is feasible to perform CCTA in single cardiac cycle in patient without heart rate control by auto-ECG-gating using Revolution CT equipped wide-volume detector.

CLINICAL RELEVANCE/APPLICATION

CCTA can be performed in patients with high heart rate through auto-ECG-gating technology on a 256-row wide-volume detector with low radiation dose.

SSA21-07 Ultimate Pulmonary Imaging: Leading-edge Ultra-High Resolution CT vs Conventional Area Detector CT

Sunday, Nov. 26 11:45AM - 11:55AM Room: S404AB

Participants
Masahiro Yanagawa, MD, PhD, Suita, Japan (*Presenter*) Nothing to Disclose
Akinori Hata, MD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Osamu Honda, MD, PhD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriko Kikuchi, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriyuki Tomiyama, MD, PhD, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Shinsuke Tsukagoshi, PhD, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Ayumi Uranishi, Osaka, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation

PURPOSE

To compare the image quality between leading-edge ultra-high resolution CT (U-HRCT) and conventional area detector CT (AD-CT).

METHOD AND MATERIALS

Eleven cadaveric lungs were scanned by both U-HRCT (Aquilion Precision™;Toshiba) and AD-CT (Aquilion ONE™;Toshiba). Each cadaveric lung was scanned at 3 different position levels. U-HRCT images were obtained with a 1.5 sec-gantry rotation, 16cm field

of view, and 120kV. Three types of modes were scanned: Normal mode (U-HRCT*N*:Detector element[DM], 896channel, 0.5mmx80row; matrix, 512; pitch factor[PF], 0.81; CTDI, 23.2mGy); Super High Resolution mode (U-HRCT*SR*:DM, 1792channel, 0.25mmx160row; matrix, 1024; PF, 0.81; CTDI, 23.2mGy); and Volume mode (U-HRCT*SR-VOL*: non-helical scan with U-HRCT*SR*; CTDI, 19.2mGy). AD-CT images were obtained with the same conditions of U-HRCT*N* (CTDI, 23.9mGy). All CT images reconstructed at 0.5mm slice thickness were graded on a 3-point scale (1=worse,2=equal,3=better) by 3 independent observers, compared with U-HRCT*N*: 1) Normal CT findings (vessel, bronchi); 2) Abnormal CT findings (ground-glass opacity, consolidation, emphysema, faint and solid nodules, interlobular septal thickening, intralobular reticular opacity, bronchiectasis, honeycombing); 3) Other CT findings (noise, artifacts [streak, dark band], overall image quality). Median scores were used as final evaluations. Noise values were calculated by measuring the standard deviation values in a circular region of interest placed on each selected image. Statistical analysis was performed using Friedman test followed by post-hoc tests.

RESULTS

Both U-HRCT*SR* and U-HRCT*SR-VOL* improved normal and abnormal CT findings and reduced streak and dark band artifacts significantly more than AD-CT($p<0.014$). U-HRCT*SR-VOL* improved a visual noise better than U-HRCT*SR* and AD-CT($p<0.00001$). Quantitative noise values were significantly higher in order of U-HRCT*SR*(median, 29.5), U-HRCT*SR-VOL* (26.2), AD-CT(15.9), and U-HRCT*N*(14.2)($p<0.0001$). U-HRCT*SR* and U-HRCT*SR-VOL* significantly provided higher overall image quality than AD-CT almost equal to U-HRCT*N*($p<0.0001$).

CONCLUSION

U-HRCT*SR* and U-HRCT*SR-VOL* can provide higher image quality than AD-CT. U-HRCT*SR-VOL* is also more advantageous in noise than U-HRCT*SR*.

CLINICAL RELEVANCE/APPLICATION

U-HRCT*SR* and U-HRCT*SR-VOL* might contribute more detailed evaluations in lung by substantially improving image quality than AD-CT.

SSA21-08 Reducing Pseudo Enhancement of Liver Cyst with Virtual Monochromatic Spectral Images: A Clinical Application Study

Sunday, Nov. 26 11:55AM - 12:05PM Room: S404AB

Participants
He Taiping, MMed, Xian Yang City, China (*Presenter*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Yu Yong, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Haifeng Duan, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

htp89956@163.com

PURPOSE

To evaluate the clinical value of using virtual monochromatic spectral (VMS) images to reduce pseudo-enhancement of liver cysts.

METHOD AND MATERIALS

10 patients with a total of 26 small liver cysts (the long diameter of less than 2 cm) who underwent enhanced spectral CT scans were included. Lesions were confirmed by the combination of ultrasound, MR and multi-phase abdominal spectral CT imaging to be liver cyst. Plain CT, contrast enhanced spectral CT scans in cortical phase (25-30s delay) and portal venous phase (60-70s delay) were performed. The 140kVp polychromatic images and 70keV VMS image of 1.25mm and 5mm thickness were reconstructed in the cortical phase and portal venous phase. CT number difference between the enhanced-phase image and the pre-contrast image was calculated, and the enhancement (pseudo) was assumed when the CT number difference was greater than the historical value of 10HU. The 140kVp polychromatic image was used as a reference to represent conventional CT imaging condition.

RESULTS

The minimum and maximum diameters of the 26 cysts were 4.7mm and 19.5mm, respectively. Using the 140kVp polychromatic image, one observed 5 and 14 pseudo-enhanced cysts in the cortical phase and portal venous phase, respectively in the 5mm slice images; and 3 and 8 cases of pseudo-enhancement in the 1.25mm slice images. The pseudo enhancement was greatly reduced to 3 and 7 cases for the 5mm slice thickness and 2 and 3 cases for the 1.25mm slice in the cortical phase and cortico-medullary phase, respectively when the 70keV VMS images were used. The total number of pseudo enhancement in the 5mm slice polychromatic images (19) was markedly reduced to 11 with the use of 1.25mm slice images ($P=0.08$), and was further reduced to 5 when the 70keV VMS images of 1.25mm thin slice was used ($P=0.001$).

CONCLUSION

The pseudo enhancement of small liver cysts existed based on the CT number threshold and influenced by image thickness. Compared with conventional polychromatic and thick slice mode, virtual monochromatic spectral images in its thin slice form can considerably reduce the phenomenon of small liver cysts pseudo-enhancement.

CLINICAL RELEVANCE/APPLICATION

Thin slice virtual monochromatic spectral images can greatly reduce the phenomenon of pseudo enhancement of small liver cysts. They have a role in identifying real enhancement characteristics of lesions.

SSA21-09 Comparison of X-Ray Phase Contrast CT at a Synchrotron Facility with Conventional Imaging Modalities on Wrists

Sunday, Nov. 26 12:05PM - 12:15PM Room: S404AB

Participants
helene labriet, grenoble, France (*Presenter*) Nothing to Disclose

Barbara Fayard, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose
Sylvain Bohic, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose
Herve Mathieu, la tronche, France (*Abstract Co-Author*) Nothing to Disclose
Jean Noel Ravey, la Tronche, France (*Abstract Co-Author*) Nothing to Disclose
Yohann Robert, la Tronche, France (*Abstract Co-Author*) Nothing to Disclose
Philippe Gaudin, la Tronche, France (*Abstract Co-Author*) Nothing to Disclose
Sebastien Berujon, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose
Emmanuel Brun, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

None of the current conventional medical imaging approaches permit to visualize and differentiate in a single image all the different tissues of a joint. For instance, X-ray absorption based Computed Tomography (CT) shows limitations for the imaging parts presenting a weak density. Although Magnetic Resonance Imaging (MRI) is crucial for soft tissue it struggles to render properly the bony changes using conventional routine sequences. Phase Contrast Imaging (PCI) takes advantage of the dual properties of the X-rays to reveal sample enhanced details of simultaneously soft and hard materials. This work presents qualitative comparison between PCI using Propagation Based Imaging CT and today's conventional medical imaging modalities (CT/MRI/US).

METHOD AND MATERIALS

PCI images were acquired using a monochromatic X-ray beam whose energy was set to 60:keV (22 µm voxel size). The sample and the detector were positioned 11:m apart. The qualitative image comparison was carried out based on 3 cadaveric human wrists. The samples were maintained fixed in dedicated containers filled with formaldehyde.

RESULTS

The results show higher image quality in PCI data sets compared to conventional clinical multi-modality imaging. Equivalently to conventional MRI routine sequence, PCI images offer good contrast for the soft tissues. In addition, spongy lamellar bone tissues are also better rendered with PCI than with clinical CT, making details of the trabeculae visible. The PCI superiority in terms of both resolution and contrast helps to differentiate the various components such as the cartilages, ligaments and muscles. The figure presents axial right wrist images reconstructed from (a) conventional CT, (b) PCI CT on a synchrotron source (b) and (c) MRI T2 sequence

CONCLUSION

This proof of concept experiment demonstrates the potential of the PCI in terms of image quality. This pre-clinical study lets foresee a widespread use of coherent X-ray sources for medical imaging in a near future. In this context, new of under development compact X-ray technologies are watched with interest.

CLINICAL RELEVANCE/APPLICATION

This study provides a comparative study of synchrotron Phase Contrast Imaging CT of wrists with hospital conventional imaging modalities (CT/MRI/US).

SSA22

Physics (MR: Applications)

Sunday, Nov. 26 10:45AM - 12:15PM Room: S405AB

MR PH

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

Participants
Edward F. Jackson, PhD, Madison, WI (*Moderator*) Nothing to Disclose
Stephen J. Riederer, PhD, Rochester, MN (*Moderator*) Nothing to Disclose

Sub-Events

SSA22-01 Reproducibility of GABA in Occipital Lobe in Healthy Subjects Employing Mega-press at 3T

Sunday, Nov. 26 10:45AM - 10:55AM Room: S405AB

Participants
Luguang Chen, Shanghai, China (*Presenter*) Nothing to Disclose
Zhuwei Zhang, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Chao Ma, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Jianqi Li, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Jianping Lu, MD, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

chen_lu_guang@sina.com

PURPOSE

To evaluate the reproducibility of γ-aminobutyric acid (GABA) in occipital lobe of normal subjects at 3T.

METHOD AND MATERIALS

Spectroscopic data were acquired from occipital lobe region in 16 normal adult volunteers (9 males and 7 females; mean age: 23.5±1.3) using J-editing technique and MEGA-PRESS pulse sequence (the sequence was developed on the platform of Siemens MR system, TR/TE=2000 ms /68 ms, VOI=25×25×25 mm3, BW=1200 Hz, Measurements=320, the editing pulses applied at 1.9 ppm or 7.5 ppm in an interleaved manner) at a 3T scanner, and each subject scanned twice (duration between scans: 7 days). The GABA data divided into three groups, Visit1, for the first scan, Visit2, for the second scan, and Visit1&2, for the first and second scans, respectively. The reproducibility of GABA was assessed by the GABA+/NAA ratio, coefficient of variation (CV) and t-test.

RESULTS

The mean GABA+/NAA ratio in the two scans of each subject was ranged from 0.179 to 0.283 (Fig. 1), during which the CVs were below 10% in eleven subjects. The mean GABA+/NAA ratios of different groups were similar, and with the CVs below 15% (Tab. 1). The t-test result showed that the two scans of all subjects had no significant difference (p=0.480). The mean GABA+/NAA ratio of male group were higher than that of female group, however, the CVs of male group were lower than that of female group (Tab. 2). In addition, the t-test results also suggested that the two scans of both the two groups had no significant difference (p=0.280, p=0.973). However, significant difference was found in the mean GABA+/NAA ratios between the two groups (p=0.022).

CONCLUSION

The measurements of GABA in occipital lobe demonstrated a good reproducibility in healthy volunteers with J-editing technique and MEGA-PRESS pulse sequence at 3T, and the mean relative concentration is higher in male than that in female.

CLINICAL RELEVANCE/APPLICATION

Detection of GABA in occipital lobe demonstrated a good reproducibility in healthy volunteers with J-editing technique and MEGA-PRESS pulse sequence is recommended in the evaluation of human brain GABA concentration.

SSA22-02 Quality Assurance of Diffusion Weighted Imaging: Comparison of a New ACR Phantom Based Method with the QIBA Method

Sunday, Nov. 26 10:55AM - 11:05AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
Eric Cameron, BS, West Lafayette, IN (*Presenter*) Nothing to Disclose
Ulrike Dydak, PhD, West Lafayette, IN (*Abstract Co-Author*) Nothing to Disclose
Chen Lin, PhD, Jacksonville, FL (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

cameron@purdue.edu

cameroe@purdue.edu

PURPOSE

Quality Assurance (QA) of diffusion weighted imaging (DWI) as recommended by the RSNA Quantitative Imaging Biomarkers Alliance (QIBA) requires a special ice water phantom that is not widely available and difficult to prepare. The ACR phantom, however, is available in many clinical MRI facilities and used for weekly QA. Therefore, it would be beneficial to develop a DWI QA procedure based on the ACR phantom (ACR DWI QA) that can be integrated into the weekly QA. The purpose of this work is to develop such a method and compare with the QIBA method.

METHOD AND MATERIALS

QIBA DWI QA was performed according to QIBA protocol (http://qibawiki.rsna.org/). For ACR DWI QA, the following adjustments were made: TR=5000ms due to a shorter T1, and averages of 2, 2, 4 and 8 for b=0, 500, 900 and 2000 s/mm2 to improve the SNR. The temperature of the ACR phantom was measured pre-/post-scan with a laser thermometer [Dr. Meter IR-20] (accuracy<1°C). Comparison of QIBA and ACR DWI QA was performed on two different scanners: 1) a Siemens 3T Prisma using a 20ch head&neck coil and 2) a GE 3T MR750 using an 8ch head coil. Apparent Diffusion Coefficient (ADC) maps were generated by the built-in software on the scanners. The mean ADC value in three different ROIs as shown in fig. 1 were averaged and compared against the theoretical value described by Holz et al. 2000 (PCCP) at the measured temperature to determine the deviation of ADC.

RESULTS

The mean deviation of ADC based on ACR DWI QA was 0.89% (SD±0.71%) for scanner 1 and 2.55% (SD±0.62%) for scanner 2. For QIBA DWI QA, they were 0.61±0.63% and 2.59±0.39%, respectively. The measured ADC with ACR DWI QA was highly reproducible and the deviation was consistent with QIBA DWI QA.

CONCLUSION

A new DWI QA method based on the ACR phantom was shown to be reproducible and able to detect similar ADC deviation as the QIBA DWI QA method. The new method is simpler and more feasible for the clinical environment although it is limited to one ADC value and correction for phantom temperature could be an additional source of error.

CLINICAL RELEVANCE/APPLICATION

Development of a DWI QA procedure using the ACR phantom would allow any ACR accredited institution to implement a DWI QA as a part of the weekly QA without additional phantoms or preparation.

SSA22-03 Modulation Transfer Function of Clinical Brain 3D-FLAIR Sequence

Sunday, Nov. 26 11:05AM - 11:15AM Room: S405AB

Participants
Juha Peltonen, MSc, Espoo, Finland (*Presenter*) Nothing to Disclose
Teemu Makela, Helsinki, Finland (*Abstract Co-Author*) Nothing to Disclose
Alexey Sofiev, Helsinki, Finland (*Abstract Co-Author*) Nothing to Disclose
Eero Salli, Helsinki, Finland (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

juha.peltonen@hus.fi

PURPOSE

Typically, image quality in magnetic resonance imaging is evaluated either quantitatively from quality control (QC) phantom images or subjective observer based evaluation of clinical images. However, the phantom-based quality measurements may not fully represent the quality of actual clinical images. An important image quality metrics among image noise and contrast is spatial resolution. In medical imaging, spatial resolution is often characterized by the modulation transfer function (MTF) at a known boundary. It describes the image contrast content at different spatial frequencies. We have developed a method to characterize image resolution by measuring MTF directly from clinical brain volumes obtained with 3D-FLAIR sequence.

METHOD AND MATERIALS

Edge profiles are extracted from a brain surface and direction-dependent MTFs are calculated. First, the original 3D-FLAIR volume is segmented using Statistical Parameter Mapping (Wellcome Trust Centre for Neuroimaging, University College London, UK). The brain mask is further trimmed with an in-house MATLAB (The Mathworks Inc., Natick, MA, USA) application. A mesh grid is fitted onto the mask volume using MATLAB-based open source toolbox iso2mesh. A typical brain surface grid includes from 150 000 to 250 000 triangular polygons. Voxel gray values and distances from the grid are then recorded within cylindrical volumes perpendicular to each polygon face and intersecting the polygon center. Each resulting edge spread function (ESF) is filtered according to predetermined acceptance criteria and the accepted ESFs are centered on the detected edge. Resulting ESFs are averaged, differentiated and Fourier transformed to obtain direction-dependent MTFs.

RESULTS

The developed method was able to determine brain surface direction-dependent MTFs from clinical 3D-FLAIR volumes. Resolution trend curves were calculated over a period of nine months.

CONCLUSION

The developed method provides a quantitative tool for measuring MTF directly from clinical 3D brain images. The MTF can be used to the compare spatial resolution in image volumes obtained with different sequence parameters and scanners. The method can be also applied on-line to follow daily image quality to detect technical or patient related issues.

CLINICAL RELEVANCE/APPLICATION

The calculation of clinical MRI volume MTF provides a quantitative tool for protocol optimization or evaluating and comparing scanners or sequences.

SSA22-04 Characteristics of MRI Patents Approved by the US Patent and Trademark Office in 2016

Sunday, Nov. 26 11:15AM - 11:25AM Room: S405AB

Participants
Sushma Gaddam, MD, New York, NY (*Presenter*) Nothing to Disclose
Gregory Lemberskiy, MSc, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Andrew B. Rosenkrantz, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

Sushma.Gaddam@nyumc.org

PURPOSE

To use data regarding MRI patents approved by the U.S. Patent and Trademark Office (USPTO) in 2016 to characterize recent trends in MRI technical development and innovation.

METHOD AND MATERIALS

The USPTO website was searched for all patents with an issue date in 2016 and a patent abstract containing the phrase "magnetic resonance". Patent characteristics available on the website were recorded. Patent assignees were manually characterized as having an industry or academic affiliation. An MRI physicist reviewed the abstracts to classify patents' themes. Observations were summarized using standard descriptive statistics.

RESULTS

A total of 423 MRI-related patents were approved by the USPTO in 2016. Of these, a total of 29% had 1 inventor, 24% had 2 inventors, and 47% had >=2 inventors (maximum of 10 inventors). The mean interval between patents being filed and awarded was 1389 ± 559 days (range, 559 to 1,327 days). The most common countries of patents' first assignee were: USA (40%), Germany (24%), Netherlands (10%), Japan (10%), and Korea (4%). There were 14 additional countries (each <2%). A total of 3% of patents included multiple assignees having different countries (most common collaborators being USA and Germany). Patents' 1st assignee had an industry affiliation in 76% vs. an academic affiliation in 21% (4% were indeterminate). A total of 3% of patents had industry-academia collaboration. Patents' most common themes were: coils (n=77), sequence design (n=65), and non-coil scanner hardware (n=41). These top themes were similar for USA, international, and industry based patents; however, for academic based patents, the most common themes were: sequence design, reconstruction, and exogenous agents. Less common themes included: image analysis, post-processing, spectroscopy, relaxometry, diffusion, motion correction, radiation therapy, implants, wireless devices, and PET/MRI.

CONCLUSION

The majority of MRI-related patents approved by the USPTO in 2016 were filed by non-U.S. inventors. A large majority had an industry affiliation; minimal industry-academic collaboration was observed. Patents from industry and academic inventors had distinct top focuses: hardware and software, respectively.

CLINICAL RELEVANCE/APPLICATION

Awareness of the most recent years' MRI patents may provide insights into forthcoming clinical translations and help guide ongoing research and entrepreneurism.

SSA22-05 SI-traceable Imaging Phantoms for MRI

Sunday, Nov. 26 11:25AM - 11:35AM Room: S405AB

Participants
Stephen E. Russek, PhD, Boulder, CO (*Presenter*) Nothing to Disclose
Michael Boss, PhD, Boulder, CO (*Abstract Co-Author*) Nothing to Disclose
Kathryn E. Keenan, PhD, Boulder, CO (*Abstract Co-Author*) Nothing to Disclose
Karl Stupic, PhD, Boulder, CO (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

stephen.russek@nist.gov

PURPOSE

To develop primary calibration structures for MRI that have precisely defined properties traceable to the International System of Units (SI). Properties include T1 and T2 proton-spin relaxation times, apparent water diffusion coefficients (ADC), resolution, and geometric distortion. In addition to the primary measurands, the properties of the phantom structure, including dielectric constant, conductivity, and magnetic susceptibility must be determined to fully understand and model MRI-based measurements.

METHOD AND MATERIALS

A suite of MRI phantoms have been designed, fabricated, and commercialized including a system phantom, a diffusion phantom and a breast phantom. These phantoms include paramagnetic solutions for T1 T2 arrays, polymer solutions for ADC calibration, fiducial spheres for geometric distortion, and fat/tissue mimics. The properties of phantom materials are determined through temperature-controlled variable-field NMR, imaging on a MRI metrology scanner, electromagnetic properties measurements, and SQUID magnetometry.

RESULTS

Rigorous but pragmatic definitions of parameters for the major MRI biomarkers have been developed. SI traceable measurement protocols for T1, T2 and ADC and initial measurements have been completed. SI-traceable measurements, with the associated certificates, are expected within 12 months. The phantoms are currently being used at clinical research sites to evaluate new faster quantitative imaging techniques, to homogenize images across scanners, and to develop quality control recommendations for clinical trials evaluating diffusion-based imaging for cancer detection/monitoring. These initial uses have indicated that it is necessary to guarantee phantom-parameter accuracy and stability of 2%.

CONCLUSION

As medical imaging improves with increased reliance on qualitative measurement of critical biomarkers, there is an increasing need for more rigorous calibration structures with the associated SI-traceable measurement of their properties. We have developed a suite of phantoms and associated measurement structure to supply this need.

CLINICAL RELEVANCE/APPLICATION

These phantoms have been used to validate new, faster quantitative imaging techniques such as MR fingerprinting, homogenize scan protocols across different scanner types, assess the change in performance of scanners due to upgrades, assess advanced diffusion imaging protocols in cancer studies and traumatic brain injury diagnosis.

SSA22-06 Display Color in the Interpretation of Apparent Diffusion Coefficient Maps for Prostate Cancer

Sunday, Nov. 26 11:35AM - 11:45AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
Silvina Zabala Travers, MD, Silver Spring, MD (*Presenter*) Nothing to Disclose
Simone Busoni, PHD, Firenze, Italy (*Abstract Co-Author*) Nothing to Disclose
Silvia Lucarini, MD,PhD, Florence, Italy (*Abstract Co-Author*) Nothing to Disclose
Vittorio Miele, MD, Florence, Italy (*Abstract Co-Author*) Nothing to Disclose
Aldo Badano, PhD, Silver Spring, MD (*Abstract Co-Author*) Research Grant, Barco nv

For information about this presentation, contact:

aldo.badano@fda.hhs.gov

PURPOSE

Color visualization is prevalent in functional and molecular imaging, the source of most reported imaging biomarkers. Color display selection varies across imaging departments because no guidelines are available and no study has evaluated reader consistency using visualization approaches. In prostate patients, water movement restriction areas in apparent diffusion coefficient (ADC) maps correlate with significant cancer. Inconsistency in quantification and localization reported could result in suboptimal patient management. We report radiologist consistency in detection of prostate lesions to determine the effect of color visualization approaches on diagnostic performance.

METHOD AND MATERIALS

Nine trained readers interpreted 165 single-slice cases, each reading sets of 55 images in 3 separate sessions using a different color scale: gray (G), hot-iron (H), and the inverted rainbow scale (iR). The standard RGB display mode was used for H and iR sessions and the GSDF mode was selected for G. Five readers repeated sessions with iR and H in GSDF mode. Readers used a 0-100 scale to rate their confidence in the presence of a malignant tumor. For cases scored above 50, readers were asked to mark the lowest ADC value within the detected lesion. Pixel values and coordinates were recorded.

RESULTS

The area under the receiver-operating-characteristic curve (AUC) was compared across color scales. Obtained AUCs were 0.79, 0.77 and 0.80 (SE = 0.03) for G, H and iR, respectively, demonstrating a small improvement in detection performance when using iR. A tendency for higher detection sensitivity was observed for RGB setting compared to GSDF for H and iR. Inconsistencies on lesion quantification and localization were non-significant across scales. These results significantly differ from those in a similar study for ischemic lesion detection in myocardial perfusion CT where performance was up to 0.1 AUC units higher using G.

CONCLUSION

Differences in quantification and localization consistency were non-significant. Further investigation is necessary to determine if color affects other diagnostic tasks.

CLINICAL RELEVANCE/APPLICATION

Our findings suggest a small non-significant impact of color for prostate lesion detection in ADC maps, disagreeing with a significant color effect observed in a similar study performed on a different modality.

SSA22-07 Quantitative Estimation of CSF Flow Using MRI Phase Contrast Technique to Assess the Postoperative Outcome of Chiari 1 Malformation with Syringohydromyelia

Sunday, Nov. 26 11:45AM - 11:55AM Room: S405AB

Participants
Rajesh Kumar Vartharajaperumal, MBBS, DMRD, Coimbatore, India (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

kumar2476rd@gmail.com

PURPOSE

To quantify the postoperative outcome of chiari 1 malformation using CSF flow study. To evaluate the efficacy of surgery and to assess the prognosis in the early postoperative period.

METHOD AND MATERIALS

Fifty patients with chiari 1 malformation with syringohydromyelia who are ideal candidate for surgery were subjected to MRI brain and spine and CSF flow analysis using MR phase-contrast technique. Region of interest was kept at the level of aqueduct and assessed the positive peak velocity , negative peak velocity and flow . All patients underwent posterior fossa decompression

surgery. Post operative velocity and flow measurements of all patients were taken. We compared the pre and post operative flow volume and velocity.

RESULTS

Of the 50 patients, 36 patients showed significant change in the velocity and flow in the early postoperative period and had resolution of clinical signs and symptoms during follow up. 10 patients showed mild changes in flow and velocity in the early postoperative period with partial recovery of symptoms during follow up and in 4 patients , there is minimal change in velocity and flow during early postoperative period with persistence of symptoms during follow up.

CONCLUSION

Patients with significant changes in flow and velocity in the early postoperative period will have better clinical recovery when compared to patients with minimal change.

CLINICAL RELEVANCE/APPLICATION

Improved CSF velocity and flow in the early postoperative period is useful in anticipation of symptomatic improvement and useful in assessing the efficacy of surgery and long term prognosis.

SSA22-08 Non-ECG-gated and Non-enhanced MR Venography in Arrhythmia

Sunday, Nov. 26 11:55AM - 12:05PM Room: S405AB

Participants
Jun Isogai, MD, Asahi, Japan (*Presenter*) Nothing to Disclose
Mitsue Miyazaki, PhD, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Kenji Yodo, Saitama, Japan (*Abstract Co-Author*) Employee, Toshiba Corporation
Takashi Yamada, Hasuda, Japan (*Abstract Co-Author*) Nothing to Disclose
Jun Kaneko, Hasuda, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To selectively visualize lower extremity varicose veins in arrhythmia patients without contrast media by the use of a free-ECG-gating Flow-Sensitive Black Blood (FSBB) technique.

METHOD AND MATERIALS

A FSBB technique doesn't need an ECG-gating and allows b values to be adjusted in increments of 0.1 value as one-tenth of usual 1 value. A protocol optimization was performed on 20 healthy volunteers while they changed their lower limb position up and down in the supine or seated position. Subsequently, the revised FSBB protocol parameters were applied to 25 arrhythmia patients of varicose veins with difficulty in diagnosis on usual ECG-gated MRA techniques. All the studies were performed on a 1.5T MRI system (EXCELART Vantage XGV Toshiba) equipped with a SPEEDER torso coil. FSBB imaging was performed as follows; T2*-weighted 3D gradient echo sequence, b value; 0.1-0.4, and typical scan time; 5 min. The performance of FSBB on the lower extremity venous systems was assessed for the image contrast as compared with the other unenhanced ECG-gated MRA techniques.

RESULTS

The scan time of FSBB was almost equal to that of time-of-flight (TOF) and half-Fourier FSE MRA (FBI) using usual ECG-gating techniques. Unenhanced MRA showed excellent depiction of complex venous plexus and age-related vasodilatation while changing their lower limb positions, especially in their legs lowered on seated position. FSBB provided an excellent anatomical depiction of tortuous varicose veins in arrhythmia patients as a dynamic imaging.

CONCLUSION

FSBB technique is independent of ECG-gating and allows exam integrity even in arrhythmia patients and can consequently shorten exam time, so it may provide a valuable procedure for diagnosis of peripheral vascular imaging. Selective visualization of varicose sources in arrhythmia patients without contrast media is of increasing significance for an interventional procedure in our aging population.

CLINICAL RELEVANCE/APPLICATION

Visualization of the lower limb venous systems of arrhythmia patients without contrast material is quite difficult using conventional unenhanced MR angiography. FSBB imaging is a new clinical tool with the use of MR susceptibility difference between tissue and vessels. It has been proven to be useful for brain imaging. In this study, we extended the application of FSBB to the lower extremity veins to investigate if FSBB could provide an additional benefit beyond the brain.

SSA22-09 Advanced Fat Suppression Techniques for Off-Center Upper Extremity MSK MRI on 3T Scanners

Sunday, Nov. 26 12:05PM - 12:15PM Room: S405AB

Participants
Judy R. James, PhD, Phoenix, AZ (*Presenter*) Nothing to Disclose
Mark J. Kransdorf, MD, Phoenix, AZ (*Abstract Co-Author*) Nothing to Disclose
Yuxiang Zhou, PhD, Phoenix, AZ (*Abstract Co-Author*) Nothing to Disclose
Anshuman Panda, PhD, Scottsdale, AZ (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

james.judy@mayo.edu

CONCLUSION

Field sensitive sequences like Spectral FS techniques can have fat suppression inhomogeneities, signal loss and blurring due to gradient pulsing and higher order eddy currents with off-center scans on 3T. Depending on patient position, the FS sequence parameters may need to be adjusted to minimize these effects.

Background

3T MR scanners provide high quality MR images, better SNR and resolution in shorter scan times. However, fat suppression on 3T is challenging for wrist and elbow MSK scans; specifically, off-center scans with small FOV. We observed inhomogeneous fat suppression, non-patient-motion related ghosting/ blurring and poor SNR on 3T for off-center scans using traditional spectral fat suppression (FS). The same protocols on iso-center scans produced excellent image quality.

Evaluation

Multiple phantom and wrist scans were performed on volunteers to determine the source for poor image quality. Mapping of the B1 (RF) field, static B0 field and the dynamic B0 field with the body coil and wrist coil were performed. Qualitative and quantitative comparisons were made with the spectral FS sequence with changes in gradient pulsing. Scan parameters were changed to maximize SNR with complete and uniform fat suppression while maintaining small FOV and high resolution requirements.

Discussion

Analysis showed that the primary source of inhomogeneous FS and lower SNR for off-center scans on 3T was higher order eddy currents (dynamic B0 field) due to gradient pulsing. No static B0 or B1 (RF) field inhomogeneities were found to be contributing to the issues. Changing the gradient pulsing changed the FS results, further confirming that errors observed were dynamic in nature. Swapping the phase or reversing the polarity of the phase encoding direction for right vs. left MSK scans, depending on the patient position (head or feet first, right or left, supine or prone) helped improve the image quality for off-center scans in terms of SNR and signal uniformity. STIR and SPAIR sequences were not evaluated due to image contrast differences from traditional sequences. But DIXON water images were chosen to be a backup if traditional off-center FS with eddy-current compensation failed.

SSA23

Radiation Oncology (Radiobiology)

Sunday, Nov. 26 10:45AM - 12:15PM Room: S104A

OI PH RO

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

FDA Discussions may include off-label uses.

Participants
Edward Y. Kim, MD, Seattle, WA (*Moderator*) Nothing to Disclose
Meng X. Welliver, MD, Columbus, OH (*Moderator*) Nothing to Disclose

Sub-Events

SSA23-01 DNA Damage in Lymphocytes after Low Dose Chest CT

Sunday, Nov. 26 10:45AM - 10:55AM Room: S104A

Participants
Wataru Fukumoto, Hiroshima, Japan (*Presenter*) Nothing to Disclose
Mari Ishida, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Chiemi Sakai, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroaki Sakane, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Satoshi Tashiro, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;

PURPOSE

CT is now the largest source of radiation exposure in diagnostic imaging and the risk of cancer from CT is a rising concern in the medical community. Therefore, various imaging techniques including iterative reconstruction algorithms have been developed to reduce radiation dose. With these techniques, chest CT can be scanned with low dose (effective radiation dose: 1-3mSv). Although earlier studies reported that DNA damage was induced by CT, it is yet unknown at what dose DNA damage is likely to occur. The purpose of this study was to determine whether DNA damage can occur with low-dose chest CT.

METHOD AND MATERIALS

We obtained institutional review board approval and the written informed consent from 74 patients (32 men, 42 women, median age 69 years, range 28-87 years) who underwent low dose chest CT. All low dose chest CT were scanned on a 320-detector CT scanner (Aquilion One; Toshiba Medical Systems, Otawara, Japan) in helical scan mode. The scan parameters were 120 kVp, 100mA, rotation time 0.5 sec, detector configuration 80 x 0.5mm. Blood samples were obtained before- and 15 minutes after CT. We identified DNA damages (DNA double-strand breaks) in lymphocytes as cytologically visible "foci" by using an antibody against γ-H2AX. The statistical difference was determined by two-sided paired t test. Difference with $P < 0.05$ was considered significant.

RESULTS

The mean γ-H2AX foci number before CT and 15 minutes after CT were 3.3 (SD: 2.2) and 3.3 (2.4) foci/cell, respectively. The γ-H2AX foci number was not significantly increased after CT. The mean effective dose of low dose chest CT was 1.9 (0.2) mSv.

CONCLUSION

Low-dose chest CT failed to induce DNA double strand breaks in lymphocytes.

CLINICAL RELEVANCE/APPLICATION

Our results may prove biological validity for CT lung cancer screening from the standpoint of radiation exposure.

SSA23-02 Nanoparticle Imaging and Treatment of Primary and Metastatic Tumor, Through Macrophage Therapy and the Abscopal Effect, Respectively, by Radiotherapy-Directed Targeted Switching of TAMs from an M2 to M1 Phenotype and Activation of Primed CD8+ T Ce

Sunday, Nov. 26 10:55AM - 11:05AM Room: S104A

Participants
Satoshi G. Harada, MD, Morioka, Japan (*Presenter*) Nothing to Disclose
Takashi Segawa, Morioka, Japan (*Abstract Co-Author*) Nothing to Disclose
Shigeru Ehara, MD, Morioka, Japan (*Abstract Co-Author*) Nothing to Disclose
Takahiro Satoh, DSc, Takasaki, Japan (*Abstract Co-Author*) Nothing to Disclose
Koichiro Sera, Takizawa, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

We aimed to image and treat primary tumors and metastasized tumors *in vivo*, through macrophage-based therapy and abscopal

We aimed to image and treat primary tumors and metastasized tumors in vivo, through macrophage-based therapy and abscopal effect, respectively, in LM17 cell xenografts in BALB/c mice using microcapsules that released liposome-protamine-hyaluronic acid nanoparticles (LPH-NPs) in response to three sessions of radiation.

METHOD AND MATERIALS

For session one, LPH-NPs containing 5% iopamiron, and 250 nmol anti-CD47 siRNA were mixed with 1.0 mL oxygen-rich solution (2200 ppm O2) containing 4.0% alginate, 3.0% hyaluronate, and 1 μg/mL P-selectin antigen (Ag) solution and added to 0.5 mM FeCl2 with 1 μg/mL a4ß1 antibody (Ab). The microcapsules (1 × 1010) were injected intravenously (IV). After 9 h, primary tumors were exposed to 10 or 20 Gy 60Coγ-rays. In session two LPH-NPs containing 200 μg anti-CD40 monoclonal Ab (MAb) and 9.0 X 105 IU IL-2 were mixed with the above cocktail and added to 0.5 mM FeCl2 with 1 μg/mL anti-P-selectin Ab. Microcapsules (1 × 1010) were injected IV and they interacted with P-selectin. After 9 h, the second radiation session was conducted using the same protocol as for the first session. In session three, 4 cGy 60Co whole-body γ-rays were administered at 24-h intervals for 5 days.

RESULTS

Following session one, anti-a4ß1 microcapsules accumulated around the primary tumors and metastases, which were detected by CT. The microcapsules released P-selectin Ag, anti-CD 47 siRNA LPH-NPs and O2-rich water, which silenced "don't eat me" signals and increased [O2] in tumors. In session two, the microcapsules accumulated around the primary tumor through a P-selectin Ag-Ab reaction. By second radiation, released LPH-NPs containing anti-CD 40 MAb /IL-2 switched the phenotype of Tumor Associated Macrophages (TAMs) from M2 to M1, and repeatedly released an O2-rich water inhibited TAMs from repolarizing back to M2 phenotype, which intensified tumor phagocytosis by M1 macrophages. Additionally, anti-CD 40 MAb enhanced cross priming of CD8+ T-cells to tumor. In session three, primed CD8+ T-cells were activated and attacked metastases. These treatments reduced the size of primary tumors and metastases by 87 ± 4.6%.

CONCLUSION

Our targeted macrophage therapy has the potential to improve tumor diagnosis and treatment.

CLINICAL RELEVANCE/APPLICATION

Nanoparticles improved tumor imaging. Targeted switching of macrophage phenotype from M1 to M2 and cross priming of CD8+ T-cells enhanced the effects of radiotherapy on primary tumors and metastases.

SSA23-03 Inhibitors of HIF-1a and CXCR4 Mitigate the Development of Radiation Necrosis in Mouse Brain

Sunday, Nov. 26 11:05AM - 11:15AM Room: S104A

Participants
Ruimeng Yang, MD,PhD, Guangzhou, China (*Presenter*) Nothing to Disclose
Chong Duan, ST.LOUIS, MO (*Abstract Co-Author*) Nothing to Disclose
Liya Yuan, MD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
John A. Engelbach, St. Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Christina I. Tsien, MD, Saint Louis, MO (*Abstract Co-Author*) Speaker, Merck & Co, Inc
Scott C. Beeman, PhD, St. Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Xia Ge, St Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Keith M. Rich, MD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Joseph J. Ackerman, PhD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Joel R. Garbow, PhD, St. Louis, MO (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

yangruimeng@gzhmu.edu.cn

PURPOSE

There is mounting evidence to indicate that, in addition to angiogenesis, hypoxia-induced inflammation via the hypoxia inducible factor-1a (HIF-1a) / CXC chemokine receptor-4 (CXCR4) pathway, may also contribute to the pathogenesis of late-onset, radiation-induced necrosis (RN). In the present study, we investigated the mitigative efficacy of an HIF-1a inhibitor, topotecan, and a CXCR4 antagonist, AMD3100, on the development of RN in an intracranial mouse model.

METHOD AND MATERIALS

Mice received a single-fraction, 50-Gy dose of hemispheric radiation using the Leksell GammaKnife and were then treated with either topotecan, from 1-12 weeks post-irradiation (PIR), or AMD3100, from 4-12 weeks PIR. The onset and progression of RN were monitored longitudinally via noninvasive, in vivo MRI from 4 to 12 weeks PIR. Conventional hematoxylin and eosin (H&E) staining and immunohistochemistry (IHC) staining were used to further evaluate the treatment response.

RESULTS

The progression of brain RN was significantly mitigated in mice treated with either topotecan or AMD3100, compared to control animals. MR-derived lesion volumes were significantly smaller for both of the treated groups, and histologic findings correlated well with the MRI data. By H&E staining, both treated groups demonstrated reduced radiation-induced tissue damage compared with controls. Further, the IHC results revealed that expression levels of VEGF, CXCR4, CXCL12, Iba-1, CD-68, CD3 and TNF-a in the lesion area were lower in treated brains vs. control brains. HIF-1a expression persisted in topotecan-treated animals, but was reduced markedly by treatment with AMD3100. IL-6 expression was unaffected by either topotecan or AMD3100.

CONCLUSION

By mitigating inflammation, both topotecan and AMD3100 can, independently, mitigate the development of RN in mouse brain. When combined with first-line, anti-angiogenic treatment, anti-inflammation therapy may provide an adjuvant therapeutic strategy for clinical, post-radiation management of tumors, with additional benefits in the mitigation of RN development.

CLINICAL RELEVANCE/APPLICATION

(Dealing with radiation necrosis and inflammation)Treatment with topotecan or AMD3100 can significantly inhibit the HIF-1a/CXCR4 axis, thereby reducing the progression of RN. Targeting the HIF-1a/CXCR4 pathway may be a promising therapy in treating

recurrent tumor post-RT, with additional benefit for mitigating the progression of RN'.

SSA23-04 Radiation Inhibits Lymphangiogenesis in Acquired Lymphedema Hindlimb Mouse Models

Sunday, Nov. 26 11:15AM - 11:25AM Room: S104A

Participants
Zhe Wang, MD, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
Kun Yung Kim, MD, Jeonju-Si, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Ho-Young Song, MD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jiaywei Tsauo, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Min Tae Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jung-Hoon Park, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

This study was aimed to evaluate the effect of radiation on acquired lymphedema in hindlimb mouse model.

METHOD AND MATERIALS

Total 20 BALB/c female mice of 8-week-old were equally assigned to two groups. In both groups, popliteal lymph node and surrounding fat pad were resected. In radiation group, all mice received 20 Gy radiation exposure 1 day after surgery. The methods of evaluation include measuring the thickness of ankle, fluorescence lymphography at the end of 1, 2, 3, 4 week.

RESULTS

The mean thickness values of ankle in radiation group at 1,2,3,4 weeks were 4.64 mm, 4.26 mm, 3.98 mm, 3.80 mm, respectively. The mean thickness values of ankle in non-radiation group at 1,2,3,4 weeks were 4.29 mm,4.10 mm,4.27 mm, 4.02 mm, respectively. Difference was statistically significant in 1 week and 2 weeks ($P<0.05$). Collateral lymph vessels draining to the inguinal LN were detected in 10% of mice in radiation group, but 100% of mice in non-radiation group at 4 week fluorescence lymphography.

CONCLUSION

Radiation inhibits the lymphangiogenesis after popliteal lymph node resection, which indicates that it is an essential factor for developing acquired lymphedema in mouse hindlimb model.

CLINICAL RELEVANCE/APPLICATION

Secondary lymphedema in humans is a common consequence of axillary lymph node dissection (ALND) to treat breast cancer. To further investigation of the mechanism and treatment of lymphedema,a stable and reproducible animal model is needed. In our present study, radiation is an essential factor for developing acquired hindlimb lymphedema mouse model, which is helpful to develop a new hindlimb lymphedema mouse model.

SSA23-05 Localized Mild Hyperthermia for Radiosensitization in an Orthotopic Prostate Tumor Model in Mice

Sunday, Nov. 26 11:25AM - 11:35AM Room: S104A

Participants
Justin Cohen, BA, Baltimore, MD (*Presenter*) Nothing to Disclose
Samanta Sunthunu, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Yannick Poirier, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Allen Alexander, MS, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Maida Ranjbar, MS, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Radmila Pavlovic, MS, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Andrew Zodda, MS, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Isabel L. Jackson, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Javed Mahmood, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Zeljko Vujaskovic, MD,PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Amit Sawant, PhD, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose
Akbar Anvari, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

Justin.Cohen@som.umaryland.edu

ABSTRACT

Purpose/Objective(s): The use of mild hyperthermia (41-43° C) as a modality for treatment of cancer is gaining interest. Studies have shown hyperthermia causes chemoradiosensitization and can be used to enhance the therapeutic effects of immunotherapy. Numerous in vivo studies have demonstrated hyperthermia-induced radiosensitization in subcutaneous tumor models; however, to our knowledge there are no studies that demonstrate the ability to deliver targeted hyperthermia from an external source to a deep-seated orthotopic tumor in the abdominal/pelvic region. Subcutaneous models lack the degree of translatability possessed by orthotopic models, as they don't represent the tumor microenvironments of the original tumor to the extent in which orthotopic tumors do. The objective of this preclinical study was to demonstrate the use of radiofrequency (RF) to induce mild hyperthermia in deep-seated tumors. In order to illustrate proof-of-concept, we developed and utilized an orthotopic intra-prostatatic tumor model in nude mice.Materials/Methods: The ventral lobes of the prostate of nude mice were injected with 1 x 105 PC3 cells transfected with luciferase through an open abdominal incision. Inoculation was confirmed with bioluminescence (BLI) imaging on day 3. BLI and ultrasound were used to track tumor growth and tumor volumes were calculated. RF-induced hyperthermia was delivered using the Oncotherm LAB EHY-100 device. The target temperature was 41° C as measured by a thermal probe placed in the rectum. RF was delivered through an electrode centered over the prostate and coupled to the skin via a thin layer of ultrasound gel in order to minimize dielectric inhomogeneities which can lead to eddy currents and thereby skin burns. The RF power was gradually increased from 0.3 watts until the desired temperature of 41° C was achieved. The treatment time per animal was 30 minutes.Results: Successful tumor inoculation was performed in all four mice as detected with bioluminescence. Average signal at confirmation was 4.25 x 107 photons/sec within the region of interest (ROI). Tumors were first detected by ultrasound on days 9-15. Average tumor

diameter at earliest detection was 4.8 mm (3.9-5.3 mm). Average tumor doubling time was 5 days. Hyperthermia was safely administered to the mice without toxicities. Fifteen to 45 minutes were needed to achieve the target temperature of 41° C.Conclusion: We were successful in establishing an orthotopic prostate tumor model in nude mice. Ultrasound and BLI both served as a reliable and efficient imaging modality to track tumor growth. To our knowledge, this is the first demonstration that radiofrequency can be used to safely and reproducibly deliver mild hyperthermia to a deep-seated tumor in the abdominal/pelvic region in a mouse model.

SSA23-07 Radiotherapy Induces Cell Arrest and Cell Apoptosis in Nasopharyngeal Carcinoma via the ATM and Smads Pathways

Sunday, Nov. 26 11:45AM - 11:55AM Room: S104A

Participants
MingYi Li, Guangzhou, China (*Presenter*) Nothing to Disclose
Jinquan Liu, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Dongping Chen, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Yawei Yuan, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Zhouyu Li, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

ABSTRACT

Purpose/Objective(s): Nasopharyngeal carcinoma (NPC) is a common malignant neoplasm worldwide and harmful to human's health. Radiotherapy is commonly used in treating NPC and it induces immediate cell cycle arrest and cell apoptosis. However, the mechanism behind is recently maintained unknown. Evidences suggested the activation of Ataxia telangiectasia mutated (ATM) pathway and Smads pathway is the crucial mediator in the functions of radiotherapy.Materials/Methods: In this study, we carried out in vitro assays with CNE-2 cells and in vivo assays with nude mice in purpose of investigating the relationship between NPC and the ATM and Smads pathways. Results: The results suggested that radiation induced activation of ATM pathway that the expression of p-ATM, p-CHK1, p-CHK2 and p15 was increased; but it induced inhibition of the Smad3/7 cascade that the increased level of Smad7 suppressed the expression of p-Smad3. As a result, the cleaved Caspase3 was up-regulated expressed and CDC25A was down-regulated expressed and thereby cell cycle arrest and cell apoptosis occurred. On the other hand, the results also suggested the interaction between the ATM and Smads pathways. Activation of Smad3 can induce inhibition to ATM pathway and thereby the efficacy of radiation will be attenuated.Conclusion: In summary, we suggest that both ATM and Smad pathways contribute to the cell cycle arrest and cell apoptosis during radiation.

SSA23-08 Quantification of Cell-Free DNA in Breast Cancer Patients Receiving Adjuvant Radiotherapy

Sunday, Nov. 26 11:55AM - 12:05PM Room: S104A

Participants
Sangjune L. Lee, MD,MENG, Toronto, ON (*Presenter*) Nothing to Disclose
Justin Burgener, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Wei Xu, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Kathy Han, MD, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Fei-Fei Liu, MD, Toronto, ON (*Abstract Co-Author*) Nothing to Disclose
Scott Bratman, MD, PhD, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

leesangjune@gmail.com

ABSTRACT

Purpose/Objective(s): Cell-free DNA (cfDNA) is released by healthy and malignant tissues into peripheral blood upon cell death. The concentration of cfDNA has been shown to vary in cancer patients, but the effects of radiotherapy (RT) are not known. The objective of this study was to serially evaluate cfDNA concentration from women receiving adjuvant RT for breast cancer. We hypothesized that cfDNA is released by damaged cells into the bloodstream resulting in an increase in total cfDNA concentration during adjuvant RT. Materials/Methods: Women receiving post-operative RT for breast cancer were enrolled in a prospective biomarker study in which phlebotomy was performed at 5 serial time points: baseline; 1 day following initiation of RT; 5 days following initiation of RT; at completion of RT; and 1 month following the completion of RT. We identified 4 patients treated with lumpectomy undergoing adjuvant RT who had provided all 5 blood samples. cfDNA was extracted from 1-2mL of peripheral blood plasma using the QIAamp Circulating Nucleic Acid Kit (Qiagen). The concentrations of double-stranded and single-stranded cfDNA at each time point were measured using Qubit kits (Life Technologies). Results: The 4 patients selected for analysis were diagnosed with ductal carcinoma in situ (N=3) or T1aN0M0 invasive lobular carcinoma (N=1). Mean age was 64 years (range: 56-75). Adjuvant RT consisted of intensity-modulated RT to a dose of 42.4Gy in 16 fractions, either to the right (N=2) or left (N=2) breast. None of the patients received chemotherapy or hormonal therapy. The lung volume receiving 20Gy or more (V20Gy) was 103-110cc for right- and 50-65cc for left-sided disease. 10cc of the heart received at least (D10cc) 0.7-0.8Gy for right- and 6.5-7.9Gy for left-sided disease. Double-stranded cfDNA concentration ranged from 1.7 – 13.3 ng per mL plasma (mean±SD 6.6±2.9). Single-stranded cfDNA concentration ranged from 8.6 – 54.4 ng per mL plasma (mean±SD 27.4±13.8). The concentrations of double-stranded and single-stranded cfDNA did not correlate with lung or heart dose and did not change significantly throughout the RT course ($p>0.05$ for all). Conclusion: The majority of plasma cfDNA exists as single-stranded DNA in patients undergoing adjuvant RT for breast cancer. The concentrations of double-stranded and single-stranded cfDNA did not change significantly throughout the RT course and did not correlate with doses to organs-at-risk.

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103rd Scientific Assembly and Annual Meeting
November 26 to December 1
McCormick Place, Chicago
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PHS-SUA

Physics Sunday Poster Discussions

Sunday, Nov. 26 12:30PM - 1:00PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Kai Yang, PhD, Boston, MA (*Moderator*) Nothing to Disclose

Sub-Events

PH200-SD-SUA1 Can Iterative Reconstruction Methods Improve Low-Contrast Detectability?

Station #1

Participants
Yoshinori Funama, PhD, Kumamoto, Japan (*Presenter*) Nothing to Disclose
Toru Higaki, PhD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Daisuke Utsunomiya, MD, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Takeshi Nakaura, MD, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;

PURPOSE

Compared with filtered back projection (FBP) with the same standard radiation dose, iterative reconstruction (IR) can reduce image noise and leads to the low-contrast improvements. However, at the same level of image noise between FBP with standard radiation dose and IR with lower radiation dose, it is uncertain whether IR essentially improves the low-contrast detectability. The purpose of this study was to investigate the improvement of low-contrast detectability at IR compared with the same level of image noise at FBP.

METHOD AND MATERIALS

Using a low-contrast module of the Catphan phantom we performed helical scans or volume scans at different CT scanners (Toshiba, Philips, GE, and Hitachi). Tube current-time product (mAs) was changed so that an image noise was approximately 10 HU. The mAs value for IR was relatively decreased than that for FBP with increasing radiation reduction level. The tube voltage was fixed at 120 kVp. FBP and vendor specific IR images including hybrid and model-based methods were reconstructed at a slice thickness of 0.5 mm or 0.625 mm with an abdomen standard kernel at different CT scanners (Philips: iDose, IMR; Toshiba: AIDR3D, FIRST; GE: ASIRV; Hitachi: Intelli IP Advanced). The image noise and the CT number in diameter of 15 mm at contrast of 1.0% were measured on FBP and IR images. The minimal size at 1.0% contrast density in the low-contrast images was evaluated by two radiologists.

RESULTS

When image noise for FBP and hybrid IR with vendor A was 9.9- and 10.2 HU, minimum size in the low contrast image was the same 4.0 mm. Model-based IR (image noise:9.2 HU) with the same vendor A was slightly inferior than that with FBP and hybrid IR due to the 10% radiation dose of FBP. In the case of hybrid IR and model-based IR with vendor B, the low-contrast detectability was lower than FBP of 4.0 mm. Especially, one observer pointed out the "jaggy" with respect to surrounding circular shapes. These were the same tendencies in the other IR images with vendor C and D; IR images did not improve the low-contrast detectability than FBP.

CONCLUSION

When the image noise for IR is the same level as FBP, IR is almost the same or lower detectability of low-contrast lesion than FBP irrespective of CT vendors and IR methods.

CLINICAL RELEVANCE/APPLICATION

The improvement of low-contrast detectability is highly related to the image noise in CT scanning and does not depend on reconstruction methods (FBP or IR).

PH201-SD-SUA2 New Usage of Size-Specific Dose Estimate: Development of Organ Dose Analysis Calculation New Software

Station #2

Participants
Tomokazu Shohji, Tokyo, Japan (*Presenter*) Nothing to Disclose
Norio Nakata, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Sosuke Higuchi, RT, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Atsushi Tachibana, MSc, RT, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose
Yoh Katoh, RT, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

cherokee95jp@yahoo.co.jp

cherokee95jp@yahoo.co.jp

PURPOSE

We must know the organ dose to think about the carcinogenic risk by computed tomography (CT). However, it is not possible to obtain an organ dose directly from size-specific dose estimate (SSDE). Therefore, we aimed to develop a new software for facilitating absorbed dose-per-pixel (pixel dose) calculation in a SSDE. And, I verified that pixel dose is more accurate than SSDE.

METHOD AND MATERIALS

First, we multiplied the linear attenuation coefficient conversion formula by each pixel of the CT image, thereby converting it to a linear attenuation coefficient image, f(x,y), from the CT image. Next, we projected the beam data of intensity I_0 reflecting the shape of a bowtie filter by 0.35°to a linear attenuation coefficient image, f(x,y), in the direction of 180° from the 12 o'clock position to the 6 o'clock position. We analyzed projection data after penetration in the phantom at X-ray intensity, I(X ,θ). Subsequently, we reconstituted the new linear attenuation coefficient F(x, y) using the filtered back projection algorithm from projection data I(X ,θ). Finally, we input the SSDE for each pixel of the image F(x, y) and calculated the pixel dose image D(x, y). We calculated the pixel dose at 10 equal points (breast, lung, heart, liver, spleen, colon, bladder, ovary, red bone marrow and skin) of anthropomorphic female thoracic phantom (RAN-110) inserted into the radiophotoluminescence glass dosimeter (RPLD) position and compared the pixel dose with the measured doses using the RPLD.

RESULTS

With this method, the measured dose of various organs ranged from 5.00 to 12.20 mGy for adults. On the other hand, the SSDE ranged from 8.00 to 16.20 mGy. The relative errors between the SSDE obtained in our study and the measured dose was 20.0 to 35.1%. In addition, the pixel dose of various organs ranged from 6.00 to 14.20 mGy for adults. The relative errors between the SSDE obtained in our study and the measured dose was 4.5 to 15.1%. In other words, the pixel dose was near the measured doses than SSDE.

CONCLUSION

This software was able to determine organ doses using SSDE.

CLINICAL RELEVANCE/APPLICATION

The software can reduce concerns about patient radiation exposure by allowing clinicians to perform organ dose evaluations after examinations.

PH202-SD-SUA3 DeepLesion: Automated Deep Mining, Categorization and Detection of Significant Radiology Image Findings using Large-Scale Clinical Lesion Annotations

Station #3

Participants
Xiaosong Wang, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Ke Yan, Bethesda, MD (*Presenter*) Nothing to Disclose
Le Lu, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Ronald M. Summers, MD, PhD, Bethesda, MD (*Abstract Co-Author*) Royalties, iCAD, Inc; Royalties, ImBio, LLC; Royalties, Zebra Medical Vision Ltd; Researcher, Ping An Insurance Company of China, Ltd; Researcher, Carestream Health, Inc; Research support, NVidia Corporation; ; ; ;

For information about this presentation, contact:

xiaosong.wang@nih.gov

PURPOSE

Extracting, harvesting and building large-scale annotated radiological image datasets is a greatly important yet challenging problem. It is also the bottleneck to designing more effective data-hungry computing paradigms (e.g., deep learning) for medical image analysis. Yet, vast amounts of clinical annotations that indicate disease image findings (marked as arrows, lines, lesion diameters, segmentation, etc.) have been collected over several decades and stored in hospitals' Picture Archiving and Communication Systems. In this paper, we mine and harvest one major type of clinical annotation data -- two-line lesion diameters -- to learn an effective multi-class lesion detector via unsupervised and supervised deep Convolutional Neural Networks (CNN).

METHOD AND MATERIALS

The extracted dataset is composed of 33,688 bookmarked radiology images from 10,825 studies of 4,477 unique patients. For every bookmarked image, a bounding box is created to cover the target lesion based on its measured diameters. We categorize the collection of lesions using an unsupervised deep mining scheme to generate clustered pseudo lesion labels. Next, we adopt a regional-CNN method to detect lesions of multiple categories as a scalable, universal or multi-purpose CAD paradigm built upon abundant retrospective medical data. Furthermore, we demonstrate that detection accuracy can be significantly improved by incorporating pseudo lesion labels (e.g., Liver lesion/tumor, Lung nodule/tumor, Abdomen lesions, Chest lymph node and others).

RESULTS

Two lesion detection setups are examined: single-class (all annotated boxes as one abnormality class), and multi-class detection (with pseudo-category labels). The top one detected lesion (with the highest detection confidence score) per testing image is computed as the positive detection if the intersection-over-union (IoU) between this predicted box and the ground-truth clinical annotation box is larger than 0.5. The averaged accuracy of the single-class detection is 60.53% ±9.58 and this score becomes 65.4%±8.85 for multi-class detection.

CONCLUSION

We demonstrate the strong feasibility of building a large- scale radiology lesion image database and employing a new multi-category lesion detection paradigm via unified deep categorization and detection.

CLINICAL RELEVANCE/APPLICATION

The proposed multi-purpose CAD system can be applied for automatically detecting lesions as a second opinion.

Participants

PH203-SD-SUA4 Potential of Photon Counting Technique for Next-Generation Type X-Ray Diagnostic System: To Provide New Medical Image Concerning Effective Atomic Numbers Using Plain X-Ray

Station #4

Natsumi Kimoto, Tokushima, Japan (*Presenter*) Nothing to Disclose
Hiroaki Hayashi, PhD, Tokushima, Japan (*Abstract Co-Author*) Equipment support, Nagase Landauer, Ltd; Research collaboration, Nagase Landauer, Ltd; Equipment support, JOB Corporation; Research collaboration, JOB Corporation;
Takashi Asahara, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Emi Tomita, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Sota Goto, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiki Mihara, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuki Kanazawa, PhD, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Tsutomu Yamakawa, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Shuichiro Yamamoto, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Masashi Yamasaki, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Masahiro Okada, Kanagawa, Japan (*Abstract Co-Author*) Employee, JOB Corporation
Daisuke Hashimoto, Osaka, Japan (*Abstract Co-Author*) Employee, R&D Direct

For information about this presentation, contact:

natsumi.kimoto.0717@gmail.com

TEACHING POINTS

1) Photon counting technique enables the production of a diagnostic X-ray image in which the effective atomic number can be precisely determined. 2) The beam hardening effect should be corrected in order to achieve precise analysis even when a part of the X-ray spectrum is analyzed.

TABLE OF CONTENTS/OUTLINE

1) Aim We aim to propose a novel material identification method based on a photon counting technique. In this system, X-ray spectrum penetrating an object is measured pixel by pixel. Each pixel has the potential to derive material composition of an object. 2) Materials and Methods We proposed a novel method. By dividing the X-ray spectrum into two energy bins, and attenuation factors of the object were calculated. In addition, we proposed a beam hardening correction procedure, which can be applied to two energy bins. The following studies were performed; 1) theory construction, 2) verification experiment using single-probe-type CdTe detector, 3) Monte-Carlo simulation, and 4) demonstration of obtaining a two dimensional X-ray image using a test imaging system. 3) Result and Discussion Our method can determine effective atomic number with an accuracy of +/-0.1 Z under actual clinical conditions during plain X-ray diagnosis. In addition to the traditional X-ray image, effective atomic number image enables precise diagnosis.

PDF UPLOAD

https://abstract.rsna.org/uploads/2017/17004368/17004368_fnrr.pdf

PH204-SD-SUA5 Task-Based Optimal Dose Partitioning In Dual-Energy CT for Virtual Non-Contrast and Iodine Imaging

Station #5

Participants
Zaiyang Long, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Lifeng Yu, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

long.zaiyang@mayo.edu

PURPOSE

Dose partitioning between low- and high-energy scans in dual-energy (DE) CT affects the quality of DE images. The purpose of this work was to determine the optimal dose partitioning for two DE tasks--virtual non-contrast (VNC) and iodine imaging, alone or jointly, using a phantom study.

METHOD AND MATERIALS

Three semi-anthropomorphic phantoms (25, 35 and 45cm wide) containing test objects with known iodine concentrations were scanned on a dual-source 192-slice CT scanner (Siemens Force), each with 3 DE kV pairs: 80/150Sn, 90/150Sn and 100/150Sn (Sn: added tin filter). For each kV pair, 5 different dose partitionings were used, with the dose percent for the low-energy scan being 30%, 40%, 50%, 60% and 70% of the total. The total CTDIvol for the three phantoms was 2.7, 9.2 and 19.8 mGy, respectively. Basis material decomposition was performed to generate the VNC and iodine images using a customized program without additional noise reduction. Noise levels on 10 contiguous VNC and 10 iodine images were measured and averaged. Normalized noise levels were also calculated for the combined task.

RESULTS

The trend of optimal noise as a function of dose partitioning was different for each task. For VNC, the lowest noise was achieved at 30% or lower partitioning for 25cm phantom (23-27% lower noise compared to the highest noise at each of the 3 kV combinations), 40%-50% partitioning for 35cm phantom (12-20% lower noise), and 50% partitioning for 45cm phantom (13-20% lower noise). In contrast, for iodine map, the lowest noise was achieved at 40% partitioning for 25cm phantom (12-18% lower noise); 50% partitioning at 100/Sn150 and 60% at the other kV pairs for 35cm phantom (6-20% lower noise); and 60% at 100/Sn150 and 70% at the other kV combinations (11-37% lower noise) for 45cm phantom. For use when both tasks are equally important, the lowest noise was achieved at 30-40% for 25cm phantom; 40-50% at 90/Sn150 and 100/Sn150 or 60% at 80/Sn150 for 35cm phantom; and 50% at 90/Sn150 and 100/Sn150 or 70% at 80/Sn150 for 45cm phantom.

CONCLUSION

The optimal dose partitioning for DE CT scans depends on the clinical task, i.e. VNC or iodine map or both tasks, as well as the kV

The optimal dose partitioning for DE CT scans depends on the clinical task, i.e. VNC or iodine map or both tasks, as well as the kV pair used and phantom size.

CLINICAL RELEVANCE/APPLICATION

Dose partitioning in dual-energy CT should be optimized based on clinical tasks, patient size, and kV combinations to achieve optimal image quality.

PH205-SD-SUA6 Characteristics of MRI Patents Approved by the U.S. Patent and Trademark Office in 2016

Station #6

Participants
Sushma Gaddam, MD, New York, NY (*Presenter*) Nothing to Disclose
Gregory Lemberskiy, MSc, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Andrew B. Rosenkrantz, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

Sushma.Gaddam@nyumc.org

PURPOSE

To use data regarding MRI patents approved by the U.S. Patent and Trademark Office (USPTO) in 2016 to characterize recent trends in MRI technical development and innovation.

METHOD AND MATERIALS

The USPTO website was searched for all patents with an issue date in 2016 and a patent abstract containing the phrase "magnetic resonance". Patent characteristics available on the website were recorded. Patent assignees were manually characterized as having an industry or academic affiliation. An MRI physicist reviewed the abstracts to classify patents' themes. Observations were summarized using standard descriptive statistics.

RESULTS

A total of 423 MRI-related patents were approved by the USPTO in 2016. Of these, a total of 29% had 1 inventor, 24% had 2 inventors, and 47% had >=2 inventors (maximum of 10 inventors). The mean interval between patents being filed and awarded was 1389 ± 559 days (range, 559 to 1,327 days). The most common countries of patents' first assignee were: USA (40%), Germany (24%), Netherlands (10%), Japan (10%), and Korea (4%). There were 14 additional countries (each <2%). A total of 3% of patents included multiple assignees having different countries (most common collaborators being USA and Germany). Patents' 1st assignee had an industry affiliation in 76% vs. an academic affiliation in 21% (4% were indeterminate). A total of 3% of patents had industry-academia collaboration. Patents' most common themes were: coils (n=77), sequence design (n=65), and non-coil scanner hardware (n=41). These top themes were similar for USA, international, and industry based patents; however, for academic based patents, the most common themes were: sequence design, reconstruction, and exogenous agents. Less common themes included: image analysis, post-processing, spectroscopy, relaxometry, diffusion, motion correction, radiation therapy, implants, wireless devices, and PET/MRI.

CONCLUSION

The majority of MRI-related patents approved by the USPTO in 2016 were filed by non-U.S. inventors. A large majority had an industry affiliation; minimal industry-academic collaboration was observed. Patents from industry and academic inventors had distinct top focuses: hardware and software, respectively.

CLINICAL RELEVANCE/APPLICATION

Awareness of the most recent years' MRI patents may provide insights into forthcoming clinical translations and help guide ongoing research and entrepreneurism.

PH103-ED-SUA7 Multicontrast MRI with Quantitative Mapping: It's Magic!

Station #7

Participants
Daniel Ginat, MD, Chicago, IL (*Presenter*) Nothing to Disclose
Timothy J. Carroll, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Yong Jeong, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

Multi-contrast MRI technique allows the user to generate multiple image contrasts (T1, T2, PSIR, FLAIR) in a single scan, thus decreasing overall scan time and providing perfect image registration. MAGiC involves a dedicated pulse sequence design that simulates how the signal behaves during the data acquisition period and then inverts the quantitative information based on the acquired data. When reading the images, the radiologist can change the contrast by manipulating parameters such as TR, TE, and TI using the mouse cursor.

TABLE OF CONTENTS/OUTLINE

What is MAGiC and how does it work? Advantages of Multicontrast MRI Limitations of Multicontrast MRI Comparison with conventional MRI acquisition Potential neuroimaging applications of quantitative mapping

Honored Educators

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

RSNA 2017 Explore. Invent. Transform.
103rd Scientific Assembly and Annual Meeting
November 26 to December 1
McCormick Place, Chicago
Explore Invent Transform

PHS-SUB

Physics Sunday Poster Discussions

Sunday, Nov. 26 1:00PM - 1:30PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Kai Yang, PhD, Boston, MA (*Moderator*) Nothing to Disclose

Sub-Events

PH206-SD-SUB1 Influence of Ultrasound-Targeted Microbubble Destruction on Biofilm

Station #1

Participants
He Nianan, Hefei, China (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

henianan71@qq.com

PURPOSE

Bacteria adhering to implanted medical devices, such as vascular catheters, prosthetic joints, and artificial heart valves, can cause persistent infections because bacteria sequestered in biofilms show increased tolerance of normal antibiotic therapies. The mechanism might include the heterogeneity of biofilm-encased bacteria and the failure of an antibiotic to penetrate into the full depth of the biofilm. To investigate whether ultrasound (US)-targeted microbubble (MB) destruction (UTMD) can influence the biofilm and bacteria in morphology.

METHOD AND MATERIALS

Twenty-hour biofilms of Staphylococcus epidermidis RP62A were treated with US or UTMD. The acoustic intensity was 0.5~1.5 W/cm2, the duty cycle was 50% and the duration was 10 minutes. After treatment, the absorbance values (A570) of biofilms stained with the crystal violet were measured to assess the biofilm density. The biofilms were observed with macroscopy and light microscopy. The biofilms were examined by confocal laser-scanning microscopy (CLSM) and scanning electron microscopy (SEM).

RESULTS

A thick and compact biofilm was observed in the untreated control group, and no obvious micropores in biofilms under macrology and light micrology. Although no significant changes under macroscopy in both biofilms treated with US only and UTMD with 0.5 W/cm2 acoustic intensity, interestingly, many micropores could be found under microscopy. The diameters of micropores increased with increasing acoustic intensities, and the micropores in biofilms treated with UTMD were bigger than those treated with US-only in the same acoustic intensity (P<0.05). The largest diameters of micropores were up to 1 mm in biofilms treated with UTMD using 1.5 W/cm2 (P<0.05). The biofilm density (A570 value) decreased with the increase of the acoustic intensities, and the values in UTMD group of 1.5 W/cm2 were the lowest (P<0.05) . Besides, micropores could be observed under CLSM. There were no obvious dead bacteria in biofilms treated with US and UTMD compared with the untreated control group (P>0.05). Under SEM, the shape of bacteria in biofilms treated with US and UTMD became irregular, and many rounded projection could be observed in the surface of the bacteria treated with UTMD.

CONCLUSION

US and UTMD can produce micropores in biofilms, which might help to promote antibiotic activities against biofilms.

CLINICAL RELEVANCE/APPLICATION

Ultrasound; Microbubble; Biofilm; Targeted-therapy

PH207-SD-SUB2 Initial Investigation of Novel Anthropomorphic Breast Ultrasound Phantoms for Radiology Resident Education

Station #2

Awards
Student Travel Stipend Award

Participants
Chris Gu, MD, Rochester, MN (*Presenter*) Nothing to Disclose
Nicholas J. Hangiandreou, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Donald J. Tradup, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Robert T. Fazzio, MD, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Andrew J. Fagan, PhD, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Jacinta Browne, PhD, Dublin 8, Ireland (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

At present, there are no suitably complex anthropomorphic breast phantoms commercially available for educational training

purposes. The purpose of this study was to evaluate the teaching and training role of a novel breast phantom which simulates both the anthropomorphic and sonographic characteristics of the different breast tissues, including benign and malignant breast lesions, in a group of radiology residents at a large medical center.

METHOD AND MATERIALS

Two similar devices (Phantom 1 and Phantom 2) were designed to produce realistic sonographic images of breast morphology with a range of embedded pathologies. The study involved a baseline assessment of nine radiology residents (2nd - 4th year) ability to detect and characterize all lesions in Phantom 1, followed by two hour teaching session on the same phantom, including a map detailing each lesion location and characteristics. All residents underwent a post-training assessment on Phantom 2 to assess for changes in the detection rate and characterization rate. Rates of lesion detection and correct lesion characterization were determined. Residents were surveyed about their views of the phantoms following the post-training assessment.

RESULTS

This study demonstrated a significant increase in the radiology residents' detection scores pre- and post-training, of 29±11 %, 31±13 % and 19±17 % for 2nd, 3rd and 4th year residents, respectively, with a pooled increase in detection score of 26±14 %, $p<0.003$. There was a significant increase in pooled correct characterization score for all residents of 17±8 %, $p<0.0003$. The survey revealed that residents rated the training experience highly in terms of increasing confidence in operating the ultrasound system controls (mean score of >4 out of 5), performing an ultrasonic examination (mean of >4 out of 5) and ability to detect breast lesions in a simulated environment (mean of >4.8 out of 5).

CONCLUSION

Anthropomorphic breast phantoms were useful for training and assessment purposes by providing a life-like simulation of breast tissue for ultrasound imaging in a non-pressurised environment. This allowed residents to practice ultrasound imaging without direct exposure to patients, thus refining their ultrasound scanning skills.

CLINICAL RELEVANCE/APPLICATION

This study demonstrates the utility of life-like ultrasound breast phantoms in the education of resident physicians and their ability to accurately and confidently detect breast lesions.

PH208-SD-SUB3 Automated Segmentation of Normal Structures of Meniscus for Diagnosis of Osteoarthritis in Ultrasonography

Station #3

Participants
Haruyuki Watanabe, PhD, Maebashi, Japan (*Presenter*) Nothing to Disclose
Yongbum Lee, PhD, Niigata, Japan (*Abstract Co-Author*) Nothing to Disclose
Tomoki Kikuchi, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Meiri Hayashizaki, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Norio Hayashi, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Masayuki Shimosegawa, PhD, Gunma, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshihiro Ogura, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Akio Ogura, PhD, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Nobuyoshi Tanki, Sakai, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiki Sumori, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Kohei Chiba, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose

TEACHING POINTS

Osteoarthritis (OA) is a chronic disease that occurs when cartilage between joints breaks down leading to pain, stiffness and swelling. Ultrasonography (US) is playing an increasingly important role in the detection and assessment of patients with OA. US can detect synovial inflammation and effusion in painful knee OA. Furthermore, the findings of meniscus using B-mode US are important to classify stage of disease. However, the diagnosis depends on observers and imaging techniques of operators in the US, it show variability of diagnostic accuracy. In order to solve this problem, a computer-aided detection (CAD) system is expected for the OA diagnosis in the US. We developed a novel CAD system to detect automatically normal tissue of meniscus toward accuracy of the OA diagnosis. The major teaching points of this exhibit are to: 1. Detect automatically normal structures of meniscus in the US. 2. Understand how to segment scheme in the CAD system. 3. Be useful for the diagnosis of the OA.

TABLE OF CONTENTS/OUTLINE

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

PDF UPLOAD

https://abstract.rsna.org/uploads/2017/17011630/17011630_6xoa.pdf

PH209-SD-SUB4 Automated Patient Positioning in CT: Accuracy and Effect on Radiation Dose of a Novel 3D Camera Body Detection System

Station #4

Participants
Ronald Booij, MSc, Rotterdam, Netherlands (*Presenter*) Research collaboration, Siemens AG
Ricardo P. Budde, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Marcel L. Dijkshoorn, RT, Rotterdam, Netherlands (*Abstract Co-Author*) Consultant, Siemens AG
Marcel Van Straten, PhD, Rotterdam, Netherlands (*Abstract Co-Author*) Research collaboration, Siemens AG

For information about this presentation, contact:

r.booij@erasmusmc.nl

PURPOSE

To assess the possible improvement in patient positioning and its effect on radiation dose of a 3D camera system with automated

To assess the possible improvement in patient positioning and its effect on radiation dose of a 3D camera system with automated patient body detection.

METHOD AND MATERIALS

Ideal table height was defined as the height at which the scanner isocenter coincides with the patient isocenter. The latter was computed by automatic skin contour extraction in each axial image and averaged over all images. Table height was suggested by a camera (Siemens) based on infrared body contour detection and fitting of a scalable patient model to the 3D data. It was tested in patients that underwent CT of the head, chest and/or abdomen on a dual-source CT scanner (Siemens). For each scan we compared the table height suggested by the camera system with the ideal height. In parallel, actual table heights chosen by radiographers and ideal heights were collected from scans made without a camera on a similar scanner within the same department. Deviations from the ideal height in mm were converted into percentages dose change using an average of 0.4% dose change/mm deviation (based on prior phantom studies).

RESULTS

152 consecutive studies with camera were performed (39 head, 47 chest, 30 abdomen and 36 chest-abdomen). 8 scans were excluded from analysis due to patient movement after body contour detection. Median (interquartile range (IQR)) absolute table height deviation was 6.6 (9.1) mm (10.7 (13.9), 4.7 (6.8), 6.7 (9.8), and 7.6 (6.8) mm for head, chest, abdomen, and chest-abdomen, respectively). Challenging cases were head scans, patients with folded clothing, electronic wires, or blankets. 314 consecutive studies without camera system were analyzed (38 head, 119 chest, 103 abdomen and 54 chest-abdomen). Median (IQR) absolute deviation was 13.9 (19.1) mm (12.2 (11.6), 15.3 (17.4), 13.4 (24.3), and 12.3 (12.9) mm for head, chest, abdomen and chest-abdomen, respectively). Median (maximum) dose changes for non-head scans were 2.7% (20%) and 5.8% (32%) for the camera system and the radiographer, respectively (p=0.001).

CONCLUSION

The 3D camera allows for accurate patient centering and it outperforms radiographers. The impact on radiation dose was limited, though deviations from the median value were less extreme.

CLINICAL RELEVANCE/APPLICATION

Patient position relative to the isocenter is relevant since it affects both automatic exposure control and image quality due to geometric magnification in the projection radiograph and the centered bowtie filter.

PH210-SD-SUB5 Potential for Highly Specific Perfusion Imaging Using Gadoteridol and K-Edge Spectral Photon-Counting CT

Station #5

Participants
Salim Si-Mohamed, Lyon, France (*Presenter*) Nothing to Disclose
Monica Sigovan, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Daniel Bar-Ness, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Silvio Aime, Torino, Italy (*Abstract Co-Author*) Nothing to Disclose
Giuseppe Digilio, Alessandria, Italy (*Abstract Co-Author*) Nothing to Disclose
Luisa Poggi, PhD, Colleretto Giacosa, Italy (*Abstract Co-Author*) Employee, Bracco Group
Philippe Coulon, PhD, Suresnes, France (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Loic Boussel, MD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Philippe C. Douek, MD, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

salim.si-mohamed@chu-lyon.fr

PURPOSE

To demonstrate the feasibility of K-edge perfusion imaging with gadoteridol by using spectral photon-counting computed tomography (SPCCT).

METHOD AND MATERIALS

Imaging was performed with an SPCCT system with multiple energy bins (Philips Healthcare, Haifa, Israel), using 100 mA, 120 kVp. Our initial experience with SPCCT showed that Gd concentrations in the range of 2 mg/ml can be detected with K-edge imaging. To achieve this concentration in vivo for perfusion imaging, a very large volume of standard Gd contrast agent (CA) needs to be administered to the animal, i.e. a volume of 8.75 ml is necessary for a 3.5 kg rabbit with a typical 0.5 M (78.5 mg of Gd /ml) formulation of CA. To overcome this limitation, we prepared a solution 1.25 M (196.25 mg of Gd /ml) of a macrocyclic polyaminocarboxylic Gd-chelate (gadoteridol) used in the clinics. Three ml of this solution were administered as a bolus injection in two NZW rabbits at 1 ml/s (3.5±0.1 kg), corresponding to a dose of 1 mmol/kg (protocol approved by the ethics committee). Dynamic angiography of the aorta and pulmonary vasculature and perfusion of the lung and myocardium was followed during 45 seconds after injection.

RESULTS

Rabbits were injected without any obvious side effects. K-edge imaging allowed the specific visualization of the contrast agent in the organs of interest with the benefit of the removal of all other anatomical structures (bone, soft tissue). Furthermore, K-edge imaging allowed assessment of organ perfusion (myocardium and lung) with the additional value of absolute quantification. Mean peak concentrations of Gd in the organs of interest, measured using hand drawn ROIs, are presented in Table 1. We observed also that the anatomical resolution was not compromised compared to the conventional CT images.

CONCLUSION

Highly concentrated Gadoteridol allows K-edge imaging for assessment of angiography and organ perfusion with a clinically compatible volume of contrast agent. This finding pinpoints major clinical applications with the additional value of gadolinium as a SPCCT agent.

CLINICAL RELEVANCE/APPLICATION

Gadoteridol presents the potential of K-edge perfusion imaging using a spectral photon-counting CT

Gadoteridol presents the potential of K-edge perfusion imaging using a spectral photon-counting CT.

PH211-SD-SUB6 Select Application of Care Bolus for the Best Monitoring Location in Head and Neck Joint Three-Dimensional Contrast-Enhanced Magnetic Resonance Venography

Station #6

Participants
Jingkai Li, beijing, China (*Presenter*) Nothing to Disclose
Zhang Kai Yuan, Beijing, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

lijingkai@xwhosp.org

PURPOSE

To evaluate the effect of different carebolus monitoring locations on the success rate of three-dimensional contrast-enhanced magnetic resonance venography

METHOD AND MATERIALS

20 patients were monitored for neck axis position, carebolus triggered scan 3D-ce-MRV,20 patients were monitored for neck coronary position , carebolus triggered scan 3D-ce-MRV,20 patients were monitored for vein of labbe to anterior wall of aortic arch line , carebolus triggered scan 3D-ce-MRV,Two readers measured venous imaging resolution on sup sagittal sinus , sigmoid sinus ,Internal jugular vein Image quality was assessed on a three-point scale

RESULTS

,20 patients were monitored for vein of labbe to anterior wall of aortic arch line , mrv imaging resolution was higher than that of the other two monitoring location triggered scan mrv imaging

CLINICAL RELEVANCE/APPLICATION

Due to the long range of the head and neck vein contrast agent, the dynamic and complex morphology of the blood vessels and blood vessels, reflux and other factors such as high intracranial pressure, the image quality of head and neck combined venous imaging is generally poor. In this study, vein of labbe to anterior wall of aortic arch line monitoring locationg trigger method was applied to the 3D-CE-MRV scan of the head and neck. It is easy to accurately determine the optimal phase of the examination, the operation is simple, and the results are satisfactory

PH104-ED-SUB7 Essential Knowledge About Gadolinium Contrast Agents on Magnetic Resonance Imaging to Plan Optimal Contrast Enhancement Protocols: Graphic Demonstration Using a Computer Simulation

Station #7

Participants
Toru Higaki, PhD, Hiroshima, Japan (*Presenter*) Nothing to Disclose
Yuko Nakamura, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Fuminari Tatsugami, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yukiko Honda, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuji Akiyama, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;

TEACHING POINTS

Although many radiologists may think pharmacokinetics of gadolinium contrast agents (Gd-CA) is same as iodine contrast agents (I-CA), there are specific characteristics in Gd-CA. First, there is no linear relationship between the concentration of Gd-CA and signal intensity on magnetic resonance (MR) imaging. Second, diffusion of Gd-CA into blood plasma according to high osmotic pressure cannot be ignored in Gd-CA as a volume of Gd-CA is much smaller than that of I-CA. From these factors, relationships between administration protocol and signal intensity are more complex for Gd-CA than I-CA. In this presentation, we will describe the basic theory of contrast enhancement for Gd-CA based on computer simulation for planning optimal contrast material injection protocols.

TABLE OF CONTENTS/OUTLINE

Physical characteristics of Gd-CA for understanding MR contrast enhanced images Relationship between concentration of Gd-CA and signal intensity Influence of the volume of contrast agent on the enhancement Influence of the injection rate of contrast agent on the enhancement Influence of the cardiac function of contrast agent on the enhancement Summary

RC121

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

Sunday, Nov. 26 2:00PM - 3:30PM 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
Ehsan Samei, PhD, Durham, NC (*Coordinator*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC
Norbert J. Pelc, DSc, Stanford, CA (*Coordinator*) Research support, Koninklijke Philips NV; Research support, General Electric Company; Research support, Siemens AG; Consultant, Varian Medical Systems, Inc; Consultant, NanoX; Scientific Advisory Board, RefleXion Medical Inc; Scientific Advisory Board, Prismatic Sensors AB; Scientific Advisory Board, Theranos, Inc; Medical Advisory Board, OurCrowd, LP

For information about this presentation, contact:

samei@duke.edu

LEARNING OBJECTIVES

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

Sub-Events

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

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

LEARNING OBJECTIVES

View Learning Objectives under main course title

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

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

For information about this presentation, contact:

jeff.siewerdsen@jhu.edu

LEARNING OBJECTIVES

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

RC121C Novel CT Acquisition Techniques

Participants
Lifeng Yu, PhD, Chicago, IL (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

yu.lifeng@mayo.edu

LEARNING OBJECTIVES

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

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RC122

Imaging for Personalized Medicine: Head and Neck

Sunday, Nov. 26 2:00PM - 3:30PM Room: S403A

HN NR PH

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

Participants
Robert Jeraj, PHD, Madison, WI (*Moderator*) Founder, AIQ Services

LEARNING OBJECTIVES

1. To learn about use of imaging in management of H&N 2. To learn about imaging for target definition in H&N 3. To learn about imaging for treatment response assessment in H&N

Sub-Events

RC122A Anatomical Imaging for Personalized Medicine in the Head and Neck

Participants
Emilie Soisson, PhD, Burlington, VT (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1. Describe the evolution of adaptive radiotherapy and relevant technological advances as they pertain to head and neck radiotherapy 2. Understand the clinical rational for of plan adaptation in the head and neck patient population 3. Describe possible routes to clinical implementation 4. Discuss risks associated with adaptive planning workflows and appropriate quality assurance

ABSTRACT

This session will focus on the practical implementation of adaptive radiotherapy for head and neck cancer. Although the concept of adaptive radiation therapy (ART) has been around now for more than two decades, routine plan adaptation has not become standard practice in the management of head and neck cancer despite huge technological advances in imaging, image registration software, and dose calculation speed. The remaining challenges in implementing ART for head and neck cancer in 2015 as well as an update of the demonstrated clinical need will be discussed. Features of successful adaptive radiotherapy implementations will be highlighted as well as a summary of useful clinical tools and required quality assurance.

RC122B Functional Imaging for Targeting and Adaptation in the Head and Neck

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

LEARNING OBJECTIVES

1) To learn how molecular imaging adds value in diagnosis/staging. 2) To learn how molecular imaging adds value in target definition. 3) To learn how molecular imaging adds value in treatment response assessment.

RC123

Molecular Imaging Mini-Course: Basics of Molecular Imaging

Sunday, Nov. 26 2:00PM - 3:30PM Room: S502AB

CT MI NM PH

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

LEARNING OBJECTIVES

New in 2017: PLEASE NOTE - All courses designated for SAM credit at RSNA 2017 will require attendees bring a personal device e.g. phone, iPad, laptop to complete the required test questions during the live session.

Sub-Events

RC123A Developing Molecular Imaging Agents

Participants
Martin G. Pomper, MD, PhD, Baltimore, MD (*Presenter*) Researcher, Progenics Pharmaceuticals, Inc; License agreement, Progenics Pharmaceuticals, Inc; Researcher, Advanced Accelerator Applications SA; License agreement, Advanced Accelerator Applications SA; Co-founder, Cancer Targeting Systems, Inc; Board Member, Cancer Targeting Systems, Inc; Researcher, Juno Therapeutics, Inc; Licensiing agreement, Juno Therapeutics, Inc; Co-founder, Neurly; Board Member, Neurly; Co-founder, Theraly Pharmaceuticals, Inc; Board Member, Theraly Pharmaceuticals, Inc; ;

LEARNING OBJECTIVES

1) Describe the ideal properties of a molecular imaging agent and molecular target. 2) Describe the in vitro and in vivo validation of the molecular imaging agent. 3) Describe specific examples of successful molecular imaging agents.

RC123B Instrumentation (PET and CT) and Image Reconstruction

Participants
John Sunderland, PhD, Iowa City, IA (*Presenter*) Research Grant, Siemens AG; Research Grant, General Electric Company

LEARNING OBJECTIVES

1) Identify the primary design components of a modern PET/CT system. 2) Design and implement a PET/CT quality control program to assure high quality and quantitatively accurate clinical imaging. 3) Describe commonly used PET reconstruction algorithms and the practical impact of reconstruction parameters upon image quality and quantitation.

RC123C Basic Clinical Applications

Participants
Hubert J. Vesselle, MD, PhD, Seattle, WA (*Presenter*) Consultant, MIM Software Inc

LEARNING OBJECTIVES

1) Describe a systematic approach to hybrid imaging (PET/CT and SPECT/CT) and its advantages. 2) Illustrate this approach through selected clinical examples.

RC125

Radiomics Mini-Course: Promise and Challenges

Sunday, Nov. 26 2:00PM - 3:30PM 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; Consultant, Carestream Health, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Coordinator*) Institutional research agreement, Siemens AG; ; ; ; ;

For information about this presentation, contact:

snapel@stanford.edu

Sub-Events

RC125A An Overview of Radiomics

Participants
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Stockholder, Hologic, Inc; Stockholder, 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, Toshiba Medical Systems Corporation

For information about this presentation, contact:

m-giger@uchicago.edu

LEARNING OBJECTIVES

1) Appreciate the motivation and scientific premise of quantitative image analysis (radiomics). 2) Learn about the role of computer-extracted hand-crafted radiomics and deep learning in quantitative radiomics. 3) Understand the role of quantitative radiomics in multi-omics cancer discovery studies and development of predictive models for precision medicine.

RC125B From Radiomics to Radiogenomics

Participants
Hugo Aerts, PhD, Boston, MA (*Presenter*) Stockholder, Sphera Inc

For information about this presentation, contact:

Hugo_Aerts@dfci.harvard.edu

LEARNING OBJECTIVES

1) Learn about the motivation and methodology of image-based phenotyping. 2) Learn about scientific radiomic studies investigating engineered and deep learning based methods for image phenotyping. 3) Learn about the potential role of radiologic AI with other -omics data within precision medicine.

RC125C Challenges for Radiomics and Radiogenomics

Participants
Karen Drukker, PhD, Chicago, IL (*Presenter*) Royalties, Hologic, Inc

For information about this presentation, contact:

kdrukker@uchicago.edu

LEARNING OBJECTIVES

1) Gain an understanding of the pitfalls along the radiomics/radiogenomics (imaging genomics) pipeline. 2) Appreciate the crucial role of statistics in the design and evaluation of radiomics and radiogenomics studies. 3) Learn about the special challenges associated with big data.

ABSTRACT

1. Introduction Basic statistical concepts Association, correlation, and causality Know when your numbers are significant 2. Reproducibility (or lack thereof) Replication studies The extent of the problem Curse of dimensionality, overfitting, multiple hypothesis testing Sample size, P-value variability 3. "Big Data" "Big data" vs. "medium data" vs. "small data" Training and testing data sets Harmonization

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RC221

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

Monday, Nov. 27 8:30AM - 10:00AM Room: S102CD

CT PH

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

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

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC221A Data Acquisition and Image Formation Methods for Multi-Energy CT

Participants
Cynthia H. McCollough, PhD, Rochester, MN (*Presenter*) Research Grant, Siemens AG

For information about this presentation, contact:

mccollough.cynthia@mayo.edu

LEARNING OBJECTIVES

1) Understand the various methods used to acquire multi-energy CT data. 2) Comprehend the different methods used to present the information obtained with multi-energy CT.

Active Handout:Cynthia H. McCollough

http://abstract.rsna.org/uploads/2017/16001048/Active RC221A.pdf

RC221B Applications

Participants
Sebastian T. Schindera, MD, Riehen, Switzerland (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the various clinical applications of multi-energy CT. 2) Discuss the most important challenges of multi-energy CT in clinical routine. 3) Identify future opportunities of multi-energy CT.

RC221C Future Prospects—Photon Counting

Participants
Taly G. Schmidt, PhD, Milwaukee, WI (*Presenter*) Research Grant, General Electric Company

For information about this presentation, contact:

tal.gilat-schmidt@marquette.edu

LEARNING OBJECTIVES

1) Understand the potential benefits and current status of photon-counting detection for Spectral CT. 2) Understand the challenges of photon-counting Spectral CT.

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RC222

Imaging for Personalized Medicine: Thorax

Monday, Nov. 27 8:30AM - 10:00AM Room: S103AB

CH PH

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

Participants
Martha M. Matuszak, PhD, Ann Arbor, MI (*Moderator*) Research Grant, Varian Medical Systems, Inc

Sub-Events

RC222A Anatomical Imaging for Personalized Medicine in the Thorax

Participants
Geoffrey Hugo, PhD, Richmond, VA (*Presenter*) Research Grant, Koninklijke Philips NV; Research Grant, Varian Medical Systems, Inc

For information about this presentation, contact:

gdhugo@vcu.edu

LEARNING OBJECTIVES

1) Understand how respiration impacts radiotherapy imaging and delivery and how to implement strategies to mitigate these issues on a patient-specific basis. 2) Understand types and magnitude of geometric changes in thoracic anatomy during radiotherapy, and determine approaches to correct for discrepancies between the planned and delivered dose to the patient.

ABSTRACT

Radiotherapy is in widespread use for both early and advanced stage lung cancer, as a sole modality and also in combination with other modalities such as chemotherapy. Due to the potential for both acute and late toxicities in organs adjacent to treated regions, modern techniques seek to limit the extent of the high dose volume. The purpose of this session is to develop an understanding for how geometric and anatomic changes during radiotherapy can be managed. The focus will be on solutions readily available in the clinic today, particularly with respect to imaging modalities and planning solutions.

RC222B Functional Imaging for Targeting and Adaptation in the Thorax

Participants
Martha M. Matuszak, PhD, Ann Arbor, MI (*Presenter*) Research Grant, Varian Medical Systems, Inc

For information about this presentation, contact:

marthamm@med.umich.edu

LEARNING OBJECTIVES

1) Understand the opportunities for targeting and avoidance based on functional imaging in lung. 2) Discuss the technical details of functional targeting for tumor and functional avoidance in normal tissue for lung cancer in the pre-treatment and adaptive settings.

ABSTRACT

Radiation therapy continues to play an important role in the treatment of lung cancer although many opportunities remain to improve local control and survival as well as reduce toxicity, especially in advanced stage lung cancer. The use of functional imaging and biomarkers to predict tumor burden and response as well as measure and predict normal tissue toxicity has begun to increase in the community. This session aims to summarize the different modalities and types of information available to perform functional targeting or avoidance of tumor and normal tissue in lung cancer, including imaging (such as PET and SPECT) and other data (such as blood-based biomarkers). The session will also highlight the technical details associated with the use of functional data for treatment planning, treatment response, and adaptation.

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RC223

Update on the Maintenance of Certification Program (MOC) for ABR Medical Physics Diplomates

Monday, Nov. 27 8:30AM - 10:00AM Room: E263

ED PH

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

Participants
G. Donald Frey, PhD, Charleston, SC (*Director*) Nothing to Disclose
G. Donald Frey, PhD, Charleston, SC (*Presenter*) Nothing to Disclose
James A. Seibert, PhD, Sacramento, CA (*Presenter*) Advisory Board, Bayer AG
Matthew B. Podgorsak, PhD, Buffalo, NY (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) The participant will understand the importance of the MOC program for medical physicists. 2) The participant will understand the Part 1, Part 2 & Part 4 requirements and how the simplified attestation process works. 3) The participant will understand how the replacement of the decennial exam with the on-line longitudinal assessment program will work. 4) The participant understand what is necessary for the annual evaluation.

ABSTRACT

The ABR MOC program has undergone many changes in the last few years. This talk will review the importance of the MOC program for maintaining clinical skills and the changes concerning the MOC program. These include simplified attestation for Part 1 - Professional Standing, Part 2 - Lifelong Learning and Part 4 - Process Quality Improvement. The new On-line Longitudinal Assessment (OLA) program that will replace the decennial exam will also be discussed. The speakers will also explain how the annual evaluation program works and how a diplomate can restore their status if the fall behind.

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RC225

Radiomics: Mini-Course: Oncologic Applications

Monday, Nov. 27 8:30AM - 10:00AM Room: S404CD

BQ OI 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; ; ; ; ;
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Consultant, Carestream Health, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

For information about this presentation, contact:

snapel@stanford.edu

Sub-Events

RC225A Breast Cancer with PET-CT

Participants
Richard L. Wahl, MD, Saint Louis, MO (*Presenter*) Consultant, Nihon Medi-Physics Co, Ltd; Contract, WhiteRabbit.AI Inc; ;

LEARNING OBJECTIVES

1) Which type of breast cancer is the most glycolytically active as measured by FDG PET/CT. 2) At least one method of assessing quantitative changes in FDG PET SUV during therapy. 3) Three radiomic features of breast cancer on FDG PET which may have prognostic significance.

ABSTRACT

Breast cancer can be imaged using PET/CT in a qualitative and a quantitative fashion. A single quantitative 'radiomic feature' SUVmax is but one of the many quantitative metrics which can be extracted from FDG PET images.This feature is associated with biological differences reflecting thebreast cancer genotype and phenotype. More complex features can be extracted and, at least when when assessed on correlated anatomic images, may be related to outcomes-- especially a feature of tumor heterogenity at baseline being associated with less favorable outcomes. More complex features are uncertain in their prognostic value. Changes in simple parameters like SUL peak are associated with outcomes of therapy and have been integrated into the PERCIST 1.0 formulation for treatment response. With other tracers such as NaF, features can also be identified, but the signal with this tracer is complicated by its indirect linkage to tumor and its more strong linkage to tumor induced remodeling. Other non FDA approved tracers such as FES and FLT can reflect biological features of tumors and simple quantiative analysis are associated with tumor phenotypes and genotypes. Radiomics in breast cancer as related to PET/CT (and PET/MRI) is in its infancy, but it is anticipated that a more thorough exploration of stable radiomic features obtained with a variety of tracers may ultimately inform the managerment of individual patients with breast cancer.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Richard L. Wahl, MD - 2013 Honored Educator

RC225B Radiogenomics of Lung Cancer

Participants
Neema Jamshidi, MD, PhD, Los Angeles, CA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

njamshidi@mednet.ucla.edu

LEARNING OBJECTIVES

1) Have a general knowledge of oncologic radiogenomics. 2) Have an understanding of progress made to date and the current status of lung cancer radiogenomics. 3) Appreciate the next steps and advancements that will be required for clinical deployment of lung cancer imaging genomics applications.

RC225C Brain Cancer: Radiomics, Radiogenomics, and Big Data

Participants
Rivka R. Colen, MD, Houston, TX (*Presenter*) Research Grant, General Electric Company;

LEARNING OBJECTIVES

1) Define and understand the keys concepts of radiomics. 2) Understand the basic concepts of radiogenomics. 3) Understand the basic analytical algorithms that are used for big data analysis and integration. 4) Know and review of of the selected important publications and literature on radiomics and radiogenomics in brain cancer.

ABSTRACT

Radiogenomics is the linkage of imaging features with genomics of tumor or tissue. In the case of cancer, radiogenomics seeks to link imaging features with the genomic composition of the tumor and/or key genomic events. Radiomics, on the other hand, are defined as imaging features that are extracted using an automated approach using multiple computational analytical methods; these are typically seen with texture analysis and go beyond the resolution of the human eye. Given that thousand of imaging features, and if combined with genomics, are extracted, we are confronted with a 'big data' problem. Numerous statitstical and machine learning approaches that deal with large data analysis can be applied to radiomics and radiogenomics.

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SSC13

Physics (CT: Dual Energy and Spectral CT)

Monday, Nov. 27 10:30AM - 12:00PM Room: S404AB

BQ CT PH

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

FDA Discussions may include off-label uses.

Participants
Xiangyang Tang, PhD, Atlanta, GA (*Moderator*) Research Grant, SINOVISION Technologies Co, Ltd
Willi A. Kalender, PhD, Erlangen, Germany (*Moderator*) Consultant, Bayer AG; Consultant, Advanced Breast-CT GmbH;

Sub-Events

SSC13-01 Organ-Specific Context-Sensitive Single and Dual Energy CT (DECT) Image Reconstruction, Display and Analysis

Monday, Nov. 27 10:30AM - 10:40AM Room: S404AB

Participants
Sabrina Dorn, Heidelberg, Germany (*Presenter*) Nothing to Disclose
Shuqing Chen, Erlangen, Germany (*Abstract Co-Author*) Nothing to Disclose
Francesco Pisana, Heidelberg, Germany (*Abstract Co-Author*) Doctoral student, Siemens AG
Stefan Sawall, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Andreas Maier, DIPLENG, Erlangen, Germany (*Abstract Co-Author*) Research support, Siemens AG; Research support, iSchemaView, Inc
Michael M. Lell, MD, Erlangen, Germany (*Abstract Co-Author*) Nothing to Disclose
Marc Kachelriess, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

sabrina.dorn@dkfz.de

PURPOSE

To combine mutually exclusive CT image properties (reconstruction kernels, monoenergetic reconstruction, dual energy classification or display settings) into a single organ-specific image reconstruction and display.

METHOD AND MATERIALS

Given a CT rawdata set there are manifold parameters for CT image reconstruction and display. To name a few of them: reconstruction algorithm and parameters, dual energy spectral properties and display settings. Often, specific settings are tied to certain organs and thus several reconstructions are required to fully exploit the diagnostic potential of the CT data. We propose a method to locally reconstruct the desired image properties by using an atlas-based context-sensitive reconstruction. Each voxel of the atlas indicates the probability of the voxel belonging to a certain organ. By aligning the atlas onto one target volume, the anatomical structures are automatically segmented and classified into the organs heart, vasculature, liver, kidney, spleen and lung. Moreover, each voxel is assigned to different tissue types (bone, fat, soft tissue and vessels). Reconstruction and display parameters most suitable for the organ, tissue type, and clinical indication are chosen automatically from a predefined set of reconstruction parameters on a per-voxel basis. The approach was evaluated using patient data acquired with a dual source CT system.

RESULTS

Ten contrast-enhanced DECT patient datasets in arterial and portal venous phase were used. We are able to reconstruct each tissue type with the most appropriate kernel by using prior anatomical knowledge. The resulting, context-sensitive enhanced images simultaneously combine the indication specific advantages of different parameter settings without experiencing algorithm related artifacts. A direct comparison with conventionally reconstructed and displayed images revealed no information loss in the compound image. Dual energy overlays or tissue classification information are shown wherever appropriate.

CONCLUSION

With the use of our context-sensitive reconstruction and display approach, the images present significantly more information to the reader simultaneously and dealing with multiple image stacks is unnecessary.

CLINICAL RELEVANCE/APPLICATION

The proposed method improves the clinical workflow and bears the potential to increase the rate of clinically relevant incidental findings.

SSC13-02 Spectral CT Analysis Using Custom Plugins for a Clinical DICOM Viewer

Monday, Nov. 27 10:40AM - 10:50AM Room: S404AB

Participants
Matthew A. Lewis, PhD, Dallas, TX (*Presenter*) Research collaborations, CMR Naviscan Corporation and QT Ultrasound Labs
Todd C. Soesbe, PhD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Lakshmi Ananthakrishnan, MD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Suhny Abbara, MD, Dallas, TX (*Abstract Co-Author*) Author, Reed Elsevier; Editor, Reed Elsevier; Institutional research agreement, Koninklijke Philips NV; Institutional research agreement, Siemens AG
Ronald M. Peshock, MD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Robert E. Lenkinski, PhD, Dallas, TX (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV Research Consultant, Aspect Imaging

For information about this presentation, contact:

matthew.lewis@utsouthwestern.edu

PURPOSE

Spectral CT potentially reduces energy-dependent artifacts and produces more quantitatively accurate images. As recognized early in CT development, this is especially true for spectral CT based on projection-space decomposition using a physics-centric basis set.

METHOD AND MATERIALS

Spectral CT fingerprinting is our term for the statistical analysis of the intrinsic 2D information content for tissue attenuation in all current forms of spectral CT, including dual source and dual layer detector. Since current clinical workflow does not facilitate spectral analysis outside specific applications (ex. iodine maps, fat quantification), we developed novel tools for spectral CT image analysis. pyOsiriX (Blackledge et al,2016) is a recently published plugin for the popular OsiriX (Pixmeo SARL) family of DICOM viewers, including open source variants Horos (horosproject.org) and Osiri-XLV. pyOsiriX facilitates the rapid development of Python-based image analysis, modeling, and interpretation in a clinical-quality DICOM environment. We deployed pyOsiriX-based software tools that interact with Spectral Basis Images (SBIs) from a detection-based spectral CT (IQon, Philips Healthcare), as well as image-space dual source studies (Siemens).

RESULTS

The pyOsiriX Spectral CT Toolbox produces new DICOM series containing scatter plots of the native spectral CT data. We denote these 2D scatter plots as material attenuation decomposition (MAD) plots, with local MAD plots being at the slice level and the global MAD plot for the entire series. The toolkit facilitates bi-directional segmentation between the volume and MAD plots, as well as annotation with libraries of known materials and tissues. Analysis results natively support both ROI tools and multi-planar reformatting. For more complicated tasks, a single slice or entire series can be seamlessly exported to NIH ImageJ/FIJI where analogous scatterplot tools are available alongside an extensive image processing library.

CONCLUSION

The pyOsiriX Spectral CT Toolbox is a robust framework for exploring intrinsic 2D spectral data and provides a more global viewpoint of the spectral CT information content than standard material decompositions and monoenergetic results.

CLINICAL RELEVANCE/APPLICATION

Analysis of spectral CT data using such tools may allow subtle changes in contrast to be better understood in terms of the underlying tissue composition and pathology.

SSC13-03 Investigation on the Repeatability of Coronary Artery Calcium Quantification Using Contrast-Enhanced Dual-Energy Computed Tomography Scans in Comparison with Unenhanced Single-Energy Scans

Monday, Nov. 27 10:50AM - 11:00AM Room: S404AB

Participants
Qin Li, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose
Benjamin P. Berman, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Tomoe Hagio, PHD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Marios A. Gavrielides, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Rongping Zeng, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Nicholas Petrick, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Berkman Sahiner, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

qin.li1@fda.hhs.gov

PURPOSE

To assess the repeatability of coronary artery calcium (CAC) scoring using contrast-enhanced dual-energy (DE) scans and compare it with conventional CAC scores obtained from unenhanced single-energy (SE) CT images.

METHOD AND MATERIALS

Synthetic vessels with iodinated blood (diameters 4 and 4.5mm) containing calcium stenoses (hydroxylapatite) of different sizes and densities were scanned in a chest phantom using a DE coronary CT angiography protocol (90kV/Sn150kV, SOMATOM Force, Siemens) with 3 doses (mAs/CTDIvol: automatic exposure control/7mGy, 160mAs/21mGy and 260mAs/32mGy) and 10 repeats. Images were reconstructed at 3mm slice thickness, with Qr36 kernel, using FBP and ADMIRE-3 (IR). As a control, a set of vessel phantoms without iodine was scanned using a standard SE CAC score protocol (automatic exposure control/3mGy). Calcium volume, mass and Agatston scores were estimated for each stenosis. For DE data, image-based three-material (calcium, iodine, soft tissue)

decomposition was applied to remove iodine before scoring. Calcium scores for 4 stenoses were analyzed (degree of stenosis: 50%, density: 300 and 450HU at 120kV). Within-subject coefficient of variation (wCV) was calculated for each stenosis and imaging condition and across corresponding scores from DE and SE data.

RESULTS

The repeatability of calcium scores varied depending on the size and density of the stenosis: wCV decreased as size and/or density of calcium increased. wCVs for DE based calcium scores were strongly impacted by image noise: higher dose reduced variability and IR outperformed FBP at the same dose level in terms of wCV. The mean wCVs of volume scores of all stenoses for DE dataset with FBP/IR from low to high doses were 0.14±0.08/0.12±0.05, 0.14±0.05/0.08±0.04, and 0.10±0.05/0.04±0.10. Only 260mAs dose level with IR yielded comparable wCV to those from SE data (0.04±0.02). All trends were consistent for volume, mass and Agatston scores.

CONCLUSION

It is feasible to extract calcium scores from contrast-enhanced images using DE based material decomposition methods. However, to achieve similar repeatability of calcium scores to that from conventional unenhanced SE CT images, much higher radiation dose is required.

CLINICAL RELEVANCE/APPLICATION

Although DE based iodine-removal method may eliminate the need for unenhanced SE scans dedicated for CAC score, our findings suggest significantly higher dose is needed to achieve good repeatability.

SSC13-04 Quantification of Cisplatin Concentration by using Material Decomposition Algorithm at 3rd Generation Dual Source Dual-Energy CT: An Experimental Phantom Study

Monday, Nov. 27 11:00AM - 11:10AM Room: S404AB

Participants
Keitaro Sofue, MD, Kobe, Japan (*Presenter*) Nothing to Disclose
Toshihide Itoh, Tokyo, Japan (*Abstract Co-Author*) Employee, Siemens AG
Ryuji Shimada, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Tatsuya Nishitani, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriyuki Negi, RT, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuro Sugimura, MD, PhD, Kobe, Japan (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, Eisai Co, Ltd; Research Grant, DAIICHI SANKYO Group
Satoru Takahashi, MD, PhD, Kobe, Japan (*Abstract Co-Author*) Research Grant, Bayer AG

For information about this presentation, contact:

keitarosofue@yahoo.co.jp

PURPOSE

Intra-arterial infusion or embolization with high-dose cisplatin has been performed following selective angiography for locally advanced head and neck cancer or hepatocellular carcinoma. The purpose of this study was to assess the ability of dual source dual-energy computed tomography (DECT) to quantify cisplatin concentration by using the material decomposition algorithm.

METHOD AND MATERIALS

Fifteen agarose-based phantom syringes that contained various concentrations of iodine (0, 1.0, 2.0 mgI/mL) and cisplatin (0, 0.5, 1.0, 2.0, 3.0 mgPt/mL) were scanned with DECT at 80 kV and Sn150 kV. Cisplatin-specific slope was determined using iodine-free agarose and cisplatin phantoms. Then, cisplatin maps were reconstructed from dual-energy calculation by using three-material decomposition algorithm of agarose, iodine, and cisplatin. HU values from six consecutive images on cisplatin maps were obtained for each phantom by placing regions of interest. The relationships between HU values on cisplatin maps and cisplatin concentration for each iodine concentration were assessed by using Spearman rank correlation coefficient (ρ) and linear regression analyses. To assess the influence of iodine on cisplatin measurements made by using cisplatin maps and cisplatin concentration, the linear regression lines for HU values on cisplatin maps and cisplatin concentrations were compared by using analysis of covariance at three levels of iodine concentration.

RESULTS

Cisplatin maps could identify the lowest cisplatin concentration of 0.5mgPt/mL. Significant linear correlations were found between HU values on cisplatin maps and cisplatin concentrations for each iodine concentration (ρ=0.980-0.981, $P<.001$). At higher iodine concentrations, the linear coefficients for HU values on cisplatin maps decreased. Analysis of covariance showed significant differences between 2.0 mgI/mL and 0 or 1.0 mgI/mL ($P<.001$) and no significant difference between 0 and 1.0 mgI/mL ($P=.068$).

CONCLUSION

Cisplatin maps generated from material decomposition algorithm allow to identify the cisplatin concentration of 0.5mgPt/mL or more. In the presence of 2.0 mgI/mL iodine concentration, cisplatin maps led to underestimation of cisplatin concentration.

CLINICAL RELEVANCE/APPLICATION

Third generation dual source DECT can estimate tissue cisplatin concentration, potentially confirming appropriate high-dose distribution during intra-arterial infusion or embolization with cisplatin.

SSC13-05 Improved X-Map for Acute Ischemic Stroke Imaging Using Non-Contrast-Enhanced Dual-Energy CT

Monday, Nov. 27 11:10AM - 11:20AM Room: S404AB

Participants
Katsuyuki Taguchi, PhD, Baltimore, MD (*Presenter*) Research Grant, Siemens AG; Consultant, JOB Corporation
Toshihide Itoh, Tokyo, Japan (*Abstract Co-Author*) Employee, Siemens AG
Karl Stierstorfer, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG

Matthew K. Fuld, PhD, Iowa City, IA (*Abstract Co-Author*) Researcher, Siemens AG
Eric Fournie, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Kyo Noguchi, MD, Toyama, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

ktaguchi@jhmi.edu

PURPOSE

A novel imaging technique ("X-map") has been developed to identify acute ischemic lesions for stroke patients using non-contrast-enhanced dual-energy CT (Noguchi K, et al., Cerebrovasc Dis, 26:34-41, 2017). Using the 3-material decomposition technique, the original X-map ("X-map1") eliminates fat and bone from the images, suppresses the gray matter-white matter tissue contrast, and enhances signals of edema induced by ischemia. There were the following three problems with the X-map1: (1) faint biases near the skull; (2) X-map1 values being qualitative, not quantitative; and (3) presence of many false positives. The aim of this study was to address these problems.

METHOD AND MATERIALS

We improved both an iterative beam hardening correction method (iBHC) and the X-map algorithm. The new iBHC modeled x-ray physics more accurately including off-focal spot radiations. The new X-map ("X-map2") first converted CT pixel values to the truly physics-based characteristic coefficients that are unique to the local tissue materials such as gray matter or white matter. The X-map2 then calculated an increased water density for each pixel, which is called the ischemia index (AISC), with the value of 100 indicating 100% normal tissue (no edema) and 0 indicating 100% water (complete edema).

RESULTS

The new iBHC provided quantitatively accurate pixel values: Pixel values near the skull were biased by 12-to-20 HU with the old iBHC, whereas the bias with the new iBHC was as small as -3-to-2 HU. Performed on the improved iBHC image, the X-map1 presented an ischemic lesion correctly; however, there were suspicious false-positive lesions and the size of the ischemic lesion was smaller than DWI-MRI image. In contrast, the X-map2 provided much fewer false-positive lesions and the correct ischemic lesion size. The extent of the lesion with AISC<90 agreed with the ischemic lesion presented in DWI-MRI.

CONCLUSION

We have improved both iBHC and X-map algorithms. The combined method decreased false positives, improved the agreement with DWI-MRI, and provided quantitative index values.

CLINICAL RELEVANCE/APPLICATION

When acute ischemic lesions, intracranial hemorrhage, and thrombus are identified correctly and confidently, the most effective therapeutic option can be chosen within 45 min of patient arrival.

SSC13-06 Cross-platform Comparison of Lower Limits of Iodine Detection with Single Source, Dual Source, and Rapid Kilovoltage Switching Dual Energy CT Platforms

Monday, Nov. 27 11:20AM - 11:30AM Room: S404AB

Participants
Nakul Gupta, MD, Houston, TX (*Presenter*) Nothing to Disclose
Charles Dodge III, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Pamela M. Mager, BA, ARRT, Arcadia, TX (*Abstract Co-Author*) Speaker, General Electric Company

For information about this presentation, contact:

ngupta@houstonmethodist.org

PURPOSE

To evaluate and compare the accuracy and lower limits of iodine quantification across multiple dual energy CT platforms, including single source, dual source, and rapid kilovoltage switching platforms.

METHOD AND MATERIALS

A commercially available phantom was used to evaluate iodine concentrations of 10, 7.5, 5, 2.5, 2 and 0 mg/ml. As there were no commercially available iodine phantoms below 2 mg/ml, an in-house phantom was developed using serial dilutions of Omnipaque 300 mg/ml to evaluate iodine concentrations of 3, 1.5, 1, 0.6, 0.3, and 0.15 mg/ml. The phantom was scanned on single source (Siemens Definition Edge), dual source (Siemens SOMATOM Force), and rapid kilovoltage switching (GE Revolution HD) CT scanners. Scan parameters were adjusted across platforms to maintain a CTDIvol of approximately 25 mGy, and images were reconstructed at 3 mm thickness. No iterative reconstruction was employed. Images were post-processed and analyzed utilizing the vendors' respective dual-energy workstation platforms, Syngo.via, and GE AW server.

RESULTS

1 mg/mL was the lowest visually perceptible concentration across all platforms. CNR at 1 mg/mL was best (2.7) on the dual source platform with monoenergetic 40 keV images, and improved progressively for all platforms on monoenergetic images as keV settings were lowered. The single and dual source platforms improved in linear fashion, while the rapid kVs platform was best modeled by a polynomial function. Both dual source and rapid kVs platforms demonstrated linear response in measured iodine concentration (R2=0.99). The lowest CNR required to be visually perceptible with optimization of window/level settings and viewing environment was approximately 1.2-1.3. On the rapid kVs platform, the Iodine material basis pair images demonstrated superior CNR to monoenergetic images, even at 40 keV.

CONCLUSION

The lowest iodine concentration that was visually discernible was 1.0 mg/ml across all platforms. The highest CNR achieved at this concentration was 2.7, by the dual source scanner on monoenergetic 40 keV images.

CLINICAL RELEVANCE/APPLICATION

Dual energy CT can accurately quantify iodine concentration across a wide dose-range, down to a minimum of approximately 1 mg/ml, which may allow its use as a quantifiable biomarker.

SSC13-07 Comparing Imaging Performance across Spectral Computed Tomography Platforms

Monday, Nov. 27 11:30AM - 11:40AM Room: S404AB

Participants
Thorsten Sellerer, MSc, Garching bei Munchen, Germany (*Presenter*) Nothing to Disclose
Peter B. Noel, PhD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Manuel Patino, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Anushri Parakh, MBBS, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Daniela Muenzel, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Dushyant V. Sahani, MD, Boston, MA (*Abstract Co-Author*) Research support, General Electric Company; Medical Advisory Board, Allena Pharmaceuticals, Inc
Sebastian Ehn, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Alexander A. Fingerle, MD, Munchen, Germany (*Abstract Co-Author*) Nothing to Disclose
Jasmin A. Holz, Cologne, Germany (*Abstract Co-Author*) Nothing to Disclose
David C. Maintz, MD, Koln, Germany (*Abstract Co-Author*) Nothing to Disclose
Franz Pfeiffer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Ernst J. Rummeny, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

thorsten.sellerer@tum.de

PURPOSE

To evaluate the imaging performance across different spectral Computed Tomography (CT) platforms, including: kVp-Switching CT, Dual-Source CT, and Dual-Layer CT.

METHOD AND MATERIALS

A semi-anthropomorphic abdomen phantom for CT performance evaluation was imaged on different spectral CT systems: kVp-Switching (Discovery CT750 HD, GE, United States), Dual-Source (Somatom Definition Flash & Force, Siemens Healthineers, Germany) and Dual-Layer CT (IQon Spectral CT, Philips Healthcare, The Netherlands). Scans were repeated three times for each radiation dose levels (CTDIvol: 10 mGy, 20 mGy and 30 mGy). To be able to better compare results all data were reconstructed in a non-iterative mode and dose modulation was switched off. The phantom was imaged with different extension rings to simulate obese patients and was equipped with a specific spectral insert, which included the following materials: water-, adipose-, muscle-, liver-, bone-like materials and a variation of iodine concentrations. Over the range of available virtual mono-energetic images (VMI) noise as well as quantitative accuracy of VMI Hounsfield Units (HU), and iodine concentrations were evaluated.

RESULTS

Over the range of VMI levels the HUs could be determined with high accuracy when comparing to the theoretical values. For kVp-Switching and Dual-Source CT an increase in noise could be observed towards lower VMI levels. A patient size dependent increase in iodine concentrations error can be observed for all platforms. For a medium patient size the iodine concentration bias was for the three dose levels (CTDIvol: 10 mGy, 20 mGy and 30 mGy): 0.344 mg/ml, 0.348 mg/ml and 0.314 mg/ml (kVp-Switching), 0.741 mg/ml, 0.736 mg/ml and 0.730 mg/ml (Dual-Source), and 0.240 mg/ml, 0.192 mg/ml, and 0.134 mg/ml (Dual-Layer).

CONCLUSION

Iodine concentrations as well as VMI HUs could be accurately determined across different spectral CT systems. In non-iterative reconstruction mode, the noise behaviour of dual-layer CT is independent of the keV VMI level, while an increase in noise is observed for kVp-Switching and Dual-Source CT.

CLINICAL RELEVANCE/APPLICATION

Current high-end spectral CT scanners allow accurate material quantification using different techniques. This should allow to move toward quantitative CT imaging in the clinical day-to-day routine.

SSC13-08 Diagnostic Spectral Image Quality Achievable in Obese Patients Using Detector Based Dual Energy CT

Monday, Nov. 27 11:40AM - 11:50AM Room: S404AB

Participants
Eric Wallace JR, MD, New Orleans , LA (*Abstract Co-Author*) Nothing to Disclose
Jonathon P. Stidham, MD, Fultondale, AL (*Presenter*) Nothing to Disclose
Carson Flores, New Orleans, LA (*Abstract Co-Author*) Nothing to Disclose
David L. Smith, MD, New Orleans, LA (*Abstract Co-Author*) Nothing to Disclose
Raman Danrad, MD, New Orleans, LA (*Abstract Co-Author*) Nothing to Disclose
Ekta D. Dharaiya, MS, Highland Heights, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Leonard R. Bok, MD, MBA, New Orleans, LA (*Abstract Co-Author*) Nothing to Disclose
Aran M. Toshav, MD, New Orleans, LA (*Abstract Co-Author*) Speakers Bureau, Koninklijke Philips NV

For information about this presentation, contact:

eric.wallacejr@gmail.com

PURPOSE

Currently, tube based dual energy CT scanners have limited ability to scan patients with large body habitus due to their low energy limitations. The purpose of our study is to assess the image quality and interpretability of monoE 70 KeV and iodine images obtained on a spectral detector CT scanner (SDCT) in obese patients.

METHOD AND MATERIALS

IRB approved, HIPAA compliant retrospective review of 15 patients over 270 lbs (122.5 kg) who underwent a CT of the abdomen and pelvis using the Philips IQon Spectral detector CT at our institution between December 2016 and March 2017 was performed. Body mass index of the 15 patients ranged from 33.87 kg/m² - 71.48 kg/m² with weights in the range of 271 lbs - 366 lbs. Two fellowship trained, board certified radiologists reviewed the images, specifically the conventional and monoE 70KeV for image quality and graded contrast to noise ratio (CNR) on a five point scale between 1 for conventional imaging superiority to 5 for monoE 70KeV superiority. Iodine map sequences were analyzed for image quality and homogenous interpretability based upon a five point scale (1-5) with 1 being uninterpretable to 5 being completely interpretable.

RESULTS

When comparing the conventional images to the monoE 70KeV images, there was a 100% concordance between the two reviewers that the monoE 70KeV images were superior to conventional images with an average score of 4.57 for reviewer 1 and 4.64 for reviewer 2. In regards to the iodine map, reviewer 1 had an average score 4.07 and reviewer 2 had an average score of 4.57. These values fall between a score of 4 and 5, with 4 being a score where the iodine map is completely interpretable, except for one organ and 5 being a score for iodine maps being completely interpretable. None of the iodine map ratings fell below a score of 3, where the iodine map is interpretable with more than one organ limitation.

CONCLUSION

SDCT scanner permits spectral imaging in obese patients who were previously considered inappropriate for dual energy scanning. MonoE 70KeV provided superior image quality in obese patients as compared to conventional images.

CLINICAL RELEVANCE/APPLICATION

Diagnostic image quality of obese patients can be achieved using the IQon SDCT.

SSC13-09 Feasibility of Dual-Energy CT for Zinc Quantification in an Experimental Phantom Model

Monday, Nov. 27 11:50AM - 12:00PM Room: S404AB

Participants
Achille Mileto, MD, Seattle, WA (*Presenter*) Nothing to Disclose
Carina Pereira, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose
Sooah Kim, MD, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose
Giuseppe V. Toia, MD,MS, Seattle, WA (*Abstract Co-Author*) Nothing to Disclose
Adam M. Alessio, PhD, Seattle, WA (*Abstract Co-Author*) Research Grant, General Electric Company

For information about this presentation, contact:

achille.mileto@gmail.com

PURPOSE

Cumulative evidence indicates that zinc may play a key role in the development of liver and pancreatic cancers. We investigated the feasibility of using dual-energy CT to quantify zinc and to differentiate it from iodine in a phantom experiment.

METHOD AND MATERIALS

Multiple 1.3-cm test tubes were filled with four zinc chloride (2 to 22 mgZn/mL), four iodine (1 to 7 mgI/mL with Iohexol 350 mgI/mL) and two mixed zinc/iodine solutions (75% zinc-to-25% iodine and vice versa), targeting clinically relevant CT numbers on the order of 25 to 150 HU. These were placed into an 85-cm-circumference torso-shaped water phantom, simulating the abdomen of a medium-sized patient. Polyethylene bags filled with vegetable fat were serially wrapped at the periphery of the water phantom to mimic large (110-cm) and extra-large (120-cm) patient sizes. The three phantom sizes were imaged in dual-energy (80/140 kVp, 600 mA) and single-energy (120 kVp) modes using a single-source dual-energy 64-MDCT scanner with fast kV switching. For reference purposes, the same scans were repeated by scanning the plastic test tubes in air. CT radiation output was kept constant for all acquisitions. Material-specific and attenuation information were extracted from raw-data.

RESULTS

A custom linear mixing algorithm was generated from dual-energy monochromatic datasets to obtain zinc maps, which yielded estimates of zinc concentration with RMSE of 0.8 mg/mL across dilution levels and phantom sizes. The lowest 2.8 mgZn/mL solution was measured to have 2.5+/-0.4 mgZn and was significantly higher than Zn estimates in the background (0.2+/-0.6 mgZn, $P<0.001$, 1-sided t-test), demonstrating that trace levels of Zn are detectable. Iodine maps from the commercially-available software yielded a RMSE of 0.5 mgI/mL. The system was unable to reliably discriminate zinc from iodine when both materials were present within the same sample.

CONCLUSION

Dual-energy CT can quantify zinc in an experimental phantom model. Dual-energy may not be able to reliably distinguish between zinc and iodine within the same tissue sample, thus suggesting that a separate dual-energy noncontrast acquisition may be needed for optimized in-vivo zinc quantification.

CLINICAL RELEVANCE/APPLICATION

Non-invasive quantification of zinc with dual-energy CT may prove useful in oncologic imaging as quantitative biomarker for early identification of malignancy and, possibly, for development of targeted therapies.

SSC14

Physics (Diagnostic X-Ray Imaging: Techniques, Radiation Dose)

Monday, Nov. 27 10:30AM - 12:00PM Room: S503AB

PH SQ

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

Participants
James A. Seibert, PhD, Sacramento, CA (*Moderator*) Advisory Board, Bayer AG
Hilde Bosmans, PhD, Leuven, Belgium (*Moderator*) Co-founder, Qaelum NV Research Grant, Siemens AG

Sub-Events

SSC14-01 Improved Detection of Foreign Bodies on Radiographs Using X-Ray Dark-Field and Phase-Contrast Imaging

Monday, Nov. 27 10:30AM - 10:40AM Room: S503AB

Participants
Katharina Hellbach, MD, Munich, Germany (*Presenter*) Research collaboration, Siemens AG
Ebba Beller, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Andreas Schindler, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Nina Hesse, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Alena Baumann, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Sigrid Auweter, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Marcus Radicke, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Sven-Martin Sutter, DIPLPHYS, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Franziska Schoeppe, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Christian Hauke, Forchheim, Germany (*Abstract Co-Author*) Employee of Siemens Healthcare GmbH.
Felix G. Meinel, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate whether the detection of foreign bodies (FB) can be improved using dark-field and phase-contrast radiography compared to conventional (transmission) radiographs.

METHOD AND MATERIALS

Experiments were performed using ex vivo pig paws that were prepared with differently sized FB of metal, wood and glass (n=10 each). Paws without FB served as controls (n=30). All images were acquired using an experimental grating-based large object radiography system. A reader study was performed to investigate the diagnostic value of adding dark-field and / or phase-contrast images to transmission images. Five blinded readers (2nd to 4th year radiology residents) were asked to assess the presence or absence of any FB.

RESULTS

Sensitivity for the detection of metal FB was 100% for all readers. The sensitivity for the detection of wooden FB increased from 0-10 % for transmission images to 70-80% when dark-field images were added. For the detection of glass FB, sensitivity increased from 80-100% for transmission images to 90-100% when adding phase-contrast images. Sensitivity for the detection of any foreign bodies was highest when transmission, dark-field and phase-contrast images were viewed simultaneously (87-93%), compared to 60-67% for the sole analysis of transmission images. Specificity was 97-100% across all readers and radiography modalities.

CONCLUSION

Analysis of dark-field images led to a substantially improved detection of wooden FB compared to the sole analysis of transmission images. Detection of glass FB was slightly improved when adding phase-contrast images.

CLINICAL RELEVANCE/APPLICATION

Improved detection of glass and wooden FB on radiographs can facilitate their removal and prevent infectious complications from missed FB.

SSC14-02 Assessing the Relevance of Testing Tube Voltage against the 1kV Remedial or 2kV Suspension Levels in Digital Mammography

Monday, Nov. 27 10:40AM - 10:50AM Room: S503AB

Participants
Kristina Wigati, Leuven, Belgium (*Presenter*) Nothing to Disclose
Lesley Cockmartin, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Guozhi Zhang, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Dimitar Petrov, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG
Soejoko Djarwani, West Java, Indonesia (*Abstract Co-Author*) Nothing to Disclose

Nicholas Marshall, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

kristinatri.wigati@uzleuven.be

PURPOSE

Current protocols give strict guidelines on remedial and suspension levels for tube voltage accuracy. This work examines whether breaching these limits results in unacceptable image quality in digital mammography.

METHOD AND MATERIALS

Images were acquired on a Siemens Inspiration system using (1) the contrast-detail phantom for mammography (CDMAM), evaluated with cdcom computerized reading, and (2) the 3D structured L1-phantom, containing acrylic beads of different diameters in water and inserted lesions (microcalcifications, spiculated and non-spiculated mass models). Five readers evaluated detectability of the inserts in a four-alternative forced-choice study. Images were acquired under automatic exposure control with tube voltage of 29kV for CDMAM and 30kV for the L1-phantom, and then for 2 lower and 2 higher tube voltage settings. Figures of merit are threshold gold thickness (T) for the 0.1 and 2mm disks for CDMAM and threshold diameter (dtr) for the L1-phantom. Mean glandular dose (MGD) was calculated using the Dance formula.

RESULTS

Threshold diameters (dtr) and their 95% confidence interval were 0.114[0.110-0.118]mm at 30kV for microcalcifications in the L1-phantom. Deviations of -1kV or +1kV did not result in significant changes in dtr, with values of 0.117[very wide]mm and 0.118[0.117-0.119]mm respectively. Likewise for -2kV, dtr was 0.110[0.109-0.112]mm, for +2kV however a slight increase in dtr was found (0.122[0.119-0.126]mm). For spiculated and non-spiculated masses similar results were obtained with dtr ranging from 4.7[4.0-5.5]mm to 4.6[2.9-6.4]mm and from 4.3[3.9-4.8]mm to 4.0[1.7-6.3]mm in going from 28kV to 32kV, respectively. Confidence intervals for T for the 0.1mm as well as for the 2mm disk were overlapping for all tube voltage levels tested. Doses ranged from 0.91 to 1.14mGy for the L1-phantom and from 1.02 to 1.29mGy for CDMAM.

CONCLUSION

Deviations in tube voltage of ±1 and ±2kV, corresponding to current remedial and suspension limits, left image quality figures for calcifications and masses largely unaffected but caused changes in dose of up to 20%.

CLINICAL RELEVANCE/APPLICATION

It is unlikely that exceeding tube voltage limits will result in suspension of a system for image quality reasons. Measuring tube voltage is required for dosimetry.

SSC14-03 Coronary Angiography with a Photon-Counting Detector: Initial Results

Monday, Nov. 27 10:50AM - 11:00AM Room: S503AB

Participants
Thorsten Sellerer, MSc, Garching bei Munchen, Germany (*Presenter*) Nothing to Disclose
Korbinian Mechlem, MSc, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Sebastian Ehn, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Manuela Duda, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Eva Braig, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Peter B. Noel, PhD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Daniela Muenzel, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Julia Herzen, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Franz Pfeiffer, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Ernst J. Rummeny, MD, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

thorsten.sellerer@tum.de

PURPOSE

To evaluate the potential of coronary angiography with a spectral photon-counting detector as an alternative to digital subtraction angiography (DSA).

METHOD AND MATERIALS

The coronary arteries of a whole pig heart were imaged with a spectral photon-counting detector after injection of contrast material (Ultravist-370, Bayer Healthcare, Germany). The photon-counting detector (Dectris Ltd., Baden, Switzerland) allows the separation of a polychromatic x-ray spectrum into four distinct energy bins. For this experiment the thresholds of the energy bins were placed at 35, 48, 55 and 66 keV. The heart has been imaged with the following parameters: 90 kVp with 4 mm aluminium filtration, 24 mAs and SID of 165 cm. To generate an iodine only image from a single acquisition, the data were decomposed into basis material line-integrals of iodine and soft tissue equivalents by an in-house developed algorithm.

RESULTS

The combination of a spectral photon-counting detector and material decomposition allowed to generate an iodine only image (featuring only the vascular structures) and a soft tissue image. Especially small vessels, which are previously hidden by the soft-tissue, could be clearly visualized. Compared to a conventional image, the contrast between vessels and soft-tissue is enhanced under the penalty of increased image noise. This increase is due to anti-correlated noise, which is common for any spectral imaging technique. Proper handling of the anti-correlated noise by an in-house developed dedicated de-noising algorithm, resulted in a superior contrast-to-noise ratio of the iodine only image (14.47) compared with the conventional image (9.66).

CONCLUSION

Spectral photon-counting angiography allows in a single acquisition to generate iodine only images. Current DSA techniques allow

high-contrast imaging of coronary arteries, however, require two consecutive acquisitions. The proposed technique provides similar contrast quality with a single acquisition and eliminates the possibility of motion artefacts which are common in DSA imaging.

CLINICAL RELEVANCE/APPLICATION

Spectral photon-counting detectors extend the possibilities of X-ray coronary angiography, which already is an invaluable tool for the diagnosis of heart diseases.

SSC14-04 Pixel Size Has No Measurable Influence on Detection and Identification of Bone Abnormalities in Hand Radiographs

Monday, Nov. 27 11:00AM - 11:10AM Room: S503AB

Participants
Jean-Denis Laredo, MD, Paris, France (*Presenter*) Research Consultant, Cardinal Health, Inc Research Consultant, Laurane Medical Research Consultant, F. Hoffman-La Roche Ltd Research Grant, SERVIER
Jean-Michel Vignolle, Moirans, France (*Abstract Co-Author*) Engineer, TRIXELL-THALES (France)
Jean-Michael Sverzut, MD, Saint Denis, France (*Abstract Co-Author*) Nothing to Disclose
Valerie Chicheportiche, MD, Paris, France (*Abstract Co-Author*) Nothing to Disclose
Eric Lespessailles, MD, Orleans Cedex 2, France (*Abstract Co-Author*) Nothing to Disclose
Bernard Munier, Moirans, France (*Abstract Co-Author*) Engineer, TRIXELL-THALES (France)
Celine Dalverny, Moirans, France (*Abstract Co-Author*) Engineer, TRIXELL-THALES (France)
Thibaut Wirth, PhD, Moirans, France (*Abstract Co-Author*) Application engineer, TRIXELL-THALES (France).

PURPOSE

To evaluate the influence of pixel size on detection and identification of bone abnormalities on hand radiographs obtained from a digital flat-panel.

METHOD AND MATERIALS

Radiographic images of the hands were acquired in 50 patients with proven rheumatoid arthritis using a high-resolution detector (85 µm pixel). A dedicated software was developed to generate, from the high-resolution image, a set of images with pixel sizes ranging from 100 to 200 µm. Image zoom was then adapted in order to standardize image size presentation on a workstation whatever the pixel size. The set of images with variable pixel size were randomly distributed into 3 reading sessions and read independently by 3 experienced musculoskeletal radiologists. Each radiologist was asked to draw a box (ROI) around each abnormality detected in the metacarpo-phalangeal joints and to classify it among 3 predefined types, namely erosions, demineralization and geodes. Finally, 2 radiologists reviewed during a consensual reading all the abnormalities mentioned by any of the 3 readers to decide if each abnormality was actual and review its classification. The results of each separate reading were then compared to those of the consensual reading in order to compute both detection rate (presence/absence) and identification rate (image type) of each reader for each pixel size.

RESULTS

Detection probability is close to 40 % for any of the 3 readers and surprisingly barely depends on pixel size within the range from 85 to 200 µm. However, once detected, an abnormality has a high probability (close to 80%) of being correctly identified. Again, no significant influence of the pixel size was found.

CONCLUSION

Besides mammography and dental, hand radiograph in rheumatic diseases is the most demanding in terms of need for fine detail detection. However, no impact of the pixel size in the 85-200 µm range was found on lesion detection and identification.

CLINICAL RELEVANCE/APPLICATION

The quality of clinical diagnosis in hand radiography shows no improvement when pixel size decreases from 200 µm to 85 µm.

SSC14-05 Performance Assessment of a Clinical X-Ray Angiography Detector with Low Electronic Readout Noise

Monday, Nov. 27 11:10AM - 11:20AM Room: S503AB

Participants
Kenneth A. Fetterly, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

PURPOSE

For x-ray angiography systems, detector electronic readout noise results in sub-quantum-limited performance at low x-ray dose levels, compromises image quality, and limits the ability to reduce patient fluoroscopy dose rates to very low levels. The purpose of this work is to assess performance of a new clinical x-ray angiography detector with low electronic noise.

METHOD AND MATERIALS

The MTF, NPS, and DQE of a standard and low electronic noise angiography detectors were measured over the dose range 2.6 to 65 nGy per frame. The pixel pitch of the standard and low noise detectors was 0.184 and 0.164 mm, respectively and both detectors had crystalline CsI scintillators. X-ray generation was controlled manually and the NPS of electronic noise only was measured using dose 0 nGy per frame. The 81 kVp x-ray beam incident to the detector was filtered with 0.3 mm Cu and attenuated with 6.35 cm Al. MTF was calculated from an image of a 1.0 mm Cu edge positioned at a slight angle with respect to the pixel matrix. Areal NPS was calculated from 100x100 pixel regions of interest from 50 frames acquired with rates 7.5, 15, and 30 s-1. Spatio-temporal NPS was calculated to assess lag. Mean photon fluence 34 mm-2 nGy-1 (~1 pixel-1 nGy-1) was use to estimate DQE.

RESULTS

The pixel value versus dose response of both detectors was linear with gain ~4.8 nGy-1. The MTF of the standard detector was higher than that of the low noise detector. NPS measurements demonstrated that the electronic noise of the standard detector was equivalent to ~5 nGy x-ray quantum noise whereas that of the new detector was ~0.5 nGy equivalent. That neither detector

demonstrated lag is consistent with the short decay time of the scintillators. The two detectors had equivalent quantum-limited low frequency DQE which did not vary with frame rate. Whereas electronic noise compromised DQE of the standard detector for dose less than ~15 nGy per frame, DQE of the new detector was quantum-limited for dose as low as 2.6 nGy.

CONCLUSION

In contrast to the standard detector for which electronic noise compromises DQE for per frame dose less than ~15 nGy, the low electronic noise detector demonstrated quantum-limited performance to very low radiation dose levels.

CLINICAL RELEVANCE/APPLICATION

The low electronic noise detector may facilitate very low radiation dose rate fluoroscopic imaging for a variety of clinical indications for both pediatric and adult patients.

SSC14-06 How Important Is the Quality of the Medical Display in Dental Radiology?

Monday, Nov. 27 11:20AM - 11:30AM Room: S503AB

Participants
Veeratrishul Allareddy, BDS, Coralville, IA (*Presenter*) Nothing to Disclose
Tom Kimpe, Kortrijk, Belgium (*Abstract Co-Author*) employee, Barco NV
Sindhura Allareddy, BDS, MS, Iowa City, IA (*Abstract Co-Author*) Nothing to Disclose
Saulo L. Sousa Melo, DDS, PhD, Iowa City, IA (*Abstract Co-Author*) Nothing to Disclose
Suvendra Vijayan, BDS, MPH, Iowa City, IA (*Abstract Co-Author*) Nothing to Disclose
Hannah Manssens, Kortrijk, Belgium (*Abstract Co-Author*) Employee, Barco NV

For information about this presentation, contact:

tom.kimpe@barco.com

CONCLUSION

The quality of the display has an important impact on perceived image quality, visibility of important anatomical features and inter- and intra-observer variability. A medical display scores significantly better on these aspects compared to a consumer display.

Background

Over the past decade, dental imaging has grown significantly as the prevalence of oral diseases worldwide has increased and there is an expanded awareness of oral health. Analog dental imaging systems that utilize cassettes, film and intensifying screens are rapidly being replaced by digital systems where images are visualized on displays. In general radiology the importance of a high quality medical display has been widely accepted, but in dental applications often consumer level displays are still being used. Some countries such as Germany (DIN 6868-157) have passed legislation to impose minimum quality requirements for dental displays. This paper aims at understanding the importance of the display system is in the overall dental imaging chain.

Evaluation

A retrospective reader study was performed. 16 cases of 4 different modalities (Intraoral radiography; Panoramic radiography; Cone-Beam CT; Cephalometric skull radiography) were read by 4 observers on two different displays. The first display was a medical display (Barco Nio Color 3MP; resolution 2048x1536, 1400:1 contrast, 500 cd/m² brightness) and the second display was a consumer display (Dell Ultra Sharp 24 inch; resolution 1920x1080, 1000:1 contrast, 250 cd/m² brightness). Readers answered questions about image quality and visibility of anatomical features using a 7-point scale.

Discussion

Pooled over the 4 different modalities the medical display scored higher than the consumer display with statistical significance. Observers judged the medical display as having better image quality and easier to perceive important anatomical structures. Also a statistically significant advantage was found in favor of the medical display for each modality individually. When analyzing inter- and intra-observer variability it was found that using a medical display reduced variability and increased reading consistency. This result was also statistically significant.

SSC14-07 Optimizing Infant Osseous Survey Techniques for a Digital Radiography Portable

Monday, Nov. 27 11:30AM - 11:40AM Room: S503AB

Participants
Loretta M. Johnson, PhD, Birmingham, AL (*Presenter*) Nothing to Disclose
Daniel Vergara, MS, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose
Ramses Herrera, Birmingham, AL (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Programming and posting an infant osseous survey chart has decreased the kVp and the exposure indices used for radiography of infants in our neonatal and continuing care nurseries.

Background

During routine quality control image review, a manager noticed an infant leg imaged with 70 kVp and 5 mAs (deviation index +12.7), and he requested a physicist develop an infant osseous survey technique chart for the relatively new Carestream Revolution DRX digital radiography (DR) portable in the neonatal nursery. From our work on neonatal chest and abdomen exams last year, we had some Lucite and Cornish hen phantom studies, and for this bone project, we obtained additional data with Lucite and aluminum phantoms, line-pair phantoms, and a low-contrast phantom, the UAB Fluoro Test Tool (Fluke Model 07-645). We also reviewed 200 images of bone exams of infants weighing between 1095 and 7945 grams (premature infants to 9 months old), noting their image quality as well as the Carestream exposure index (relative x-ray exposure).

Evaluation

The line-pair phantoms and low-contrast phantom were imaged under thicknesses of Lucite appropriate to the thicknesses of these

infants (5.5 to 15 cm, AP and lateral), and they appeared the most clear with 40 to 55 kVp, with specific voltages preferred for specific thicknesses. These phantom studies, along with prior Cornish hen and Lucite phantom studies, also yielded a range of mAs for each kVp and phantom thickness that produced images within our target exposure index range. We then correlated infant bone exams by body part thickness, kVp, mAs, and exposure index, to further narrow our desired technique ranges.

Discussion

The infant osseous survey chart was first posted a month ago, and fifty infant bone images have been acquired since then. Only one of these images exceeded our target exposure index range; the previous month, eleven of 29 infant bone images exceeded our target exposure index range.

SSC14-08 Dose Reduction to the Lens of the Patient's Eye when Using Small Lead Shields over the Temporal Region of the Head and its Effect on Image Quality for Neuro Cone-Beam Computed Tomography (CBCT) Scans and Interventional Fluoroscopic Procedure

Monday, Nov. 27 11:40AM - 11:50AM Room: S503AB

Participants
Zhenyu Xiong, MS, Buffalo, NY (*Presenter*) Research support, Toshiba Medical Systems Corporation
Sarath Vijayan, PHD, Buffalo, NY (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation
Stephen Rudin, PhD, Buffalo, NY (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation
Daniel Bednarek, PhD, Buffalo, NY (*Abstract Co-Author*) Research Grant, Toshiba Corporation

For information about this presentation, contact:

zhenyuxi@buffalo.edu

PURPOSE

The purpose of this study was to evaluate the effectiveness and feasibility of placing small lead shields over the thin bone in the temple region of the skull to reduce radiation dose to the lens of the eye during CBCT scans and interventional fluoroscopically-guided procedures of the head.

METHOD AND MATERIALS

EGSnrc Monte Carlo software modeled the x-ray source of a C-arm fluoroscope and was used to determine the lens dose for single x-ray projections and CBCT scans (different kVps and protocols) for the Zubal computational head phantom, which is based on a CT scan of an adult male whose eye lenses were individually segmented. The eye lens dose was calculated without and with small lead patches of different thicknesses placed over the temporal region. Also CBCT scans were taken with a clinical C-arm system on anthropomorphic head phantoms with lead patches, 0.1 mm to 0.3 mm thick, and the images were compared to assess the effect of the shields on image quality.

RESULTS

For single lateral x-ray projections, a 0.1 (0.3) mm thick lead patch reduced the dose to the left-eye lens by 40%-60% (55%-80%) from 45° to 90° RAO and to the right-eye lens around 30% (55%) from 70° to 90° RAO. For the low, middle and high frame-number CBCT protocols, the reduction of lens dose with 0.1 (0.3) mm thick lead patch is 11.3% (20.3%), 22.2% (40.7) and 27.4% (53.2%) at 110 kVp, respectively. Moreover, the reduction of lens dose with a 0.1 mm thick lead patch decreases from 26% to 21% when the tube peak voltage increases from 90 kVp to 120 kVp for the middle frame-number protocol. For the anthropomorphic phantom CBCT scans, the lead patch introduces streak artifacts that are primarily evident in the orbital region but insignificant in the brain region where most neuro-interventional activity occurs.

CONCLUSION

The use of small lead shields placed over the temple region of the head can reduce the patient's dose to the eye lens considerably without significantly compromising image quality in neuro imaging procedures.

CLINICAL RELEVANCE/APPLICATION

A simple method is presented to reduce the patient's lens dose and thus the risk of cataract induction for neuro-interventional procedures.

SSC14-09 Simulation of Microcalcifications for a Breast Phantom Made through Inkjet Printing

Monday, Nov. 27 11:50AM - 12:00PM Room: S503AB

Participants
Lynda C. Ikejimba, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose
Bahaa Ghammraoui, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Stephen J. Glick, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

lynda.ikejimba@fda.hhs.gov

CONCLUSION

A new type of method was developed to create a breast phantom with realistic microcalcifications through inkjet printing. With a range of MC detectability, the phantom can be used for regular QC and for observer studies.

Background

Breast phantoms serve as an integral part of assessing clinical systems as part of ongoing quality control (QC) as well as for conducting reader studies. Existing breast phantoms may comprise materials with unrealistic properties, or simulate breast structure that is not fully anthropomorphic. This work presents the use of novel materials with inkjet printing to simulate the fibroglandular, adipose, and microcalcification (MC) tissues of the breast, in order to create realistic phantoms for use in QC and reader studies

Evaluation

A digital voxelized breast phantom was first generated using analytical expressions, modelled after a breast with 27% glandular density. Inkjet printing was then used to realize the phantom. To print the fibroglandular-mimicking components, pigmented ink doped with iohexol was created, and printed onto an adipose background consisting of parchment paper. To simulate the MCs, two approaches were taken. For the first, an ink was made by dissolving potassium iodide (KI) salt into a mixture with pigmented ink. For the second, disks of hydroxyapatite, the main component in certain MCs, were created from powder via mechanical press, then crushed, sieved, and placed in a stencil with regular pentagon patterns. Both effective and linear attenuation coefficients of the various materials were measured on a clinical mammography system and by using energy dispersive x-ray spectroscopy systems, respectively.

Discussion

As expected, the linear attenuation of the hydroxyapatite closely modeled that of real MCs. The effective linear attenuation of the KI ink alone was sufficiently high as well, with a single layer of ink. The signal strength can be increased by printing over the signals multiple times, or decreased by reducing the concentration of the salt. Signals of varying strength would be used to achieve different levels of MC difficulty in the phantom.

PHS-MOA

Physics Monday Poster Discussions

Monday, Nov. 27 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
David M. Gauntt, PhD, Birmingham, AL (*Moderator*) Nothing to Disclose

Sub-Events

PH212-SD-MOA1 Simulation Ultrasound as a Breach Between Physics and the Ultrasound Machine

Station #1

Participants
Luis F. Serrano, MD, BOGOTA, Colombia (*Presenter*) Nothing to Disclose
Humberto A. Rivera Gonzalez, MD, Bogota, Colombia (*Abstract Co-Author*) Nothing to Disclose
Hernan D. Paez Rueda, MD, Bogota, Colombia (*Abstract Co-Author*) Nothing to Disclose
Angela P. Moreno, MD, Bogota, Colombia (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

MONOSERRANO@GMAIL.COM

CONCLUSION

With the inclusion ofultrasound simulation techniques in breast imaging we offer trainees the opportunity to both suceed and fail in a controlled environment without the risk of adverse events or harm to patients . Through simulating interventions we can teach physics, utilization of equipment presets, how to correct parameters, and artifacts. The simulation techniques laid out above will help our students and residents to deveolop skills to recognized imaging errors and solution solving problems by correcting the right parameter.

Background

By way of maximizing the learning experience in physics for the utrasound modality for our students, residents and fellows, we designed a simulation lab with departmental/homemade variety of phantoms, which recreate many biochemical ultrasound behivors, which place several scenarios in our imaging, that allow us to review the ultrasound system presets and correct parameters, by understanding the physics and how it translates into each echotexture. Additionally the hands on simulation while doing interventions, improve the trainee skills, and help better to understand lesion content, what to expect, best approach, and also understanding the angulation between probe and needle to use, and feeling how different is the resistant of each different tisue, like in cases of a breast biopsy compared to a clear versus thick aspiration or even a muscle drainge or bone biopsy.

Evaluation

By multiple hand-on sessions, and simulation lab we recreate a life experience, similar to the patient care examination. Our departamental -made phantoms are created and builted up according to our needs and specific situations, so we can recreate ultrasound findings like cysts of different contents (clear, colored, thick, viscous, etc),

Discussion

Ultrasound modality is the real time exam which needs all the attention and the true expertise of the examiner. Knowing how to deal with the ultrasound machine, allows the radiologist and technologist maximize the power of thesystem which translates in perfect quality imaging, less artifacts, but most importantly, human ability to correct errors by understanding the physics behind the scenes.

PH213-SD-MOA2 Ultra-Low-Dose versus Low-Dose CT of the Paranasal Sinuses with Using Volumetric 320-Row Detector CT System

Station #2

Awards
Student Travel Stipend Award

Participants
Berhan Pirimoglu, MD, Erzurum, Turkey (*Presenter*) Nothing to Disclose
Recep Sade, MD, Erzurum, Turkey (*Abstract Co-Author*) Nothing to Disclose
Sedat Sakat, Erzurum, Turkey (*Abstract Co-Author*) Nothing to Disclose
Hayri Ogul, Erzurum, Turkey (*Abstract Co-Author*) Nothing to Disclose
Suat Eren, MD, Erzurum, Turkey (*Abstract Co-Author*) Nothing to Disclose
Mecit Kantarci, MD,PhD, Erzurum, Turkey (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

berhan.dr@gmail.com

PURPOSE

To evaluate image quality of low-dose (LD) and ultra-low-dose(ULD) protocol in the paranasal sinus CT using single volumetric 320-row multidetector CT technique.

METHOD AND MATERIALS

From September to December 2016, Both of the LD including 135 kVp and 5 mAs and ULD including 80 kVp and 5 mAs paranasal CT protocols were simultaneously performed on 40 patients using single volumetric 320-row multidetector CT device. LDCT images assigned to control group and ULDCT images also assigned to study group. Image quality for bony structures, air filled structures and soft tissues were independently assessed for each group by three blinded observers using a three-point grading scale (0=not diagnostic, 1=partially diagnostic 2=diagnostic). Effective dose was calculated from the dose-length product.

RESULTS

The effective radiation dose which calculated for the control group scans was 0.037 ± 0.003mSv. But, it was 0.0099± 0.001mSv for the study group scans. The effective radiation dose of study group was statistically significant lower than control group ($p<0.001$). For observer 1, 2 and 3; the overall mean diagnostic values were 1.71, 1.73 and 1.92 in the study group, respectively; the overall mean diagnostic values also were 1.87, 1.95 and 1.99 in the control group, respectively. Despite significant lowering of the radiation doses, image qualities were sufficient for evaluating all the bony structures, air filled structures and soft tissues except for eye muscle, retrobulbar fat and eye bulb.

CONCLUSION

As compared to control group`s findings, we suggest that the radiologists could be perform our ultra-low-dose paranasal CT protocol in evaluating bones and air filled structures except for soft tissue structures. Our results present that low-dose and ultra-low-dose protocols provide significant dose reduction without the loss of diagnostic image quality for paranasal sinus CT. Paranasal sinus CT imaging can be performed at very low radiation exposure maintaining high image quality using a single volume 320-row detector CT device using 135 kVp and 80 kV with 5 mAs.

CLINICAL RELEVANCE/APPLICATION

The paranasal sinus CT imaging can be performed at very low radiation exposure maintaining high image quality using single volume 320-row detector CT device via 135 kV and 80 kV with 5 mAs.

PH214-SD-MOA3 Radiation Dose Reduction with Frame Rate Conversion in X-Ray Fluoroscopic Imaging Systems with Flat Panel Detector: Clinical Retrospective Analysis

Station #3

Participants
Noriyuki Sakai, Bunkyo, Japan (*Presenter*) Nothing to Disclose
Katsuyuki Tabei, Bunkyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Jiro Sato, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Keiichi Yano, Bunkyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Osamu Abe, MD, PhD, Itabashi-ku, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Frame rate conversion (FRC) is a new technology in X-ray fluoroscopic imaging systems with flat panel detector. FRC provides images at a frame rate twice the X-ray pulse rate by interpolation of two consecutive fluoroscopic images. For example, when X-ray pulse rate is 6.25 pulses per second (p/s), FRC provides 12.5 frames per second images. These interpolation frames are created based on motion tracking technique by detecting the vector of the motion of objects. We hypothesized that FRC would reduce radiation dose in X-ray fluoroscopic examinations without extending fluoroscopy time. Our purpose was to retrospectively compare radiation dose and fluoroscopy time between examinations with and without FRC in clinical examinations.

METHOD AND MATERIALS

The institutional review board approved the clinical retrospective analysis. We extracted examinations performed with FRC (FRC group: 6.25 p/s) and without FRC (Conventional group: 12.5 p/s) from May 23, 2016 to Dec. 31, 2016. The extracted 270 examinations were consisted of 63 upper gastrointestinal series, 57 urographies, 44 fistulographies, 31 nerve root blocks, 31 myelographies, 26 small bowel series, 16 examinations such as removing ileus tube, and two joint dislocation reductions. We compared the mean cumulative dose area products (DAP) of fluoroscopy and mean fluoroscopy time between the groups with FRC (n=159) and without FRC (n=111), respectively. We used the Brunner-Munzel test to identify any significant differences between the groups in both the mean cumulative DAP and mean fluoroscopy time, because the F-test did not show the equality of variances. A p-value less than 0.05 was considered significant.

RESULTS

There was a significant difference in mean cumulative DAP of fluoroscopy between the groups (FRC group, 2647.99 mGy·cm2; Conventional group, 5055.73 mGy·cm2; $P < 0.001$). There was no significant difference in mean fluoroscopy time between the groups (FRC group, 218 sec; Conventional group, 240 sec; $P > 0.05$).

CONCLUSION

FRC significantly reduced cumulative DAP of fluoroscopy to 52% compared with the conventional method, although there was no significant difference in fluoroscopy time.

CLINICAL RELEVANCE/APPLICATION

Dose reduction could be achievable in X-ray fluoroscopic examinations without extending fluoroscopy time by using FRC.

PH215-SD-MOA4 High Dynamic Range Ultrasound for Imaging Tendon Pathology

Station #4

Participants
Yiming Xiao, PhD, Montreal, QC (*Presenter*) Nothing to Disclose

Hassan Rivaz, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Hoda Hashemi, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose
Mathieu Boily, MD, Montreal, QC (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

As a cost-effective and accessible imaging modality, ultrasound (US) allows the physicians to obtain diagnostic images in real-time. Conventional B-mode US scans compress raw imaging signals with a logarithm function to fit the limited dynamic range of the display. This results in the loss of anatomical details and frequent image gain adjustments that can potentially impact the diagnosis. We propose a new high dynamic range (HDR) US to alleviate the drawbacks, and show the application in imaging patellar tendon pathologies.

METHOD AND MATERIALS

US scans were obtained from 3 patients with patellar tendinosis using the E-cube R12 scanner (Alpinion, Bothell, WA), and the raw radio-frequency (RF) images were saved. Amplitude demodulation was performed using Hilbert transformation of RF images, and then the results were processed with HDR tone mapping similar in photography for displaying HDR US. To evaluate the performance of HDR US, we measured the contrast-to-noise ratios (CNR) between the abnormal and healthy regions of the tendons, and image entropy that measures the richness of image content. Results of HDR US were compared against conventional log compression US at 0dB (no adjustment) and -26dB (best 2D gain setting) gains.

RESULTS

For log compression US at 0dB and -26dB gains, and HDR US, the mean CNRs between the tendinosis and healthy tendon regions are measured at 3.05, 5.42, and 8.70 while the mean image entropies were computed at 7.42, 7.50, and 7.69 respectively. In addition, the mean CNRs of torn tissue against tendinosis regions are 3.01, 4.81, and 6.54 for log compression US at 0dB and -26dB gains, and HDR US. HDR ultrasound outperforms the log compression US in both metrics. Visually, tendinosis and partial tears can be better delineated using HDR US.

CONCLUSION

HDR US can effectively enhance the anatomical details, and particularly the abnormal regions without the need for manual adjustments of 2D gain. To the best of our knowledge, it is the first time HDR processing is used in ultrasound.

CLINICAL RELEVANCE/APPLICATION

Without the need for manual gain adjustments, HDR US can better image abnormal tendons and potentially help improve the diagnostic accuracy. The technique can also be extended to other ultrasound applications.

PH216-SD-MOA5 Potential for Coronary K-Edge Imaging with Spectral Photon-Counting CT

Station #5

Participants
Salim Si-Mohamed, Lyon, France (*Presenter*) Nothing to Disclose
Monica Sigovan, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Daniel Bar-Ness, Bron, France (*Abstract Co-Author*) Nothing to Disclose
Louis Perrier, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Philippe Coulon, PhD, Suresnes, France (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Loic Boussel, MD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose
Philippe C. Douek, MD, PhD, Lyon, France (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate coronary K-edge angiography of a spectral photon-counting CT system (SPCCT).

METHOD AND MATERIALS

SPCCT (Philips, Haifa, Israel) with multiple energy bins was used to scan three ex vivo human hearts filled with wax for a morphological shape and with gadolinated contrast agent in the coronary arteries. Concentrations of gadolinium were chosen such as they simulated attenuation found in clinical coronary angiography (400 HU for both, i.e. 14% dilution of dotarem, gadoteride, 0.5 mmol/ml). Conventional CT images and gadolinium specific K-edge images were reconstructed. Measurements of coronary lumen diameter in regions of calcifications were performed on both image types and results were compared using a paired t-test.

RESULTS

SPCCT allowed full 3D heart imaging (Figs A-B) with clear differentiation between calcification and gadolinium using spectral K-edge images (Fig C). Gd-specfici K-edge images demonstrated exclusively the lumen with the benefit of removal of all the other structures, e.g. calcified plaque, soft tissue and with absence of blooming artefact. Mean lumen diameters (n=21) measured on K-edge images were higher than measured on conventional CT images in case of calcifications (2.0±0.13 cm vs 1.8±0.1 cm, $p<0.05$).

CONCLUSION

SPCCT allowed better depiction of coronary lumen using K-edge imaging with a gadolinated contrast agent.

CLINICAL RELEVANCE/APPLICATION

Better evaluation of coronary lumen is achievable by K-edge gadolinium angiography.

PH217-SD-MOA6 Virtual Dual-Energy (VDE) Imaging: Separation of Bones from Soft Tissue in Chest Radiographs (CXRs) by Means of Anatomy-Specific (AS) Orientation-Frequency-Specific (OFS) Deep Neural Network Convolution (NNC)

Station #6

Participants
Amin Zarshenas, MSc, Chicago, IL (*Presenter*) Nothing to Disclose
Jaimeet V. Patel, BS, Des Plaines, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

Paul Forti, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Kenji Suzuki, PhD, Chicago, IL (*Abstract Co-Author*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

mzarshen@hawk.iit.edu

PURPOSE

Many lung nodules that were missed by radiologists, as well as computer-aided detection (CAD) systems, overlapped ribs and/or clavicles in CXRs. Our purpose was to develop a VDE imaging technique to separate ribs and clavicles from lung nodules and soft tissue in CXRs by means of ASOFS NNC.

METHOD AND MATERIALS

We developed a mixture of expert ASOFS deep NNC models employing neural network regression with 3 layers in a convolutional manner to convert a standard CXR to an image that looks like a dual-energy bone image; thus, term VDE. A 2-level Wavelet decomposition was employed to obtain 7 orientation-frequency-specific components, forming deep NNC with 13 layers. Histogram-based segmentation was used to obtain 8 anatomic segments. We employed 56 (8 anatomies 7 orientation-frequency components) NNC experts, each of which was trained to learn the relationship between input CXRs and the corresponding "teaching" dual-energy bone images, focusing on a specific anatomy, orientation-frequency component. We trained our NNC with four CXRs with nodules. Once trained, our technology no longer required dual-energy images, and it provided VDE bone images where soft tissue was substantially attenuated, while bony structures were preserved. This image was then subtracted from the corresponding CXR to provide a VDE soft-tissue image from which bones were removed. For testing, we collected an independent database of 118 CXRs with nodules with corresponding "gold-standard" dual-energy images acquired with a dual-energy imaging system (FCR 9501 ES, Fuji Medical Systems, CT). We performed quantitative evaluation of our results by using the structural similarity (SSIM) image-quality index.

RESULTS

Our NNC VDE technology was able to separate ribs and clavicles from lung nodules and soft-tissue structures very accurately in 118 CXRs and provided bone-like and soft-tissue-like images. Comparing to the original CXRs, our VDE bone images had substantially higher (t-test; $P<.05$) similarity (SSIM from 0.57 to 0.91) to the "gold-standard" dual-energy bone images.

CONCLUSION

Our ASOFS deep learning converted CXR images to VDE soft-tissue images, where bony structures were separated from soft tissue accurately, which offered the improved conspicuity of lung nodules and vessels.

CLINICAL RELEVANCE/APPLICATION

VDE technology requiring only a "single" CXR without additional radiation dose would be useful for radiologists as well as CAD in detecting lung nodules in CXRs.

PH218-SD-MOA7 Preprogrammed Tube Current Modulation vs Attenuation-Based Tube Current Modulation vs Fixed Current Acquisitions: Which Technique Delivers the Lowest Doses in Dental CBCT Scans?

Station #7

Participants
Andreas Stratis, Leuven, Belgium (*Presenter*) Nothing to Disclose
Guozhi Zhang, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Ria Bogaerts, Herestraat 49, Belgium (*Abstract Co-Author*) Nothing to Disclose
Reinhilde Jacobs, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG

For information about this presentation, contact:

andreas.stratis@uzleuven.be

PURPOSE

To compare 3 different tube current schemes for selected clinical protocols on a dental CBCT (dCBCT) scanner via Monte Carlo (MC) calculations of organ doses.

METHOD AND MATERIALS

An EGSnrc MC framework was customized and validated for a NewTom-Vgi-evo (QR srl, IT) dCBCT. The max and min mA of the rotation are defined by an AP and LAT prescan acquisition respectively; a mathematical formula (Preprogrammed Tube Current Modulation-PTCM) is then used to predefine the mA at each projection. We calculated organ doses for a 12 y.o male who was scanned for an upper-premolar (UP), lower-premolar (LP) 5x5 cm^2 and an upper-lower-jaw (ULJ) 8x8cm^2 protocol with MC and a 12 y.o voxel model from CT images. Theoretical attenuation-based TCM schemes (ATCM) were generated via raytracing for the different FOVs of the three protocols in Matlab. The mA at each projection was based on the formula: $mA\theta = mAref * (A\theta/Aref)^a$, where $A\theta$ is the attenuation per projection, the (Aref,mAref) are the attenuation and the respective mA values of a reference projection and a is the modulation strength. We considered AP as reference projection as this is the most attenuating one and would determine the noise in the image when scanned with fixed mA. We calculated the doses for different modulation strengths ($0 <= a <= 1$). Finally, we calculated the dose for fixed mA, defined by the same AP prescan acquisition.

RESULTS

Compared to the fixed mA, the PTCM reduced the organ doses with an average of 23% , 24% and 31% in ULJ, LP and UP protocols respectively (highest dose decrease to salivary glands and oral mucosa). For ATCM, the highest dose reductions were observed for a=1 (constant noise in all projections) with on average 39%, 48% and 49% organ dose decrease for ULJ, LP and UP respectively (max reduction to salivary glands) compared to fixed mA scans. The PTCM provided doses similar to a =0.5 of ATCM for ULJ (where the centre of the FOV is along the midline of the mouth cavity) and to a=0.25 for UP and LP (center of FOV off-midline positioned) implying an influence of the PTCM from the position of the FOV.

CONCLUSION

PTCMs can lead to large dose reductions, yet ATCMs can further reduce the dose especially in off-midline-laterally positioned FOVs

CLINICAL RELEVANCE/APPLICATION

Dose-reduction-techniques (ATCM, PTCM) shall be employed by dCBCT vendors to keep doses ALARA and to dosewise counteract to the increasing use of dCBCTs in radiology, especially for pediatric patients

PH106-ED-MOA9 Virtual High-Dose (VHD) Technology: Radiation Dose Reduction in Digital Breast Tomosynthesis (DBT) by Means of Supervised Deep-Learning Image Processing (DLIP)

Station #9

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

For information about this presentation, contact:

jliu118@hawk.iit.edu

TEACHING POINTS

1) To understand the radiation dose issue with DBT in breast cancer screening 2) To learn the basics of DLIP as an approach to reduce the radiation dose in breast cancer screening 3) To understand the performance and clinical utility of our radiation dose reduction technology for DBT

TABLE OF CONTENTS/OUTLINE

Outline: A. Radiation dose issue with DBT for breast cancer screening B. Basics of DLIP for converting lower-dose (LD) to higher-dose (HD) tomosynthesis images to reduce radiation dose C. Radiation dose reduction, pre-clinical study: Breast cadaver phantom image analysis D. Radiation dose reduction, clinical translation study: Clinical cases image analysis E. Quantitative evaluation: Image quality vs. radiation dose reduction F. Benefits and limits of DLIP for DBT We present: 1) Radiation dose in DBT exams can be 1.4-2.3 times higher than that in 2D digital mammography 2) DLIP converted 25% dose images (1.35 mGy) of cadaver phantoms to VHD images with image quality equivalent to 119% dose images (6.41 mGy), achieving a 79% dose reduction 3) The image quality of VHD images of clinical cases was equivalent to that of full-dose images. Our technology significantly reduced noise in half-dose images, while preserving tissue and lesions 4) The processing time for a DBT study was 0.48 sec. on a GPU (GeForce GTX TITAN Z, Nvidia, CA)

PHS-MOB

Physics Monday Poster Discussions

Monday, Nov. 27 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
David M. Gauntt, PhD, Birmingham, AL (*Moderator*) Nothing to Disclose

Sub-Events

PH220-SD-MOB1 Measurement of Effective Dose of Ovaries in Hysterosalpingography using a Patient-Specific 3D-Printed Phantom

Station #1

Participants
Chae Yeon Han, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
Sang Jun Lee, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Mi-Seob Ahn, RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Young Cheol Joo, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Il Soo Lee, RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jung Soo Yoon, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Han Yong Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Yun Jae Lee, RT,RT, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Dong Min Youn, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

ytotese@naver.com

PURPOSE

Hysterosalpingography (HSG) is a widely-used radiological examination method for the assessment of abnormalities related to the uterus and fallopian tube. However, this method requires that the patient receive unavoidably high dose of irradiation to the ovaries. It is difficult to measure radiation dose for the ovaries. Therefore, we developed a patient-specific, 3D-printed phantom. This study aimed to measure the radiation dose to the ovaries directly using this patient-specific, 3D-printed phantom.

METHOD AND MATERIALS

Ten HSG examinations were perfomed in 2017 using conventional X-ray or fluoroscopy. All information concerning exposure conditions were recorded for each patient. We obtained computed tomography images of all 10 patients and converted these images to 3D printer files. We then made 10 patient-specific, 3D-printed phantoms using a 3D printer. Total body volume and the position of the ovaries were measured, and any differnces between the patients and phantoms were calculated. A metal-oxide-semiconductor field-effect transistor was inserted on each side of all ovaries on the patient-specific, 3D-printed phantom under the same conditions as the patients. We then measured the absorbed and effective dose to the ovaries.

RESULTS

Patient-specific, 3D-printed phantoms had the same total body volume and the same ovary positions as the patients. The maximum absorbed dose to the ovaries from the 10 HSG procedures was 2.53 cGy, the minimum absorbed dose was 1.25 cGy, and the mean absorbed dose was 1.85±0.36 cGy. The maximum effective dose to the ovaries was 2.02 mSv, the minimum effective dose was 1.00 mSv, and the mean effective dose was 1.48±0.29 mSv.

CONCLUSION

Although HSG is a useful radiological examination, it requires a high dose of radiation to the ovaries. Because the ovaries are one of the most radiosensitive organs, knowledge of the exact dose to the ovaries is necessary. In this study, we were able to measure the effective dose of the ovaries in 10 HSG patients. This suggests that the patient-specific, 3D-printed phantom will help to determine diagnostic reference levels (DRLs) and to predict patient dose in HSG and other examinations.

CLINICAL RELEVANCE/APPLICATION

Hysterosalpingography is a widely-used radiological examination method of infertile women and is recommended in the uterus of the commonest abnormalities.

PH221-SD-MOB2 Do Lead Glasses Protect Only the Eyes? A Study on the Effect of Protective Devices in the Dose Received By the Brain of Interventional Radiologists

Station #2

Participants
Edilaine Honorio da Silva, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Lara Struelens, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Peter Covens, Brussels, Belgium (*Abstract Co-Author*) Nothing to Disclose
Filip Vanhavere, Mol, Belgium (*Abstract Co-Author*) Nothing to Disclose
Nico Buls, DSc, PhD, Jette, Belgium (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

ehdsilva@sckcen.be

PURPOSE

To assess the impact of using lead glasses, lead caps and ceiling screens on the radiation dose to the hippocampus and white matter of the physician's brain during interventional procedures.

METHOD AND MATERIALS

Anthropomorphic mathematical phantoms were used both as patient and operator models to simulate an interventional procedure in which the thorax of the patient was irradiated. The head of the operator, including the hippocampus and white matter, was simulated in greater detail by the Zubal phantom, composed of soft tissue, muscles, bones, blood, fat and skin. Furthermore, the operator phantom was equipped with a 0.5 mm thick lead apron and thyroid collar. Other simulated protection devices included: two models of lead glasses (frontal lenses 0.75 mm thick), with and without side shielding (0.5 mm thick), two models of lead caps (surgical and hood) both 0.5 mm thick and two sizes of ceiling screens (big: 61x76 cm and small: 40x50 cm, both 0.5 mm thick). Different distances between the ceiling screen and the patient ´s body (1 cm and 15 cm), as well as different beam projections were simulated using the Monte Carlo code MCNPX.

RESULTS

All protection devices reduced the dose in the brain, with varying effectiveness. The most effective was the ceiling screen for which the size was less important than positioning. When placed far from the patient, the dose reduction by the big screen could be as low as 28%, whereas the lowest dose reduction obtained with the small screen placed close to the patient was already 65%. Lead glasses can provide up to 20% dose reduction to the left hemisphere, regardless having side shielding. The lead cap of surgical model provides poor shielding (less than 21%), but the hood model reduces the dose by more than 50%

CONCLUSION

Our study shows that protective glasses offer some additional dose reduction to the brain of the operator. A ceiling screen remains the most effective device among those studied

CLINICAL RELEVANCE/APPLICATION

Interventional radiologists and cardiologists receive the highest occupational doses in radiology. The use of protection devices can dramatically decrease the dose to their brain.

PH222-SD-MOB3 Ultra-Low-Dose Periradicular Infiltration of the Lumbar Spine: Spot Scanning and Its Potential for Further Dose Reduction by Replacing Helical Planning CT

Station #3

Participants
Fabian Elsholtz, Berlin, Germany (*Presenter*) Nothing to Disclose
Lars-Arne Schaafs, MD, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose
Christoph Erxleben, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose
Bernd K. Hamm III, MD, Berlin, Germany (*Abstract Co-Author*) Research Consultant, Toshiba Medical Services Corporation ; Stockholder, Siemens AG; Stockholder, General Electric Company; Research Grant, Toshiba Medical Services Corporation Research Grant, Koninklijke Philips NV; Research Grant, Siemens AG ; Research Grant, General Electric Company; Research Grant, Elbit Imaging Ltd; Research Grant, Bayer AG ; Research Grant, Guerbet SA; Research Grant, Bracco Group; Research Grant, B. Braun Melsungen AG; Research Grant, KRAUTH medical KG ; Research Grant, Boston Scientific Corporation; Equipment support, Elbit Imaging Ltd; Investigator, CMC Contrast AB
Stefan M. Niehues, MD, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

fabian.elsholtz@charite.de

PURPOSE

Computed tomography (CT)-guided periradicular infiltration has become an accepted procedure for treating radiculopathy-associated low back pain. The purpose of this study is to compare spot scanning and segmental helical planning CT in terms of dose reduction.

METHOD AND MATERIALS

Eighty-five patients underwent CT-guided single-site lumbar periradicular therapy using an ultra-low-dose protocol. Prior imaging was not available for planning. Sixty-three patients were examined with a new

dedicated spot scanning technique (group I), and 22 patients underwent conventional segmental planning CT examinations with helical image acquisition and served as controls (group II). The examinations were reviewed retrospectively for dose-length product (DLP) and number of acquisitions required for intervention. The pain reduction accomplished with the intervention was recorded for quality assurance.

RESULTS

The median DLP was 0.80 mGy*cm for spot scanning versus 6.50 mGy*cm for segmental planning CT. Thus, the contribution of the planning scan to the total interventional dose decreased from 73% to 25% As a result, the total interventional dose was reduced significantly from a median DLP of 8.90 mGy*cm to 3.20 mGy*cm (-64%). The acquisitions required during the intervention had a median DLP of 2.40 mGy*cm for group I and 2.35 mGy*cm for group II, showing no significant difference. Median pain reduction in both groups was 2 points on the numeric rating scale.

CONCLUSION

Dedicated spot scanning for planning reduced the total median effective dose of the intervention by more than 64 % without increasing the number of images required during the interventional procedure. Significant pain reduction was achieved with both approaches. Spot scanning is recommended for dose reduction.

CLINICAL RELEVANCE/APPLICATION

In CT fluoroscopy spot scanning and single volume acquisition for planning purpose will significantly reduce overall dose compared to limited helical acquisition. This dose reduction does not impact the interventional procedure itself nor the outcome as seen in periradicular infiltration.

PH223-SD-MOB4 Automated Multi-Organ Segmentation in Abdominal CT with Hierarchical 3D Fully-Convolutional Networks

Station #4

Participants
Holger R. Roth, PhD, Nagoya, Japan (*Presenter*) Nothing to Disclose
Hirohisa Oda, MENG, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuichiro Hayashi, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Masahiro Oda, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Natsuki Shimizu, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Kensaku Mori, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Michitaka Fujiwara, MD, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazunari Misawa, MD, PhD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

rothhr@mori.m.is.nagoya-u.ac.jp

PURPOSE

Automated segmentation is an important yet challenging problem for medical image analysis and computer-aided diagnosis. Recent advances in deep learning have made it feasible to produce dense voxel-wise predictions of volumetric images. We show that a multi-class 3D fully convolutional network (FCN) trained on manually labeled CT scans of seven abdominal structures (artery, vein, liver, spleen, stomach, gallbladder, and pancreas) achieves competitive segmentation results, while avoiding the need for handcrafting features or training organ-specific models.

METHOD AND MATERIALS

We propose a two-stage, coarse-to-fine approach that trains a FCN model to roughly delineate the organs of interest in the first stage (seeing ~40% of the voxels within a simple, automatically generated binary mask of the patient's body). We then use these predictions to define candidate regions that will be used to train a second FCN. This step reduces the areas the FCN has to classify to ~10% while maintaining a recall high of >99%, focusing on more detailed segmentation of the organs. Our dataset includes 331 contrast-enhanced abdominal CT images in the portal venous phase. Each CT volume consists of 460-1177 slices of 512×512 pixels. The voxel dimensions are [0.59-0.98, 0.59-0.98, 0.5-1.0] mm. A random split of 281/50 patients is used for training and validating the network, i.e., determining when to stop training to avoid overfitting. In both training stages, we employ smooth B-spline deformations to both the image and label data for data augmentation. We test our models on completely unseen data of 150 CT scans acquired at a different hospital.

RESULTS

Our approach achieves an improved Dice score of 7.5 percentage points per organ on average in the validation set. In challenging organs of the unseen test set, like the pancreas, our model improves the mean Dice score from 68.5 to 82.2%, achieving the highest reported score on this dataset.

CONCLUSION

Our model can produce competitive results for multi-organ segmentation on a clinical CT dataset while running on a single GPU. It compares favorably to recent state-of-the-art work on a completely unseen dataset.

CLINICAL RELEVANCE/APPLICATION

The method can be applied the other sets of organs and/or can be utilized for transfer learning where it can act as initialization for applications with less annotated examples available.

PH224-SD-MOB5 A Grating-Based Phase-Contrast Mammography Clinical Investigational Device

Station #5

Participants
Carolina Arboleda Clavijo, MSc,DIPLENG, Zurich, Switzerland (*Presenter*) Nothing to Disclose
Zhentian Wang, PhD, Villigen, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Konstantins Jefimovs, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Iwan Jerjen, Villigen PSI, Switzerland (*Abstract Co-Author*) Departmental Research Grant, Koninklijke Philips NV
Thomas Koehler, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Udo Van Stevendaal, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Norbert Kuhn, Hamburg, Germany (*Abstract Co-Author*) Philips employee
Sven Prevrhal, PhD, San Francisco, CA (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV
Serafino Forte, MD, Baden, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Rahel A. Kubik-Huch, MD, Baden, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Cornelia Leo, Baden, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Gad Singer, MD, Baden, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Magda Marcon, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Andreas Boss, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Ewald Roessl, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Marco Stampanoni, PhD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

carolina.arboleda@psi.ch

PURPOSE

Grating-based phase-contrast mammography might facilitate breast cancer detection, as several works have indicated. The technological transfer of the method to clinical operation requires covering a large field of view (FOV) within limited exposure time and dose. We addressed this challenge by integrating a grating interferometer into a Philips Microdose Spectral Mammography (PMSM) L50 system. The investigational device has been recently commissioned by measuring freshly resected human breast mastectomy samples.

METHOD AND MATERIALS

Three identical interferometers (consisting of a source grating and three phase-analyzer grating pairs) were used to cover the whole FOV (26 cm x 21 cm). The original L50 compression paddle was used as breast support and a dedicated compression holder was built for sample compression, accommodating a sample thickness up to 3.4 cm. The Aluminum filter was removed from the original device, to compensate for the flux loss caused by the gratings. A mastectomy sample (obtained via ethical approval Nr. EKNZ 2015'132) was imaged directly after surgical extraction at 38 kVp with a total scanning time of 15 s. Its compression thickness was 2.2 cm and, in this experimental setup, where filtration and technique factors had not been optimized, the calculated MGD was 2.3 mGy (air kerma: 4 mGy), assuming an 18.1 % glandular density. Differential phase and dark-field images of the sample were retrieved with an iterative algorithm.

METHOD AND MATERIALS

Three identical interferometers (consisting of a source grating and three phase-analyzer gratings pairs) were used to cover the whole FOV (26 cm x 21 cm). The original L50 compression paddle was used as breast support and a dedicated compression holder was built for sample compression, accommodating a sample thickness up to 3.4 cm (Fig. 1a). A mastectomy sample (obtained via ethical approval Nr. EKNZ 2015'132) was imaged directly after surgical extraction at 38 kVp with an exposure time of 15 s. Its compression thickness was 2.2 cm and the calculated MGD was 3.6 mGy, assuming an 18.1 % glandular density. Differential phase and dark-field images of the sample were retrieved with an iterative algorithm [5].

RESULTS

Gratings were successfully aligned and a Moiré fringe of 20 % mean visibility was generated. The fused DPC/absorption image obtained with the novel investigational device was able to provide a sharper delineation of the structure edges inside the sample.

CONCLUSION

A first-Talbot-order grating-based phase contrast mammography investigational device based on a Philips L50 system has been successfully commissioned and tested by measuring a fresh human breast mastectomy sample. Future work will address some vibration-induced issues, in order to fine-tune hardware and software and prepare for further, more extensive tests toward in-vivo measurements. In addition, a fifth-Talbot-order interferometer, which is expected to be more sensitive to scattering changes, will be implemented as well.

CLINICAL RELEVANCE/APPLICATION

We introduce the first grating-based phase-contrast mammography investigational device, fully compatible with clinical operation constraints.

PH225-SD-MOB6 Evaluation of Iodine Contrast to Noise Ratio for Monoenergetic Images on a Photon Counting Detector CT

Station #6

Participants
Wei Zhou, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Dilbar Abdurakhimova, MA, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Michael R. Bruesewitz, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG

PURPOSE

The purpose of this study is to determine the optimal iodine contrast-to-noise ratio (CNR) achievable for different object sizes using a single protocol on photon-counting-detector (PCD) CT and monoenergetic

images, and to compare to single energy (SE) and dual-source, dual-energy (DSDE) CT.

METHOD AND MATERIALS

Vials containing 3 concentrations of iodine (5, 10, and 20 mgI/cc) were placed in torso-shaped water phantoms of 5 sizes (widths of 25, 30, 35, 40, 45 cm). Phantoms were scanned on a 2nd generation DSDE scanner (Definition Flash, Siemens Healthcare) with both SE (80, 100, 120, 140 kV) and dual energy modes (80/Sn140, 100/Sn140 kV). Tube current was automatically adjusted based on phantom size (CareDose4D, 120 kV, 200 QRM), with CTDIvol ranging from 5.1 to 22.3 mGy for different phantom sizes. PCD scans were all performed at 140 kV, with energy thresholds of 25 and 75 keV. CTDIvol of both DSDE and PCD were matched to that of the SE scans. All images were reconstructed with D30 kernel and 60 mm field of view. Monoenergetic Plus (Mono+) images for DSDE and PCD acquisitions were generated using an offline tool (Siemens Healthcare). CNR was calculated for each scan. The optimal keV or kV was chosen at the point of highest CNR that had no noticeable artifacts.

RESULTS

For 10 mgI/cc vials in the 35 cm phantom, the optimal CNR of Mono+ images for PCD and DSDE protocols was at 50 keV. The optimal CNR of Mono+ images on PCD (22.4) was comparable to that of the best DSDE protocol (23.9) and was slightly higher than that of the best SE kV (80kV: 19.7). The difference of optimal CNR values between PCD and SE protocols in general increased with phantom size. For 10 mgI/cc vials, optimal CNR value of PCD Mono+ images was 6.5% higher than that of SE at the 25 cm phantom size, while at the 45 cm phantom size, the optimal CNR of PCD Mono+ images was 28.1% higher than that of SE.

CONCLUSION

PCD CT demonstrated comparable iodine CNR of Mono+ images to that of DSDE across patient sizes, and superior iodine CNR to SE protocols, especially for objects larger than 35 cm. These findings point to the ability to simplify protocol selection, using a single kV and Mono+ images for all patient sizes.

CLINICAL RELEVANCE/APPLICATION

PCD CT has the potential to acquire images with optimal iodine CNR using a single source, a single protocol (having a single kV) and a single acquisition, regardless of patient size.

PH226-SD-MOB7 **High Resolution Extremity Cone-Beam CT with a CMOS X-Ray Detector: System Design and Applications in Quantitative Assessment of Bone Health**

Station #7

Participants
Qian Cao, Baltimore, MD (*Presenter*) Nothing to Disclose
Michael Brehler, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc
Alejandro Sisniega, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc
Gaurav K. Thawait, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Joseph W. Stayman, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Elekta AB Research Grant, Varian Medical Systems, Inc
John Yorkston, PhD, Penfield, NY (*Abstract Co-Author*) Employee, Carestream Health, Inc
Shadpour Demehri, MD, Baltimore, MD (*Abstract Co-Author*) Research support, General Electric Company; Research Grant, Carestream Health, Inc; Consultant, Toshiba Corporation;
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;
Wojciech Zbijewski, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG

For information about this presentation, contact:

qcao@jhmi.edu

PURPOSE

A prototype extremity cone-beam CT (CBCT) system with a high-resolution CMOS x-ray detector was developed. The performance of CMOS-CBCT is evaluated in comparison to conventional flat-panel detector extremity CBCT (FPD-CBCT) in quantitative assessment of trabecular structure.

METHOD AND MATERIALS

The CMOS-CBCT prototype utilizes a compact rotating anode source with 0.3 focal spot (IMD RTM 37) and a Dalsa Xineos3030 CMOS detector with 99 µm pixel size and a custom 400 µm thick CsI scintillator, selected in task-based optimization to maximize detectability in high resolution imaging. The system was built using a CBCT gantry that allows for weight-bearing and non-weight-bearing imaging of the extremities. Imaging was performed at 90 kVp and 12 mGy dose. System resolution was assessed in a reconstruction of a tungsten wire (25 µm voxels); performance in quantitative measurements of trabecular architecture was evaluated in a cadaveric ulna (75 µm voxels). For comparison, the same objects were acquired on an FPD extremity CBCT system (139 µm pixel size and a 0.5 focal spot x-ray source) using matching imaging techniques. Twenty 4 mm3 ROIs were randomly placed at matching locations in the CMOS-CBCT, FPD-CBCT and gold standard µCT images of the ulna. Trabecular spacing (Tb.Sp) and trabecular number (Tb.N) were measured.

RESULTS

Spatial resolution was improved in CMOS-CBCT compared to FPD-CBCT, as evidenced by a 30% reduction in the FWHM of the tungsten wire and enhanced visualization of fine trabecular detail. CMOS-CBCT also outperformed FPD-CBCT in metrics of trabecular microarchitecture, achieving correlations with µCT of 0.97 for Tb.Sp and 0.92 for Tb.N, compared to 0.84 and 0.67, respectively, for FPD-CBCT. Adequate visualization of critical soft tissue structures was found in CMOS-CBCT reconstructions of a cadaveric knee (voxel size: 225 µm) obtained at ~12 mGy imaging dose.

CONCLUSION

The novel CMOS-based extremity CBCT provides high-resolution imaging consistent with quantitative assessment of trabecular architecture. The system will be evaluated in pilot clinical studies of bone health in early osteoarthritis.

CLINICAL RELEVANCE/APPLICATION

A novel cone-beam CT system for imaging of the extremities delivers high spatial resolution that enables quantitative assessment of trabecular microarchitecture in humans in vivo.

PH227-SD-MOB8 **Effect of Beam Geometry and Number of Arcs on VMAT Planning for Large Field Gynecologic Cancer Patients**

Station #8

Participants
Shiv Srivastava, PHD, Phoenix, AZ (*Presenter*) Nothing to Disclose

ABSTRACT

Purpose/Objective(s): The quality of VMAT plans vary based on number of isocenters, gantry angle, collimator rotation, and field size, specified manually on a trial-and-error basis. Field size and number of arcs play a significant role on large field plan quality which has not been extensively studied. Varian Linacs use a120 MLC, with preferred max X jaw opening at 15 cm allowing MLC leaves to travel across the entire field for beam modulation. We investigate the effect of field size and number of arcs on plan quality and, delivery efficiency, for large gynecologic targets.Materials/Methods: 7 VMAT plans were retrospectively generated for 5 gynecologic patients for a total of 35 plans. PTV range was 1408.9-4714.0 cc. For 2 plans (A1& A2) the X jaw was open beyond 15 cm to fully enclose the PTV. In the remaining 5 plans (A3- A7) the effective X jaw size was kept at 15 cm while increasing the number of arcs(from 2-6). All plans used full arcs with the same isocenter and optimization criteria. Plan quality was compared based on dosimetric and quality metrics-conformity (CI), homogeneity (HI), and gradient index (GI). Delivery efficiency was evaluated based on the total MUs, and beam-on-time.Results: All plans were normalized to achieve ~ 95% PTV coverage. The parameters are listed in table.The global max reduced from 119% to 111% to 110% from 2 to 4 to 6 arcs. HI improved with PTV mean dose approaching prescription with the addition of arcs. Plan conformity improved, with increasing arcs with highest CI for A7 (1.006 ± 0.0241) Vs A4 (1.024±0.029) Vs A1 (1.244 ± 0.1578). GI showed similar pattern For OARs, increasing from 2 to 6 arcs showed decrease in mean dose for rectum~4Gy and bladder ~2 Gy, max dose for bowel ~6 Gy and Bone marrow ~4 Gy.MUs and Beam-on time increased from 454 MU Vs 943 MU and 81sec Vs 489sec respectively in moving from max field geometry to the field restricted geometry, and further increased going from 2 to 3 arcs. However, the variation in MUs was minimal (range: 1033-943) in increasing from 3 to 6 arcs. Body-PTV mean dose was least with 6 arcs Vs A1 (12.9-15Gy).Conclusion: 6 arc plans are most conformal, homogeneous with sharpest fall-off and maximum sparing of OARs however, at the cost of longest treatment time. Improvement in plan quality is minimal beyond 4 arcs. Body- PTV shows significant improvement with 6 arcs which may be of benefit in certain clinical situations. Clinical significance of this study needs further investigation. PTVDose to Normal TissueOARs [Gy] Global Max [%]Mean [Gy]CIHIGIMean Dose [Gy]Rectum MeanBladder MeanBowel MaxBone Marrow MaxA1118.847.81.2440.1644.79214.943.043.252.652.6A2116.347.21.1340.1225.05614.244.341.554.250.2A3119.947.51.1800.1574.55414.144.941.854.752.3A4112.446.41.0440.0984.73613.141.240.349.149.4A5111.

PH009-EB-MOB **Evaluation of Eye Radiation Exposure of Medical Workers: What is the Most Desirable Method?**

Hardcopy Backboard

Awards
Certificate of Merit

Participants
Fumitaka Sato, Sendai, Japan (*Presenter*) Nothing to Disclose
Koichi Chida, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshihiro Haga, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroki Ishii, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Kou Satsurai, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuji Kaga, RT, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Takafumi Honda, BSC, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Mitsuya Abe, PhD, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose
Taiichirou Meguro, Sendai, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

fs.aaf39223@gmail.com

TEACHING POINTS

-To understand the importance of correct radiation evaluation of the eye lens. -To discuss the various methods of evaluating the radiation eye dose of medical workers and elucidate the advantages/disadvantages of these methods. -To clarify the basic performance of a new occupational eye dosimeter (DOSIRIS).

TABLE OF CONTENTS/OUTLINE

Advantages/limitations of occupational eye dose evaluation methods DOSIRIS, i2 system, Pocket dosimeter, Glass badge, Quixel badge, dose-related factors, *etc.,* were compared. *Evaluation of fundamental characteristics of a new occupational eye dosimeter (DOSIRIS)* Energy dependence, angular dependence, reproducibility, *etc.,* were studied. OUTLINE: The ICRP reviewed epidemiological evidence and suggested that eye tissue reactions such as cataracts occur at radiation doses lower than those considered acceptable previously. It is important to measure the radiation dose to the eye. Fundamental characteristics among several occupational dosimeters were evaluated. In general, the DOSIRIS exhibited excellent fundamental performance. Correct evaluation of the lens dose [3-mm dose equivalent, Hp(3)] using an eye dosimeter such as DOSIRIS is necessary. Although the DOSIRIS does not provide real-time dose monitoring, we believe that the DOSIRIS facilitates accurate monitoring of occupational eye doses.

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McCormick Place, Chicago
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SPPH21

Basic Physics Lecture for the RT: Standardizing Image Quality in Digital Radiography

Monday, Nov. 27 1:30PM - 2:45PM Room: S402AB

PH

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
Alisa Walz-Flannigan, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the diagnostic need for standardization of radiographic image quality. 2) Refresh or expand familiarity with the basics of radiographic image acquisition and processing that influence image quality. Develop an intuitive grasp of these concepts through image examples. 3) Gain strategies for standardizing and optimizing image quality: desirable information to collect and analyze, the need for feedback processes, and tools for implementation. 4) Build confidence in troubleshooting techniques for addressing image quality issues.

ABSTRACT

The flexibility of digital radiography (DR) can be both a strength and a challenge in creating consistently high-quality images with optimized exposures. Often, the setting of acquisition techniques and image processing is an art form practiced by individual technologists. While image variation can be constrained through tight communication between radiologist and technologist, this is made more difficult with larger and distributed health systems that may have multiple radiologists viewing a site's images. In addition, modern DR systems have complexities that vary by vendor and may confound a technologist that trained with film, or hasn't been given the tools to appreciate a particular system's idiosyncrasies. While vendors are beginning to provide better acquisition feedback such as with exposure index, there is still a wide-range in availability of DR analytics and how they are used. Starting with the need for image quality standardization, this course delves into the interplay between technique, processing and image quality in DR. Through presentation of image problem examples and their resolution, technologists will be provided with tools to better understand how DR works and how to troubleshoot image problems. Through example of practice analysis and quality feedback strategies, participants are provided with ideas to build their own program for image quality standardization and optimization.

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SPPH22

Physics Symposium: Proton

Monday, Nov. 27 1:30PM - 5:45PM Room: S503AB

PH RO

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

FDA Discussions may include off-label uses.

Participants
Indra J. Das, PhD, New York, NY (*Moderator*) Nothing to Disclose

For information about this presentation, contact:

indra.das@nyumc.org

ABSTRACT

This is a moderated session on proton beam therapy distributed among 10 speakers (Radiation oncologists as well as Physicists). It covers breadth of proton beam, history, advances, production, clinical application, treatment planning, pencil beam scanning, Biology, imaging, motion management and neutron beam. This session is a followup of the AAPM summer school on proton beam that took place in June 2015 in Colorado Spring, Co, culminating to the publication of the book 'Principles and Practice of Proton Beam Therapy' edited by IJ Das and H Paganetti.

Active Handout:Indra J. Das

http://abstract.rsna.org/uploads/2017/17001455/Active SPPH22.pdf

Sub-Events

SPPH22A Introduction: History & Advances in Proton Therapy

Participants
Indra J. Das, PhD, New York, NY (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

indra.das@nyumc.org

LEARNING OBJECTIVES

1) History of proton beam therapy. 2) Development of seminal events. 3) New innovations from scattered beam to pencil beam scanning. 4) Future of proton beam therapy.

ABSTRACT

Introduction to proton beam therapy from the beginning of 1905 till today is presented in terms of seminal work by William H Bragg on the stopping powers and range of alpha particles, introduction of proton beam as hydrogen nucleus by Ernest Rutherford, introduction of cyclotron by Ernest Lawrence at Berkley and hint of clinical use by Robert Wilson that spanned the proton work to Harvard Cyclotron in 1954 for patient care. The first hospital based clinical proton machine was built at Loma Linda in 1990 followed by conversion of Indiana university cyclotron facility (IUCF) for clinical use in 1999 which was named as Midwest Proton Research Institute (MPRI) that treated over 2000 patients till it was closed in 2014. Currently over 35 centers are treating patients with various types of machines. Modern machines have sophisticated beam delivery system coupled with advanced imaging and 360 deg gantry angles for patient care. Advances in pencil beam scanning, cone beam CT (CBCT) and advanced optimization in treatment planning has propelled proton beam to a new height. Clinical outcomes are being analyzed to provide meaningful debate in the cost and growth of proton therapy which will be presented.

Active Handout:Indra J. Das

http://abstract.rsna.org/uploads/2017/17001456/Active SPPH22A.pdf

SPPH22B Proton Therapy: Promises, Principles, and Proof

Participants
Nancy P. Mendenhall, MD, Gainesville, FL (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To understand the basic principles of radiation therapy that govern treatment planning and radiation therapy outcomes, e.g., the factors affecting the therapeutic ratio. 2) To understand the promise of proton therapy for increasing the therapeutic ratio. 3) To understand the current level of clinical evidence regarding proton therapy efficacy, safety, and comparative effectiveness.

SPPH22C Miniaturization Technology and Proton Machines

Participants

Vladimir Derenchuk, MSc, Knoxville, TN (*Presenter*) Director, ProNova Solutions, LLC; Spouse, Employee, ProNova Solutions, LLC

For information about this presentation, contact:

laddie.derenchuk@pronovasolutions.com

LEARNING OBJECTIVES

1) Become familiar with the latest techniques used to reduce the size and cost of proton therapy systems while maintaining state of the art delivery techniques.

ABSTRACT

Miniaturizing innovations in the design of accelerators and gantries include the use of superconducting magnets, combined function magnets and novel methods of range modulation. A description of the innovations currently in use and additional innovations being developed will be discussed.

URL

http://provisionhealthcare.com/proton-therapy/proton-therapy-system/

SPPH22D Advances in TPS and Optimization

Participants
Tony Lomax, Switzerland, Switzerland (*Presenter*) Research Grant, Varian Medical Systems, Inc

LEARNING OBJECTIVES

1) Understand the concepts for treatment planning of Pencil Beam Scanned (PBS) proton therapy. 2) Understand the advantages and limitations of PBS proton therapy. 3) Understand the importance of anatomical changes and adaptive radiotherapy.

SPPH22E Pencil Beam Scanning

Participants
Ronald X. Zhu, PhD, Houston, TX (*Presenter*) Nothing to Disclose

SPPH22F Administrative Hurdles of Setting Up Proton Beam

Participants
Anita Mahajan, MD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) What is different about proton therapy in contrast to x-ray based therapy facilities. 2) Basic personnel requirements of proton therapy. 3) Patient populations who could benefit the most from proton therapy. 4) Current status of proton therapy in the US and the world and approaches that have been taken to finance and manage them.

ABSTRACT

Proton therapy is a radiotherapy modality that has great promise especially since technology has advanced and lower cost and smaller facilities are now feasible. The similarities and differences between xray and proton therapy will be discusses and the essential personnel to develop and run a safe and efficient program will be discussed. Patient populations that coudl benefit from proton therapy will be described. Some of the financial hurdles, special expertise, technical infrastructure and collaborations that are needed to develop a robust, efficient and safe proton facility will be described. Various approaches to the funding and structuring these programs from established programs in the United States and elsewhere will be discussed.

SPPH22G Proton Therapy for Ocular Cancers

Participants
Alexei V. Trofimov, PhD, Boston, MA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

atrofimov@mgh.harvard.edu

LEARNING OBJECTIVES

1) Review types of ocular cancers, and treatment options. 2) Learn about the development and current status of proton therapy for ocular tumors.

ABSTRACT

Nearly 1 in 5 of overall proton therapy patients to date worldwide were treated for ocular tumors. The techniques for treating ocular targets with proton beam were first developed in 1970s. The dose distributions are advantageous for maintaining visual function in a large proportion of cases. Charged particle therapy proved to be quite successful in achieving local tumor control in uveal melanomas, while preserving the eye globe.

SPPH22H Proton Imaging: Advances, Promises and Peril

Participants
Katia Parodi, Garching b. Munich, Germany (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

Katia.Parodi@lmu.de

LEARNING OBJECTIVES

1) Understand the issue of range uncertainties in clinical practice of proton beam therapy. 2) Understand the different possible

1) Understand the issue of range uncertainties in clinical practice of proton beam therapy. 2) Understand the different possible implementations of in vivo range verification before, during and after treatment. 3) Understand the merits, challenges and performances of the different proposed in vivo range verification approaches. 4) Understand the prospects of in vivo range/dose verification and the potential clinical impact.

ABSTRACT

Despite all recent technological advances in beam delivery and imaging, full clinical exploitation of the favorable ballistic properties of proton beams is still hampered by the yet unsolved problem of range uncertainties. To this end, several approaches are being extensively investigated to tackle this issue at the stage of treatment planning or treatment delivery. This presentation will review the broad range of proposed verification techniques, critically discussing the main ongoing developments and initial clinical experience with focus on the challenges as well as the prospects of novel imaging for in vivo range (and potentially even dose) verification in proton therapy.

SPPH22I Motion Management in Particle Therapy

Participants
Shinichiro Mori, Chiba, Japan (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

mori.shinichiro@qst.go.jp

SPPH22J Neutrons in Proton Beam

Participants
Chee-Wai Cheng, PHD, Cleveland, OH (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

chee-wai.cheng@uhhospitals.org

LEARNING OBJECTIVES

1) Neutron production in proton therapy. 2) Performance characteristics of a neutron specific flat panel detector. 3) Potential application of the neutron panel for real time proton therapy imaging.

ABSTRACT

A neutron imaging flat panel detector (FPD) from PerkinElmer is explored for its potential real time imaging application in proton therapy. Neutrons are produced by impinging a proton beam from a Mevion S250 unit on a brass plug (water equivalent thickness 30cm) and a solid water phantom (9cm thick). The FPD response characteristics to proton dose and dose rate and its imaging performance characteristics such as MTF and contrast resolution are characterized. A Leeds and a Las Vegas phnatom are used to determine the MTF and the contrast resolution of the FPD. The results are compared with those obtained with 6 MV x rays. The detector characteristics increases linearly with MU and MU/min. The MTF and the contrast resolution are comparable to those of the MV FPD from the Elekta machines. Images of a keyset obtained wtih neutron FPD produced in a solid water phantom illustrates the potential application of neutron imaging in proton therapy.

URL

SSE21

Physics (CT: Cone Beam)

Monday, Nov. 27 3:00PM - 4:00PM Room: S403A

CT PH

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

Participants
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Moderator*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;
Srinivasan Vedantham, PhD, Tucson, AZ (*Moderator*) Research collaboration, Koning Corporation

Sub-Events

SSE21-01 Three-dimensional Digital Subtraction Angiography (3D-DSA) from a Single C-arm Acquisition Using a Convolutional Neural Networks-Based Deep-Learning Method

Monday, Nov. 27 3:00PM - 3:10PM Room: S403A

Participants
Juan Montoya, Madison, WI (*Presenter*) Nothing to Disclose
Yinsheng Li, BEng, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Charles M. Strother, MD, Madison, WI (*Abstract Co-Author*) Research Consultant, Siemens AG; Research support, Siemens AG; License agreement, Siemens AG
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

PURPOSE

The purpose of this work was to develop a deep-learning method, based on convolutional neural networks (CNN), to generate 3D-DSA angiograms from a single contrast-enhanced exam without mask acquisition.

METHOD AND MATERIALS

Clinical image volumes of 30 patients scanned with a C-arm cone-bean CT system (Axiom Artis zee; Siemens Medical Solutions) using a standard 3D-DSA imaging protocol for the assessment of cerebrovascular abnormalities were retrospectively collected. Images from 22 subjects were used to extract labeled image patches that were used as training data set. A 30-layer CNN was trained to classify three tissue types (vasculature, bone and soft tissue). The trained CNN deep-learning model was then applied for the task of tissue classification in a test cohort consisting of the remaining image volumes from 8 subjects. The final vasculature tissue class was used to generate the 3D-DSA images. To quantify the generalization error of the trained model, tissue classification accuracy was measured in 8 million image patches from clinically relevant anatomy in the test data set. Finally, the generated 3D-DSA images were subject to a quantitative assessments of contrast enhancement in the internal carotid artery (ICA), middle cerebral artery (MCA), anterior cerebral artery (ACA) and the distal branches of the MCA and ACA. A qualitative assessment for the presence of inter-sweep motion artifacts was also performed.

RESULTS

Tissue classification accuracy in the testing dataset was 98.7% and 98.1% on a per-voxel and per-patient basis respectively. The average relative increase in vessel contrast enhancement compared to the vendor's DSA was 18.7%, 21.7%, 20.5% for the ICA, MCA, ACA respectively. Nearly a 2-fold increase in vessel opacification was observed for the distal branches of the MCA and ACA. No residual signal from osseous structures was observed for all cases generated using the proposed method.

CONCLUSION

A deep learning based method was developed to generate 3D-DSA images without mask data acquisition. The proposed method successfully eliminates mis-registration artifacts induced by inter-sweep patient motion, improves image quality and potentially reduces radiation dose in clinical 3D-DSA imaging.

CLINICAL RELEVANCE/APPLICATION

Mask-free 3D-DSA imaging using a deep-learning based method may allow radiation dose reduction by omitting a mask scan and eliminate mis-registration artifacts induced by inter-sweep patient motion.

SSE21-02 Time-Resolved CBCT Angiography (TR-CBCTA) Imaging from a Single-Sweep C-Arm CBCT Acquisition

Monday, Nov. 27 3:10PM - 3:20PM Room: S403A

Participants
Yinsheng Li, BEng, Madison, WI (*Presenter*) Nothing to Disclose
Beverly A. Kienitz, MD, DDS, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Charles M. Strother, MD, Madison, WI (*Abstract Co-Author*) Research Consultant, Siemens AG; Research support, Siemens AG; License agreement, Siemens AG

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

For information about this presentation, contact:

yli292@wisc.edu

PURPOSE

Generating time-resolved cone-beam CT (CBCT) angiography (TR-CBCTA) images from multi-sweep CBCT acquisition has previously been demonstrated. To reduce dose, motion artifacts, and data acquisition time, in this work, a new technique was developed to generate high-quality TR-CBCTA images from a single-sweep CBCT data acquisition.

METHOD AND MATERIALS

A newly developed image reconstruction technique, Synchronized Multi-Artifact Reduction with Tomographic Reconstruction (SMART-RECON), enables several sub-image frames to be generated from a single 200-degree contrast enhanced scan. Each sub-image frame corresponds to a short segment of the projection data, but using SMART-RECON is reconstructed without limited-view artifacts. The first virtual non-contrast enhanced sub-image frame is subtracted from other sub-image frames, generating the desired TR-CBCTA images without requiring a separate mask scan. The proposed method was applied retrospectively to intra-arterial (IA-DSA) datasets of 15 human subjects with various neurovascular pathologies such as aneurysms, large vessel occlusion, or arteriovenous malformation.

RESULTS

Single-sweep TR-CBCTA images of the 15 human subjects were successfully generated. These images demonstrated time- resolved information of the cerebrovascular contrast dynamics. In addition, they demonstrated potentially improved image quality compared with the clinical standard multi-sweep images, as they were less prone to artifacts arising from inter-sweep involuntary patient motions and misregistration. The noise standard deviations measured in the SMART-RECON enabled TR-CBCTA images are 11±2 HU, compared with 31±5 HU of clinical 3D-DSA images. The CNR values of SMART-RECON enabled TR-CBCTA images, and clinical 3D-DSA images are 18±10 and 8±3, respectively. The subjective conspicuity of neurovascular abnormalities such as aneurysms and stenoses was improved in the SMART-RECON enabled TR-CBCTA images.

CONCLUSION

High-quality TR-CBCTA imaging can be achieved using a single C-arm CBCT data acquisition to reduce overall image acquisition time, reduce artifacts associated with inadvertent patient motion, and reduce radiation dose.

CLINICAL RELEVANCE/APPLICATION

TR-CBCTA from a single CBCT scan enables clinicians to extract precious time-resolved information of vasculature from a single CBCT acquisition to reduce dose and reduce motion artifacts.

SSE21-03 Importance of Prior Information for Accurate Scatter Correction of Truncated Cone-Beam CT (CBCT) Data

Monday, Nov. 27 3:20PM - 3:30PM Room: S403A

Participants
Nadine Waltrich, Heidelberg, Germany (*Presenter*) Nothing to Disclose
Sedat Aktas, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Stefan Sawall, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Joscha Maier, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Kai Stannigel, PhD, Bensheim, Germany (*Abstract Co-Author*) Employee, SIRONA Dental GmbH
Kai Lindenberg, PhD, Bensheim, Germany (*Abstract Co-Author*) Employee, Sirona Dental GmbH
Marc Kachelriess, PhD, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

nadine.waltrich@dkfz.de

PURPOSE

To compare different methods of detruncation with respect to scatter correction and to provide a quantitative scatter correction approach for truncated CBCT data.

METHOD AND MATERIALS

In CBCT scatter correction is of high importance to obtain artifact-free and quantitative CT images. While scatter correction itself is difficult it becomes even more challenging when the data are longitudinally and laterally truncated due to limited detector sizes, as it is often the case in C-arm CT or in dental CT, for example. Several scatter correction methods and several detruncation methods are known and need to be combined. It is unclear to what accuracy the extrapolation needs to be done in order to get accurate CT images. We therefore combined our Monte Carlo-based scatter correction with several detruncation approaches: no (N), constant (C), cosine roll-off (R), adaptive (A) [EurRadiol 15:1008-1014, 2005], and prior-based (P) detruncation [MedPhys 41(2):021906, 2014]. The latter uses anatomical data of a different patient for data-completion. To validate our approach we corrected measured dental CBCT data of a head phantom and patients (truncated to 11 cm diameter due to small detector size), CBCT patient data of a pelvis scan (manually truncated) and C-arm CT phantom measurement of the QRM liver phantom (truncated to 24 cm diameter).

RESULTS

Images corrected by the simple detruncation algorithms suffer from an overestimated scatter, the reason being the overestimation of the detected intensities, making a patient specific empirical correction factor necessary. For the dental CBCT patient case the CT-values for soft tissue/dentin were corrected from -140/1094 HU (FDK reconstruction) to -30/1879 HU (N), -30/1905 HU (C), -10/1976 HU (R), -23/1975 HU (A) and 69/2375 HU (P). In all cases (P) leads to the most accurate CT-values while not requiring the empirical factor.

CONCLUSION

Prior-based detruncation leads to a proper and robust scatter estimation which is mainly important for scatter correction.

CLINICAL RELEVANCE/APPLICATION

Quantitative CT images from truncated CBCT scans are possible. However, scatter correction must be combined with strong prior information incorporating anatomical data from a similar patient.

SSE21-04 Compensating for Irregular Respiratory Motion in Cone-Beam CT (CBCT): Motion Vector Field Resampling

Monday, Nov. 27 3:30PM - 3:40PM Room: S403A

Participants
Sebastian Sauppe, Heidelberg, Germany (*Abstract Co-Author*) Nothing to Disclose
Marcus Brehm, Baden-Dattwil, Switzerland (*Abstract Co-Author*) Employee, Varian Medical Systems, Inc
Pascal Paysan, PhD, Baden-Dattwil, Switzerland (*Abstract Co-Author*) Employee, Varian Medical Systems, Inc
Dieter Seghers, Baden-Daetwill, Switzerland (*Abstract Co-Author*) Employee, Varian Medical Systems, Inc
Marc Kachelriess, PhD, Heidelberg, Germany (*Presenter*) Nothing to Disclose

PURPOSE

To minimize motion blurring in 4D respiratory motion-compensated CBCT in case of irregular breathing patterns.

METHOD AND MATERIALS

CBCT images often suffer from respiratory motion. Gated reconstruction minimizes the motion artifacts but introduces significant sparse view artifacts. Motion-compensated (MoCo) image reconstruction has the potential to minimize both, motion artifacts and sparse view artifacts while simultaneously making use of 100% of the rawdata [MedPhys 40(10): 101913, 2013]. Irregular breathing, however, still is problematic. In general we have to distinguish between phase and amplitude gating for 4D image reconstruction. Depending on the breathing pattern less motion blurring emerges in amplitude-gated images than in phase-gated reconstructions. However motion estimation based on amplitude-gated images is not always realizable especially for non-cyclic breathing pattern or when strong variation of the breathing amplitude occurs during the image acquisition. This is also, because the procedure of amplitude gating is not well defined. We propose a hybrid MoCo approach that starts with a robust phase gating procedure for the initial motion vector field (MVF) estimation and switches later to an adapted amplitude gating method. This switching implies a resampling of the MVF to make them become amplitude-specific. Our MVF resampling method ensures that the MVFs, that have been estimated based on phase-gated reconstructions, are still valid for all amplitude-gated images. To validate the method we use an artificially deformed clinical CT scan with adaptive breathing pattern and several patient data sets acquired with a TrueBeam™ 4D CBCT system (Varian Medical Systems).

RESULTS

The MVF resampling-based hybrid 4D CBCT MoCo algorithm is able to significantly reduce motion blurring. This is visible in phantom and patient data especially for irregular breathing patterns. Our sharpness metric, measuring the slope of profiles normal to anatomical borders, improved by up to 8%, depending on breathing pattern, acquisition parameter and anatomical feature.

CONCLUSION

Resampling MVFs from phase- to amplitude-gating helps to improve the image quality of MoCo reconstructions in particular for rather irregular breathing patterns. Thus, the new method increases the robustness of motion estimation with CBCT.

CLINICAL RELEVANCE/APPLICATION

Improved motion estimation from CBCT images potentially allows for more accurate tumor tracking.

SSE21-05 Effect of Flat and Curved System Geometry on X-Ray Scatter Distribution and Selection of Antiscatter Grids

Monday, Nov. 27 3:40PM - 3:50PM Room: S403A

Participants
Alejandro Sisniega, PhD, Baltimore, MD (*Presenter*) Research Grant, Carestream Health, Inc
Wojciech Zbijewski, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG
Pengwei Wu, Baltimore, MD (*Abstract Co-Author*) Research collaboration, Carestream Health, Inc
Joseph W. Stayman, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Elekta AB Research Grant, Varian Medical Systems, Inc
Nafi Aygun, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Vassiliss Koliatsos, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Xiaohui Wang, PhD, Rochester, NY (*Abstract Co-Author*) Employee, Carestream Health, Inc
David H. Foos, MS, Rochester, NY (*Abstract Co-Author*) Employee, Carestream Health, Inc
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;

PURPOSE

System geometries for cone-beam CT (CBCT) vary broadly according to clinical requirements, with strong implications for the magnitude of x-ray scatter and selection of antiscatter grid. This work analyzes such effects for a range of geometries, including curved configurations of the detector and grid that support increasingly compact system design.

METHOD AND MATERIALS

Scatter was estimated using a Monte Carlo (MC) engine with system geometry ranging from long (SDD = 1000 mm) to compact (SDD = 500 mm) for a broad range of grid / detector curvatures. We considered a 41 x 33 cm2 detector with 0.6 mm CsI scintillator and focused antiscatter grids with grid ratio ranging from 6:1 to 10:1 (all 1.25 lp/mm). Scatter distributions (3.6x1011 photons over

360 projections) were computed using a voxelized anthropomorphic head (0.5 mm voxels) containing a skull and heterogeneous brain with soft-tissue contrast up to 60 HU. Scatter estimates were denoised with a 6x6 mm2 Gaussian kernel. Primary fluence was computed with a polychromatic Siddon projector. Poisson noise was added to the total signal with dose fixed at 25 mGy at isocenter. CT volumes were reconstructed using a PWLS approach with a Huber penalty.

RESULTS

For longer system geometries, differences in scatter among curvatures were negligible. For the most compact geometry, the average magnitude of scatter increased up to 23% for the strongest curvature compared to a flat configuration. Interestingly, the increased scatter at the periphery of the field of view resulted in a more uniform SPR distribution and reduced cupping (80 HU cupping vs 115 HU for flat configurations). Antiscatter grids performed similarly for all scenarios up to GR = 8:1, beyond which gains were minimal. Using an 8:1 grid improved soft-tissue CNR from 0.85 to 1.56 for the long flat geometry and from 0.59 to 1.25 for the compact curved geometry.

CONCLUSION

MC provides guidance to selection of geometry, detector curvature, and antiscatter grid for increasingly compact CBCT configurations. Compact designs exhibited larger scatter magnitude but showed comparable performance using a knowledgeable chosen antiscatter grid.

CLINICAL RELEVANCE/APPLICATION

Understanding the effects of x-ray scatter in novel compact CBCT systems improves system design and guides the development of systems with improved image quality.

SSE21-06 Comparison of a Novel Two-Dimensional Antiscatter Grid Prototype with a Conventional Antiscatter Grid in CBCT

Monday, Nov. 27 3:50PM - 4:00PM Room: S403A

Participants
Timur Alexeev, PhD, Aurora, CO (*Presenter*) Nothing to Disclose
Brian D. Kavanagh, MD, Aurora, CO (*Abstract Co-Author*) Nothing to Disclose
Moyed Miften, Aurora, CO (*Abstract Co-Author*) Nothing to Disclose
Cem Altunbas, PhD, Aurora, CO (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

timur.alexeev@ucdenver.edu

CONCLUSION

2DASG can provide improved soft tissue visualization with respect to existing CBCT systems that employ conventional 1DASGs. With improved CT number accuracy provided by 2DASG, quantitative imaging applications may be enabled in CBCT based imaging modalities.

Background

A novel 2D antiscatter (2DASG) grid prototype was developed for flat panel detector (FPD) cone beam computed tomography (CBCT) systems, which aims to improve both quantitative accuracy and soft tissue visualization. A 2DASG prototype was fabricated by using scalable powder bed laser melting additive manufacturing process, and employed in Varian TrueBeam CBCT system. Gantry angle specific flat-field correction and a novel total variation minimization method were implemented to remove 2DASG's septal shadows. CBCT images were reconstructed using a modified FDK algorithm. A Catphan phantom and an annuli mimicking abdomen/pelvis anatomy was employed in imaging experiments. CT number accuracy and contrast to noise ratio (CNR) were assessed. Using the same imaging setup, a conventional ASG (1DASG) with 1D lead lamellae, fiber spacers and a grid ratio of 10 was evaluated, and compared to the 2DASG prototype.

Evaluation

Hounsfield Unit (HU) accuracy was measured across multiple ROIs located in the uniform sections of the Catphan phantom. With 1DASG HU values were underestimated by 300±43 HU. With 2DASG, HU underestimation was reduced down to 43±15 HU. With 1DASG, CNR in 3 inserts were 2.0, 2.892, and 14.2, respectively. With 2DASG, CNR was further increased to 3.2, 3.3, and 18 at the same material inserts.

Discussion

2DASG prototype showed significant improvements in CT number accuracy, and contrast resolution when compared to 1DASG and NOASG. Shading artifacts commonly observed in CBCT images were diminished with 2DASG. Additionally, gantry angle specific flat field correction and our novel total variation minimization approach successfully reduced 2DASG's footprint in projections and artifacts in CBCT images.

SSE22

Physics (Radiation Therapy and Cancer Imaging)

Monday, Nov. 27 3:00PM - 4:00PM Room: S403B

OI PH RO

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

FDA Discussions may include off-label uses.

Participants
Kristy K. Brock, PhD, Houston, TX (*Moderator*) License agreement, RaySearch Laboratories AB; ;
Rebecca M. Howell, PhD, Houston, TX (*Moderator*) Nothing to Disclose
Shiva K. Das, PhD, Chapel Hill, NC (*Moderator*) Nothing to Disclose

Sub-Events

SSE22-01 Prediction of Clinical Target Volume for Nasopharyngeal Carcinoma Using Hidden Markov Model Trained from 2000 Patient Dataset

Monday, Nov. 27 3:00PM - 3:10PM Room: S403B

Participants
Fu Li, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Sha Yu, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Yao Lu, PhD, Guangzhou, China (*Presenter*) Nothing to Disclose
Ying Sun, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Li Lin, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

lifu5@mail.sysu.edu.cn

PURPOSE

Radiotherapy is one of the efficient routine treatment for nasopharyngeal carcinoma (NPC). Clinical target volume (CTV) of NPC, which not only contains gross tumor volumes (GTV) can be seen on scan images like CT or MRI, but also contains underlying irregular tumor region due to tumor invasion. Accurate delineation of CTV takes an essential role on assisting doctors to determinate the radiation dose and the range of exposure. It is noteworthy to point out that the delineation of CTV is time-consuming with about 4-6 hours/case, just for an initial treatment plan. Therefore, in order to develop an automatic delineation method for CTV, we design a new CTV prediction model for NPC, which can predict the tumor expansion and accurately compute tumor invasion probability.

METHOD AND MATERIALS

Our model includes two parts: Hidden Markov Model (HMM) and rule-based learning. HMM is employed in simulating three-dimensional tumor expansion. By computing transition probability between adjacent voxels from GTV iteratively, probability map is generated. Associate rules learned from large-set clinical data, which is able to discover interesting relations in dataset, is used to quantify the spread trend among tiny tissues. We collected 2000 patient's NPC patient data with IRB approval, which are used for training dataset. Each patient data contains a series of GTV contours that are manually annotated by experienced doctors. All GTV contours have been uniformly registered on CT templates. For model evaluation, 50 NPC patients was independently collect. Dice similarity coefficient (DSC) was used to compare computerized model with the reference standard.

RESULTS

In current clinical practice, the assessment time of CTV is between 4-6 hours. Our automated tool took less than 5 minutes to assess the CTV. We compute 50 patients' CTV1 and CTV2 for evaluation, which represent 10% and 5% invasion probability respectively. The average DSC between two radiologists was 0.81 while the average DSC of radiologists and computer was 0.80.

CONCLUSION

This model is applied successfully for the prediction of NPC CTV and can be easily used for other types of tumor. Our automated tool greatly reduces the total time by 48-72 times compared to clinical doctors.

CLINICAL RELEVANCE/APPLICATION

Our NPC CTV prediction model is very useful in radiotherapy treatment, not only reduces the workload of radiotherapists but also provides a more objective way for CTV prediction.

SSE22-02 Considerations and Experience in Lung Treatment with SBRT+DIBH in Arms-down Position

Monday, Nov. 27 3:10PM - 3:20PM Room: S403B

Participants
Yulin Song, PhD, West Harrison, NY (*Abstract Co-Author*) Nothing to Disclose

Kenneth Dow, BS, West Harrison, NY (*Abstract Co-Author*) Nothing to Disclose
Boris Mueller, MD,MPH, West Harrison, NY (*Abstract Co-Author*) Nothing to Disclose
Jeho Jeong, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Ceferino H. Obcemea, PhD, Washington, DC (*Abstract Co-Author*) Nothing to Disclose
Ziad Saleh, PhD, West Harrison, NY (*Presenter*) Nothing to Disclose
Xiaoli Tang, PhD, Chapel Hill, NC (*Abstract Co-Author*) Nothing to Disclose
Melissa Zinovoy, MD, West Harrison, NY (*Abstract Co-Author*) Nothing to Disclose
Daphna Y. Gelblum, MD, MS, Commack, NY (*Abstract Co-Author*) Nothing to Disclose
Borys R. Mychalczak, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

songy@mskcc.org

ABSTRACT

Purpose/Objective(s): Many elderly and frail patients are unable to tolerate the arms-up position for extended periods. This creates a significant challenge for certain types of radiation treatment, such as lung SBRT. Although the arms-up position provides maximal freedom for optimal beam placement and avoids dose to arms, frequent involuntary arm movement can cause significant target displacement and adversely impact dosimetry. This phenomenon is further amplified for lung SBRT+DIBH treatment. The combined modality paradigm prolongs treatment time dramatically when delivered on a machine without FFF beams. From the perspective of treatment accuracy, patient comfort level and stability are crucial for the precision of any immobilization device and on-board imaging system. In this study, we investigated a technique to treat lung patients with SBRT+DIBH in the arms-down position. Our objective was to determine whether the arms-down position could produce a plan dosimetrically comparable to that for the arms-up position. Materials/Methods: A 92-year-old patient was diagnosed with lung cancer of the right lower lobe. The patient was simulated supine on a reversed wide prostate board with arms by sides and palms up under buttocks. Both arms were positioned tightly against the body for stability and reproducibility. A custom Aquaplast body mask was fabricated with an opening cut around the xyphoid process of the sternum for placement of an RPM gating block. A free-breathing CT scan was acquired first for patient marking, followed by a DIBH scan for treatment planning. The patient was treated with SBRT+DIBH protocol with a prescription dose of 1200 cGyx4. A VMAT plan was computed using 6X photon beams. To achieve acceptable PTV conformity and coverage, the plan used six partial arcs. To improve patient comfort during treatment, all six arcs were short and low in MU so that each arc could be delivered in two DIBH sessions. Results: We found that with a well-designed optimization strategy and a proper arc arrangement, the arms-down plan was dosimetrically comparable to the arms-up plan in terms of PTV coverage and OAR sparing. For this case, the right arm was only 3.4 cm away from the PTV. To create a sharp dose gradient, it was contoured and constrained during optimization, achieving PTV D95 = 100% without out-of-PTV hot spots. The maximum dose to the right arm was 1673.6 cGy, with a mean dose of 93.2 cGy. Other dosimetric parameters also met our institutional tolerances. By using multiple short arcs, the MU of each arc was significantly reduced, thus, favorable for DIBH treatment. The MUs were 527, 531, 434, 468, 406, and 409, respectively.Conclusion: Under special circumstances, the arms-down position is a safe and effective way to treat lung cancer patients. The central issue using this approach is determining how to securely confine the arms to minimize TMR perturbation. VMAT is relatively insensitive to small variations in arm position. The arc smearing effect will compensate for uncertain TMR.

SSE22-03 RTOG3507: A Multi-Institutional Planning Comparison Study to Determine the Feasibility of a Randomized Study of Pembrolizumab Plus Stereotactic Re-Irradiation versus SBRT Alone for Locoregionally Recurrent or Second Primary Head and Neck Cancer

Monday, Nov. 27 3:20PM - 3:30PM Room: S403B

Participants
Saiful Huq, PhD, Pittsburgh, PA (*Abstract Co-Author*) Nothing to Disclose
Si Young Jang, PHD, PITTSBURGH, PA (*Presenter*) Nothing to Disclose

ABSTRACT

Purpose/Objective(s): RTOG foundation will soon open a randomized phase II study to evaluate the safety of the addition of Pembrolizumab to re-irradiation with SBRT for patients with recurrent or new second primary head and neck carcinoma (CA). This is the first multi-institutional study that involves SBRT of head and neck cancer. Treatment planning requirements for this study are very stringent. Therefore, it is important to determine the feasibility of performing such a study in a multi-institutional clinical trial setting. The goal of this study was to evaluate whether cancer centers around the country can generate protocol compliant treatment plans for challenging locoregionally recurrent or second primary head and neck carcinoma test cases. Materials/Methods: Five challenging test cases were circulated among five institutions and each of the institutions was asked to generate treatment plans according to protocol guidelines. The cases investigated were all recurrent tumors including: 1) A squamous cell CA of the oral tongue located very close to the skin, 2) A squamous cell CA of the right base of tongue located at lower neck 3) A recurrent tumor of the oropharynx close to mandible, 4) A recurrent tumor of left neck located near spinal cord, and 5) A recurrent tumor located in right maxillary sinus. PTV volumes ranged between 27cc and 95cc. Static IMRT or VMAT techniques with a calculation grid size of = 2mm were used for dose calculation. The RX dose was 40Gy in five fractions. Treatment plans were normalized to the maximum dose of the plan in which 100% of the isodose line corresponded to. The prescription isodose line encompassed at least 99% of the GTV and 95% of the PTV and ranged between 80% and 90%.Results: The protocol provided specific guidelines for compliance for GTV_4000, PTV_4000, and various organs at risk such as spinal cord, brain stem, optic nerve/chiasm, brachial plexus, carotid artery, esophagus, skin, and dose spillage. The GTV and PTV coverages were found to be over 99% and 95% respectively for all institutions, and doses for various organs at risk were mostly within the protocol specifications: mean values of maximum cord, cord+5mm, and brain stem doses were 7.0Gy, 9.3Gy, and 4.1Gy, respectively; mean values of conformity index, R50%, and D2cm for all multi-institution plans were 1.1, 4.0, and 26.1Gy, respectively; however, some institutions could not meet protocol guidelines for skin dose for the case abutting with the skin and for carotid dose for the case located inside the target (skin: =30Gy, carotid artery: =42Gy). Conclusion: This multi-institutional study shows that it is feasible for centers around the country to meet protocol requirements when generating SBRT treatment plans for challenging recurrent and second primary head and neck carcinoma.

SSE22-04 Dosimetric Uncertainty of Homogeneous Dose Calculation in Lung SBRT Patients with Low Lung Density

Monday, Nov. 27 3:30PM - 3:40PM Room: S403B

Participants
Michael Petronek, Oak Brook, IL (*Presenter*) Nothing to Disclose
Michelle Sands, PhD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Tingliang Zhuang, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Qi Peng, PhD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Anthony L. Magnelli, MS, North Royalton, OH (*Abstract Co-Author*) Nothing to Disclose
Kevin L. Stephans, MD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Gregory Videtic, MD, FRCPC, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Salim Balik, PhD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

mpetronek2015@gmail.com

ABSTRACT

Purpose/Objective(s): For patients with low lung density, the lack of equilibrium and insufficient dose build-up may cause significant deviation from planned dose distributions if heterogeneous tissue is assumed to have water density. It is hypothesized that significant dosimetric variations may happen in peripheral lung SBRT cases using the RTOG protocols of 60 Gy in 3 fractions with homogenous dose calculation compared to a recalculated plan with heterogeneity corrections for patients with low lung density.Materials/Methods: The patient selection process narrowed down a group of 120 patients previously treated to 60 Gy in 3 fractions to patients with the twelve lowest (below -813 HU) and the twelve highest (above -657) lung density. For each patient, a 5 mm expanded internal target volume (ITV) represented the planning target volume (PTV). Additional ring structures were created by expanding the PTV (PTV ring) and ITV (ITV ring) by 1 cm to analyze the surrounding tissue density and Hounsfield Unit (HU) values. VMAT plans consisting of two coplanar half arcs were made for each patient without heterogeneity corrections. The clinically acceptable, optimized plan met several organs at risk (OAR) dose limits and the following planning goals: PTV V60Gy = 95%, PTV V54Gy = 100%, ITV V60Gy = 100%. Finally, the monitor units were held constant and the plan was recalculated with the original heterogeneous tissue densities from the image set using collapsed cone convolution algorithm. Results: Low Density High Density Mean HU Mean density (g/cm3) Mean HU Mean density (g/cm3) Lung -838 ± 21 0.20 ± 0.03 -613 ± 27 0.45 ± 0.03 RingPTV -774 ±107 0.26 ± 0.11 -478 ± 53 0.57 ± 0.05 RingITV -789 ± 93 0.25 ± 0.09 -562 ± 51 0.49 ± 0.04 Table 1. The mean Hounsfield Units (HU) for the 120 patient pool was -728 ± 69 HU (range: -875 – 557 HU). Results of this study showed that planning goals were not met for patients with low lung densities when dose calculation was completed using heterogeneous tissue densities. The PTV V60Gy goal of 95% dropped significantly to a mean of 76.9% ± 17.2% for patients with low lung density (range: 43.3% - 96.2%) while the patient group with high lung density met planning goals with a mean of 96.1% ± 3.0% (range: 88.5% - 99.9%) (p = 0.004). After the dose calculation with heterogeneity corrections, respectively for the low and high lung density patients, the mean V54Gy was 95.5 ± 5.7% (81.0% - 99.8%) and 99.9 ± 0.1%, p=0.01; the mean ITV V60Gy was 99.4 ± 1.1% (96.3 – 100.0%) and 100.0 ± 0.02% (99.9 -100.0%), p = 0.06. The decrease in PTV 60Gy for the low lung density patients correlated better with RingITV (r = 0.71). The results were not correlated with the lung density or HU. Conclusion: The dosimetric variations were significantly large for patients with very low lung density compared to high lung density. It may be beneficial to evaluate patient lung density for SBRT plans following protocols that require homogeneous dose calculation.

SSE22-05 A Non-Uniform and Non-Coplanar VMAT Dose Delivery Markedly Reduces Lung Dose in Lung SBRT

Monday, Nov. 27 3:40PM - 3:50PM Room: S403B

Participants
Jens Fleckenstein, Mannheim, Germany (*Presenter*) Nothing to Disclose

ABSTRACT

Purpose/Objective(s): In this retrospective treatment planning study, the effect of different formalisms of prescribing dose to a target volume (PTV)- a uniform and a non-uniform PTV coverage and volumetric modulated arc therapy (VMAT) dose delivery options – a coplanar and a non-coplanar delivery approach- for lung lesions treated with stereotactic body radiation therapy (SBRT) were compared.Materials/Methods: Treatment plans for 46 lesions in the peripheral lungs (VPTV 20.5±17.5cm³, VPTV,min 3.8 cm³, VPTV,max 85.4 cm³) were generated. The D95%(PTV) was 60Gy, delivered in 5 fractions. For each patient three different treatment plans were generated:First, a coplanar 360° VMAT treatment plan with a uniform dose prescription in the target. The planning objective was to cover all voxels in the PTV with 95%-107% of the prescription dose (in agreement with ICRU report 50). Second, a coplanar 360° VMAT treatment plan with a non-uniform dose distribution. The dose in the PTV was limited to a maximum of 150% of the prescription dose as proposed in RTOG trial 0915. Third, a non-coplanar VMAT dose delivery from four different couch angles (0°, ±35°, 90°) combined with a non-uniform PTV prescription as described above was used.All treatment plans were optimized with the described PTV coverage with as low as achievable dose to the lungs. Dose calculation was performed with a clinically commissioned, Monte Carlo based treatment planning system. The treatment sequences were delivered on a conventional medical linear accelerator with flattening-filter-free (FFF) dose delivery and 10MV nominal acceleration potential and the beam-on times were recorded.Results: For the three different scenarios (uniform coplanar, non-uniform coplanar, non-uniform non-coplanar) the delivered monitor units (MU) were (5141±117) MU, (4104±786) MU, and (3657±710) MU, and the corresponding beam-on times were (177±54)s, (143±29)s, and (148±26)s, respectively. This resulted in the following median dose-volume-histogram metrics for PTV, ipsilateral (ILL), and contralateral lung (CLL): uniformcoplanarnon-uniform coplanarnon-uniformnon-coplanarD99%(PTV) in (Gy)58.657.456.8D50%(PTV) in (Gy)62.769.568.4D1%(PTV) in (Gy)66.778.984.1V>5Gy(ILL) in (%)24.820.920.9V>10Gy(ILL) in (%)15.613.410.9V>20Gy(ILL) in (%)6.36.14.2V>30Gy(ILL) in (%)2.82.62.0V>40Gy(ILL) in (%)1.41.21.0V>5Gy(CLL) in (%)3.20.50.3All presented dosimetric results and dose to volume differences between (uniform, coplanar and non-uniform, non-coplanar treatment plans are significant (pConclusion: For SBRT treatments, a non-uniform dose prescription in the PTV, combined with a non-coplanar VMAT arc arrangement, significantly spares surrounding lung tissue while increasing the dose to the PTV.

SSE22-06 ZnS:Ag Scintillator as a Quality Assurance Tool for Scanned Carbon Ion Therapy

Monday, Nov. 27 3:50PM - 4:00PM Room: S403B

Participants

Takumi Narusawa, Sagamihara, Japan (*Presenter*) Nothing to Disclose
Katsunori Yogo, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Tatsuaki Kanai, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Akihiko Matsumura, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Hikaru Souda, Maebashi, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuya Tatsuno, Minami-ku, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose
Kouhei Kamada, Minami-ku, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazushige Hayakawa, MD, PhD, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

mm16032@st.kitasato-u.ac.jp

mm16032@st.kitasato-u.ac.jp

CONCLUSION

We tested a ZnS:Ag scintillator as a QA tool for carbon ion therapy. The tool showed potential as a quick, precise way to measure the depth and lateral dose profiles of carbon pencil beams.

Background

Recently, quick and accurate measurement of dose distribution is essential for quality assurance (QA) of treatments with scanned carbon pencil beams. We developed an easy-to-use dose measurement tool that employed a ZnS:Ag scintillator and charge-coupled device (CCD) camera. One of the challenges in dose measurement of pencil beams for clinical use is the precise measurement of the lateral dose profile, including the low-dose envelope. We tested the tool's performance using pencil beams, comparing the depth and lateral brightness profiles with the dose profiles.

Evaluation

A sheet of the ZnS:Ag scintillator was placed perpendicular to the beam axis in a dark box to eliminate any background light. The water level of the tank above the dark box was controlled remotely to adjust the measurement depth. The scintillation light produced by irradiation with a carbon ion beam was reflected with a mirror and was recorded with a CCD camera; 290 MeV/nucleon mono-energetic carbon pencil beams were used. The depth and lateral brightness distributions from the scintillator were compared with the dose distribution, which was measured with an ionization chamber and a diode.The brightness of the ZnS:Ag scintillator was proportional to the dose (0.5-3 Gy). The depth brightness profile measured with the scintillator was underestimated by about 12% at the Bragg peak, compared with the depth dose profile measured with the chamber. Lateral brightness profiles at the entrance depth showed good agreement with the relative dose profiles measured with the diode. In contrast, there was a discrepancy of over 40% at the Bragg peak.

Discussion

In future, improvement of the signal-to-noise ratio of lateral brightness profiles at the Bragg peak, including the low-dose envelope will be necessary.

SSE23

Physics (Image Processing and Image Quality)

Monday, Nov. 27 3:00PM - 4:00PM Room: S404AB

PH

AMA PRA Category 1 Credit ™: 1.00
ARRT Category A+ Credit: 0

Participants
Joseph Lo, PhD, Durham, NC (*Moderator*) Nothing to Disclose
Karen Drukker, PhD, Chicago, IL (*Moderator*) Royalties, Hologic, Inc

Sub-Events

SSE23-02 Effect of Motion Compensation on the Image Quality of Cone Beam CT Scans in Musculoskeletal Setting

Monday, Nov. 27 3:10PM - 3:20PM Room: S404AB

Participants
Gaurav K. Thawait, MD, Baltimore, MD (*Presenter*) Nothing to Disclose
Alejandro Sisniega, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc
Shadpour Demehri, MD, Baltimore, MD (*Abstract Co-Author*) Research support, General Electric Company; Research Grant, Carestream Health, Inc; Consultant, Toshiba Corporation;
Delaram Shakoor, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Joseph W. Stayman, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Elekta AB Research Grant, Varian Medical Systems, Inc
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;
Wojciech Zbijewski, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG

PURPOSE

To assess whether motion compensation (MC) applied to musculoskeletal cone beam CT (CBCT) images would demonstrate improved image quality and superior diagnostic value.

METHOD AND MATERIALS

18 study participants (13 male 5 female, average age 32 years) who underwent cone beam CT imaging and had motion artifacts in their scans were retrospectively selected. Image datasets were reconstructed using a recently developed motion compensation algorithm. The algorithm uses an "autofocus" approach that numerically estimates the motion trajectory by maximizing the sharpness of the reconstructed image. Image quality was graded using a 5-point Likert scale (1 and 2 non diagnostic, 5 excellent) by two experienced readers in consensus for cortical bone, trabecular bone, joint space, patellar tendon and severity of artifact. Data was analyzed using Visual Grading Characteristics (VGC) curve analysis. Artifact magnitude was quantified as the standard deviation in a soft-tissue region adjacent to bone and centered on the most prominent hyperattenuating streak artifact.

RESULTS

The amplitudes of patient motion, as estimated by the compensation algorithm, varied from 2.3 mm to 8 mm (mean=5.6 mm). All 18 datasets improved in image quality from non-diagnostic (ratings 1 and 2) in original CBCT images to diagnostic (ratings 4 and 5) in MC CBCT images for cortical and trabecular bones. All visualization tasks were significantly in favor of the MC CBCT (Area under curve 0.75 to 0.89, for all tasks). Quantitatively, the artifact magnitude was reduced from 230 HU (min=94 HU, max=334 HU) before compensation to 150 HU after MC.

CONCLUSION

MC improved the image quality of CBCT scans rendered non-diagnostic by motion artifact. The correction was more significant in bone as compared to soft tissue structures.

CLINICAL RELEVANCE/APPLICATION

As the scan times for CBCT examinations are usually longer than conventional CT (~30 sec. vs ~1 sec.), the likelihood of motion artifacts is increased in CBCT. This motion compensation algorithm has, therefore, the potential to be a valueble tool in growing use of dedicated musculoskeletal CBCT imaging.

SSE23-03 Algorithm and Parameter Optimization for Whole-Body Deformable Registration between MR T1-Weighted and Dixon Images (for PET/MR)

Monday, Nov. 27 3:20PM - 3:30PM Room: S404AB

Participants
Jung-Wen Kuo, Cleveland, OH (*Presenter*) Nothing to Disclose
Kuan-Hao Su, Cleveland, OH (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV
Atallah Baydoun, MD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose

Adina N. Crisan, ARRT, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Hugh R. Mihaloew, RT, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Daniel J. Bucklan, MD, University Heights, OH (*Abstract Co-Author*) Nothing to Disclose
Bryan J. Traughber, MD, Cleveland Heights, OH (*Abstract Co-Author*) Spouse, Employee, Koninklijke Philips NV
Robert S. Jones, MD, Cleveland, OH (*Abstract Co-Author*) Nothing to Disclose
Raymond F. Muzic Jr, PhD, Cleveland, OH (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV

For information about this presentation, contact:

jung-wen.kuo@case.edu

PURPOSE

While whole-body MR T1-weighted (T1W) and Dixon images can provide diagnostic and localization information at high spatial resolution for PET/MR interpretation and attenuation correction, the images may be misregistered in lung and upper abdomen due to respiration and patient motion which cannot be corrected using rigid-body registration. To address this, we developed a fully automatic deformable registration with algorithm optimization.

METHOD AND MATERIALS

Six whole-body MR Dixon and T1W data sets were collected (Philips Ingenuity TF PET/MR). Having the highest spatial resolution, the Dixon in-phase images were treated as reference for the registration. Rigid-body registration was first performed. Then, an open-source application, REGGUI, was used for non-gradient-based deformable registration. The optimal method was chosen among block-matching (BD), sum of square difference (SSD), BD-SSD with gradient, and local phase algorithms. In addition, a pre-regularization and a fluid regularization with different filters and parameters was applied and optimized for the best performance. SSD, mutual information (MI), normalized MI (norMI) and correlation coefficient (R) were recorded at the end of each iteration for performance evaluation.

RESULTS

The deformed whole-body T1W images were aligned with the Dixon images, especially in the areas of lung, liver, and upper abdomen. The local phase deformable algorithm shows the best result among the four methods. The pre- or fluid- regularization filters did not improve the registration. The majority of the mismatch between original T1W and Dixon images was from the deformation of lung and organs due to different breathing techniques and can be reduced with the deformable registration. This whole-body registration is insensitive to the change of the parameters and do not require filtering. The deformable registration currently takes 1 h but can be automated for clinical practice until computational optimizations are implemented.

CONCLUSION

The automatic registration with whole-body T1W and Dixon images are feasible using non-gradient-based deformation. The local phase without regularizations shows the best performance for this whole-body deformable registration.

CLINICAL RELEVANCE/APPLICATION

This study established a clinical practicable approach for an automatic deformable registration between whole-body T1W and Dixon images.

SSE23-04 A Viewer for Dynamic Whole-Body PET/CT Studies with Integrated Voxel-based Patlak Analysis

Monday, Nov. 27 3:30PM - 3:40PM Room: S404AB

Participants
Jeffrey P. Leal, BA, Baltimore, MD (*Presenter*) Nothing to Disclose
Evrim B. Turkbey, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Lilja B. Solnes, MD, MBA, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Steven P. Rowe, MD, PhD , Parkville, MD (*Abstract Co-Author*) Nothing to Disclose
Arman Rahmim, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Nicolas Karakatsanis, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Martin A. Lodge, PhD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

jleal1@jhmi.edu

PURPOSE

The purpose of our project was to develop a software system for the display, quantitation and voxel-based Patlak analysis of dynamic whole-body PET/CT imaging studies.

METHOD AND MATERIALS

We developed a DICOM image viewer and analysis system in the Java programming language. The viewer can load dynamic (multi-timepoint) DICOM whole-body image sets as well as aggregating separately acquired whole body image series. In addition, the viewer can load any co-registered anatomical imaging (e.g. CT, MR) for fusion display and anatomical localization, employing multiple look-up tables and user control of image blending. We incorporated regions-of-interest (ROIs) which provide real-time display of Time-Activity-Curves (TACs) and corresponding image statistics. For the voxel-by-voxel Patlak analysis, ROIs are used to provide the necessary input function data, either providing the entire function if imaging captures the time of injection, or used to scale a population input function when only later imaging timepoints are available.

RESULTS

Integrated PET/CT display of dynamic whole-body PET was provided, allowing user navigation of study time points in a similar fashion to conventional clinical image review. In addition to providing simple navigation of fused datasets across all timepoints, the system provided for the generation of summed image datasets, as well as the generation and display of Patlak slope, intercept and correlation images resulting from a voxel-based Patlak analysis. ROIs drawn on any one dataset were dynamically applied to any other dataset, providing real-time TACs across both original and derived images. Tabular ROI statistics from any dataset are exportable for further analysis.

CONCLUSION

Modern PET/CT scanners are faster and more efficient than ever before, enabling dynamic whole-body acquisitions which previously were not feasible. The software presented here provides many of the required features to properly display and analyze these new datasets, and does so in an implementation which is easily navigable by the user and executable on the widest variety of computing platforms.

CLINICAL RELEVANCE/APPLICATION

Dynamic whole-body PET/CT imaging is possible and, when provided with the right toolset, clinicians can begin to exploit the additional dimension of information which this imaging strategy provides.

SSE23-05 Novel Approach to Estimate Source-Detector Alignment of Cone-Beam X-Ray Systems Using Collimator Edge Tracking

Monday, Nov. 27 3:40PM - 3:50PM Room: S404AB

Participants
Christoph Luckner, MSc, Erlangen, Germany (*Presenter*) External Employee, Siemens Healthcare GmbH
Andreas Fieselmann, PhD, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens Healthcare GmbH
Thomas Mertelmeier, PHD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG Stockholder, Siemens AG
Andreas Maier, DIPLENG, Erlangen, Germany (*Abstract Co-Author*) Research support, Siemens AG; Research support, iSchemaView, Inc
Ludwig Ritschl, Nurnberg, Germany (*Abstract Co-Author*) Employee, Siemens Healthcare GmbH

For information about this presentation, contact:

christoph.luckner@fau.de

PURPOSE

Due to upcoming applications for clinically well-established digital X-ray systems, like workflow automation or high-quality free exposures with mobile detectors, knowing and reproducing the exact source-detector alignment is a crucial factor. Hence, it is important to determine their exact alignment without complicating the clinical routine or adding any additional hardware. Furthermore, novel X-ray systems with independently moveable source and detector might benefit from this method.

METHOD AND MATERIALS

The presented method utilizes the fact that the position of the collimator relative to the source is known, and determines the intrinsic parameters of a projection matrix using a two-staged algorithm.1. Detect the corners of the collimator in the projection image and find a preliminary set of intrinsics such that the difference between the projection of the known 3-D collimator coordinates and the detected corners is minimal in a least-squares sense.2. Use these intrinsic parameters as initial values for an optimization, to find the optimal set of intrinsics (f, u0, v0) which maps the 3-D coordinates best to the 2-D ones on the detector, by maximizing the sum along the line integral between the projections of two collimator corner points using a precomputed gradient magnitude image.For validation, a simulation study was carried out, simulating the projection of the collimator, taking the introduced blurring due to the focal spot size into account. In total, 27 data sets (2880x2880 px á 0.15 mm, f = 1200 mm) with various detector rotations and translations were simulated and used for evaluation. Each variable was then compared to the ground truth separately.

RESULTS

It was shown that the presented method is able to estimate the detector offset (u0, v0) with an accuracy of ±1.35 px and the focal length f with an accuracy of ±5 mm.

CONCLUSION

The presented algorithm is capable of estimating the source-detector alignment of cone-beam X-ray systems, utilizing only already existing information of the X-ray system. Thus, this method might enable new clinical applications which could lead to a benefit in the clinical routine.

CLINICAL RELEVANCE/APPLICATION

The proposed method might open up the possibility of further workflow automation and image quality improvement in well-established digital X-ray systems. Additionally, emerging technologies like CBCT using robotic devices might profit.

SSE23-06 Feasibility Study of the NPWE Model Observer for Objective Image Quality Assessment of Processed Digital Mammography Images

Monday, Nov. 27 3:50PM - 4:00PM Room: S404AB

Participants
Christiana Balta, MSc, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose
Ramona Bouwman, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Ioannis Sechopoulos, PhD, Atlanta, GA (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Toshiba Medical Systems Corporation; Speakers Bureau, Siemens AG; Scientific Advisory Board, Fischer Medical
Mireille Broeders, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Nico Karssemeijer, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Director and Shareholder, ScreenPoint Medical BV; Shareholder, Volpara Health Technologies Limited; Consultant, QView Medical, Inc; Shareholder, QView Medical, Inc;
Ruben E. van Engen, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Wouter J. Veldkamp, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

c.balta@lrcb.nl

PURPOSE

To investigate how image processing algorithms in digital mammography affect the detectability of calcification-like discs embedded in an anthropomorphic breast phantom for both human and model observers.

METHOD AND MATERIALS

A 3D printed phantom was constructed from a patient breast CT image, and cut into two transverse slabs. Between the slabs, aluminum squares with gold discs of 0.1 mm and 0.25 mm diameter (1.80 µm and 0.50 µm thick) were inserted. Images were acquired at four dose levels using two mammography systems, and images with and without processing were used to create 200 signal-present and 200 signal-absent regions of interests (ROIs) per system type, image type, dose level and disc size. The ROIs were scored by a non-prewhitening with eye-filter (NPWE) model observer and by three human observers in two-alternative-forced-choice experiments. As a measure of performance, the proportion of correct (PC) responses was obtained.

RESULTS

For system A, for the 0.1 mm discs, PCNPWE increased with dose and ranged from 0.74-0.89 and 0.75-0.92 (p=0.12); PCH varied 0.73-0.93 and 0.71-0.95 (p=1), in case of ROIs with and without processing respectively. Similar results were obtained for the 0.25 mm discs and for both disc sizes on system B. The correlation between humans and model observer was high and resulted in R2=0.77 for the 0.1 mm and R2=0.85 for the 0.25 mm disc. As expected, all PC values increased with dose and trends were similar for both systems and unprocessed/processed images.

CONCLUSION

For the task of detecting a specific disc size, model and human observers have a consistent correlation in PC in images with and without processing under different conditions (dose levels, type of system). Therefore, an NPWE model observer and real acquired images of a realistic breast phantom could be used in the assessment of detection of calcification-like discs in images including image processing

CLINICAL RELEVANCE/APPLICATION

Model observers and anthropomorphic phantoms could be used to assess the impact of image processing algorithms on lesion detectability, allowing for task-based testing of this important post-acquisition stage.

RC321

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

Tuesday, Nov. 28 8:30AM - 10:00AM Room: E352

CT PH

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

Participants

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

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC321A Contrast Administration for Cardiovascular Imaging and Beyond

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

Active Handout:Dominik Fleischmann

http://abstract.rsna.org/uploads/2017/16001080/Active RC321A.pdf

RC321B Perfusion Techniques and Applications—Stroke and Cancer

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

For information about this presentation, contact:

tlee@robarts.ca

LEARNING OBJECTIVES

1) Comprehend the principles of CT Perfusion imaging in stroke and cancer applications. 2) Apply the principles to discern errors that my occur in perfusion calculation. 3) Design scanning protocols for CT Perfusion imaging of stroke and cancer. 4) Apply dose saving techniques to reduce radiation dose. 5) Discuss the application of CT Perfusion imaging in stroke and cancer with examples.

Active Handout:Ting-Yim Lee

http://abstract.rsna.org/uploads/2017/16001082/Active RC321B.pdf

RC321C Perfusion Techniques and Applications—Cardiac

Participants
Aaron So, PhD, London, ON (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

aso@robarts.ca

LEARNING OBJECTIVES

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

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103rd Scientific Assembly and Annual Meeting
November 26 to December 1
McCormick Place, Chicago
Explore Invent Transform

RC322

MRI: Imaging for Radiation Treatment Planning

Tuesday, Nov. 28 8:30AM - 10:00AM Room: S104B

MR RO PH

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

Participants
Eric Paulson, PHD, Milwaukee, WI (*Moderator*) Nothing to Disclose

Sub-Events

RC322A MRI for Anatomical Definition

Participants
Eric Paulson, PHD, Milwaukee, WI (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the advantages of MRI simulation for anatomical delineation in both external beam radiation therapy and brachytherapy. 2) Understand the differences between images obtained during MRI simulation versus diagnostic MRI. 3) Understand the current solutions to address technical challenges of using MRI for anatomical delineation in Radiation Oncology.

ABSTRACT

MRI is rapidly emerging as a primary imaging modality in Radiation Oncology, fueled by innovations in MRI-guided treatment delivery, MRI simulation systems, and the role of MRI in individualizing and adapting radiation therapy. This course will discuss the advantages and technical challenges of using MRI for anatomical definition in radiation treatment planning. Current solutions to tailor MRI to the unique demands of Radiation Oncology will be explored. Clinical examples illustrating the use of MRI for anatomical delineation in both external beam radiation therapy and brachytherapy will be presented.

RC322B MRI for Functional Definition

Participants
Uulke A. van der Heide, PhD, Amsterdam, Netherlands (*Presenter*) Research support, Elekta AB; Speaker, Koninklijke Philips NV

LEARNING OBJECTIVES

1) Get an overview of the most relevant functional MRI modalities are available. 2) Understand how they can be used to improve target definition. 3) Understand their limitations and specific concerns for use in radiation oncology.

ABSTRACT

In addition to anatomical imaging, MRI affords a range of functional techniques. Diffusion-weighted MRI images the restriction of water mobility in tissue, thus probing microanatomy. This is used to identify tumors and monitor response to treatment. Dynamic contrast-enhanced MRI shows the tracer kinetics of contrast agents and reflects the characteristics of the microvasculature, such as flow and permeability. These and other techniques can be used to improve target definition, and to characterize tumor tissue for radiotherapy dose painting.

RC323

MR Safety

Tuesday, Nov. 28 8:30AM - 10:00AM Room: N229

MR PH SQ

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

Participants
Yunhong Shu, PhD, Rochester, MN (*Director*) Nothing to Disclose

LEARNING OBJECTIVES

1) List several MR Safety incidents and describe their root causes. 2) List a variety of commonly implanted Neurostimulators and MR Conditional Pacemakers. 3) Identify potential risks associated with scanning patients implanted with these devices using MRI in the clinical environment. 4) Describe special MR Safety hazards present in the MR interventional environment, and identify countermeasures to reduce the associated risks. 5) Describe MR Safety guidelines and recommendations to prevent accidents and injuries.

Sub-Events

RC323A Case Review of Real MR Safety Incidents

Participants
Armen Kocharian, PhD, Houston, TX (*Presenter*) Research collaboration, General Electric Company

For information about this presentation, contact:

akocharian@houstonmethodist.org

LEARNING OBJECTIVES

1) Identify main safety risk factors from incident reviews at MR Imaging sites. 2) Assess and address the MRI safety potential risks. 3) Implement preventive measures in clinical practice for improved standard of care.

Active Handout:Armen Kocharian

http://abstract.rsna.org/uploads/2017/16001094/Active RC323A.pdf

RC323B MRI Safety of Deep Brain and Other Simulators

Participants
Yunhong Shu, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) List a variety of commonly implanted neurostimulators. 2) Understand the importance of MRI as a diagnostic imaging tool for patient with implanted neurostimulator. 3) Identify the potential risks associated with scanning patient with implanted neurostimulator using MRI. 4) Describe MR safety guidelines and recommendations to prevent accidents and injuries.

ABSTRACT

A neurostimulator is a surgically placed programmable device. It delivers mild electrical signals to the targeted area through thin wires. The purpose is usually for pain relief or improving patient's ability to perform daily activities. There are a variety of commonly used neurostimulators include deep brain stimulator, spinal cord stimulator, vagus nerve stimulator and sacral nerve stimulator. MRI is clinically important for post-implantation evaluation. It is very likely that a patient will require an MRI scan after the neurostimulator is implanted. The risks of performing MRI on patients with neurostimulators are related to static magnetic field, gradient magnetic field and the RF field. The talk will provide an imaging physics overview on the potential risks and make recommendations for MR imaging safety procedure.

RC323C MRI Conditional Pacemakers: What to Do?

Participants
Anshuman Panda, PhD, Scottsdale, AZ (*Presenter*) Nothing to Disclose

Active Handout:Anshuman Panda

http://abstract.rsna.org/uploads/2017/16001096/Handout Panda Pacer RSNA 2017.pdf

RC323D MRI Safety in the MR-Guided Interventional Environment

Participants
Krzysztof Gorny, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Presentation will include overview of interventional MRI practice within context of generally accepted principles of MRI safety. 2)

Description of the practice will be provided including example protocol for safety testing of previously unlabeled equipment considered for potential use inside Zone 4.

Active Handout:Krzysztof Gorny

http://abstract.rsna.org/uploads/2017/16001097/Active RC323D.pdf

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November 26 to December 1
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RC324

What Physics Brings to Value-based Care: Measurement and Quantification of Quality in Imaging Practice

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

PH SQ

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

FDA Discussions may include off-label uses.

Participants
Ehsan Samei, PhD, Durham, NC (*Moderator*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC324A Philosophy and Characterization of Value in Value-based Imaging

Participants
Robert Saunders JR, PhD, Washington, DC (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To describe the current programs that seek to measure the value of radiology services or medical imaging. 2) To further be able to describe the current types of measures used to assess value in radiology and medical imaging, including their limitations and challenges.

RC324B Quantification of Imaging Quality in Terms of Individualized Radiation Dose and Image Quality

Participants
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

For information about this presentation, contact:

samei@duke.edu

RC324C Quantification of Imaging Quality in Terms of Care Outcome

Participants
Mika K. Kortesniemi, PhD, Helsinki, Finland (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

mika.kortesniemi@hus.fi

LEARNING OBJECTIVES

1) To describe the challenges when pursuing to utilize heterogeneous, multidimensional and multifrequent data to estimate outcome. 2) To describe how the quantitative optimization task and methodology could be approached to reach outcome based metrics.

Active Handout:Mika Karel Kortesniemi

http://abstract.rsna.org/uploads/2017/17002331/Active RC324c.pdf

RC325

Radiomics Mini-Course: From Image to Omics

Tuesday, Nov. 28 8:30AM - 10:00AM 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; ; ; ; ;
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Consultant, Carestream Health, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

For information about this presentation, contact:

snapel@stanford.edu

Sub-Events

RC325A Image Annotation and Semantic Labeling

Participants
Daniel L. Rubin, MD, MS, Stanford, CA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

daniel.l.rubin@stanford.edu

LEARNING OBJECTIVES

1) To understand the role of image annotations in capturing essential information about images in radiomics. 2) To learn about standards for capturing image annotation information, particularly Annotation and Image Markup (AIM) and DICOM-SR. 3) To see example use cases for image annotation in enabling radiomics research and clinical practice.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Daniel L. Rubin, MD, MS - 2012 Honored EducatorDaniel L. Rubin, MD, MS - 2013 Honored Educator

RC325B Image Feature Computation and Considerations

Participants
Sandy Napel, PhD, Stanford, CA (*Presenter*) Medical Advisory Board, Fovia, Inc; Consultant, Carestream Health, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

For information about this presentation, contact:

snapel@stanford.edu

LEARNING OBJECTIVES

1) To understand the utility of various image feature categories (e.g., shape, edge sharpness, histogram, texture) and how image features are computed. 2) To appreciate the differential sensitivity of image features to variations in segmentation. 3) To appreciate the sensitivity of image features to acquisition protocols and image artifacts. 4) To understand how to use standard and customized workflows to compute image features for their own cohorts and for publicly available ones (e.g., TCIA).

RC325C Correlating Image Features with Multi-Omics Data

Participants
Mu Zhou, PhD, Mountain View, CA (*Presenter*) Nothing to Disclose

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. The community is beginning to extract image features from the MRI, CT and/or PET images in TCIA, including tumor volume, shape, margin sharpness, voxel-value histogram statistics, image textures, and specialized features developed for particular acquisition modes. They are also annotating the images with semantic descriptors 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. This workshop will describe datasets and tools that enable research at the intersection of imaging and genomics, and that point to opportunities to develop future applications that leverage this knowledge for diagnostic decision support and treatment planning.

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. The community is beginning to extract image features from the MRI, CT and/or PET images in TCIA, including tumor volume, shape, margin sharpness, voxel-value histogram statistics, image textures, and specialized features developed for particular acquisition modes. They are also annotating the images with semantic descriptors 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. This workshop will describe datasets and tools that enable research at the intersection of imaging and genomics, and that point to opportunities to develop future applications that leverage this knowledge for diagnostic decision support and treatment planning.

RCC31

Cybersecurity for Imaging Departments and Imagers - Threats, Vulnerabilities and Best Practices: Part 1

Tuesday, Nov. 28 8:30AM - 10:00AM Room: S501ABC

IN PH SQ

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

Participants
James Whitfill, MD, Scottsdale, AZ (*Moderator*) President, Lumetis, LLC; Speaker, FUJIFILM Holdings Corporation;

LEARNING OBJECTIVES

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

SAM

New in 2017: PLEASE NOTE - All courses designated for SAM credit at RSNA 2017 will require attendees bring a personal device e.g. phone, iPad, laptop to complete the required test questions during the live session.

Sub-Events

RCC31A Medical Device Security in a Connected World

Participants
Kevin McDonald, Rochester, MN (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

mcdonald.kevin@mayo.edu

LEARNING OBJECTIVES

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

RCC31B Knowing if Your Imaging Systems are Secure and Keeping Them That Way

Participants
James A. Seibert, PhD, Sacramento, CA (*Presenter*) Advisory Board, Bayer AG

For information about this presentation, contact:

jaseibert@ucdavis.edu

LEARNING OBJECTIVES

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

RCC31C Cyberattacks in Healthcare: The Rising Threats to Our Patients' Health

Participants
James Whitfill, MD, Scottsdale, AZ (*Presenter*) President, Lumetis, LLC; Speaker, FUJIFILM Holdings Corporation;

For information about this presentation, contact:

jwhitfill@lumetis.com

jwhitehill@lumetis.com

LEARNING OBJECTIVES

1) Appreciate the evolving landscape of cyberthreats to healthcare and Radiology. 2) Understand the different targeting strategies used by cyber attackers. 3) Understand the difference between cyberthreats to patient's health and patients' health information.

PS31

Tuesday Morning Plenary Session

Tuesday, Nov. 28 10:30AM - 12:00PM Room: E451B

IN PH

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credit: .75

Participants
Richard L. Ehman, MD, Rochester, MN (*Presenter*) CEO, Resoundant, Inc; Stockholder, Resoundant, Inc;
Melissa C. Martin, MS, Signal Hill, CA (*Presenter*) Nothing to Disclose

Sub-Events

PS31A RSNA/AAPM Physics Symposium: Machine Learning in Radiology: Why and How?

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

LEARNING OBJECTIVES

1) To learn what machine learning is, and how it is evolving. 2) To learn the current and potential impacts of machine learning and AI on radiology. 3) To learn how radiology can utilize machine learning and AI to improve outcomes.

PS31B Harnessing Artificial Intelligence

Participants
Keith J. Dreyer, DO, PhD, Boston, MA (*Presenter*) Nothing to Disclose

PS31C Assistive AI for Cancer Treatment

Participants
Antonio Criminisi, PhD, Cambridge, United Kingdom (*Presenter*) Employee, Microsoft Corporation

For information about this presentation, contact:

antcrim@microsoft.com

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November 26 to December 1
McCormick Place, Chicago
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SSG13

Physics (CAD and Machine Learning)

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

BQ CT IN PH

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

Participants
Robert M. Nishikawa, PhD, Pittsburgh, PA (*Moderator*) Royalties, Hologic, Inc Research Consultant, iCAD, Inc
Nico Karssemeijer, PhD, Nijmegen, Netherlands (*Moderator*) Director and Shareholder, ScreenPoint Medical BV; Shareholder, Volpara Health Technologies Limited; Consultant, QView Medical, Inc; Shareholder, QView Medical, Inc;

Sub-Events

SSG13-01 Observer Performance Study for Bladder Cancer Treatment Response Assessment in CT Urography With and Without Computerized Decision Support

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

Participants
Kenny H. Cha, MSc, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Institutional research collaboration, General Electric Company
Richard H. Cohan, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Elaine M. Caoili, MD, MS, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Ravi K. Samala, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Kimberly L. Shampain, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Nathaniel B. Meyer, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Daniel T. Barkmeier, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Sean A. Woolen, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Alon Z. Weizer, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Ajjai S. Alva, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To evaluate whether a computerized decision support system for bladder cancer treatment response assessment (CDSS-T) can assist radiologists in identifying patients who have complete response after neoadjuvant chemotherapy.

METHOD AND MATERIALS

With IRB approval, pre- and post-chemotherapy CTU scans of 123 patients were collected retrospectively, resulting in 158 pre- and post-treatment lesion pairs. The pathological cancer stage after treatment, as determined by cystectomy, was collected as the reference standard of whether a patient fully responded to treatment. Twenty-five percent of the lesion pairs (40/158) had T0 cancer stage after chemotherapy, which corresponds to a complete response. We have developed a CDSS-T system that uses a combination of DL-CNN and radiomics features to distinguish between cases that have fully responded to treatment and those that have not. Two abdominal radiologists and 4 residents trained in abdominal radiology estimated the likelihood of stage T0 disease after treatment by viewing each pre-post-treatment CTU pair displayed side by side on a specialized graphic user interface designed for CDSS-T. The observer provided an estimate without CDSS-T first and then might revise the estimate, if preferred, after the CDSS-T score was displayed. The cases were randomized differently for each observer. The observers' estimates with and without CDSS-T were analyzed with multi-reader, multi-case (MRMC) receiver operating characteristic (ROC) methodology. The area under the curve (AUC) and the statistical significance of the difference were calculated.

RESULTS

The AUC for prediction of T0 disease after treatment was 0.80±0.04 for the CDSS-T alone. Each observer's performance increased with the aid of CDSS-T. The average AUC for the observers were 0.75 (range: 0.70-0.79) without CDSS-T, and increased to 0.78 (range: 0.73-0.81) with CDSS-T. The differences in the average AUC values between without CDSS-T and with CDSS-T were statistically significant ($p < 0.01$).

CONCLUSION

Our study demonstrated that our CDSS-T system for bladder cancer treatment response assessment in CTU can improve radiologists' performance in identifying patients who fully responds to treatment.

CLINICAL RELEVANCE/APPLICATION

CDSS-T has the potential to improve radiologists' accuracy in bladder cancer treatment response assessment, which is vital for identifying non-responders and allowing them to seek alternative therapy.

SSG13-02 DeepBreath: Automated Lung Nodule Detection and Segmentation with Convolutional Neural Networks

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

Participants
Felix Lau, San Francisco, CA (*Presenter*) Senior Machine Learning Scientist, Arterys
Jesse Lieman-Sifry, San Francisco, CA (*Abstract Co-Author*) Researcher, Arterys Inc
Sean Sall, San Francisco, CA (*Abstract Co-Author*) Researcher, Arterys Inc
Matthieu Le, San Francisco, CA (*Abstract Co-Author*) Researcher, Arterys Inc
John Axerio-Cilies, PhD, San Francisco, CA (*Abstract Co-Author*) Founder, Arterys Inc Officer, Arterys Inc
Daniel Golden, PhD, San Francisco, CA (*Abstract Co-Author*) Employee, Arterys Inc
Albert Hsiao, MD, PhD, La Jolla, CA (*Abstract Co-Author*) Founder, Arterys, Inc Consultant, Arterys, Inc Research Grant, General Electric Company

For information about this presentation, contact:

felix@arterys.com

PURPOSE

To automatically detect and segment lung nodules in Computed Tomography (CT) scans for computer-aided detection of lung cancer

METHOD AND MATERIALS

Following the LUng Nodule Analysis (LUNA) 2016 challenge, our dataset contains 888 CT scans from Lung Image Database Consortium (LIDC) with slice thickness <= 3mm. There are 1,186 nodules in which the median diameter is 6.43mm (min=3.25mm, max=32.27mm). We designate 80% of the scans as training set, 10% as validation set and 10% as test set. We report all metrics on the test set. Our approach consists of the following three stages: First, we use a 2D U-Net-based segmentation proposal network to suggest initial nodule candidates for each scan. We apply higher weight to the loss in the center of the nodules with gradual drop-off towards the edges to encourage the network to learn the nodule center and boundary. Next, we use a 2.5D ResNet-based classifier to reduce the number of false positives (FP). We extract 9 views (6 diagonal and 3 orthogonal) for each candidate and oversample positive nodules to account for label imbalance. Finally, we segment positive nodules with a 3D U-Net based network to obtain fine-grained nodule masks. The network is trained on 3D patches centered on the nodule with ground truth masks based on agreement of three of the four LIDC annotators. We evaluated our method using nodule recall at 2 FP per scan and nodule recall from the proposal network. For nodule segmentation, we report the dice coefficient between ground truth and prediction segmentation.

RESULTS

In the first stage, the proposal network has a recall of 92.04% with an average of 969.34 FP/scan. By ensembling two proposal networks, we achieve a recall of 95.57% with 1161.24 FP/scan. After the classifier stage, the number of FP has been reduced by 500x to 2 FP/scan while maintaining a high recall of 85.86%, 95% CI [75.01% and 92.67%]. For nodule segmentation, the mean volumetric dice coefficient is 0.76 ± 0.14.

CONCLUSION

Our automated nodule detection method yields a high nodule recall rate while maintaining a low false positive rate. Furthermore, our nodule segmentation method provides accurate and detailed nodule segmentation in 3D to assist clinical management and follow-up.

CLINICAL RELEVANCE/APPLICATION

A reliable lung CADe system may become essential for detection of lung lesions for early diagnosis of cancer. It may improve radiologist accuracy and efficiency as a second reader.

SSG13-03 Direct Coronary Artery Calcium Scoring in Low-Dose Chest CT Using Deep Learning Analysis

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

Participants
Bob De Vos, MSc, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Nikolas Lessmann, MSc, Utrecht, Netherlands (*Presenter*) Nothing to Disclose
Pim A. De Jong, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Max A. Viergever, Utrecht, Netherlands (*Abstract Co-Author*) Research Grant, Pie Medical Imaging BV
Ivana Isgum, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Research Grant, Pie Medical Imaging BV; Research Grant, 3mensio Medical Imaging BV; Research Grant, Koninklijke Philips NV; ;

For information about this presentation, contact:

bob@isi.uu.nl

PURPOSE

Coronary artery calcium (CAC) score determined in screening with low-dose chest CT is a strong and independent predictor of cardiovascular events (CVE). However, manual CAC scoring in these images is cumbersome. Existing automatic methods detect CAC lesions and thereafter quantify them. However, precise localization of lesions may not be needed to facilitate identification of subjects at risk of CVE. Hence, we have developed a deep learning system for fully automatic, real-time and direct calcium scoring circumventing the need for intermediate detection of CAC lesions.

METHOD AND MATERIALS

The study included a set of 1,546 baseline CT scans from the National Lung Screening Trial. Three experts defined the reference standard by manually identifying CAC lesions that were subsequently quantified using the Agatston score. The designed convolutional neural network analyzed axial slices and predicted the corresponding Agatston score. Per-subject Agatston scores

were determined as the sum of per-slice scores. Each subject was assigned to one of five cardiovascular risk categories (Agatston score: 0, 1-10, 10-100, 100-400, >400). The system was trained with 75% of the scans and tested with the remaining 25%. Correlation between manual and automatic CAC scores was determined using the intra class correlation coefficient (ICC). Agreement of CVD risk categorization was evaluated using accuracy and Cohen's linearly weighted κ.

RESULTS

In the 386 test subjects, the median (Q1-Q3) reference Agatston score was 54 (1-321). By the reference, 95, 37, 86, 94 and 75 subjects were assigned to 0, 1-10, 10-100, 100-400, >400 risk categories, respectively. The ICC between the automatic and reference scores was 0.95. The method assigned 85% of subjects to the correct risk category with a κ of 0.90. The score was determined in <2 seconds per CT.

CONCLUSION

Unlike previous automatic CAC scoring methods, the proposed method allows for quantification of coronary calcium burden without the need for intermediate identification or segmentation of separate CAC lesions. The system is robust and performs analysis in real-time.

CLINICAL RELEVANCE/APPLICATION

The proposed method may allow real-time identification of subjects at risk of a CVE undergoing CT-based lung cancer screening without the need for intermediate segmentation of coronary calcifications.

SSG13-04 Investigating the Depth of Convolutional Neural Networks (CNNs) in Computer-aided Detection and Classification of Focal Lesions: Lung Nodules in Thoracic CT and Colorectal Polyps in CT Colonography

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

Participants
Nima Tajbakhsh, PhD, Chicago, IL (*Abstract Co-Author*) Employee, CureMetrix, Inc
Amin Zarshenas, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Kenji Suzuki, PhD, Chicago, IL (*Presenter*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

ksuzuki@iit.edu

PURPOSE

In deep learning research in medical image analysis, how deep we should go is an open question. Our purpose was to investigate how the depth of CNNs affects the performance in detection and classification of focal lesions in medical images.

METHOD AND MATERIALS

We collected 3 databases containing (a) 50 lung nodules (4-27 mm) including 38 biopsy-confirmed lung cancers in 32 patients in screening CT for detection of nodules, (b) 28 polyps (5-25 mm) in 146 CT colonography scans in 73 patients for detection of polyps, and (c) 76 biopsy-confirmed malignant nodules and 413 confirmed benign nodules (3-29 mm) in 342 patients in thoracic CT for classification between benign and malignant. We employed CNN architectures with N convolutional and max-pooling layers, a fully-connected layer followed by a soft-max layer. From the 1st to 5th convolutional layer, 11x11, 5x5, 3x3, 3x3, and 4x4 filters (kernels) were used, by following the standard CNN design. We trained and compared 5 CNNs with 5 different depths by reducing the number of convolutional and max-pooling layers. We also changed the number of filters in the convolutional layers from 8, 16, 32, to 64 to investigate the impact of both network depth and width on the performance. We used 5-fold cross validation for training and testing (100 CNNs in total for each database). We evaluated the performance by using receiver-operating-characteristic (ROC) analysis for the classification task and Jackknife alternative free-response ROC (JFROC) analysis for the detection tasks, with the area under the curve as a metric.

RESULTS

There was no statistically significant difference (>.05) among different depth CNNs when 8 or 64 filters were used in the convolutional layers, suggesting that deeper architectures were not effective if CNNs were sufficiently wide. CNNs with 3 or 4 convolutional layers were more effective than shallower architectures, but a further performance gain was not observed by using deeper architectures.

CONCLUSION

Sufficiently wide CNNs with 3 or 4 convolutional layers might be adequate for focal lesion detection and classification in CT. Thus, the use of an unnecessarily deeper deep-learning model would result in inferior performance.

CLINICAL RELEVANCE/APPLICATION

A properly deep deep-learning model would result in higher performance, and such a high-performance computer-aided system would be useful for radiologists in their lesion detection and classification.

SSG13-05 Two Deep-Learning Models for Lung Nodule Detection and Classification in CT: Convolutional Neural Network (CNN) vs Neural Network Convolution (NNC)

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

Participants
Nima Tajbakhsh, PhD, Chicago, IL (*Abstract Co-Author*) Employee, CureMetrix, Inc
Amin Zarshenas, MSc, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

Kenji Suzuki, PhD, Chicago, IL (*Presenter*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

ksuzuki@iit.edu

PURPOSE

Deep learning achieved overwhelming success in object classification in computer vision. Our purpose was to develop and compare two classes of deep-learning models in lung nodule detection and classification in CT: CNN models that were imported from the computer vision field vs. NNC that was proposed by us in the medical imaging field.

METHOD AND MATERIALS

We developed, trained, and compared extensively 5 representative CNN models and our NNC model in 1) lung nodule detection and 2) classification in CT. The 5 CNN models were an AlexNet (5 convolution (CL), 3 pooling (PL) and 3 fully-connected layers (FL)), a LeNet (2 CL, 2 PL and 2 FL), a shallow CNN (1 CL, 1 PL and 1 FL), relatively deep CNN (4 CL, 4 PL and 2 FL), and a transfer-learned AlexNet. Our NNC architecture consisted of an ensemble of multiple NNC models, each of which has 3-layer neural network regression (NNR) with a scoring layer, followed by 3 fully-connected layers for classification. Each NNC in the ensemble was trained to classify a specific type of non-nodule from nodules. In NNC, convolution of the NNR was performed to process the entire image, but unlike CNN it was done outside the network. Our databases contained 1) 50 lung nodules including 38 biopsy-confirmed lung cancers from 32 patients in screening CT and 2) 76 biopsy-confirmed malignant nodules and 413 confirmed benign nodules in 342 patients in thoracic CT. We trained and tested the 6 deep-learning models with each of the 2 databases in 5-fold cross validation. We evaluated and compared the performance by using receiver-operating-characteristic (ROC) analysis and free-response ROC analysis.

RESULTS

In 1) nodule detection, our NNC achieved a 100% sensitivity with 2.7 false positives (FPs)/patient, whereas the best performing CNN (transfer-learned AlexNet) generated 22.7 FPs/patient ($P<.05$). In 2) nodule classification, our NNC yielded an area under the ROC curve (AUC) of 0.881 which was significantly ($P<.05$) higher than an AUC of 0.776 for the best performing CNN model.

CONCLUSION

We developed and compared 5 CNN models and our NNC in detection and classification of lung nodules in CT. Our NNC achieved higher performance than the best performing CNN model.

CLINICAL RELEVANCE/APPLICATION

A high-performance deep-learning model would help improve radiologists' diagnostic performance in lung nodule detection and classification in CT.

SSG13-06 Assessing the Performance of CAD in Lung Nodule Detection from Low-Dose Lung Cancer Screening CT Exams Under Different Combinations of Radiation Dose Level, Slice Thickness, and Reconstruction Kernel

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

Participants
Nastaran Emaminejad, MSc, Los Anegeles, CA (*Presenter*) Nothing to Disclose
Muhammad W. Wahi-Anwar, BS, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
John M. Hoffman, BS, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Kathleen Ruchalski, MD, Santa Monica, CA (*Abstract Co-Author*) Nothing to Disclose
Jonathan G. Goldin, MBChB, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Angela Sultan, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Hyung J. Kim, PhD, Los Angeles, CA (*Abstract Co-Author*) Research Consultant, MedQIA
Matthew S. Brown, 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; ; ; ; ;

For information about this presentation, contact:

nemaminejad@mednet.ucla.edu

PURPOSE

The goal of this study was to assess the impact of dose reduction and various reconstruction parameters, on the detection of lung nodules by CAD software applied to low dose Lung Cancer Screening CT exams.

METHOD AND MATERIALS

Our dataset consisted of data from 59 subjects who underwent low dose CT for lung cancer screening at our institution. Scans were performed using a 64 slice MDCT with Tube Current Modulation (TCM) according to the AAPM lung cancer screening protocols which yielded a CTDIvol of approximately 2 mGy. For each case, image data and raw projection data were collected. A total of 71 solid nodules larger than 4mm (30 in LungRad1, 25 in LungRAD2, 11 in LungRAD3, 5 in LungRAD4) were identified by radiologists (on original scans with 1mm slice thickness and B45 kernel). Noise was added to the raw projection data to simulate reduced dose scans at 3 dose levels of 10%, 25%, and 50% (corresponding to CTDIvol of 0.2, 0.5 and 1 mGy). All original and simulated raw data were reconstructed with slice thicknesses of 0.6, 1, and 2mm and at three reconstruction kernels (smooth, medium and sharp). Lung regions were segmented using original image data and were mapped to all other image datasets. An in-house CAD software was used to detect nodules on simulated images. Subject level mean sensitivity (in LungRADS categories) and mean false-positive for each of acquisition conditions were calculated.

RESULTS

Subject level mean sensitivity values ranged between 40% to 80% for LungRAD4, 27% to 55% for LungRAD3, 22% to 50% for

LungRAD2, and 10% to 53% for LungRAD1. Sensitivity was stable at all dose levels in LungRAD3 and LungRAD4 categories (even down to 10% of screening dose), with a medium kernel and either 1mm or 0.6 mm slice thickness. Mean false-positive was between 2-9 per patient with most conditions yielding < 4.

CONCLUSION

CAD detection sensitivity was reasonably robust to dose, slice thickness and kernel, though the sharper kernel yielded the most variable performance. False positives were also surprisingly stable except at very high noise (low dose, thin slice, sharp kernel) conditions.

CLINICAL RELEVANCE/APPLICATION

CAD detection of lung nodules in low dose Lung Cancer Screening CT exams may provide assistance to radiologists; the performance may be robust across acquisition and reconstruction conditions.

SSG13-07 Multi-Task Transfer Learning Deep Convolutional Neural Network for Improved Computer-aided Diagnosis of Masses in Mammography

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

Participants
Ravi K. Samala, PhD, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Institutional research collaboration, General Electric Company
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Kenny H. Cha, MSc, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Mark A. Helvie, MD, Ann Arbor, MI (*Abstract Co-Author*) Institutional Grant, General Electric Company
Caleb Richter, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

A multi-task transfer learning (MTTL) deep convolutional neural network (DCNN) was formulated to translate the 'knowledge' learned from non-medical images to medical imaging 'interpretation' tasks through supervised training and to simultaneously increase the generalization capabilities of DCNNs by learning auxiliary tasks. We compared the MTTL approach to traditional transfer learning method for classification of malignant and benign masses in mammography.

METHOD AND MATERIALS

From the University of South Florida (USF) digitized screen-film mammogram (SFM) database and with IRB approval from the University of Michigan (UM), heterogeneous mammography data sets of SFMs and digital mammograms (DMs) with a total of 2,282 mammograms containing 2,461 lesions were collected. With data augmentation, 19,688 regions-of-interests containing biopsy-proven masses were obtained. Through inductive transfer learning, the objective predictive model from IMAGENET DCNN trained on 1.2 million non-medical images was induced into the target task of classifying masses. In the multi-task learning, the transfer network learned three target tasks (SFM-UM, SFM-USF, DM-UM). In contrast, the single-task learning was trained with a SFM-UM data set alone. Using the training set, a 4-fold case-based cross-validation was performed to select the best training strategy in terms of the depth of convolutional layers that should be frozen during transfer learning. Each experiment was repeated for 10 stochastic initializations to evaluate the robustness of the trained DCNN. An independent test set containing 909 lesions sequestered from SFM-UM was used to assess the difference in performance between the DCNNs trained with single- and multi-task transfer learning by ROC analysis.

RESULTS

Transfer learning by freezing the first convolution layer alone provided the best training. The independent test *AUC* for single- and multi-task transfer learning reached 0.79±0.02 and 0.82±0.02, respectively. The *AUC* difference between the two methods was statistically significant (p-value=0.007).

CONCLUSION

When using transfer learning for DCNNs, multi-task supervised learning achieved better generalization to unknown cases than single-task learning.

CLINICAL RELEVANCE/APPLICATION

The MTTL DCNN framework for classification of masses in mammography has the potential to be extended to digital breast tomosynthesis while utilizing auxiliary tasks from large SFM and DM data sets.

SSG13-08 Deep Learning Analysis for Automatic Calcium Scoring in Routine Chest CT

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

Participants
Nikolas Lessmann, MSc, Utrecht, Netherlands (*Presenter*) Nothing to Disclose
Bram Van Ginneken, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Stockholder, Thirona BV Co-founder, Thirona BV Research Grant, MeVis Medical Solutions AG Research Grant, Delft Imaging Systems Research Grant, Toshiba Corporation
Pim A. De Jong, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Wouter B. Veldhuis, MD, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Max A. Viergever, Utrecht, Netherlands (*Abstract Co-Author*) Research Grant, Pie Medical Imaging BV
Ivana Isgum, PhD, Utrecht, Netherlands (*Abstract Co-Author*) Research Grant, Pie Medical Imaging BV; Research Grant, 3mensio Medical Imaging BV; Research Grant, Koninklijke Philips NV; ;

For information about this presentation, contact:

n.lessmann@umcutrecht.nl

PURPOSE

Coronary artery calcium (CAC) is a robust predictor of cardiovascular events (CVE) in asymptomatic individuals. Several guidelines

recommend reporting of CAC scores in ungated chest CT exams. In addition, chest CT can be used to quantify thoracic aorta calcification (TAC) and cardiac valve calcification (CVC), which may further improve prediction of CVE. This study evaluates the performance of an automatic method for scoring of CAC, TAC and CVC on routine chest CT exams.

CONCLUSION

Fully automatic scoring of coronary, aortic and cardiac valve calcifications highly correlates with manual scoring, even in ungated routine chest CT.

CLINICAL RELEVANCE/APPLICATION

Automatic calcium scoring in routinely acquired ungated chest CT enables identification of subjects at elevated cardiovascular risk without additional reading time.

SSG13-09 Automated Contrast Timing Classification with Deep Convolutional Neural Networks

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

Participants
Qiao Huang, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Laurent Dercle, MD, New York, NY (*Presenter*) Nothing to Disclose
Lin Lu, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Philip Lichtenstein, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Jianguo Zhu, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Deling Wang, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Lawrence H. Schwartz, MD, New York, NY (*Abstract Co-Author*) Committee member, Celgene Corporation Committee member, Novartis AG Committee member, ICON plc Committee member, BioClinica, Inc
Binsheng Zhao, DSc, New York, NY (*Abstract Co-Author*) License Agreement, Varian Medical Systems, Inc; Royalties, Varian Medical Systems, Inc; License Agreement, Keosys SAS; License Agreement, Hinacom Software and Technology, Ltd; License Agreement, ImBio, LLC; License Agreement, AG Mednet, Inc; Research Grant, ImBio, LLC;

For information about this presentation, contact:

qh2162@cumc.columbia.edu

PURPOSE

To investigate whether a machine learning technique known as deep learning, e.g., Deep Convolutional Neural Networks (CNNs), which selects image pixel data directly (rather than utilizing human-designed features) in the extraction of image descriptors, has potential to explore and discover latent imaging features that are difficult to categorize by the human visual system and thus be used in a development of novel imaging biomarkers. We aim to evaluate if machine learning can achieve a classification of the contrast enhancement timing without any human annotation.

METHOD AND MATERIALS

700 CTs acquired at the portal venous phase had their contrast timing determined by a consensus reading between experienced radiologists. Patients were divided between optimal-timing (n=443) vs non-optimal timing (early or late, n=257). These timing data were used as the reference standard for the automated timing classification system. The whole 3D voxel images (normalized to 512*512*150) were used directly as input to a deep learning method (CNNs) to maximally explore the potential imaging features. The proposed network consisted of 5 convolutional layers and LeakyReLU activations, followed by average pooling layers and three dense layers. The outputs were equivalent to the classes: optimal and non-optimal. To train and evaluate the CNN we used a dataset of 700 CTs, within which 600 (396:204) were used as training and validation. The remaining 100 (57:43) were not included in the training set and were thus totally blind to the computer when used for testing. Five-fold cross validation was used to assess performance.

RESULTS

The classification performances were 89.3% (SE:0.01) in the training set and 93.2% (SE:0.01) in the validation set, which demonstrated the potential of CNNs in automatically analyzing contrast enhancement timing classification in CT scans.

CONCLUSION

There is great potential for the application of deep learning methods as an aid to radiologists in the analysis of medical images. Larger datasets with a wider spectrum of timing will be needed to refine performance and the learned imaging features needed to be examined.

CLINICAL RELEVANCE/APPLICATION

An immediate, unbiased appraisal of contrast timing can reduce medical error because certain pathologies are invisible outside of the appropriate contrast phase.

SSG14

Science Session with Keynote: Physics (Breast Tomosynthesis, Breast CT)

Tuesday, Nov. 28 10:30AM - 12:00PM Room: S405AB

BR CT PH

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

FDA Discussions may include off-label uses.

Participants
Stephen J. Glick, PhD, Silver Spring, MD (*Moderator*) Nothing to Disclose
Ioannis Sechopoulos, PhD, Atlanta, GA (*Moderator*) Research Grant, Siemens AG; Research Grant, Toshiba Medical Systems Corporation; Speakers Bureau, Siemens AG; Scientific Advisory Board, Fischer Medical

Sub-Events

SSG14-01 Physics Keynote Speaker: X-Ray Imaging of the Breast in 3D

Tuesday, Nov. 28 10:30AM - 10:40AM Room: S405AB

Participants
Srinivasan Vedantham, PhD, Tucson, AZ (*Presenter*) Research collaboration, Koning Corporation

For information about this presentation, contact:

svedantham@radiology.arizona.edu

ABSTRACT

X-ray Imaging of the breast in 3D Prospective clinical trials, retrospective multi-reader studies and observational studies from clinical practices have shown the benefits of digital breast tomosynthesis (DBT), a limited-angle tomographic technique, in breast cancer screening. These include reduced callback rates, particularly reduction in false-positive callbacks, and increased cancer detection rates, particularly for invasive cancers. While DBT continues to be rapidly adopted in clinical practices, studies on further optimization and improvements to DBT continue. In this session, knowledge-gaps in terms of reducing breast compression, system-specific optimization of angular range and angular sampling, model-based iterative reconstruction techniques, methods to monitor system performance using phantoms, and developing a framework for conducting virtual clinical trials to evaluate the potential performance improvements are addressed. Dedicated breast CT is an emerging modality with tremendous potential to be the future of breast imaging addressing numerous clinical needs from screening to surgical planning and monitoring therapy response. It eliminates the need for multiple views with breast compression, as a single scan provides volumetric data with near isotropic spatial resolution that allows viewing the breast in any orientation. It is inherently quantitative and allows for risk estimation by quantifying fibroglandular tissue volume, discriminating malignant and benign lesions by analyzing the enhancement from administered contrast media and quantifying treatment response by monitoring temporal changes in tumor volume.

SSG14-02 Optimized Technique for Reducing Breast Compression in Digital Breast Tomosynthesis

Tuesday, Nov. 28 10:40AM - 10:50AM Room: S405AB

Participants
Paul R. Fisher, MD, East Setauket, NY (*Abstract Co-Author*) Research Grant, Siemens AG;
David A. Scaduto, PhD, Stony Brook, NY (*Presenter*) Research Grant, Siemens AG
Hailiang Huang, MS, Stony Brook, NY (*Abstract Co-Author*) Research support, Siemens AG
Chunling Liu, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Kim Rinaldi, RT, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Wei Zhao, PhD, Stony Brook, NY (*Abstract Co-Author*) Research Grant, Siemens Healthineers

For information about this presentation, contact:

david.scaduto@stonybrook.edu

PURPOSE

Digital breast tomosynthesis (DBT) provides tissue separation superior to mammography, and thus may obviate the need for breast compression, used to reduce breast thickness and consequently improve image quality and reduce mean glandular dose (MGD). Previous attempts to reduce breast compression have either resulted in poorer image quality or increased MGD. We optimized and evaluated an imaging technique for DBT with minimal breast compression without compromising image quality or MGD.

METHOD AND MATERIALS

Imaging technique for a Siemens MAMMOMAT Inspiration DBT system using reduced breast compression (<4 daN) was optimized using a signal-difference-to-noise ratio (SDNR) model accounting for the increase in scattered radiation due to increased breast thickness. Optimal tube potential (kVp) was determined by limiting MGD increase to <10% without decreasing SDNR. The optimized technique was evaluated in an IRB-approved, HIPAA-compliant prospective clinical study, where 21 patients with abnormal mammograms underwent DBT scans using full compression (FC) and minimal compression (MC). Skin markers were affixed to either side of the breast for motion assessment. Two breast radiologists scored lesion conspicuity in the two sets of images using a five-

point scale (-2: full compression much better, to +2: minimal compression much better).

RESULTS

Increasing the tube potential by 2-3 kVp over the FC technique causes no significant change in MGD or image quality. Conspicuity of 26 masses and 6 microcalcification clusters in 21 patients were compared. MGD for FC and MC were not significantly different; patient motion was shown to be comparable. Mass conspicuity was equivalent for FC and MC (mean score = -0.15, bootstrapped 95% CI: -0.38, 0.08); microcalcification conspicuity for MC was noninferior to FC (mean score = -0.17, 95% CI: -0.5, 0). All patients reported MC to be more comfortable than FC.

CONCLUSION

By optimizing imaging technique, breast compression can be reduced to less than half in DBT without sacrificing image quality or increasing MGD. The resulting increase in patient comfort may improve compliance with recommended screening practices.

CLINICAL RELEVANCE/APPLICATION

Breast compression in DBT may be reduced to <4 daN without compromising image quality or dose by optimizing imaging technique, potentially improving patient compliance with screening protocols.

SSG14-03 Design and Application of a Phantom for Testing Tomosynthesis Systems with Particular Emphasis on Automatic Cloud-Based Monitoring

Tuesday, Nov. 28 10:50AM - 11:00AM Room: S405AB

Participants
David J. Goodenough, PhD, Myersville, MD (*Presenter*) Consultant, The Phantom Laboratory
Joshua Levy, Salem, NY (*Abstract Co-Author*) Stockholder, The Phantom Laboratory President, The Phantom Laboratory Stockholder, Image Owl, Inc
Hildur Olafsdottir, Salem, NY (*Abstract Co-Author*) Research funded, Image Owl, Inc
Ingvi S. Olafsson, BSc, Reykjavik, Iceland (*Abstract Co-Author*) Research supported, Image Owl, Inc

For information about this presentation, contact:

goodenou@gwu.edu

PURPOSE

To investigate the possibility of using a newly developed Tomosynthesis Phantom specifically developed for remote monitoring of DBT sites

METHOD AND MATERIALS

A newly developed Tomosynthesis QA Phantom has been developed for testing DBT systems. The phantom is also designed to allow remote analysis via web or cloud. The phantom includes: phantom positioning and alignment (important for remote analysis); scan geometry (x and y); chest wall offset; scan slice width and SSP(z) slice geometry (slice width); scan slice incrementation (z); Z axis geometry bead; low contrast from low contrast spheres; Point Spread Function (PSF); Image uniformity and Contrast to Noise Ratio (CNR). This study shows the success of remotely monitoring this phantom via cloud based uploads of Dicom data to a central processing system.

RESULTS

Results are shown for monitoring each of the parameters as listed in Methods and Materials. Data is shown for all known commercial Tomosynthesis systems. System reproducibility and performance over time, and long term trend analysis are shown. The results show robust and reproducible results. Results are shown for monitoring each of the parameters as listed in Methods and Materials. Data is shown for all known commercial Tomosynthesis systems. System reproducibility and performance over time, and long term trend analysis are shown. The results show robust and reproducible results. The ability to measure phantom position and alignment including roll, yaw, and pitch are found to be important but easily handled by the current software. Data on SSP and in plane resolution (MTF) are found to vary greatly among systems, depending on the DBT design, but amenable to remote monitoring and performance tracking.

CONCLUSION

It is possible to design and utilize phantoms for remote monitoring and performance tracking of Tomosynthesis DBT systems. Slice widths (SSP), and in plane resolution PSF and corresponding MTF although vary greatly among systems depending on the DBT design, are amenable to remote monitoring.

CLINICAL RELEVANCE/APPLICATION

A DBT phantom that is robust in performance measurements, and amenable to remote monitoring, offers clinicians, physicists, and administrators a tool to track the performance of the system.

SSG14-04 Impact of Tomosynthesis Angular Range on Mass Conspicuity in Patients with Dense Breasts

Tuesday, Nov. 28 11:00AM - 11:10AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
David A. Scaduto, PhD, Stony Brook, NY (*Presenter*) Research Grant, Siemens AG
Hailiang Huang, MS, Stony Brook, NY (*Abstract Co-Author*) Research support, Siemens AG
Chunling Liu, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Kim Rinaldi, RT, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Axel R. Hebecker, PhD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG; Stockholder, Siemens AG
Thomas Mertelmeier, PHD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG Stockholder, Siemens AG
Sebastian Vogt, PhD, Monument, CO (*Abstract Co-Author*) Employee, Siemens Medical Solutions USA Inc.; Stockholder, Siemens AG

Paul R. Fisher, MD, East Setauket, NY (*Abstract Co-Author*) Research Grant, Siemens AG;
Wei Zhao, PhD, Stony Brook, NY (*Abstract Co-Author*) Research Grant, Siemens Healthineers

For information about this presentation, contact:

david.scaduto@stonybrook.edu

PURPOSE

Recent studies have suggested that cancer detection rates for digital breast tomosynthesis (DBT) are poor for patients with heterogeneously to extremely dense breasts. These studies have been predominantly limited to narrow-angle DBT. Increasing angular range (AR) reduces breast structural noise and increases image contrast for masses, potentially improving mass detection in dense breasts. We investigate the effect of AR on mass detectability using a previously validated cascaded linear system model (CLSM) for DBT, and compare theoretical results with clinical findings in an IRB-approved pilot study.

METHOD AND MATERIALS

Mass conspicuity in DBT reconstructions was modeled as a function of AR using a normalized detectability index *d'*, incorporating breast structural noise and image contrast. Under IRB-guidance, DBT images for 6 patients with heterogeneously or extremely dense breasts were compared using both the Hologic Selenia Dimensions DBT system (AR = 15°) and the Siemens MAMMOMAT Inspiration DBT system (AR = 50°). Two breast radiologists were presented with both sets of images for each patient and compared lesion conspicuity on a five-point scale (-2: lesion much more conspicuous on narrow-angle DBT, to +2: lesion much more conspicuous on wide-angle DBT).

RESULTS

Mass detectability was predicted to increase with increasing AR due to reduced structural noise and increased contrast in the reconstructed image slices. Increasing AR from 15° to 50° was predicted to increase detectability of 2, 5 and 10 mm masses by 85.3%, 87.5% and 87.9%, respectively. Clinical findings corroborated simulation results, with mass conspicuity shown to be equivalent or superior for wider-angle DBT, with a mean score of 0.89 (95% CI: 0.44, 1.44). Importantly, masses found in areas with high masking risk (defined as high local density as characterized by the radiologist) were more conspicuous on wider-angle DBT.

CONCLUSION

Using a normalized detectability index *d'*, mass conspicuity was shown to increase with increasing AR. These results were corroborated by a pilot reader study, and motivate a larger clinical study comparing mass conspicuity for differing DBT acquisition geometries.

CLINICAL RELEVANCE/APPLICATION

Tomosynthesis with wider angular ranges may provide mass conspicuity superior to tomosynthesis with narrow-angular range for patients with heterogeneously to extremely dense breasts.

SSG14-05 Reduced Anatomical Noise in Digital Breast Tomosynthesis with Model Based Iterative Reconstruction

Tuesday, Nov. 28 11:10AM - 11:20AM Room: S405AB

Participants
John W. Garrett, PhD, Madison, WI (*Presenter*) Nothing to Disclose
Yinsheng Li, BEng, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ke Li, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

For information about this presentation, contact:

jwgarrett@wisc.edu

PURPOSE

The anatomical background of the breast strongly influences mass detection performance in breast imaging. Anatomical noise has previously been quantified using a parameter, ß, which is strongly correlated with mass detection. Reported values of ß in clinical modalities are approximately 3.3 for mammography, 3.2 for digital breast tomosynthesis (DBT), and 2.0 for breast CT. The purpose of this work was to determine whether the anatomical clutter in DBT reconstructions can be reduced using MBIR.

METHOD AND MATERIALS

The anatomical noise power spectrum (NPS) was measured for 105 clinical DBT exams acquired using Hologic Selenia Dimensions systems. A power-law model (NPSa=af-ß) fitting of the anatomical NPS was performed. The exponent, ß, was used as a surrogate for the anatomical noise background and compared between the commercial reconstruction (FBP) and an in-house MBIR method. ß was measured as a function of position within the breast (central 25 slices) and averaged for each breast. The mean measured ß values were compared using a two-tailed t-test (H0:ßComm=ßMBIR) to determine if the difference was statistically significant. The reconstructed images were also assessed subjectively.

RESULTS

The measured ß for the commercial reconstruction method was 3.27±0.40, consistent with previously published values. For the MBIR method, the measured ß value was 2.30±0.55. The reduction in anatomical noise was significant using the MBIR method compared with the commercial method ($p<<0.001$). The variation in ß at different slice locations was negligible in both reconstruction methods. The appearance of anatomical clutter was reduced substantially in reconstructed images as well.

CONCLUSION

MBIR significantly reduced the anatomical noise in DBT reconstructions as quantified using a power-law fitting of the anatomical NPS. The reduction of ß from 3.3 to approximately 2.3 indicates that with MBIR the anatomical noise in DBT is more similar to breast CT than mammography.

CLINICAL RELEVANCE/APPLICATION

Reducing anatomical noise in DBT images with MBIR may improve mass detection for DBT images. This has the potential to improve the sensitivity of treatable cancers for breast screening

SSG14-06 Digital Breast Tomosynthesis as a Replacement of Full-Field Digital Mammography for the Detection of Breast Cancer: An Open-Source, In-Silico Clinical Trial

Tuesday, Nov. 28 11:20AM - 11:30AM Room: S405AB

Participants
Aldo Badano, PhD, Silver Spring, MD (*Presenter*) Research Grant, Barco nv
Andreu Badal-Soler, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Stephen J. Glick, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Christian G. Graff, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Frank W. Samuelson, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Diksha Sharma, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose
Rongping Zeng, PhD, Silver Spring, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

aldo.badano@fda.hhs.gov

PURPOSE

To determine the comparative performance of digital breast tomosynthesis (DBT) as a replacement to full-field digital mammography (FFDM) using entirely in silico open-source methods and to compare results to previously reported clinical trials. Secondary objectives include measurements of the differential performance in subpopulations and across lesion types.

METHOD AND MATERIALS

Analytic breast phantoms modeling anatomical structures were generated in large numbers corresponding to 4 size and apparent density combinations (from 3.5 to 6 cm compressed thickness and 4 BIRADS density categories) and were compressed using finite-element modeling prior to imaging. Lesions were inserted representing microcalcification clusters and spiculated masses. Phantoms were imaged using a detailed Monte Carlo simulation approach with the GPU-accelerated, freely available MC-GPU code with improved focal spot and tube motion models and thick-layer detector description including fluorescence, anti-scatter grid, and electronic noise. 50-micron voxelized models were simulated using a binary tree geometry and delta-scattering transport. The detection algorithm uses a location-known-exactly paradigm with a channelized Hotelling Observer and spatial frequency filtering for irregular morphology. A small set of readers were trained with distinct training sets of normals and cancers and tested on independent sets. Uncertainty was estimated using a fully-paired multiple-reader, multiple-case analysis. The study was sized to achieve uncertainties lower than those seen in human trials for the differential performance in terms of area-under-the-ROC curve (AUC).

RESULTS

The performance AUC for FFDM during the prepilot stage ranged between 0.87 and 0.96. Sizing of the pivotal trial indicates that 30 computational readers trained on subsets of 100 pairs of cancer and normal regions-of-interest achieve the target uncertainty of approximately 0.01.

CONCLUSION

The findings indicate that the performance seen in in silico trials for FFDM is comparable, under reasonable assumptions, to results obtained in trials using patients and clinicians.

CLINICAL RELEVANCE/APPLICATION

This report describes the first imaging clinical trial performed exclusively using open-source computational methods. Our findings stimulate discussion around increasing the use of computational modeling in the assessment of imaging systems for regulatory evaluation.

SSG14-07 Initial Experimental Results from the First X-Ray Dark Field Breast Tomosynthesis Prototype System

Tuesday, Nov. 28 11:30AM - 11:40AM Room: S405AB

Awards
Student Travel Stipend Award

Participants
Yongshuai Ge, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
John W. Garrett, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ran Zhang, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Xu Ji, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Juan Pablo Cruz Bastida, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG
Ke Li, PhD, Madison, WI (*Presenter*) Nothing to Disclose

PURPOSE

X-ray digital breast tomosynthesis imaging systems have been successfully introduced in current clinical practice. However, the image contrast is limited as it depends on a single contrast mechanism: x-ray absorption. In this work, the first prototype breast tomosynthesis imaging system with both absorption contrast and a new contrast mechanism: dark-field contrast, was constructed and initial experimental results to assess imaging performance are presented.

METHOD AND MATERIALS

The prototype dark field tomosynthesis imaging system was based on a full field digital mammography system (Senographe 2000D,

The prototype dark field tomosynthesis imaging system was based on a full field digital mammography system (Senographe 2000D, GE Healthcare) with a dual-track rotating anode (Rh/Mo) tube and a CsI-based plat panel detector with 100 µm pixel size. Three x-ray gratings were integrated into the mammography system. The dark field tomosynthesis image acquisition was performed using the Grossman geometry, in which the gantry (including both the x-ray tube and detector) rotate around a fixed image object over an arc of 28° (2° interval). The system was operated at 36 kVp/180 mAs with the Rh anode and Rh filter. From a single tomosynthesis acquisition, both dark field and conventional absorption contrast tomosynthesis images were reconstructed using the shift-and-add algorithm; the images have an in-plane pixel size of 70 µm and a slice thickness of 0.5 mm. Two test objects, an overlay of microcalcifications on top of microbubbles and a mouse lung specimen, were used to perform the initial evaluation of the prototype system.

RESULTS

In addition to the conventional absorption contrast tomosynthesis imaging, x-ray dark field tomosynthesis imaging provided complementary image information for detailed structures in the two specimens. The contrast-to-noise ratio of the low-attenuating microbubbles was boosted from 5.9 in absorption tomosynthesis images to 21.0 in dark field tomosynthesis images.

CONCLUSION

A clinically compatible x-ray dark field breast tomosynthesis prototype system was developed. Based on the promising initial results using both phantom and biological specimen studies, this system will be used to evaluate the potential clinical utility of x-ray dark field tomosynthesis imaging.

CLINICAL RELEVANCE/APPLICATION

This is the very first report of a prototype x-ray dark field tomosynthesis system that will enable future clinical evaluation of the x-ray dark field breast tomosynthesis imaging method.

SSG14-08 A Novel Automatic Segmentation Algorithm for Tissue Classification of Dedicated Breast CT Images

Tuesday, Nov. 28 11:40AM - 11:50AM Room: S405AB

Participants
Marco Caballo, MSc, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose
Ritse M. Mann, MD, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Research agreement, Siemens AG; Research agreement, Seno Medical Instruments, Inc; Research agreement, Identification Solutions Inc; Research agreement, Micrima Limited; Scientific Advisor, ScreenPoint Medical BV
Ioannis Sechopoulos, PhD, Atlanta, GA (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Toshiba Medical Systems Corporation; Speakers Bureau, Siemens AG; Scientific Advisory Board, Fischer Medical

For information about this presentation, contact:

marco.caballo@radboudumc.nl

PURPOSE

To develop and validate a fully automatic classification algorithm to identify voxels containing skin, adipose, fibroglandular and vasculature in dedicated breast CT (BCT) images.

METHOD AND MATERIALS

The developed algorithm involves the following steps: i) an intensity and region-based segmentation method for skin detection; ii) a combination of unsupervised neural networks and energy minimizing splines for fibroglandular tissue segmentation and iii) an unsupervised data mining approach to classify the remaining tissue into fat and vasculature. To evaluate the accuracy of the algorithm, one slice each from five different patient BCT images were manually segmented under the supervision of an experienced breast radiologist and considered the gold standard. To evaluate the robustness of the algorithm to image noise, Gaussian, Poisson and speckle noise were separately added to another five patient BCT slices. Finally, to evaluate the classification of the vasculature, three different pre- and post-contrast injection patient BCT images were classified and compared. Dice Similarity Coefficients (DSCs) were calculated for all comparisons.

RESULTS

The DSCs between the manually and automatically segmented slices were (mean ± 1 std.dev): skin: 0.949 ± 0.005; fibroglandular: 0.955 ± 0.009; adipose: 0.986 ± 0.016; vasculature: 0.879 ± 0.052. The DSCs between the original segmentation result and the ones corrupted by noise were 0.887 ± 0.07 for Gaussian, 0.920 ± 0.06 for speckle and 0.912 ± 0.03 for Poisson noise. Finally, the vasculature DSCs for the three patient cases between the pre- and post-contrast injection images were 0.974, 0.952 and 0.891.

CONCLUSION

The algorithm results in accurate and robust breast tissue classification with no prior training and with the ability to detect blood vessels even in non-enhanced images. Potential applications include breast density quantification and tissue pattern characterization, both biomarkers of cancer development. Further possibilities include automatic identification of breast skin thickening, related to cancer development, and development of patient image-based phantoms which could be used for breast imaging research.

CLINICAL RELEVANCE/APPLICATION

Classification of breast CT images can provide quantitative assessments of breast tissue composition, density and distribution, all biomarkers of breast cancer development.

SSG14-09 Patient-Based 4D Digital Phantom for Dynamic Contrast-Enhanced Breast CT Imaging

Tuesday, Nov. 28 11:50AM - 12:00PM Room: S405AB

Participants
Marco Caballo, MSc, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose
Ritse M. Mann, MD, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Research agreement, Siemens AG; Research agreement, Seno Medical Instruments, Inc; Research agreement, Identification Solutions Inc; Research agreement, Micrima Limited; Scientific

Advisor, ScreenPoint Medical BV
Ioannis Sechopoulos, PhD, Atlanta, GA (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Toshiba Medical Systems Corporation; Speakers Bureau, Siemens AG; Scientific Advisory Board, Fischer Medical

For information about this presentation, contact:

marco.caballo@radboudumc.nl

PURPOSE

To develop a realistic patient-based 4D digital breast phantom including time-varying contrast enhancement for dedicated breast CT perfusion imaging.

METHOD AND MATERIALS

A phantom was created by first segmenting a breast CT scan from a healthy patient into skin, fibroglandular tissue, adipose tissue and vasculature using an automated classification algorithm developed in our laboratory. A tumor model (a sphere with a radius of 10 voxels, equivalent to 2.6 mm) was inserted within the segmented fibroglandular tissue. Average values for blood volume and wash-in and wash-out rates were defined for each tissue type and for the tumor based on results from contrast enhanced dynamic breast MRI. Given these parameters, the proposed algorithm automatically calculates input functions for each tissue type, including the tumor. Then, blood flow (BF) and mean transit time (MTT) are computed for each voxel, taking into account the Hounsfield unit values from the original patient image. Finally, time attenuation curves are calculated for each voxel by convolving the inputs with an exponential function that depends on the BF and MTT values associated with that voxel.

RESULTS

The first 4D voxel phantom constructed in the present study has dimensions of 1008x1008x198x560 (x, y, z, t) with a sampling time of 1 s. Results show the expected enhancement of tissues according to the given input parameters. Moreover, the tumor presents a higher and much faster enhancement compared to the other healthy tissues, as expected. Additional phantoms from other patient cases can be generated at will.

CONCLUSION

The proposed digital phantom can model the behaviour of contrast in the breast during 4D breast CT image acquisition, displaying the different enhancement dynamics that may be found in a patient breast. These phantoms will be used to optimize the development of dynamic contrast enhanced dedicated breast CT imaging to obtain the highest possible image quality with the minimum possible dose. Future work includes the evaluation of the enhancement of different tumor types, 4D breast CT simulations and estimation of radiation dose.

CLINICAL RELEVANCE/APPLICATION

The proposed phantom can be used for optimizing 4D breast CT imaging, which has the potential to aid in the staging and characterization of breast tumors and in the monitoring of treatment.

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SSG15

Physics (CT: Image Quality)

Tuesday, Nov. 28 10:30AM - 12:00PM Room: S503AB

CT PH

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

FDA Discussions may include off-label uses.

Participants
James M. Kofler JR, PhD, Rochester, MN (*Moderator*) Nothing to Disclose
Dianna D. Cody, PhD, Houston, TX (*Moderator*) In-kind support, General Electric Company

Sub-Events

SSG15-01 Efficient and Quantitative CT Protocol Optimization using Channelized Hoteling Observer

Tuesday, Nov. 28 10:30AM - 10:40AM Room: S503AB

Participants
Lifeng Yu, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
Shane Dirks, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Thomas J. Vrieze, RT, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Jayse Weaver, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Andrea Ferrero, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Christopher P. Favazza, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

yu.lifeng@mayo.edu

PURPOSE

To develop a framework and software tool for efficient optimization of CT protocols using a channelized Hotelling observer (CHO) and associated task-based image quality metrics.

METHOD AND MATERIALS

The lack of efficient tools for CT image quality assessment and protocol optimization has been one of the main reasons for a large variation of radiation dose among CT practices. In this work, we developed a quantitative framework for protocol optimization and a software tool to address this issue. A phantom containing 21 objects of various contrast levels and sizes was 3D-printed and inserted into anthropomorphic phantoms of 3 sizes to mimic different adult attenuation levels. The software tool consists of two major components: (1) automated CHO calculation and (2) protocol optimization. The first component performs automated CT image quality assessment after loading the phantom images, which includes calculation of contrast-dependent spatial resolution, 2D and 3D noise power spectrum, index of detectability (d'), and area under the ROC curve (AUC) for a low-contrast detection task. The AUC and d' were based on a previously validated CHO model, with Gabor channels optimized to improve the statistical performance. The second component of the software tool automates the process of protocol optimization by using a predefined target AUC value or an AUC value associated with a reference protocol. As an example, the tool was tested on a 128-slice scanner to determine the dose reduction potential of iterative reconstruction (IR) in a routine abdomen/pelvis protocol.

RESULTS

CHO can be efficiently calculated using the developed tools with the number of Gabor channels reduced to 12 and the required number of repeated scans reduced to 15-20 without sacrificing the CHO accuracy. In the example of protocol optimization for IR, when the predefined target AUC was 0.9, acceptable dose reduction was between 20% and 30%, depending on the phantom sizes.

CONCLUSION

The developed framework for protocol optimization and software tool allows for efficient and objective determination of task-based image quality, which can be used for quantitative protocol optimization in CT.

CLINICAL RELEVANCE/APPLICATION

CT protocols can be efficiently and objectively optimized using the proposed quantitative method based on model observers, which may lead to reduced dose variation across CT practice.

SSG15-02 Task-based Parameter Optimization for Low Signal Correction in Low-Dose CT

Tuesday, Nov. 28 10:40AM - 10:50AM Room: S503AB

Participants

Daniel Gomez-Cardona, MSC, Madison, WI (*Presenter*) Nothing to Disclose
John W. Hayes, MS, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ran Zhang, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ke Li, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Juan Pablo Cruz Bastida, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

For information about this presentation, contact:

gomezcardona@wisc.edu

PURPOSE

Low signal correction (LSC) techniques applied to raw projection data in CT are an effective means to reduce noise streaks and noise amplitude in CT, enabling high quality CT images at reduced dose levels. Current empirical parameter selection in LSC requires many trial-and-error experiments, and often leads to variable performance for different imaging tasks. The purpose of this work is to present a task-based parameter optimization framework for LSC methods in low dose CT.

METHOD AND MATERIALS

Since LSC methods reduce noise in the raw data locally, noise and spatial resolution may not be uniform across the field of view (FOV). In the proposed framework, noise and spatial resolution were measured through repeated scans at a given dose level and incorporated into a mathematical observer model to calculate detectability. The detectability index was then used as figure of merit to optimize parameter selection for a given LSC method. Detectability maps obtained for a given LSC parameter space were incorporated into the following parameter selection criteria: a) maximize detectability for a given imaging task and given spatial location, b) maximize global detectability across imaging tasks for a given location, c) maximize detectability for a given imaging task across spatial locations, or d) maximize global detectability across imaging tasks and across locations.

RESULTS

Noise and spatial resolution properties were found to vary considerably across the FOV. Once these metrics were incorporated into the detectability index, the imaging performance for a given operating point in the parameter space was found to have a strong dependence on spatial location and imaging task. The proposed parameter selection criteria addressed the selection of the optimal filter parameters for LSC.

CONCLUSION

A task-based detectability framework was developed to optimize the selection of parameters for LSC. This framework is generalizable to any LSC methods that can be parameterized.

CLINICAL RELEVANCE/APPLICATION

LSC methods play an essential role in low dose CT technologies. An imaging task-based parameter selection framework can provide a means to achieve radiation dose reduction while to maintain diagnostic performance in low dose CT exams.

SSG15-03 CT Number Bias in Low Dose MDCT with Model Based Iterative Reconstruction (MBIR)

Tuesday, Nov. 28 10:50AM - 11:00AM Room: S503AB

Participants
Daniel Gomez-Cardona, MSC, Madison, WI (*Presenter*) Nothing to Disclose
Adam Budde, MS, Madison, WI (*Abstract Co-Author*) Employee, General Electric Company
John W. Hayes, MS, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Ke Li, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Guang-Hong Chen, PhD, Madison, WI (*Abstract Co-Author*) Research funded, General Electric Company Research funded, Siemens AG

For information about this presentation, contact:

gomezcardona@wisc.edu

PURPOSE

New technologies have been developed and deployed in the field to enable radiation dose reduction. Although clinical benefits seem to be apparent, the potential challenges associated with radiation dose reduction have not been fully investigated. In this work, systematic studies were performed to investigate the change of CT number bias from reference with the decrease of radiation exposure levels and to compare the potential difference between CT number bias in conventional FBP reconstruction and model based iterative reconstruction (MBIR).

METHOD AND MATERIALS

To extract CT number bias, multiple repeated scans were performed on a quality assurance phantom and a clinical MDCT system equipped with both FBP and MBIR reconstruction methods. The CT number of 7 inserts with different attenuation levels was measured from a combined set of 10 exposure levels and 3 tube potentials, with each parameter set repeated 50 times. These measurements were finally compared to a reference consisting of the average of an ensemble of 50 scans obtained at a reference dose level at each kV. CT number bias was defined as the difference between the ensemble average CT number measured at a given exposure level and the ensemble average CT number measured at a reference exposure level for a given kV.

RESULTS

There are three important findings from this work: (1) CT number bias increases with decreasing radiation dose levels for both FBP and MBIR; (2) For a given material insert, the CT number biases in FBP and MBIR are completely inverted, i.e., for FBP a positive bias was obtained as the exposure level decreased; in stark contrast, for MBIR the bias becomes negative at low exposure levels; (3) CT number bias was found to be proportional to its own CT number level for both FBP and MBIR.

CONCLUSION

CT number bias increases with radiation dose reduction in both FBP and MBIR and a peculiar CT number bias inversion with respect to FBP, was experimentally observed for MBIR as exposure level was reduced.

CLINICAL RELEVANCE/APPLICATION

The discovery of increased CT number bias in low dose CT sets a new lower bound for radiation dose reduction to maintain diagnostic accuracy in low dose CT clinical exams.

SSG15-04 CT Iterative Reconstruction Kernels: Noise Characteristics and Their Differences

Tuesday, Nov. 28 11:00AM - 11:10AM Room: S503AB

Participants
Gary Ge, Lexington, KY (*Presenter*) Nothing to Disclose
Victor Weir, PHD, Dallas, TX (*Abstract Co-Author*) Nothing to Disclose
Jie Zhang, PhD, Lexington, KY (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To better understand noise characterization of computed tomography (CT) images reconstructed with iterative reconstruction kernels and demonstrate their differences.

METHOD AND MATERIALS

Unsubtracted and subtracted noise power spectra (NPS) and modulation transfer function (MTF) were measured using CT images acquired from a routine water phantom on Siemens Definition Edge, Force, and GE Revolution, respectively. Series of cutting-edge iterative reconstructions in Sinogram Affirmed Iterative Reconstruction (SAFIRE I31f-I70f), Advanced Modeled Iterative Reconstruction (ADMIRE I31f-I70f, and Br20s-Br70s in dual-source), and Advanced Statistical Iterative Reconstruction-V (ASIR-V Bone, Lung, Detail, Standard) were evaluated and compared at different strength settings (1-5 for Siemens, 20-100 for GE).

RESULTS

Each NPS demonstrates the expected shape of traditional back-projection filters. The peak frequency gradually shifts to lower frequency with the increased strength, corresponding to stronger smoothing effect. Low-frequency structured noise is observed in unsubtracted NPS for all kernels and is successfully removed in subtracted NPS. With the increases in filter sharpness, the NPS shifts to higher frequencies, preserving higher-frequency noise. The series of I kernels in SAFIRE and ADMIRE demonstrate comparable NPS. However, the Br kernels in ADMIRE dual-source shows differences from I kernels. There are notable differences in the NPS between manufacturers. Comparing the NPS of ADMIRE and ASIR-V shows that the GE kernels generally exhibit a larger decrease in peak noise resolution due to increasing kernel strength and a generally wider NPS profile than comparable Siemens kernels. Over-enhancing is observed in all sharp kernels.

CONCLUSION

Analysis of NPS helps characterize image noise associated with various reconstruction kernels and identify their differences to help in their clinical application. A comparison between manufacturers potentially helps standardize protocols across different CT scanners.

CLINICAL RELEVANCE/APPLICATION

Understanding how reconstruction kernels affect noise pattern allows tailoring protocols to task-specific clinical applications.

SSG15-05 Contrast Dose Reduction in Coronary CT Angiography on 16cm Wide-Detector CT with Reduced Injection Time

Tuesday, Nov. 28 11:10AM - 11:20AM Room: S503AB

Participants
Zhijun Hu SR, xi`an, China (*Presenter*) Nothing to Disclose
Zhen Tang Liu, xi`an, China (*Abstract Co-Author*) Nothing to Disclose
Qi Wang, xi`an, China (*Abstract Co-Author*) Nothing to Disclose
Dan Dan Ning, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Yuhuan Chen, MD, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Xin Li, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Ai h. Li, Xian, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

41088898@qq.com

PURPOSE

To investigate the effect of contrast agent injection time on coronary artery image quality in coronary CT angiography (CCTA) with wide-detector CT.

METHOD AND MATERIALS

A total of 40 patients underwent CCTA on a 16cm wide-detector Revolution CT with 100kVp tube voltage and automatic tube current modulation for noise index of 21HU. The contrast agent iopamidol (370mg/ml) was used at a dose rate of 25mgI/kg/s. The patients were divided into two groups based on the injection time: Group A (n=20 with standard 12s injection time) and Group B (n=20,8s) The CT value and standard deviation in the lumen of the ascending aorta,right coronary artery,left anterior descending branch,proximal lumen of LCX and adjacent tissue were measured to calculate the contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR) for arteries. Two imaging radiologists with cardiovascular diagnosis experience over 8 years assessed image quality independently for subjective score using a 5-point scoring system (5: best,1: worst,>= 3: diagnosable). Measurements between the two groups were compared using T test or rank sum test.

RESULTS

There was no significant difference in age,heart rate and body mass index between the two groups (P>0.05); The CT number,SNR,CNR,effective dose and subjective score of the two groups were statistically the same (p>0.05). There was a significant difference in contrast dose between group A (54.7±8.3ml) and group B (37.9±6.5ml) (P<0.05),a reduction of about 30%.

CONCLUSION

Reduction of contrast injection time from the conventional 12s to 8s in CCTA with 16cm wide-detector CT effectively reduces contrast dose by 30% while maintaining image quality.

CLINICAL RELEVANCE/APPLICATION

Faster scan time enables the shortening of contrast injection time to save contrast dose by 30% while maintaining image quality in CCTA with 16cm wide-detector.

SSG15-06 Framework for Objective Clinical Image Quality Assessment in Thorax CT: A 3D Model Observer in Combination with A 3D Printed Lung Phantom Containing Nodules

Tuesday, Nov. 28 11:20AM - 11:30AM Room: S503AB

Participants
Irene Hernandez-Giron, PhD, Leiden, Netherlands (*Presenter*) Nothing to Disclose
Koos Geleijns, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Geert J. Streekstra, PhD, Amsterdam, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Wouter J. Veldkamp, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

I.Hernandez_Giron@lumc.nl

PURPOSE

To apply a 3D model observer to analyze the detectability of lung nodules in a 3D printed lung phantom in CT images acquired at different dose levels.

METHOD AND MATERIALS

A model of the distribution of the lung vessels, based on published morphometry based human data, was generated using an in-house algorithm developed in MATLAB. The simulated lung vessels had diameters between 8.5 and 0.2mm. The model was printed in a ProJet HD 3000 3D printer using Visijet EX200 as material. A PMMA thorax shaped holder (20x30x3cm3) was created to contain the lung insert. Twenty cork spheres (6mm diameter) were placed at different positions as nodules surrogates. The phantom was scanned with a thorax protocol (Toshiba Aquilion Genesis, 120kV, collimation=0.5x80mm, pitch=0.637, RFOV=400mm, AIDR3D, FC18 kernel, 0.5mm slice thickness and interval, 250-30-5-3mAs)). Twenty acquisitions were performed for each dose level, 10 with lesions and 10 without. Volumes of interest (16x16x8.5mm3), centered on the nodule locations, were selected. Volumes were also cropped in equivalent anatomical positions in the nodule-free images. For the highest dose, ROIs were taken on the bigger vessels and also in the central slice of the nodules to estimate their attenuation. A 3D channelized Hotelling model observer (CHO) , with 20 Gabor channels was used to analyze the samples with and without lesions for each dose level. Half of the images were used for training and half for testing for each condition. Test-statistics were calculated over the distributions of the model observer outcomes and a detectability index was calculated for each dose level.

RESULTS

The phantom vessels had a mean pixel value of (118±5HU) and the nodules (-815±20HU). The detectability of the lesions increased with increasing mAs value, for the 3D model observer. The d' values, from highest to lowest dose level (CTDIvol=10.9-2.6-0.4-0.2mGy) were (13.8±1.1, 11.2±0.8, 8.3±0.6, 7.5±0.5).

CONCLUSION

A 3D model observer was applied to analyze the detectability of nodules in CT images of a 3D printed lung phantom mimicking the human vessel distribution. The detectability of the lesions increased with dose. These results represent a step towards measurement of clinical image quality with 3D model observers in CT.

CLINICAL RELEVANCE/APPLICATION

A 3D model observer can be a useful tool towards measuring clinical image quality in CT, in particular, for lung nodule detection tasks in a 3D printed lung phantom.

SSG15-07 Noise Suppression Dependency on Patient Size and Lesion Size with Adaptive Statistical Iterative Reconstruction in Adult Abdomen CT

Tuesday, Nov. 28 11:30AM - 11:40AM Room: S503AB

Participants
Yifang Zhou, PhD, Los Angeles, CA (*Presenter*) Nothing to Disclose
Jessica L. Nute, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Christina M. Lee, BS,ARRT, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Alexander W. Scott II, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To demonstrate the noise suppression dependency on patient size, lesion size and dose with adaptive statistical iterative reconstruction (ASIR) in adult abdomen CT.

METHOD AND MATERIALS

Three adult abdomen phantoms simulating the small, medium and large patient were scanned using a GE VCT 64-slice scanner.

Different dose levels were applied (CTDI_vol 2 mGy to 40 mGy). The images were reconstructed with variable ASIR fractions (0 - 100%). The noise images were obtained using subtraction between eight nearest neighbor slices. They were partitioned into matrices of square elements scaled 1.8 mm - 10 mm to match the lesion sizes of interest, and the statistically defined minimum detectable contrast (MDC) were computed to represent the noise suppression. To describe the relative noise suppression over FBP images, the normalized MDC (N_MDC) was defined as the ratio of the MDC with ASIR to the MDC with FBP. N_MDC was obtained at each element size from different ASIR blending fractions at variable dose levels.

RESULTS

N_MDC was found to decrease linearly as the ASIR blending fraction increases. The slope of the N_MDC, however, depends on the lesion size, patient size and dose. The slope was fitted against the lesion size by a power law with more contrast enhancement at smaller lesion size ($R^2 > 0.935$ among all cases). The contrast enhancement or noise suppression was found to be more pronounced as the phantom size increases or as the dose decreases. The difference on noise suppression due to different doses was also observed smaller for the smaller lesion sizes.

CONCLUSION

The suppression using ASIR in adult abdomen CT not only depends on the ASIR blending fraction, but also depends on the lesion size, patient size and dose.

CLINICAL RELEVANCE/APPLICATION

Adult abdomen CT dose optimization

SSG15-08 Impact of Iterative Reconstructions on Image Quality in Clinical CT Images Demonstrated by a Novel Noise Power Spectrum Measurement Tool

Tuesday, Nov. 28 11:40AM - 11:50AM Room: S503AB

Participants
Hugo Pasquier, MSc, Creteil, France (*Presenter*) Nothing to Disclose
Francois Gardavaud, MSc, Paris, France (*Abstract Co-Author*) Nothing to Disclose
Alain Rahmouni, MD, Nogent Sur Marne, France (*Abstract Co-Author*) Nothing to Disclose
Alain Luciani, MD,PhD, Creteil, France (*Abstract Co-Author*) Research Consultant, Bracco Group; Research Grant, Bracco Group; Research Consultant, General Electric Company; Research Consultant, Siemens AG

For information about this presentation, contact:

hugo.pasq@gmail.com

PURPOSE

To quantify noise texture and magnitude characteristics of clinical Computed Tomography (CT) images obtained with Iterative Reconstructions (IR) techniques.

METHOD AND MATERIALS

An algorithm was developed to extract noise texture and magnitude metrics from 10 chest and abdomen clinical CT-scans (Discovery CT750 HD; GE Healthcare, Wisconsin) performed for oncology follow-up by measuring a global Noise Power Spectrum (NPS). After subtraction of adjacent slices, a segmentation algorithm was applied to exclude remaining anatomical structures. Noise magnitude (i.e. area under the 1D-NPS curve) and peak frequency (fpeak) were measured, within all the available regions of interest that did not contain edge pixels, and compared for chest and abdomen on image subsets of all CT scans reconstructed using Filtered Back Projection (FBP), Adaptive Statistical Iterative Reconstruction 30 % (ASIR30), 50 % (ASIR50) and Model-Based Iterative Reconstruction (MBIR).

RESULTS

Compared to FBP, ASIR30 and ASIR50, MBIR reduced noise magnitude by 31 %, 17 % and 13 % in chest and by 47 %, 34 % and 29 % in abdomen respectively ($p < 0.01$ each). These noise magnitude reductions were also associated to changes in noise texture: for chest and abdomen, fpeak were significantly lower for MBIR (0.08 and 0.09 mm^{-1} respectively), ASIR50 (0.13 and 0.14 mm^{-1} respectively) and ASIR30 (0,16 and 0.18 mm^{-1} respectively) compared to FBP (0.23 and 0.27 mm^{-1} respectively; $p < 0.01$ each).

CONCLUSION

Assessing NPS of clinical CT examinations can demonstrate the reduction of noise magnitude and the changes of noise texture associated to IR. This method could be used to tailor CT protocols according to radiologists' preferences regarding noise texture and magnitude.

CLINICAL RELEVANCE/APPLICATION

The proposed technique enables automatic quality control monitoring of image noise characteristics in clinical practice.

SSG15-09 Objective Quantification of the Impact of Image Artifacts on Lesion Detectability Using a Channelized Hotelling Model Observer

Tuesday, Nov. 28 11:50AM - 12:00PM Room: S503AB

Participants
Andrea Ferrero, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Kenneth A. Fetterly, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Beth A. Schueler, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

ferrero.andrea@mayo.edu

PURPOSE

Objective assessment of the impact of image artifacts on the diagnostic quality of a cone-beam CT (CBCT) images is difficult, as conventional image quality metrics are not adequate to assess the influence of non-uniform artifacts. In this work, we investigated the use of a channelized Hotelling observer (CHO) to quantify the impact of artifacts arising from both the test object and external sources on lesion detection in CBCT data.

METHOD AND MATERIALS

A custom phantom insert containing vessels of diameter 2, 4 and 8 mm was filled with diluted iodine contrast medium to produce different image contrast levels (range 0-300 HU) and placed inside an anthropomorphic thoracic phantom. Projection images were acquired at 1.5º/frame over a 200º range using a C-arm. Severe external image artifacts were introduced by placing two metal pins adjacent to the posterior surface of the phantom. Detectability index (d') of a CHO was estimated using 150 background only images and 150 images of the iodine vessels with and without external artifacts. Using a standard CHO implementation, the total contribution of the vessels and artifacts to d' was estimated. The contribution of the artifacts was determined by masking the image area of the iodine vessels prior to channelization. d' of the artifacts was then subtracted from the total d's to estimate d' of the iodine vessels only.

RESULTS

Per expectation, the contribution to d' of artifacts originating from the iodine vessels was proportional to the HU contrast of the iodine vessels whereas that of the external artifacts was independent of iodine concentration. As the severity of the externally produced artifacts was variable across the 2D images, their estimated contribution to d' was also variable with location in the image. After correcting for external artifacts, d' of the iodine vessels with external artifacts present was 4-67% lower than that without external artifacts.

CONCLUSION

This work proposes masking of the test object to directly estimate CHO d' of CBCT image artifacts arising both from the test object and external sources. This method may be used to directly estimate the magnitude of image artifacts and to remove their influence on d' estimates.

CLINICAL RELEVANCE/APPLICATION

Artifacts present in CBCT images can confound CHO performance. A correction method is proposed to eliminate their effect and provide valuable information on their influence on lesion detection in CBCT.

PHS-TUA

Physics Tuesday Poster Discussions

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

PH

AMA PRA Category 1 Credit ™: .50

Participants
Bob Liu, PhD, Boston, MA (*Moderator*) Nothing to Disclose

Sub-Events

PH228-SD-TUA1 Subtraction Quality Assessment of Hepatic Dynamic Contrast Enhanced MRI by Using Non-Rigid 3D-Registration for Subtraction Technique

Station #1

Participants
Meng Wang, Guangzhou, China (*Presenter*) Nothing to Disclose
Shiting Feng, MD, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Ziping Li, MD, PhD, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To investigate the application of non-rigid 3D-registration technique in evaluation of the subtraction quality of hepatic dynamic contrast enhanced (DCE) MR images.

METHOD AND MATERIALS

The subtraction quality of hepatic DCE MR images before and after correction in 20 cases were evaluated. Qualitative assessment was based on the presence of artifacts and the anatomical mismatch. In quantitative assessment, the SNR of the vessels (aorta, left and right hepatic arteries, portal vein and left, right portal veins) on the unenhanced, arterial and portal venous phase before and after correction were measured. SNR variation curves were drawn. The fitness of the SNR variation curves between left and right hepatic arteries, between portal vein and left, right portal veins were evaluated.

RESULTS

Before correction, all of the 20 cases demonstrated different degrees of artifacts caused by anatomical mismatch. After correction, there were no obvious anatomical mismatch or artifacts. SNR variation curves of left and right hepatic arteries were mismatched before correction but were well matching after correction. SNR variation curves of portal vein and left, right portal veins were matching before and after correction.

CONCLUSION

The non-rigid registration technique can significantly improve the overall substraction quality of liver DCE MRI.

CLINICAL RELEVANCE/APPLICATION

The technique can improve the substraction quality of liver DCE MRI.

PH229-SD-TUA2 Apparent Diffusion Coefficient in Brain is Affected by Respiration

Station #2

Participants
Yuki Hiramatsu, BS,RT, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Tosiaki Miyati, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Naoki Ohno, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Mitsuhito Mase, MD, Nagoya, Japan (*Abstract Co-Author*) Nothing to Disclose
Satoshi Kobayashi, MD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshifumi Gabata, MD, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

yuuki050226@gmail.com

PURPOSE

The apparent diffusion coefficient (ADC) is used for the quantitative evaluation of numerous brain diseases. We revealed in a previous study that the ADC of the brain significantly changed during the cardiac cycle, even when the bulk motion effect was minimized due to intracranial pressure changes and fluid fluctuations. We hypothesized that ADC changes are caused during the respiratory cycle because the intracranial pressure changes during the respiratory cycle. Therefore, we assessed dynamic changes in the ADC in the brain during the respiratory cycle using cine diffusion magnetic resonance imaging (MRI).

METHOD AND MATERIALS

With a 3.0-T MRI system, we used respiratory- and ECG-triggered single-shot diffusion echo-planar imaging (b = 0 and 1000 s/mm2) with sensitivity encoding and half-scan techniques to minimize bulk motion. We obtained diffusion-weighted images from

eight healthy volunteers with the following scan parameters: echo time, 65 msec; flip angle, 90 degrees; section thickness, 4 mm; imaging matrix, 64 x 64; field of view, 256 mm; number of signals averaged, two; and number of cardiac phases, 14-33 (heart- or respiratory-rate dependent). We calculated the maximum ADC (*ADC*max), minimum ADC (*ADC*min), and maximum change in the ADC (*ΔADC*) during the respiratory and cardiac cycles in the white matter.

RESULTS

The ADC in the white matter significantly changed during the respiratory and cardiac cycles. However, the ADC change during the respiratory cycle (approximately 5% change) was smaller than that during the cardiac cycle (approximately 11% change). The mean *ADC*max, *ADC*min, and *ΔADC* values in the white matter during the respiratory cycle were 0.79 ± 0.04 x 10-3 mm2/s, 0.75 ± 0.02 x 10-3 mm2/s, and 0.04 ± 0.03 x 10-3 mm2/s, respectively. The mean *ADC*max, *ADC*min, and *ΔADC* values in the white matter during the cardiac cycle were 0.81 ± 0.04 x 10-3 mm2/s, 0.72 ± 0.04 x 10-3 mm2/s, and 0.09 ± 0.04 x 10-3 mm2/s, respectively.

CONCLUSION

The ADC of the brain changes during the respiratory cycle, and analysis of the dynamic diffusion change makes it possible to obtain more accurate ADC.

CLINICAL RELEVANCE/APPLICATION

Analysis of the dynamic diffusion change is recommended for more accurate ADC evaluation, and may be useful for the quantitative evaluation of brain diseases.

PH230-SD-TUA3 Better Reproducibility of 7T Parallel Transmit with Interleaved Transmission at the Calibration

Station #3

Participants
Hiroyuki Kameda, Sapporo, Japan (*Presenter*) Nothing to Disclose
Kohsuke Kudo, MD, Sapporo, Japan (*Abstract Co-Author*) Nothing to Disclose
Tsuyoshi Matsuda, Yahaba, Japan (*Abstract Co-Author*) Nothing to Disclose
Taisuke Harada, Morioka, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuji Iwadate, Hino, Japan (*Abstract Co-Author*) Employee, General Electric Company
Ikuko Uwano, PhD, Morioka, Japan (*Abstract Co-Author*) Nothing to Disclose
Fumio Yamashita, PhD, Morioka, Japan (*Abstract Co-Author*) Nothing to Disclose
Makoto Sasaki, MD, Yahaba, Japan (*Abstract Co-Author*) Research Consultant, Hitachi, Ltd; Research Consultant, Toshiba Medical Systems Corporation; l Research Grant, Hitachi, Ltd; Speaker, General Electric Company; Speaker, Hitachi, Ltd; Speaker, DAIICHI SANKYO Group; Speaker, Otsuka Pharmaceutical Co, Ltd; Speaker, Mitsubishi Corporation ; Speaker, Johnson & Johnson; Speaker, Boehringer Ingelheim GmbH ; Speaker, Novartis AG; Speaker, FUJIFILM Holdings Corporation
Hiroki Shirato, MD, PhD, Sapporo, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

kamesen0718@gmail.com

PURPOSE

B0/B1+ mappings in the calibration of parallel transmit (pTx) for the human brain at 7T are not reproducible owing to the respiration-induced phase shift. The reproducibility can be improved by breath-holding (BH); however, BH cannot be applied for long scans. We examined whether interleaved transmit (Tx) at the calibration, in which the RF Tx coils are switched in every phase-encoding step, can improve the reproducibility and homogeneity of pTx.

METHOD AND MATERIALS

Nine healthy subjects were scanned with a 7T MRI (MR950, GE Healthcare) and a 2-ch quadrature head coil. The calibration scan (B0/B1+ mapping) was performed with the following three conditions: sequential-Tx/free-breathing (Seq-FB), interleaved-Tx/FB (Int-FB), and Seq/BH. The B0 map was calculated with two different echo times, while the B1+ map was obtained using the Bloch-Siegert method. To evaluate the distribution of flip-angle, actual flip-angle imaging (AFI) was performed using pTx with the above-mentioned three conditions and quadrature-Tx (qTx). All the scans were acquired for five sessions. The reproducibility of the B0/B1+ maps and AFI was evaluated using inter-session SD. The in-plane homogeneities of the AFI were also evaluated using in-plane SD.

RESULTS

The inter-session SDs for the B0/B1+ maps were significantly smaller in the Int-FB (mean±SD: 175.0±68.1 and 52.2±16.0) and Seq-BH (260.1±84.6 and 104.2±38.2) than in the Seq-FB (811.0±446.9 and 286.7±103.6; $P<0.01$ and $P<0.05$, respectively). The inter-session SDs for the AFI were also significantly smaller in the Int-FB (43.4±14.4) and Seq-BH (45.3±12.7) than in the Seq-FB (75.0±15.7; $P<0.01$ and $P<0.05$, respectively). The in-plane SDs for the AFI in the Seq-FB (22.1±2.0), Int-FB (22.4±2.8), and Seq-BH (20.7±2.2) were significantly smaller than those in the qTx (34.1±4.0; $P<0.001$ for all). There were no significant differences among the Seq-FB, Int-FB, and Seq-BH.

CONCLUSION

Interleaved transmission in pTx calibration could improve the reproducibility of the flip angle distribution in pTx.

CLINICAL RELEVANCE/APPLICATION

This technique can facilitate further development of pTx for imaging of the human brain at 7 T.

PH231-SD-TUA4 Highly Efficient Biomarker Selection (BS) Based on Novel Binary Coordinate Accent (BCA) for Machine Learning with a Large Dataset in Radiomics

Station #4

Participants
Amin Zarshenas, MSc, Chicago, IL (*Presenter*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Kenji Suzuki, PhD, Chicago, IL (*Abstract Co-Author*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN

Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

mzarshen@hawk.iit.edu

PURPOSE

BS for machine learning is one of the most important components in radiomics since it determines the final performance and robustness. BS, however, takes substantially long time especially for a large dataset (>1000 cases), which makes the development of a radiomics system handling a large dataset impossible. Our purpose was to develop a highly efficient BS while maintaining the performance.

METHOD AND MATERIALS

Having N biomarkers, our proposed BCA-BS starts from an empty set and based on the BCA optimization procedure iteratively examines exclusion or inclusion of biomarkers, one at a time in the binary space of biomarker subset candidates. Our BCA-BS adds/removes a biomarker instantly (unlike other stepwise feature selection) if inclusion/exclusion improves the classification performance. This process is repeated until convergence. To test out BCA-BS, we experimented on 3 distinct radiomics systems as follows: classification of polyps in CT colonography (database: 46 polyps and 2624 false positives, given 79 biomarkers), diagnosis of benign and malignant in fine needle aspiration (database: 212 malignant and 357 benign lesions, given 30 biomarkers), and classification of Parkinson's disease (database: 48 patients versus 147 healthy subjects, given 22 biomedical voice measurements). We employed 3 well-known machine-learning methods: artificial neural networks (ANN), support vector machines (SVM), and naïve Bayes (NB). We trained and tested our models using stratified 10-fold cross validation with area under the receiver operating characteristic curve (AUC) as the performance metric. We compared with "gold-standard" sequential forward floating selection (SFFS).

RESULTS

Our BCA-BS and the gold-standard SFFS obtained comparable AUCs of 0.90±0.1 and 0.89±0.1, respectively (Friedman tests; P=0.8). SFFS required an average of 4 days of running time, whereas our BCA-BS required an average of only 18 minutes on a PC (Intel Core i7-4790K, 4.0 GHz).

CONCLUSION

Our BCA-BS was 388 times faster than the gold-standard SFFS, while it achieved a comparable AUC to SFFS. Our highly efficient BS would make it possible to develop machine learning that can deal with a 388-times larger dataset than existing methods in radiomics.

CLINICAL RELEVANCE/APPLICATION

Our highly efficient radiomics system with high performance would be able to handle a large number of cases that support a wide spectrum of diseases. Such a system would be beneficial to radiologists.

PH232-SD-TUA5 New Reconstruction Algorithm for Breast Tomosynthesis: Better Image Quality for Humans and Computers

Station #5

Participants
Albert Gubern-Merida, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Itsara Wichakam, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Alejandro Rodriguez-Ruiz, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose
Suzan Vreemann, MSc, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Ramona Bouwman, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Ruben E. van Engen, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Nico Karssemeijer, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Director and Shareholder, ScreenPoint Medical BV; Shareholder, Volpara Health Technologies Limited; Consultant, QView Medical, Inc; Shareholder, QView Medical, Inc;
Ritse M. Mann, MD, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Research agreement, Siemens AG; Research agreement, Seno Medical Instruments, Inc; Research agreement, Identification Solutions Inc; Research agreement, Micrima Limited; Scientific Advisor, ScreenPoint Medical BV
Ioannis Sechopoulos, PhD, Atlanta, GA (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Toshiba Medical Systems Corporation; Speakers Bureau, Siemens AG; Scientific Advisory Board, Fischer Medical

For information about this presentation, contact:

alejandro.rodriguezruiz@radboudumc.nl

PURPOSE

To compare two breast tomosynthesis reconstruction algorithms used on the Siemens Mammomat Inspiration: the standard Filtered Back Projection (FBP) and the new FBP with iterative optimizations (EMPIRE), using qualitative analysis by human readers and detection performance of machine learning algorithms.

METHOD AND MATERIALS

A visual grading analysis observer study was carried out by four readers specialized in breast imaging (1 radiologist, 1 PhD student, 2 physicists specialized in mammography) who scored 100 cases reconstructed with both algorithms (medio-lateral oblique views, 40 biopsy proven malignant, 30 biopsy proven benign, and 30 normal; involving 29 calcification lesions and 49 soft tissue lesions). Scoring was performed on a 5-point scale (1-poor to 5-excellent quality) on six aspects of normal anatomy (presence of noise and artifacts, visualization of skin line and Cooper's ligaments, contrast, and overall image quality) and, when present, visibility and sharpness of lesions. Results were analyzed with a generalized estimating equations model. In parallel, two 3D deep learning convolutional neural networks (CNN) were trained (n=69 breast volumes with malignant calcifications) and validated (n=12), one with FBP-based volumes and the other with EMPIRE-based volumes, to discriminate between samples with and without malignant calcifications. The area under the ROC curve was used for comparison.

RESULTS

EMPIRE reconstructions showed slightly better contrast (3.23 vs 3.10, p=0.010, significant for 2 readers), better overall image quality (3.22 vs 3.03, p<0.001, significant for 3 readers), fewer artifacts (3.26 vs 2.97, p<0.001, significant for all readers), and better visibility of calcifications (3.53 vs 3.30, p=0.053, significant for 2 readers, see example on Fig. 1). No differences were found for the other features. The 3D-CNN-EMPIRE showed better performance than the one trained and tested with FBP (AUC-EMPIRE=0.997 vs AUC-FBP=0.953; p<0.001).

CONCLUSION

The new algorithm provides DBT volumes with better contrast, overall image quality, and fewer artifacts for the human observers as well as improved visibility of microcalcifications for both humans and deep learning algorithms.

CLINICAL RELEVANCE/APPLICATION

The new reconstruction algorithm improves image quality of DBT, which might enhance the characterization and diagnosis of breast lesions and improves the performance of machine learning detection algorithms.

PH233-SD-TUA6 Quantitation of Lu-177 Using General Purpose Whole-Body Solid State CZT and Standard SPECT/CT Cameras

Station #6

Participants
John A. Kennedy, PhD, Haifa, Israel (*Presenter*) Nothing to Disclose
Rachel Lugassi, BSC, Haifa, Israel (*Abstract Co-Author*) Nothing to Disclose
Ilya Reizberg, MD, Haifa, Israel (*Abstract Co-Author*) Nothing to Disclose
Zohar Keidar, MD, PhD, Haifa, Israel (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Overall, Lu177 quantitation was equivalent on general purpose whole-body solid state CZT and standard SPECT/CT cameras. The high energy mode on CZTC and the double peak acquisitions on either camera did not improve significantly the quantitative results. MEGP collimation on NaIC provided less artefactual uptake in the "lung" insert than obtainable with LEHR on CZTC. CZTC showed no measurable dead time loss during Lu177 imaging.

Background

Parameters for accurate quantitation of lutetium-177 (Lu177) whole body SPECT studies were determined for a solid state CZT (cadmium zinc telluride) camera (CZTC) and a sodium iodide (NaI) based device (NaIC).

Evaluation

Image quality was assessed for a phantom emulating clinical count rates loaded with a "lung" insert and 6 hot spheres with a 12:1 target-to-background ratio of Lu177. For CZTC a rectangular hole low energy high resolution (LEHR) collimator was used for 4 acquisition protocols: (1) LE113TEW - low energy mode (LE), using the 113 keV peak and triple energy window scatter correction (TEW); (2) high energy mode (HE), using the 113 and 208 keV peaks with TEW; (3) HE with the 208 keV peak and TEW; (4) as per (3) with dual energy window scatter correction (DEW). For NaIC the 4 protocols were: (a) LEHR113TEW - using an LEHR collimator and 113 keV peak with TEW; (b) using a medium energy general purpose collimator (MEGP), 113 and 208 keV peaks, and TEW; (c) MEGP with the 208 keV peak and TEW; (d) MEGP208DEW - as per (c) with DEW.

Discussion

LE113TEW results on CZTC compared to LEHR113TEW on NaIC were not significantly different (rank sum tests, p<0.05) for contrast, peak standardized uptake values (3 largest spheres: 11.5 ± 2.7 g/mL vs. 11.8 ± 2.6 g/mL, respectively; mean ± std. dev.), lung insert residual error (58.5 ± 9.7 % vs. 53.4 ± 5.3 %), background quantitation error, and mean squared error of recovery coefficients (MSE). MSE of LE113TEW did not differ significantly from the best NaIC method (MEGP208DEW), but was significantly lower than HE methods. Lung residual errors were significantly lower with MEGP (29.5 ± 8.8 % for MEGP208DEW) compared to LEHR on NaIC or CZTC. Dead time loss was <3.2 % for MEGP208DEW on NaIC while LE113TEW on CZTC showed no dead time loss.

PH234-SD-TUA7 Annual Eye Lens Doses for Computed Tomography Technologists When Restraining Patients in Scanning Room

Station #7

Participants
Kosuke Matsubara, PhD, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Keita Sakuda, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiroki Kawashima, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Tadanori Takata, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Thunyarat -. Chusin, Phitsanulok, Thailand (*Abstract Co-Author*) Nothing to Disclose
Rena Okubo, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshifumi Gabata, MD, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

matsuk@mhs.mp.kanazawa-u.ac.jp

PURPOSE

Computed tomography (CT) technologists receive considerably scattered doses to eye lenses when they restrain patients in the CT scanning room. However, data are limited on eye lens doses for CT technologists. This study aims to measure eye lens doses for CT technologists and examine the effects of X-ray protective eyewear for reducing eye lens doses.

METHOD AND MATERIALS

Specially made acrylic head phantom, with small optically stimulated luminescence (OSL) dosimeters placed at 3-mm depth from the surface of the phantom, was used to obtain conversion coefficients from air kerma to Hp(3). Two CT technologists wore X-ray

protective eyewear (0.07 mmPb) equipped with small OSL dosimeters from January to December 2016, when they restrained patients in the CT scanning room, and the air kerma was obtained from the small OSL dosimeters every month. Hp(3) was calculated by multiplying the air kerma with the conversion coefficient. The type and number of examinations were recorded for each technologist. The reduction ratios of eye lens doses with the use of X-ray protective eyewear were also estimated by comparing air kerma between inside and outside of the eyewear.

RESULTS

The obtained air kerma to Hp(3) conversion coefficients for X-ray of 120 kVp CT were 1.22, 1.74, and 1.13 at the center of the eyewear, left and right of the eyewear, and the neck, respectively. The annual Hp(3) for two technologists obtained from the small OSL dosimeters equipped at the center of the eyewear were 31.0 and 13.3 mSv, thus one of the technologists had a possibility to exceed the equivalent dose limit for the eye lens for occupational exposure, which is 20 mSv/y, averaged over defined periods of 5 years. The reduction ratios of eye lens doses of two technologists with the use of X-ray protective eyewear were 49.7 and 47.2%.

CONCLUSION

Eye lens doses for CT technologists have the potential to exceed the revised occupational equivalent dose limit.

CLINICAL RELEVANCE/APPLICATION

A reduction in the dose limit to the eye lens was recommended in 2011. The measurement of the eye lens dose for medical staff is essential for the optimization of radiation protection.

PH235-SD-TUA8 Model versus Human Observer for Localization of Liver Lesions: Can the Model Predict Human Performance?

Station #8

Participants
Samantha Dilger, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Baiyu Chen, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Rickey Carter, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Christopher P. Favazza, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Lifeng Yu, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

Yu.Lifeng@mayo.edu

PURPOSE

The time requirements for human observer studies preclude their widespread use for protocol optimization. We hypothesize a channelized Hotelling observer (CHO) can predict human observer performance for both uniform water and anatomical liver backgrounds, regardless of reconstruction algorithm, dose, or lesion size.

METHOD AND MATERIALS

Segmented human liver lesions (5, 7, and 9mm diameter) were inserted into the CT projection data of patient disease-free livers and water phantoms. The projection data were then reconstructed with filtered back projection (FBP) and iterative reconstruction (IR) at three dose levels: full dose and simulated half and quarter dose. For each observer trial, 66 lesion-present and 34 lesion-absent two-dimensional images were extracted from the reconstructed volumes. Three medical physicists independently reviewed the thirty-six 100-image trials, marked the location of the lesion, and provided a confidence score for each image. A Gabor-based CHO was trained and tasked with lesion localization using the same image data. Observer performance was assessed using the area under the localization receiver operating characteristic curve (AzLROC) and compared between the human and model observers. Spearman's correlation coefficient was used to test the correlation between the two data sets.

RESULTS

Observer performances of the human and model observers were highly correlated for a given configuration (same lesion size, dose level, background, and reconstruction type). Spearman's correlation coefficient for the model to human observer comparison was 0.9267 (95% CI: 0.82-0.98). The average difference between human and model observer performance was 0.05 (range: 0.004-0.10). The AzLROC of the model observer performance in a uniform background was strongly correlated to that of human observers in the liver background (ρ=0.94, CI: 0.80-1.0).

CONCLUSION

Model and human observer performances are highly correlated, and the degree of correlation present between liver and uniform background suggests that future optimization studies within the liver could be carried out using highly-efficient model observers.

CLINICAL RELEVANCE/APPLICATION

Human observer studies are performed to determine the effects of CT parameter changes at great time expense; these results suggest model observers could be an accurate predictor of human performance.

PH004-EB-TUA Photon Counting Detector CT: System Design and Clinical Applications of an Emerging Technology

Hardcopy Backboard

Awards
Identified for RadioGraphics

Participants
Michael R. Bruesewitz, Rochester, MN (*Presenter*) Nothing to Disclose
Norbert G. Campeau, MD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Ahmed Halaweish, PhD, Rochester, MN (*Abstract Co-Author*) Employee, Siemens AG

Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

bruesewitz.michael@mayo.edu

TEACHING POINTS

1) Describe the design of a whole body photon counting detector CT (PCCT) system. 2) Explain the utility of increased CNR and clinical applications 3) Illustrate the clinical benefits of ultra-high-resolution (UHR) imaging using PCCT 4) Show new multi-energy applications enabled by photon counting technology 5) Compare PCCT to state of art CT scanners with energy integrating detector (EID)

TABLE OF CONTENTS/OUTLINE

1.Principles of PCCT and System Design a. Physics principles b. System geometry and detector configuration c. Imaging modes and workflow 2.Improved Contrast to Noise Ratio (CNR) a. Phantom studies b. Cadaver comparison c. Thoracic and Head & Neck CTA (large animal model) 3. Improved Spatial Resolution and Dose Efficiency a. UHR imaging configuration b. Phantom/Cadaver comparison with EID c. Clinical Applications - Lung, Temporal bones, Vascular, MSK 4. Multi-energy Applications a. Material decomposition b. Conventional dual energy applications c. Novel multi-energy applications (e.g. k-edge imaging, new contrast agents) CONCLUSION/SUMMARY 1) Clinically comparable image quality to EID at clinical doses 2) Increased CNR and reduced radiation dose 3) Dose efficient UHR mode increases spatial resolution for multiple clinical areas 4) Multi-energy imaging enables potential new clinical applications

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PHS-TUB

Physics Tuesday Poster Discussions

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

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Bob Liu, PhD, Boston, MA (*Moderator*) Nothing to Disclose

Sub-Events

PH236-SD-TUB1 Effect of Sleep State on ADC Change during Cardiac Cycle in the Human Brain

Station #1

Participants
Yuki Hiramatsu, BS,RT, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Tosiaki Miyati, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Ryoko Yamamori, RT,BS, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Naoki Ohno, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshiharu Kurita, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Seika Miki, Sabae, Japan (*Abstract Co-Author*) Nothing to Disclose
Akiko Sekiya, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuri Hoshina, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshifumi Gabata, MD, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

yuuki050226@gmail.com

PURPOSE

The glymphatic system is a recently defined, brain-wide, paravascular pathway for cerebrospinal fluid and interstitial fluid exchange that facilitates efficient clearance of interstitial waste, including amyloid-ß, from the brain. During sleep, the increase in the interstitial influx, which is driven by cerebral arterial pulsation, results in faster waste removal. However, to date, that has not been established in the human brain. We have previously reported on significant change in the apparent diffusion coefficient (ADC) of the brain during the cardiac cycle even with minimization of the effect of bulk motion. This change shows the degree of fluctuation of water molecules due to arterial inflow as the driving force, and reflects the dynamic state of water movement in the brain. Therefore, we analyzed fluctuation of water molecules, i.e., dynamic ADC change in the cardiac cycle, in the brain of healthy subjects in awake and sleep states.

METHOD AND MATERIALS

On a 3-T magnetic resonance imaging (MRI) system, ECG-triggered single-shot diffusion echo-planar imaging (b = 200 and 1000 s/mm2) was used with sensitivity encoding and half-scan techniques to minimize the bulk motion. We then determined the maximum ADC (*ADC*max), minimum ADC (*ADC*min), and maximum change in ADC (*ΔADC*) during the cardiac cycle in the frontal, occipital, and temporal white matter. These values were compared in awake and light sleep (non-rapid eye movement, stages 1 or 2) states in seven healthy subjects.

RESULTS

*ADC*max and *ΔADC* of the temporal white matter in sleep state were significantly higher than those in awake, indicating increase in the activity of glymphatic system during sleep. However, there were no significant differences in *ADC*min of all regions between awake and sleep states.

CONCLUSION

*ADC*max and *ΔADC* of the white matter in human brain increase in sleep state. Dynamic ADC analysis facilitates the noninvasive evaluation of the dynamic state of water movement in the brain in sleep state.

CLINICAL RELEVANCE/APPLICATION

Dynamic ADC analysis facilitates the noninvasive evaluation of the dynamic state of water movement in the brain in sleep state as a glymphatic MRI.

PH237-SD-TUB2 Which is More Important for Quantitative Susceptibility Mapping? SNR of Phase vs Spin Dephasing

Station #2

Participants
Yuki Matsumoto, BS, Tokushima City, Japan (*Presenter*) Nothing to Disclose
Yuki Kanazawa, PhD, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshiaki Sasaki, BS, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Natsuki Ikemitsu, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose

Hiroaki Hayashi, PhD, Tokushima, Japan (*Abstract Co-Author*) Equipment support, Nagase Landauer, Ltd; Research collaboration, Nagase Landauer, Ltd; Equipment support, JOB Corporation; Research collaboration, JOB Corporation;
Mitsuharu Miyoshi, Hino, Japan (*Abstract Co-Author*) Employee, General Electric Company
Masafumi Harada, MD, PhD, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose
Hideki Otsuka, MD, PhD, Tokushima, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

lakaisbmtyk@gmail.com

TEACHING POINTS

Quantitative measurement of QSM depends on SNR of phase and spin dephasing. Determination of imaging parameters considering physical factors of biomaterials is important in QSM.

TABLE OF CONTENTS/OUTLINE

Aim The aim of this study is to investigate quantitative measurement of QSM focusing on the SNR of phase and spin dephasing. Materials and Methods In this study, phantom and healthy volunteer studies were conducted. Ultra-short TE (UTE) with 4 echoes was used to acquire MR data from both phantom and healthy volunteers. After acquiring the MR data, QSMs were derived from 0.032-5.8 and 20-27 ms TE datasets for SNR of phase analysis and spin-dephasing analysis, respectively. Results In the phantom study, the intercept of regression line was different for each dataset (-0.099 and -0.047). In healthy volunteers, QSM derived from the 0.032-5.8 ms dataset was in good agreement with theoretical value (error rate: 14.8 vs 90.7 %). In this study, spin-dephasing was evaluated using mean resultant length which is the length of the average vectors calculated from all phase angles in the ROI. Mean resultant length for off-set frequency value derived from the 20-27 ms dataset decreased when compared with the QSM derived from the 0.032-5.8 ms dataset. In conclusion, the importance of spin dephasing in QSM is suggested.

PDF UPLOAD

https://abstract.rsna.org/uploads/2017/17009178/17009178_tgky.pdf

PH238-SD-TUB3 Variation of Iodine CT Number for Spectral CT Imaging Using a First-Generation Dual-Layer CT: Effect of Object Size and Tube Voltage

Station #3

Participants
Daisuke Sakabe, MS, Kumamoto, Japan (*Presenter*) Nothing to Disclose
Yoshinori Funama, PhD, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Daisuke Utsunomiya, MD, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Nakaura Takeshi, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Seitaro Oda, MD, Kumamoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Yasuyuki Yamashita, MD, Kumamoto, Japan (*Abstract Co-Author*) Consultant, DAIICHI SANKYO Group

PURPOSE

Unlike the two-tube voltage beam method, dual-layer CT (DLCT) is the first detector-based CT using a single-tube voltage beam. With DLCT, low-energy photons are absorbed by the first detector layer and high-energy photons are absorbed by the second one. A stable iodine CT number is expected with spectral CT imaging by DLCT regardless of the object size and tube voltage, even though the conventional polychromatic images is decreased with increasing object size because of a beam-hardening effect. The purpose of this study was to investigate the effect of variations in iodine CT number on spectral CT images of objects of different sizes and tube voltages using DLCT.

METHOD AND MATERIALS

Using two different size acrylic phantoms (20 and 30 cm), helical scans were performed using a first-generation DLCT scanner (IQon spectral CT; Philips Healthcare). Three different iodine concentrations (15.0, 7.5, and 3.75 mgI/mL) were inserted into the phantom. The tube voltage for obtaining spectral images was set at 120 or 140 kVp. The tube current was set using an image quality reference. Conventional CT images were acquired at 80 kVp. Conventional and spectral images obtained at 120 or 140 kVp were reconstructed at a slice thickness of 1.0 mm with an abdomen standard kernel (C). The CT number was measured for each iodine concentration on 120-kVp image and 40-200 keV images.

RESULTS

At an iodine concentration of 15 mgI/mL, the CT numbers for 20- and 30-cm images obtained at 80-, 120-, and 140-kVp were 654 and 602 HU, 424 and 379 HU, and 355 and 319 HU, respectively, which showed a decrease with increasing phantom size of 8.0%, 10.5%, and 10.4%, respectively. In contrast, the CT numbers of the spectral CT images obtained at 120 kVp were controlled regardless of the phantom size (e.g., 40 keV, 2.7%: 1175 HU at 16 cm vs. 1143 HU at 30 cm), which exhibited the same tendencies as the spectral CT images obtained at 140 kVp. Compared with spectral CT images obtained at 120 and 140 kVp, iodine CT numbers was virtually unchanged regardless of the tube voltage (e.g., 7.5 mgI/mL and 30-cm phantom: 40 keV, 558 HU vs. 549 HU).

CONCLUSION

Compared with conventional polychromatic image, spectral CT imaging obtains a stable iodine CT number regardless of the object size and tube voltage.

CLINICAL RELEVANCE/APPLICATION

Spectral CT imaging provides accurate quantification analysis with stable iodine concentrations and CT numbers regardless of the patient's body size.

PH239-SD-TUB4 Comparison of Contrast-Enhanced Dual Energy Mammography and Contrast-Enhanced Digital Breast Tomosynthesis for Lesion Assessment and Radiation Dose

Station #4

Participants
Hailiang Huang, MS, Stony Brook, NY (*Presenter*) Research support, Siemens AG

David A. Scaduto, PhD, Stony Brook, NY (*Abstract Co-Author*) Research Grant, Siemens AG
Chunling Liu, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Jie Yang, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Chencan Zhu, BS, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Kim Rinaldi, RT, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Jason Z. Eisenberg, MD, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Jingxuan Liu, MD,PhD, Stony Brook, NY (*Abstract Co-Author*) Nothing to Disclose
Mathias D. Hoernig, DIPLPHYS, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Julia Wicklein, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Sebastian Vogt, PhD, Monument, CO (*Abstract Co-Author*) Employee, Siemens Medical Solutions USA Inc.; Stockholder, Siemens AG
Thomas Mertelmeier, PHD, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG Stockholder, Siemens AG
Paul R. Fisher, MD, East Setauket, NY (*Abstract Co-Author*) Research Grant, Siemens AG;
Wei Zhao, PhD, Stony Brook, NY (*Abstract Co-Author*) Research Grant, Siemens Healthineers

For information about this presentation, contact:

hailiang.huang@stonybrook.edu

PURPOSE

Digital breast tomosynthesis combined with contrast-enhanced dual energy mammography (DBT+CEDEM) is being investigated for diagnostic accuracy. Contrast-enhanced digital breast tomosynthesis (CEDBT) provides coregistered low energy DBT and 3D contrast enhancement map. Synthetic CEDEM may also be generated and paired with synthetic mammogram. This study compares CEDBT with CEDEM for lesion assessment and dose efficiency.

METHOD AND MATERIALS

A Siemens MAMMOMAT Inspiration DBT system modified for dual energy contrast-enhanced imaging is used. Patients with BIRAD 4 and 5 lesions and scheduled for biopsy were recruited for an IRB-approved CE imaging study. CEDEM images were acquired 120 seconds after injection of iodine contrast agent, followed by CEDBT acquisition under the same breast compression. Eleven malignant lesions from 12 patients were confirmed by pathology result. A reader study of side-by-side comparison between CEDEM and CEDBT is performed to assess lesions on 1) Contrast enhancement level and 2) Margin identification, using a 5-point scale from -2 (CEDEM much better) to 2 (CEDBT much better). The radiation dose recorded by the DBT system is reviewed for DBT+CEDEM and CEDBT. Synthetic CEDEM is created with dual-energy subtracted projections from CEDBT using software developed by Siemens Healthineers.

RESULTS

For malignant lesions, CEDEM shows higher enhancement level than CEDBT slices (mean score=-0.64; 95% CI: -1.09, -0.18). CEDBT shows lesion margin better than CEDEM (mean score=0.78; 95% CI: 0.11, 1.44). In CEDBT slices, background parenchymal enhancement is less intense, and motion artifact is less severe than that in CEDEM. On average, CEDBT reduces dose by 32.8% ± 9.9% compared to DBT+CEDEM (average dose 1.91 ± 0.74 mGy vs. 2.86 ± 1.04 mGy). Synthetic CEDEM has similar mammographic appearance to CEDEM, and shows the same enhanced lesions.

CONCLUSION

CEDBT provides better lesion margin identification and reduces structural noise due to background parenchymal enhancement and motion compared to CEDEM, while the intensity of lesion enhancement is lower. CEDBT uses lower dose than DBT+CEDEM. Synthetic CEDEM can be created from CEDBT to quickly identify lesion enhancement.

CLINICAL RELEVANCE/APPLICATION

With the advent of DBT replacing FFDM, contrast imaging can potentially be done in full 3D setting (CEDBT) facilitated by synthetic 2D images (synthetic mammogram and synthetic CEDEM).

PH240-SD-TUB5 Organ Dose Estimation in CT through Voxelized Phantoms and Monte Carlo Methods: Impact of Wrong Patient-Phantom Matching

Station #5

Participants
Federica Zanca, PhD, Digem, Belgium (*Presenter*) Employee, General Electric Company
Xochitl Lopez-Rendon, PhD, Diegem, Belgium (*Abstract Co-Author*) Employee, General Electric Company
Pierre Guntzer, MSc, Strasbourg, France (*Abstract Co-Author*) Employee, General Electric Company
Mathieu Bedez, Strasbourg, France (*Abstract Co-Author*) Employee, General Electric Company
Francesco Ria, DMP, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
David E. Miller, PhD, Kirkland, WA (*Abstract Co-Author*) Employee, General Electric Company
Joshua Wilson, PhD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

PURPOSE

The aim of this study was to assess the impact on organ dose estimation for Body CT examinations when the patient is matched to the wrong virtual phantom.

METHOD AND MATERIALS

Patient-specific organ dosimetry is estimated using a Monte Carlo framework and matching patients to voxelized virtual human phantoms (hereafter 'phantoms'). Software for automatic patient scout segmentation was developed to identify anatomical landmarks, which are then used to match the patient with a phantom model. From the AP scout collected by a dose tracking system (DoseWatch, GE Healthcare), the patient contour, gray scale intensity profiles, and bone symmetry and edges are used to identify anatomical regions. The extracted patient-specific landmarks were then used to select the matching phantom from a database of 69 phantoms. Patient-specific organ doses were automatically estimated for a sample of 130 patients who underwent a chest/abdomen/pelvis exam. To verify the accuracy of the software, the AP scouts were also visually inspected to identify the correct landmarks manually. These correct landmarks led to a matched phantom, which could be the same or a different one from the one enabled by the automatic landmarks detection. Organ doses were estimated again and were compared to the one

estimated using the automatic software for landmarks recognition.

RESULTS

Preliminary results on 40 scouts show that the anatomical landmarks tool failed in detecting the correct landmarks in 17.5% of the cases (2% in chest, CAP, and kidney to bladder; 5% in abdomen and 5% in abdomen-pelvis) with an error ranging from 21 to 34 mm for abdomen, from 35 mm to 67 mm for abdomen-pelvis and up to 87 mm for CAP. The differences resulted in a wrong phantom selection in 15% of the cases. The associated differences in organ dose estimation due were higher for the partially irradiated organs (up to 96%) for all anatomical regions; for totally irradiated organ like stomach and liver the differences were up to 30%.

CONCLUSION

The study showed that error in dose estimation as large as 30% for fully irradiated may occur if the patient is matched to the wrong phantom.

CLINICAL RELEVANCE/APPLICATION

Quantifying and monitoring computed tomography (CT) radiation dose for an individual patient has become necessary to practice medical imaging risk assessment and protocol optimization. For this, an accurate organ dose estimation is needed.

PH241-SD-TUB6 Determining the Suitability of Ultrasound Systems as Fit-for-Purpose for Early Pregnancy Assessment Through the Use of Color Doppler Sensitivity Performance

Station #6

Participants
Jacinta Browne, PhD, Dublin 8, Ireland (*Presenter*) Nothing to Disclose
Sean Cournane, MSc, PhD, Dublin 8, Ireland (*Abstract Co-Author*) Nothing to Disclose
Andrew J. Fagan, PhD, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

jacinta.browne@dit.ie

PURPOSE

Foetal cardiac activity is well documented as the earliest proof of a viable pregnancy. Ultrasound imaging, particularly Doppler imaging using a transvaginal (TV) probe, has become the main diagnostic means of examining the health and development of the foetus. The aim of this study was to evaluate the Color Doppler sensitivity and detectability of ultrasound systems used in early pregnancy evaluation using a commercially available flow phantom, with the addition of distortion layers placed on the top of the scanning window to produce acoustic clutter in the Color Doppler image. The impact of these distortion layers was investigated through measurements of the signal-to-noise ratio (SNR) of the Color Doppler signal within the image.

METHOD AND MATERIALS

An evaluation of Color Doppler sensitivity for a range of ultrasound systems with both transvaginal and curvilinear transducers was carried out using a Mini-Doppler Flow Phantom (Gammex-RMI). The effect of distortion layers on the Doppler sensitivity and detectability was evaluated using a fat mimicking material and Perspex layers. The quality of the Color Doppler signal was analysed in terms of the Color Doppler SNR and was determined by an in-house developed MATLAB program which analyzed the variation in the Colour Doppler signal within a region of interest over sequential images.

RESULTS

The use of the phantom alone did not sufficiently challenge any of the systems, however the incorporation of the distortion layers produced a significant challenge, reducing the achievable penetration depth and quality of the signal as can be seen in Figure 1. It was found that the Color Doppler SNR values at the greatest penetration depth for each system were similar, corresponding to a value of 1.7±0.5; thus providing a useful parameter to determine whether an ultrasound system is it-for-purpose for this important clinical application.

CONCLUSION

The Doppler Sensitivity Performance Index can provide good differentiation between different machines of different class, particularly in identifying Doppler ultrasound machines which could be used for detecting early pregnancy foetal heart beat.

CLINICAL RELEVANCE/APPLICATION

The Doppler Sensitivity Performance Index can provide good differentiation between different machines of different class, particularly in identifying Doppler ultrasound machines which could be used for detecting early pregnancy foetal heart beat.

PH242-SD-TUB7 Optimization of Reconstruction Parameters for High and Ultra-high Definition Images with Next-generation Digital PET/CT

Station #7

Participants
Katherine Binzel, PhD, Columbus, OH (*Presenter*) Nothing to Disclose
Jun Zhang, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Richard Moore, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michael T. Friel, BS, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Michael V. Knopp, MD, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

knopp.16@osu.edu

PURPOSE

Next-generation digital PET/CT allows for improved image quality and quantitative accuracy through the use of high and ultra-high definition image reconstruction. Previous clinical evaluations have shown the improvement in visual quality and lesion detectability

with these image protocols. Here we validate the quantitative improvement in phantom data.

METHOD AND MATERIALS

A NEMA phantom with hollow sphere inserts was filled with 18F with 2:1, 4:1, 8:1, 16:1, 32:1 and 64:1 activity concentration ratios. Data were acquired on a pre-commercial release digital photon counting system (Philips Vereos) and reconstructed using a variety of reconstruction protocol settings. Matrix sizes used were 144x144 for standard definition (SD) 4x4x4 mm voxel lengths, 288x288 matrix for high definition (HD) 2x2x2 mm voxel lengths, and 576x576 matrix for ultra-high definition (UHD) 1x1x1 mm voxel lengths. For each matrix size, the number of iterative subsets was changed from 1-35 in increments of 5. Activity concentrations and recovery coefficients (RC) were recorded for each image set.

RESULTS

HD and UHD images were more quantitatively accurate than SD. For the 16, 8, 4, 2, 1, and 0.5 mL spheres, the SD RCs were 1.08, 1.04, 1.05, 1.02, 0.84, and 0.57, respectively, when using 15 subsets. For the HD reconstructions also with 15 subsets, the RCs were 1.10, 1.06, 1.08, 1.05, 0.91, and 0.64. UHD images had RCs of 1.09, 1.08, 1.11, 1.05, 0.89 and 0.65. We additionally found that a lower number of subsets for HD and UHD reconstructions provided the same overall improvement in quantification. These results are in line with previous blinded reviews of clinical data sets, showing the best image quality at a lower number of subsets for HD and UHD images. We conclude that fewer than 15 subsets for HD and fewer than 10 for UHD image reconstruction is optimal.

CONCLUSION

We have validated the improvement in quantitative accuracy enabled by the use of a larger reconstruction matrix with next-generation digital photon counting. Further, we have demonstrate that HD and UHD reconstruction protocols reach quantitative robustness at a different number of subsets than SD protocols.

CLINICAL RELEVANCE/APPLICATION

Next-generation digital PET/CT provides the opportunity for high and ultra-high definition image reconstruction, with improved quantitative accuracy over standard definition reconstructions.

PH243-SD-TUB8 The Influence of keV and Target Material on Spatial Resolution of Virtual Monochromatic Image

Station #8

Participants
Takayuki Kobayashi, MS, Minatoku, Japan (*Presenter*) Nothing to Disclose
Tsutomu Gomi, PhD, Sagamihara, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Clarify the effect that energy (keV) and the target materials has on the spatial resolution of the virtual monochromatic image(VMI).

METHOD AND MATERIALS

We have extracted the four rods (Liver Rod; Inner Bone; CB2-30%; Cortical Bone) from The Gammex 467 Tissue Chartacterization Phantom. The extracted four rod and iodide-containing acrylic resin rod (iodine-acrylic-rod) was placed in cylinder phantom. Using the CT scanner (Revolution GSI; GE Healthcare), cylinder phantom was scanned in the single energy scan and the Dual energy scan. The kernel used for image reconstruction is 'standard'. Modulation transfer function (MTF) of five kinds of rod images was calculated. The reconstructed images are 40 keV, 70 keV, 100 keV, 140 keV, 120 kVp.

RESULTS

The MTF of VMI varies depending on KeV and the target material. In the image reconstruction of high-keV, MTF of Iodine-acrylic-rod and the Inner Bone rod was value in the vicinity of 0.3 cycle/mm exceeds 1.0. And the shape of the MTF Curve was significantly different compared to that of 120kVp. MTF of 70keV and MTF of 120kVp is almost the same in all of the rod. The value of the cut-off frequency of the low keV was lower than that of the high keV. The change of MTF varies depending on the line attenuation coefficient of the target material.

CONCLUSION

Even reconstructed VMI from the same raw data, if the keV and the target material is different to change the resolution characteristics of VMI. Sometimes the shape of the MTF curve change.

CLINICAL RELEVANCE/APPLICATION

VMI with low keV can obtain high CT value and reduce contrast medium. However, the resolution characteristics are deteriorated. Therefore, set the keV in consideration of the size of the target vessel in the 3DCTA of the blood vessel.

PH244-SD-TUB9 Shape and Texture Feature Classification of Angiomyolipoma without Visible Fat and Clear Cell Renal Cell Carcinoma in Contrast-Enhanced CT Images

Station #9

Participants
Han Sang Lee, MS , Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Helen Hong, PhD, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
Junmo Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Dae Chul Jung, MD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Koon Ho Rha, MD, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

hlhong@swu.ac.kr

CONCLUSION

Our method can be used to the multi-class classification of renal masses and the early diagnosis of renal cancer.

Background

Classification of renal masses as benign angiomyolipoma without visible fat (AMLwvf) and malignant clear cell renal cell carcinoma (ccRCC) in CT images is an important task for early diagnosis of renal cancer. Two masses are known to be similar in intensity in CT images, but it has been also known that ccRCC is more heterogeneous in quantitative texture and AMLwvf is less circular and is more invasive in shape. Thus, we propose a quantitative texture and shape feature classification method for distinguishing AMLwvf from ccRCC in contrast-enhanced (CE) CT images.

Evaluation

Our method was evaluated on a dataset consisting of 80 abdominal CE CT scans from 39 patients with AMLwvf and 41 patients with ccRCC. Scans were acquired on multi-detector scanners at 100s to 120s delays after contrast injection. For each scan, a renal mass was manually marked by a radiologist. From these mass regions, 102 texture features consisting of 7 histogram features, 14 GLCM, 22 GLRLM, and 59 LBP, and 7 shape features consisting of area-perimeter ratio, convex area, eccentricity, major and minor axes lengths, perimeter, and solidity, were extracted. A support vector machine (SVM) and random forest (RF) classifiers were then trained to classify the unseen masses. Experiments were cross validated by leave-one-out method and the training images were 250-fold augmented by random rotation, translation, and scaling to avoid the overfitting. The classification performance of the texture feature alone was 73.8% for both SVM and RF, while the performance of the texture and shape features was improved to 78.8% and 76.3% for SVM and RF, respectively.

Discussion

Our texture features provide the distinctive patterns of renal masses which are difficult to visually distinguish. Our shape features further improve the classification performance by reflecting the shape difference between two masses to the classifier. Throughout our experiments, it is quantitatively confirmed that there is a meaningful difference in texture and shape between two renal masses.

SSJ07

Gastrointestinal (Radiomics)

Tuesday, Nov. 28 3:00PM - 4:00PM Room: E350

CT GI MR PH

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

Participants
Andrew D. Smith, MD,PhD, Jackson, MS (*Moderator*) President, Radiostics LLC; President, eRadioMetrics LLC; Patent holder, eRadioMetrics LLC; President, Liver Nodularity LLC; Patent holder, Liver Nodularity LLC; President, Color Enhanced Detection LLC; Patent holder, Color Enhanced Detection LLC
Kathryn J. Fowler, MD, Saint Louis, MO (*Moderator*) Nothing to Disclose

Sub-Events

SSJ07-01 Radiomics-Based Quantification and Classification of the Phenotype of Pancreas Cystic Neoplasms on Abdominal CT Images

Tuesday, Nov. 28 3:00PM - 3:10PM Room: E350

Participants
Seyoun Park, Baltimore, MD (*Presenter*) Nothing to Disclose
Linda C. Chu, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Elliot K. Fishman, MD, Baltimore, MD (*Abstract Co-Author*) Institutional Grant support, Siemens AG; Institutional Grant support, General Electric Company; Co-founder, HipGraphics Inc;

For information about this presentation, contact:

spark139@jhmi.edu

PURPOSE

Pancreatic cystic masses are detected in greater than 2% of abdominal CTs, and they vary in malignant potential based on underlying pathologic diagnosis. Many of these cystic masses share overlapping imaging features and are difficult to confidently diagnose based on visual assessment of these imaging features. The purposes of this study are to quantify the phenotype pancreas cystic neoplasms and to use these radiomics features to classify different types of pancreatic cystic masses.

METHOD AND MATERIALS

This was an IRB-approved retrospective study. 103 patients with pathologically proven pancreatic cystic masses with preoperative dual-phase pancreatic protocol CT were identified from the radiology and pathology database from 2003 to 201 6. This included 60 intraductal papillary mucinous neoplasm (IPMN), 8 mucinous cystic neoplasm, 20 serous cystadenoma, 10 solid pseudopapillary epithelial neoplasm, and 5 pancreatic neuroendocrine tumor. Primary cystic masses and whole pancreas were manually segmented using dedicated software, the Medical Imaging Interaction Toolkit (MITK) . The phenotype of each cyst was expressed by 478 radiomics features, including the first order statistics, shape, texture, and textures from wavelet and Laplacian of Gaussian. Additional 10 statistics from the whole pancreas and 2 demographic features of age and gender were also used for the analysis of the types of cyst. The minimum redundancy maximum relevance feature selection was applied for feature dimension reduction.

RESULTS

Among the whole 490 features, thirty features were found for the binary classification of IPMN. The matching results to clinical outcomes show 0.883 of sensitivity and 0.721 of specificity with 81.6% of overall accuracy (AOC area: 0.873). For all five types, thirty-five features were extracted with 72.8% of correctly classified cases by 10-fold cross validation. Age, median and mean intensities of wavelets, and fractal dimension were highly ranked for the both classifications.

CONCLUSION

Radiomics features were significantly different among different types of pancreatic cystic neoplasms and were helpful for the classification of pancreatic cystic neoplasms.

CLINICAL RELEVANCE/APPLICATION

Radiomics features can be used for the classification of pancreatic cystic neoplasms.

SSJ07-02 Radiomics Approach to Characterize Microsatellite Instability (MSI): A CT-Based Radiomic Signature for the Detection of the MSI-H Phenotype in Colorectal Cancer

Tuesday, Nov. 28 3:10PM - 3:20PM Room: E350

Participants
Yanqi Huang, Guangzhou, China (*Presenter*) Nothing to Disclose
Zaiyi Liu, MD, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

yikiann@126.com

PURPOSE

To develop and validate a CT-based radiomic signature for the preoperative detection of the MSI-H (high levels of microsatellite instability) phenotype in patients with colorectal cancer.

METHOD AND MATERIALS

Ethical approval by the institutional review board was obtained for this retrospective analysis, and the informed consent was waived. The primary cohort of this study consisted of 140 patients with clinicopathologically confirmed CRC, with data gathered from January to December 2011; while the independent validation cohort consisting of 114 consecutive patients collected from January to December 2012. 591 radiomic features were extracted from preoperative portal venous-phase computed tomography (CT) of CRC. Lasso regression model was used for data dimension reduction, feature selection, and radiomics signature building. The discrimination and calibration performance of the developed radiomics signature was assessed in primary cohort and then validated in the independent validation cohort.

RESULTS

After feature redcution and selection, 29 radiomics features were used to develop the radiomic signature. In both the primary and validation cohort, the radiomic signature was significantly associated with the MSI-H phenotype (P<0.001 for primary cohort; P=0.012 for validation cohort). The radiomic signature showed good discrimination, with a C-index of 0.914 (95%CI: 0.901, 0.927) in primary cohort and 0.702 (95%CI: 0.677, 0.727) in validation cohort. Good calibration of the radiomic signature was depicted in calibration curves in both the primary and validation cohort.

CONCLUSION

This study presents a CT-based radiomic signature that can be conveniently used to facilitate the preoperative individualized detection of MSI-H phenotype in CRC patients, which could be useful for informing patient prognosis and guiding the personalized therapy of CRC including adjuvant chemotherapy, targeted therapy, and immune checkpoint inhibitor therapy.

CLINICAL RELEVANCE/APPLICATION

The developed and validated CT-based radiomic signature could facilitate the preoperative individualized detection of MSI-H phenotype CRC, which further advances the role of MSI in informing patient prognosis and guiding the personalized therapy of CRC including adjuvant chemotherapy, targeted therapy, and immune checkpoint inhibitor therapy.

SSJ07-03 Comparison between Radiomics Analysis and Subjective Visual Assessment of T2-weighted MRI Images for the Identification Of >=T3 Rectal Cancer

Tuesday, Nov. 28 3:20PM - 3:30PM Room: E350

Participants
Ines A. Santiago, MD, Lisbon, Portugal (*Presenter*) Nothing to Disclose
Eleonora Di Campli, Chieti, Italy (*Abstract Co-Author*) Nothing to Disclose
Joao Santinha, Lisbon, Portugal (*Abstract Co-Author*) Nothing to Disclose
Jose Cruz, Lisbon, Portugal (*Abstract Co-Author*) Nothing to Disclose
Antonio Galzerano, Lisbon, Portugal (*Abstract Co-Author*) Nothing to Disclose
Celso Matos, MD, Brussels, Belgium (*Abstract Co-Author*) Nothing to Disclose
Nickolas Papanikolaou, PhD, Lisbon, Portugal (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

ines.santiago@fundacaochampalimaud.pt

PURPOSE

To determine if radiomics outperforms visual assessment based on T2-weighted imaging (T2-W) for the discrimination between <=T2 and >=T3 rectal cancer

METHOD AND MATERIALS

The study included all patients with rectal cancer who underwent total mesorectal excision as primary curative treatment, without neoadjuvant therapy, at our institution, between October 2013 and December 2016 (n=26, 14 males, mean age=67 years). Two patient groups were formed based on pathological stage, <=T2 (n=13) and >=T3 (n=13). All patients underwent staging MRI before surgery comprising T2-W imaging in axial, coronal and sagittal planes. T2-W images were blindly reviewed in consensus by 2 radiologists and primary tumors were classified as >=T3 or <=T2. A volume of interest (VOI) was drawn in consensus by the 2 radiologists, based on axial T2-W images, encompassing the whole primary tumor and corresponding datasets were analyzed using the PyRadiomics package. Wilcoxon-Mann-Whitney test was used to define the discriminating power between the 2 groups, of each of the 1831 features separately. Feature reduction was done using a cut-off correlation coefficient of 0.99 to remove redundant features. Multiple comparisons correction was done based on an FDR test. The best performing feature was selected, and its diagnostic accuracy was compared to that of visual radiological assessment using DeLong's test

RESULTS

23 radiomics features provided with statistically significant differences (p<0.05) between the 2 groups, while the best performing feature was the Low Gray Level Run Emphasis - GLRLM of the exponential of the original image with sensitivity, specificity and area under the ROC curve (AUROC) of 0.79, 0.92 and 0.92, respectively. Sensitivity, specificity and AUROC were 0.93, 0.67 and 0.80, respectively, for visual radiological evaluation. The performance difference between visual assessment and radiomics analysis was not statistically significant (p=0.21)

CONCLUSION

Our preliminary results indicate that radiomics analysis doesn't provide higher performance compared to visual radiological assessment for the identification of >=T3 rectal cancer based on T2-W images.

CLINICAL RELEVANCE/APPLICATION

Radiomics analysis and difficult issues in rectal cancer staging: applicability in the identification of >=T3 rectal cancer

SSJ07-04 Predicting Early Recurrence of Hepatocellular Carcinoma with Texture Analysis of Pre-Operative Magnetic Resonance Imaging: A Radiomics Study

Tuesday, Nov. 28 3:30PM - 3:40PM Room: E350

Awards
Student Travel Stipend Award

Participants
Terrence C. Hui, MBBS,MRCS, Singapore, Singapore (*Presenter*) Nothing to Disclose
Tong Kuan Chuah, PhD, Singapore, Singapore (*Abstract Co-Author*) Nothing to Disclose
Zi Lin Tan, Singapore, Singapore (*Abstract Co-Author*) Nothing to Disclose
Reena Divya, Singapore, Singapore (*Abstract Co-Author*) Nothing to Disclose
Cher Heng Tan, MBBS, FRCR, Singapore, Singapore (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

terrencehui123@gmail.com

PURPOSE

To study the feasibility of using texture analysis in pre-operative magnetic resonance imaging (MRI) to predict early recurrence (ER) in hepatocellular carcinoma (HCC) post-curative surgery.

METHOD AND MATERIALS

Institutional review board was obtained. A retrospective review of all patients who underwent hepatectomy between 1 Jan 2007 and 31 Dec 2015 was performed. Inclusion criteria: pre-operative MRI, tumor size >=1cm, new cases of HCC. Exclusion criteria: Loss-to-follow-up, ruptured HCCs, movement artifacts and previous hepatectomy or interval adjuvant therapy. Patients were divided into ER and late or no recurrence (LNR) groups. Early recurrence was defined as new foci of HCC within 730 days of curative surgery. Plain, diffusion-weighted, arterial and portovenous acquisitions were imported into MATLAB (Mathworks, Matick, MA, USA). Radiomics feature extraction was performed on the largest cross-sectional area of each tumor. MaZda software (version 4.6.2.0) was used to analyze 290 texture parameters and PRTools was used for feature selection.

RESULTS

Fifty-seven patients (49 male, mean age 66.5 years) were divided into ER (n=21) and LNR (n=36) groups. Differences in alpha-fetoprotein level (p=0.021), tumor size (p=0.011), restricted diffusion (p=0.01) and vascular invasion (gross and/or microvascular, p=0.047) between the 2 groups were found to be statistically significant. Texture analysis revealed 79% accuracy in classifying arterial images using 1-nearest neighbor using parameters S(1,0)Contrast or S(5,-5)Entropy. The parameter S(5,-5)Entropy has also resulted in 77% accuracy in classifying T2 images.

CONCLUSION

Early recurrence of HCC can be predicted on pre-operative MRI with 79% accuracy using the appropriate texture analysis parameter.

CLINICAL RELEVANCE/APPLICATION

Post-operative recurrence of HCC results in mortality and the time-to-recurrence duration is an independent prognostic factor of survival. The ability to identify these high-risk patients pre-operatively will potentially guide both surgical management, such as resecting a wider margin or liver transplantation, as well as post-operative surveillance and therapeutic interventions.

SSJ07-05 Quantification of Hepatocellular Carcinoma Heterogeneity with Multiparametric Magnetic Resonance Imaging

Tuesday, Nov. 28 3:40PM - 3:50PM Room: E350

Awards
Trainee Research Prize - Resident

Participants
Stefanie Hectors, PhD, New York, NY (*Presenter*) Nothing to Disclose
Mathilde Wagner, MD, PhD, Paris, France (*Abstract Co-Author*) Consultant, Toshiba Medical Systems Corporation
Octavia Bane, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Cecilia Besa, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Sara Lewis, MD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Romain Remark, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Nelson Chen, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Isabel Fiel, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Hongfa Zhu, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Sacha Gnjatic, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Miriam Merad, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Yujin Hoshida, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Bachir Taouli, MD, New York, NY (*Abstract Co-Author*) Consultant, MEDIAN Technologies ; Grant, Guerbet SA

For information about this presentation, contact:

stefanie.hectors@mountsinai.org

PURPOSE

To quantify heterogeneity in hepatocellular carcinoma (HCC) using multiparametric (mp) magnetic resonance imaging (MRI), and to

report preliminary data correlating quantitative MRI parameters with histopathology and gene expression in a subset of patients.

METHOD AND MATERIALS

Thirty-two HCC patients (M/F 26/6, mean age 59 years) with 39 HCC lesions were included in this prospective study. The mpMRI protocol consisted of diffusion-weighted imaging (DWI), blood-oxygenation-level-dependent (BOLD), tissue-oxygenation-level-dependent (TOLD) and dynamic contrast-enhanced (DCE)-MRI. Histogram characteristics [central tendency (mean, median) and heterogeneity (standard deviation, kurtosis, skewness) MRI parameters] in HCC and liver parenchyma were compared using Wilcoxon signed-rank tests. Histogram data was correlated between MRI methods in all patients and with histopathology and gene expression in 14 patients.

RESULTS

HCCs exhibited significantly higher intra-tissue heterogeneity vs. liver with all MRI methods (P<0.042). Although central tendency parameters showed significant correlations between MRI methods and with each of histopathology and gene expression, heterogeneity parameters exhibited additional complementary correlations between BOLD and DCE-MRI and with histopathologic hypoxia marker HIF1a and gene expression of Wnt target GLUL, pharmacological target FGFR4, stemness markers EPCAM and KRT19 and immune checkpoint PDCD1.

CONCLUSION

Histogram analysis combining central tendency and heterogeneity mpMRI features is promising for noninvasive HCC characterization on the imaging, histologic and genomics level.

CLINICAL RELEVANCE/APPLICATION

The proposed mpMRI approach could potentially be used to stratify hepatocellular carcinoma treatment and to noninvasively predict treatment outcome.

SSJ07-06 Prediction of Target Therapy Related Gene Expression Level for Hepatocellular Carcinoma: Preoperative Gd-EOB-DTPA Enhanced MRI and Histopathological Correlation

Tuesday, Nov. 28 3:50PM - 4:00PM Room: E350

Participants
Kun Huang, Guiyang, China (*Presenter*) Nothing to Disclose
Zhi Dong IV, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Huasong Cai, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Mengqi Huang, MD, Guang Zhou, China (*Abstract Co-Author*) Nothing to Disclose
Yingmei Jia, guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Yanji Luo, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Zi-Ping Li, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Shiting Feng, MD, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Our aim of the study is to investigate the feasibility of prediction for target therapy related gene expression level in hepatocellular carcinoma (HCC) using preoperative Gd-EOB-DTPA enhanced magnetic resonance imaging (MRI).

METHOD AND MATERIALS

91 patients with solitary HCC who underwent preoperative Gd-EOB-DTPA enhanced MRI were prospectively analyzed. Features including tumor size, signal homogeneity, tumor capsule, tumor margin, intratumoral vessels, peritumor enhancement in mid-arterial phase, peritumor hypointensity during hepatobiliary phase, signal intensity ratio on DWI and apparent diffusion coefficients (ADCs), T1 relaxation times and the reduction rate between pre- and post-contrast enhancement images were assessed. HCC target therapy related gene (B-Raf,Raf-1,VEGFR2,VEGFR3) expression level in excision specimens were evaluated using immunohistochemical staining. Correlation between these MRI features and B-Raf,Raf-1,VEGFR2,VEGFR3 gene expression level were analyzed by Rank sum test, Spearman correlation and multivariate logistic regression so as to establish a prediction model.

RESULTS

Univariate analysis showed that tumor incomplete or non capsule (p<0.001), intratumoral vessels (P=0.002) were significantly related with the B-Raf gene expression level, and tumor capsule status (p=0.001), intratumoral vessels (P=0.013) significantly correlated with the Raf-1 gene expression level. There was no significant association between the expression level of VEGFR2, VEGFR3 and all the MRI features. Multivariate logistic regression analysis demonstrated that incomplete tumor capsule (P=0.002, OR=11.870, 95% CI: 2.473~56.975) or non capsule (P=0.004, OR=15.750, 95% CI: 2.373~104.537) were independent risk factors of HCC with high B-Raf gene expression level, and incomplete tumour capsule (P< 0.001, OR=11.250, 95%CI: 3.206~39.474) or non capsule (P=0.040, OR=5.556, 95%CI: 1.078~28.635) were independent risk factors of HCC with high Raf-1 gene expression level.

CONCLUSION

It is feasible to predict the expression level of B-Raf and Raf-1 gene using preoperative Gd-EOB-DTPA enhanced MRI.

CLINICAL RELEVANCE/APPLICATION

Incomplete or non capsule, or presence of intratumoral vessels are potential indicator for the high expression of B-Raf and Raf-1. Gd-EOB-DTPA enhanced MRI may facilitate the determination for choosing gene therapy for the patient with HCC.

RSNA 2017 Explore. Invent. Transform.
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SSJ21

Physics (Ultrasound)

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

PH US

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

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
Timothy J. Hall, PhD, Madison, WI (*Moderator*) Equipment support, Siemens AG; Technical support, Siemens AG

Sub-Events

SSJ21-01 How to Identify Optimum Incident Acoustic Output for Utilizing Subharmonic Amplitude from Ultrasound Contrast Microbubbles for Pressure Measurements: A Solution for Real-Time Clinical Applications

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

Participants
Cara Esposito, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Flemming Forsberg, PhD, Philadelphia, PA (*Abstract Co-Author*) Equipment support, Toshiba Medical Systems Corporation; Research Grant, Toshiba Medical Systems Corporation; Equipment support, Siemens AG; In-kind support, General Electric Company; In-kind support, Lantheus Medical Imaging, Inc
Kris Dickie, Burnaby, BC (*Abstract Co-Author*) Employee, Clarius Mobile Health Corp
Jaydev K. Dave, PHD, Philadelphia, PA (*Presenter*) Research Grant, Koninklijke Philips NV; Equipment support, Lantheus Medical Imaging, Inc; Equipment support, General Electric Company

For information about this presentation, contact:

Jaydev.Dave@jefferson.edu

PURPOSE

At optimum incident acoustic output (IAO), subharmonic aided pressure estimation (SHAPE), based on subharmonic signals from microbubbles, is useful for estimating clinical pressures. However, real-time SHAPE application is impeded because the optimum IAO level varies on a case-by-case basis. Purpose of this work was to address this problem by identifying the optimum IAO for SHAPE in real-time.

METHOD AND MATERIALS

The SHAPE algorithm was developed to sequentially step through each available IAO level, extract the subharmonic amplitude, perform a spline fit (subharmonic amplitude vs. IAO), and identify the IAO level with maximum derivative as the optimum IAO. This algorithm was implemented using a customized interface on a SonixTablet scanner (BK Ultrasound, Peabody, MA) using C/C++ and Qt libraries (The Qt Company, Oslo, Norway). In vitro tests were conducted using a closed-loop flow system with activated Definity (Lantheus Medical Imaging, N Billerica, MA, USA; 0.1 mL) mixed in 750 mL isotonic diluent. A pressure catheter (Millar Inc., Houston, TX) provided ambient pressure values. A pulsed Doppler gate was placed within the lumen of the vessel in the flow system, then the SHAPE algorithm was initiated (ftransmit: 5.6 MHz; chirp down transmit pulse in pulse inversion mode). Catheter pressure and subharmonic data were acquired simultaneously at, below and above the optimum IAO level (10secs; n=3), then a linear correlation was performed between the subharmonic and catheter data using Matlab (MathWorks, Natick, MA, USA).

RESULTS

Correlation coefficient values between SHAPE and the pressure catheter data at, below and above the optimum IAO level were -0.73±0.1, -0.55± 0.2, and -0.70±0.1, respectively, confirming best correlation occurring at the identified IAO level. At the optimum IAO, the sensitivity of the subharmonic signal to the ambient pressure was 13.5±1.0 mmHg/dB. Occasionally at relatively higher IAO levels (2.9 MPap-p), correlation coefficients as high as -0.9 were also noted, presumably due to bubble destruction.

CONCLUSION

Identification of optimum IAO (in real-time) for insonating microbubbles to be utilized for SHAPE has been demonstrated; this will pave the way for real-time clinical applications.

CLINICAL RELEVANCE/APPLICATION

Real-time implementation to determine optimum IAO for insonating microbubbles for SHAPE has been demonstrated and verified; this paves the way for real-time SHAPE applications.

SSJ21-02 Contrast-Enhanced Ultrasound Assisted Percutaneous Nephrostomy: A Technique to Increase Success Rate for Patients with Non-dilated Renal Collecting System

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

Participants
Baoxian Liu, Guangzhou, China (*Presenter*) Nothing to Disclose
Xioahua Xie, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Guangliang Huang, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose
Xiaoyan Xie, Guangzhou, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

xian_1121@163.com

CONCLUSION

CEUS assisted PCN in patients with nondilated renal collecting system is valuable with high technical success rate and acceptable complications.

Background

For percutaneous nephrostomy (PCN), lack of proper guidance system may lead to hazardous results, especial for these patients with nondilated renal collecting systems. The purpose of our study is to report our single-center experience of contrast-enhanced ultrasound (CEUS) assisted PCN for patients with nondilated renal collecting system.

Evaluation

From November 2011 to September 2015, 47 patients(mean age, 51.9±16.2 years; range, 11-80 years) with clinical necessity to urinary drainage, urinary diversion, or provision of access to the collecting system and with nondilated renal collecting system were performed 48 CEUS assisted PCNs. Ultrasound contrast agent was injected through the puncture needle and the drainage catheter to confirm successful PCN. The technical success rate was 100%(47/47, 95%CI: 93.8%, 100%) per patient and 100% (48/48, 95%CI: 94.0%, 100%) per kidney. For each kidney, the mean number of needle passes was 1.4 ± 0.5 (rang, 1-3). The mean duration of the complete procedure was 18.9±4.8 min (range, 8-30 min). The mean dose of contrast-enhanced agent was 12.9 ± 3.2 ml (range, 8-25 ml). No major complication was observed. Only 4 patients (4/47, 8.5%, 95%CI: 2.37%, 20.4%) had minor complications, including perirenal hematoma last 9 days on ultrasound images in 1 and transitant macroscopic hematuria last about 1-2 days in 3.

Discussion

Several modalities are considered to assist PCN in a nondilated collecting system. CEUS is known to have exclusive advantages including real-time scanning, no radiation, and easy operation, which is also recommended for intracavitary administration. Although PCN in the nondilated collecting system is a technical challenging, our results displayed that CEUS assisted PCN showed comparable success rate with conventional PCN placement in patients with dilated collecting systems.

SSJ21-03 Comparison of Computerized Analysis for Uniformity Assessment in Ultrasound QA

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

Participants
Zhimin Li, PhD, Brookfield, WI (*Presenter*) Software support, Cablon Medical BV
James A. Zagzebski, PhD, Madison, WI (*Abstract Co-Author*) Researcher, General Electric Company; Equipment support, Analogic Corporation; Research agreement, Siemens AG

For information about this presentation, contact:

zhiminli@wisc.edu

zhiminli@wisc.edu

CONCLUSION

The MBCA method with the mean image shows good sensitivity for UA compared to UiQ, although this is a limited cohort of data available. We will enlarge our sample pool by acquiring cine loops routinely to facilitate this analysis for all probes.

Background

Performing uniformity assessment (UA) and detecting transducer defects of concern is an important component of Ultrasound QA testing. Although visual inspections of acquired phantom images are most frequently done, there is an increasing trend toward computerized analysis of cine files acquired during QC. It is important to understand performance differences between various computerized analysis methods for UA.

Evaluation

We developed a Matlab-based computerized analysis (MBCA) program for UA. It creates a mean image of frames in a cine loop acquired while a transducer is translated over a phantom. Element dropout defects are recognized as "shadows" emanating from the transducer surface. The code calculates a defect cutoff threshold (DCT) based on 3 standard deviations below the data's mean or 3 Median absolute deviations (MAD) below the data's median by utilizing only the ring-down portion of the phantom images. The detection performance was compared with that of a commercial program, UltraiQ(UiQ) that analyzes image data from a ROI having a 12 mm axial extent in the gray scale image. The comparisons were done for linear array transducers (LTA) and GE Logiq scanners evaluated during annual tests during the past year. Nine probes were judged defective, and three of these had recorded cine loops. Seven defects had been visually identified in this data set. Using the cutoff threshold described, the MBCA program applied to the mean image detected all 7 dropout areas (visually identified) from the 3 transducers with no false positive detection. On the other hand, the UiQ only detected four of the dropout areas with three false detections.

Discussion

Our MBCA currently works for LTAs but can be modified to analyze curvilinear arrays. The improved performance over UiQ can be related to a high signal to noise ratio in the ring-down part of the image and to the minimal spread of the defect shadow in this area.

SSJ21-04 Freehand 3D Ultrasound Construction via Preoperative MRI Co-Registration for Spine Needle Interventions

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

Participants
Tharindu De Silva, PhD, Baltimore, MD (*Presenter*) Nothing to Disclose
Ali Uneri, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Joshua Punnoose, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Xiaoxuan Zhang, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Runze Han, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Joseph Goerres, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Matthew W. Jacobson, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Sebastian Vogt, PhD, Monument, CO (*Abstract Co-Author*) Employee, Siemens Medical Solutions USA Inc.; Stockholder, Siemens AG
Gerhard Kleinszig, Salzburg, Austria (*Abstract Co-Author*) Employee, Siemens AG
Daniel M. Sciubba, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;

PURPOSE

Ultrasound (US)-guided spine needle interventions have limited clinical adoption due to confounding visualization of deep bony anatomy. Image registration between previously acquired MRI and real-time US could provide useful anatomical context to accurately guide needles toward target locations. Registration of MRI with an initially acquired, baseline 3D US image facilitates the mapping of anatomy in MRI to intraoperative US imaging space. This work proposes a method to register a 2D US image sequence to MRI and simultaneously construct a MRI-aligned, 3D US volume to be subsequently used for real-time navigation.

METHOD AND MATERIALS

Within the registration framework, US images were simulated from MRI using a US wave propagation model that incorporated reflection, refraction, and attenuation properties. Acoustic impedances were derived from T1-weighted MR values using a non-linear mapping function with relevant values for vertebra, CSF, fat, muscle, and intervertebral disc. Simulated US was compared with each actual US image using normalized cross-correlation metric and optimized using Powell's method to compute the best corresponding slice from MRI. Registered slices were interpolated in a volumetric grid to construct the 3D volume. Experiments were performed by acquiring axial slices of a lumbar puncture phantom using a 2D, linear, 128-element array probe at 5 cm depth. For comparison, 3D US image was constructed by optically tracking the calibrated 2D US probe.

RESULTS

The error between corresponding anatomical distances between US volumes constructed from the two methods (registration vs tracking) was found to be 1.3 ± 1.2 (mean ± std) mm. Registration accuracy measured as the point-based distance between corresponding anatomical locations from MRI and US was 4.5 ± 5.9 (median ± iqr) mm. Deformation due to applied US probe pressure contributed substantially to this error and it will be incorporated to the simulation model in ongoing work to improve accuracy.

CONCLUSION

Registration between actual and simulated US images could provide a useful method to yield MR-aligned 3D US volume for navigation in spine pain procedures.

CLINICAL RELEVANCE/APPLICATION

The proposed method could provide 3D US images registered to MRI to facilitate accurate needle targeting during spine needle interventions.

SSJ21-05 Can Speed of Sound Be Better Than Conventional Elastography for Breast Characterization?

Tuesday, Nov. 28 3:40PM - 3:50PM Room: S403A

Participants
Sergio J. Sanabria, Zurich, Switzerland (*Presenter*) Nothing to Disclose
Marga B. Rominger, MD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Corin F. Otesteanu, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Farrukh I. Sheikh, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Volker Klingmueller, Giessen, Germany (*Abstract Co-Author*) Nothing to Disclose
Orcun Goksel, PhD, Zurich, Switzerland (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To compare a novel speed of sound (SoS) method and conventional elastography (strain ratio SR and shear wave velocity SWV) in breast with respect to tissue compression and differentiation.

METHOD AND MATERIALS

A healthy volunteer (42 yr) was repeatedly assessed with SoS and SWV at five different compression levels in order to identify non-linearity confounders. The examinations were performed in the cranio-caudal view and retromammillar segment for both non-diseased breasts. Also, five women with biopsy proven lesions (3 invasive ductal carcinoma IDC, 1 fibroadenoma FA, 1 cyst) were tested to identify differences between SoS, SR and SWV. Ultrasound examination was performed with a commercially available ultrasound system (SonixTouch, Ultrasonix, Richmond, Canada). B-mode imaging was used for lesion localization. Hand-held SoS images were generated for lesion characterization. A flat passive plexiglass reflector positioned opposite to a linear probe was used as a timing reference for the ultrasound signals transmitted through the lesions. Synthetic aperture data was acquired and average SoS values across the lesions were measured with an accuracy of <0.7%. Elastography (SWS and SR) was performed with a GE Logiq E9 machine.

RESULTS

Breast compression was 60 to 25 mm. SWV correlates with breast compression (R2>0.5) while SoS does not show a significant correlation (R2<0.2). The average SoS value was 1465 m/s (SD 7 m/s) and the average SWS value 2.5 m/s (SD 0.2 m/s). The SoS increments in the lesions were [cyst = 0.9%, FA = 0.8%, IDC [2.7-3.0%], while for SWS [cyst = 2.5 m/s, FA = 5.4 m/s, IDC = 4.1-3.95%] and SR [cyst = 1.6, FA = 5.0, IDC 2.8]. While all lesions could be correctly classified with a single SoS threshold, both SE and SWS failed to differentiate FA from IDC.

CONCLUSION

Hand-held speed of sound showed less dependency on compression than SWS and a better differentiation in an exemplary population of benign and cancerous lesions. Further studies are needed to confirm its utility.

CLINICAL RELEVANCE/APPLICATION

A hand-held SoS add-on to conventional ultrasound system provides additional information (Bulk Modulus) to conventional elastography (Young Modulus) for multi-parametric tissue characterization. SoS may reduce operator dependency and outperform conventional elastography in selected clinical scenarios. This novel technique can be implemented on a standard ultrasound machine.

SSJ21-06 Acoustic Lens-Based Photoacoustic-Ultrasound System for Noninvasive Thyroid Imaging

Tuesday, Nov. 28 3:50PM - 4:00PM Room: S403A

Participants
Francis Kalloor, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Bhargava K. Chinni, MS, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Zichao Han, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Navalgund A. Rao, PhD, Rochester, NY (*Abstract Co-Author*) Nothing to Disclose
Vikram S. Dogra, MD, Rochester, NY (*Presenter*) Editor, Wolters Kluwer nv;

For information about this presentation, contact:

vikram.Dogra54@gmail.com

Vikram.Dogra54@gmail.com

CONCLUSION

A combined non-invasive PA and US imaging system, with functional and structural capability can be a potential alternate for FNAB.

Background

Among thyroid cancer screening techniques, ultrasound (US) is the most widely used modality followed by invasive fine needle aspiration biopsy (FNAB). Approximately 5% of FNAB results are inconclusive and are compromised by insufficient sampling. The US (being a structural imaging method) can depict thyroid cysts and nodules clearly but lacks the ability to differentiate between cancerous and benign nodules. We propose a hybrid multispectral photoacoustic (PA) and ultrasound imaging system for non-invasive. With the combined functional nature of PA imaging capturing physiologic changes and structural image from US image high specificity is expected. This estimate can be depicted as an image that can be used to detect, characterize, diagnose, and monitor suspect lesions in thyroid disease management.

Evaluation

The proposed PA probe consists of a light delivery system, acoustic lens and US transducers that enable real-time frontal plane imaging of the tissue. A fast Fourier-based image formation is considered for volume image formation. Axial and lateral resolution of the probe was evaluated to be 0.3 millimeters (mm) and 1.6 mm. Ex-vivo thyroid studies demonstrated high specificity greater than 96%. A circular scanning stage obtains images from multiple angles using the probe, which improves system signal to noise ratio and a fivefold improvement in lateral resolution. A polyvinylidene fluoride (PVDF) film used as a US source can provide impedance image of the tissue. Adding US imaging to PA will add value co-registering with functional information in locating the nodules.

Discussion

PA absorption image of deoxy and oxyhemoglobin shows a clear distinction between cancerous and benign. The ex-vivo studies suggest that thyroid disease classification accuracy was comparable to that of FNAB. Characterization of the proposed prototype in phantoms with human thyroid geometry are in progress. With multiple view of the target tissue a minimum detectable cancer region of 0.3 mm with high specificity is expected.

SSJ22

Physics (CT: Radiation Dose I)

Tuesday, Nov. 28 3:00PM - 4:00PM Room: S403B

CT PH SQ

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

Participants
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Moderator*) Institutional research agreement, Siemens AG; ; ; ; ;
Lifeng Yu, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

SSJ22-01 Examining the Effects of Lung and Breast Dose CT Scans Using an Organ-Based Tube Current Modulation

Tuesday, Nov. 28 3:00PM - 3:10PM Room: S403B

Participants
Anthony Hardy, BS, Los Angeles, CA (*Presenter*) Nothing to Disclose
Maryam Bostani, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Rick R. Layman, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Dianna D. Cody, PhD, Houston, TX (*Abstract Co-Author*) In-kind support, General Electric Company
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Abstract Co-Author*) Institutional research agreement, Siemens AG; ; ; ; ;

PURPOSE

The purpose of this work was to use Monte Carlo simulation techniques to examine the effects of chest CT scans performed with an organ-based tube current modulation (OBM) scheme on lung and breast doses.

METHOD AND MATERIALS

Image and raw projection data were collected for twenty-three patients (14 males, 9 females) undergoing CT chest examinations under IRB approval. These scans actually used a combination of organ based and attenuation-based modulation (XCARE + CAREDose4D, Siemens Healthineers, Forchheim, Germany). From the image data, voxelized models of chest anatomy were generated for use in a previously validated Monte Carlo (MC) simulation code; lung and glandular breast tissues were segmented from patient image data and specifically identified for the simulation. Estimates of lung and breast dose were obtained using an MDCT source model with the tube current modulation values extracted from the raw projection data. These contain precise information about the tube current values as a function of angle and table location. Lung and breast doses were tallied and normalized by scan-specific 32cm CTDIvol values based upon the average tube current across the entire scan length. Water equivalent (Dw) was used as the size metric and was calculated at the center of the scan volume for each patient. These normalized doses were then compared with previously developed estimates of breast and organ dose based on attenuation based modulation only (CAREDose4D).

RESULTS

For normalized lung dose, six patients experienced dose reduction to the lungs, while ten patients experienced an increase to breast dose, with greatest reduction being 50% and greatest increase being 114% relative to CAREDose4D chest protocol. For normalized breast dose, four patients experienced dose reduction to the breast while five patients experienced an increase to breast dose, with greatest reduction being 40% and greatest increase being 55% relative to CAREDose4D chest protocol.

CONCLUSION

The combination of organ based and attenuation based modulation may, at times, increase both lung dose and breast dose in some patients. This may be dependent on the location of the glandular breast tissue relative among other factors.

CLINICAL RELEVANCE/APPLICATION

Organ and attenuation based tube current modulation does reduce breast dose, but some patients may receive substantial dose reduction from attenuation based modulation alone.

SSJ22-02 Radiation Dose Reduction in Thin-Slice Chest CT at a Micro-Dose (mD) Level by Means of 3D Deep Neural Network Convolution (NNC)

Tuesday, Nov. 28 3:10PM - 3:20PM Room: S403B

Participants
Amin Zarshenas, MSc, Chicago, IL (*Presenter*) Nothing to Disclose
Yuji Zhao, BSC, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Junchi Liu, MS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Toru Higaki, PhD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;

Kenji Suzuki, PhD, Chicago, IL (*Abstract Co-Author*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;

For information about this presentation, contact:

mzarshen@hawk.iit.edu

PURPOSE

Radiation dose reduction in chest CT is highly demanded since current radiation dose is still very high for screening. Our purpose was to develop a deep-learning NNC technique to convert thin-slice mDCT to higher-dose (HD) CT volumes where noise and artifacts are significantly reduced.

METHOD AND MATERIALS

We developed a mixture of expert anatomy-specific (AS) NNC models employing volume-based neural network regression in a convolutional manner to convert thin-slice (0.5 mm) mDCT to HD-like CT volumes. We trained 3 AS NNC models with soft-gating layers with 3 anatomic areas in input lower-dose CT (10 mAs, 120 kVp, 0.37 mSv) volumes and those in "teaching" HDCT (550 mAs, 120 kVp, 34.9 mSv) volumes of an anthropomorphic chest phantom (Kyoto Kagaku, Kyoto, Japan). Through training, our NNC learned to convert lower-dose CT to volumes that look like HDCT, where noise and artifact are substantially reduced; thus, term "virtual" HD (VHD) CT. Once trained, our technology no longer requires HDCT. To determine a dose reduction rate, we acquired 5 more studies of the same phantom at different radiation doses (0.74, 1.49, 2.97, 6.21, and 10.68 mSv) by changing tube currents. Structural SIMilarity (SSIM) index was used to evaluate the image quality. For testing, we collected mD (120 kVp, 5 mAs, 0.2 mSv) and full-dose (120 kVp, 50 mAs, 2.0 mSv) thin-slice CT volumes of 50 clinical cases including 30 cases with nodules (Aquilion One, Toshiba, Japan).

RESULTS

Our VHD technology converted lower-dose CT of the testing phantom to VHDCT, improving (t-test; P<.05) image quality from SSIM of 0.15 to 0.77 (equivalent to 14.0 mSv), achieving 97.4% dose reduction. With our technology, the contrast-to-noise-ratio (CNR) of mDCT of clinical cases was improved from 4.1±3.9 dB to 21.5±4.9 dB which was also higher (t-test; P<.05) than that of "gold-standard" full-dose CT volumes (CNR: 13.4±5.1 dB). Our NNC reduced the noise and artifacts substantially while preserving anatomic structures and pathologies.

CONCLUSION

Our NNC converted thin-slice mDCT volumes of 50 clinical cases to VHDCT volumes that have higher image quality (in terms of CNR) than "gold-standard" full-dose CT volumes, achieving 90% dose reduction. Our phantom study demonstrated up to 97% dose reduction.

CLINICAL RELEVANCE/APPLICATION

Substantial reduction in radiation dose in CT by our VHD technology would potentially make micro-dose CT screening possible, and it would be beneficial to screening population.

SSJ22-03 Estimating Organ Dose from Low Dose Lung Cancer Screening CT Exams Performed with Tube Current Modulation

Tuesday, Nov. 28 3:20PM - 3:30PM Room: S403B

Awards
Trainee Research Prize - Resident

Participants
Anthony Hardy, BS, Los Angeles, CA (*Presenter*) Nothing to Disclose
Maryam Bostani, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Christopher H. Cagnon, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Michael F. McNitt-Gray, PhD, Los Angeles, CA (*Abstract Co-Author*) Institutional research agreement, Siemens AG; ; ; ; ;

For information about this presentation, contact:

mmcnittgray@mednet.ucla.edu

PURPOSE

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

METHOD AND MATERIALS

Monte Carlo simulation methods were used to estimate organ doses from a low-dose lung cancer CT screening protocol for a 64-slice CT (Definition AS64, Siemens Healthineers, Germany) that used TCM. Scanning parameters were from the AAPM's Alliance for Quality CT protocols. Data from 26 patients (14 female, 12 male) were obtained under IRB approval. For each patient, both the image data as well as the raw projection data (which contains details of the tube current modulation) were collected. Voxelized patient models were created from the image data reconstructed to full 500 mm Field of View that also had all lung, and for females the glandular breast tissue, identified. Data from the actual TCM schemes were extracted from the raw data and incorporated into the Monte Carlo simulation. The water equivalent diameter (WED) was determined by estimating the attenuation at the center of the scan volume for each patient model. Monte Carlo simulations were performed using the unique TCM scheme for each patient model. Organ doses were tallied and all dose values were normalized by both CTDIvol (32 cm phantom) and DLP for each patient. Absolute and normalized doses were reported as a function of WED for each patient model.

RESULTS

Water equivalent diameters (WED) ranged from 17.4 to 34.2 cm for the females and 14.4 to 24.5 cm for the males. CTDIvol (32 cm phantom) values ranged from 1.37 to 6.0 mGy for females and 1.25 to 2.85 for males. Monte Carlo esimated lung doses ranged from 1.03 to 4.11 mGy for females and 0.91 to 1.88 mGy for males; female breast doses ranged from 0.77 to 6.67 mGy. There is a

relationship between lung dose and WED that also indicates some difference between males (R^2= .77) and females (R^2=0.53). Breast dose also appears to have a relationship to WED (R^2 value 0.7)

CONCLUSION

This work demonstrates the ability to estimate breast and lung doses from a lung cancer screening CT exam using tube current modulation (TCM). The relationship between lung dose and patient size appears to be slightly different between males and females and warrants further investigation.

CLINICAL RELEVANCE/APPLICATION

This work describes investigations to estimate lung and breast dose from lung cancer screening CT exams that use tube current modulation.

SSJ22-04 Comparison of Four SSDE Calculation Approaches in Thoracoabdominal CT

Tuesday, Nov. 28 3:30PM - 3:40PM Room: S403B

Participants
Christoph Aberle, PhD, Basel, Switzerland (*Abstract Co-Author*) Institutional Research Grant, Siemens AG
Karlheinz Dorn, DIPLENG, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Markus M. Obmann, MD, Basel, Switzerland (*Presenter*) Nothing to Disclose
Bram Stieltjes, MD,PhD, Basel, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Sebastian T. Schindera, MD, Riehen, Switzerland (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

christoph.aberle@usb.ch

PURPOSE

To evaluate SSDE (Size Specific Dose Estimate) calculations relative to a method recommended in the AAPM Report 220 using thoracoabdominal CT examinations.

METHOD AND MATERIALS

SSDE values of 112 adult thoracoabdominal exams (50 male, 62 female, BMI-range 15.8 to 39.9 kg/m2) from three CT scanners (Siemens Somatom Definition AS+, Flash and Edge) were evaluated using four calculation methods. First, the study's reference was calculated from reconstructed axial images according to the AAPM Report 220. A dedicated reconstruction with non-overlapping slices and a 500 mm field of view was used. Slice by slice, the water-equivalent diameter (WED) was calculated excluding the patient table, the CTDIvol was extracted and the SSDE was determined. The average over all slices was used as the reference SSDE. Secondly, the WED of only one slice at the center of the scan region was calculated and the SSDE was obtained using the mean CTDIvol. The third and fourth SSDE results were extracted from two commercial dose monitoring software tools (Radimetrics, Bayer HealthCare and teamplay Dose, Siemens Healthineers). The results from the dose monitoring software tools were obtained from the localizer radiographs.

RESULTS

Compared to the reference method, on average the SSDE values from the central slice method were 4% lower and the SSDE values from Radimetrics were 5% lower (1% higher) before (after) optimization of the scan region to phantom mapping in the software. The SSDE values from teamplay were 9% lower (1% higher) on average compared to the reference method before (after) optimization of scan region.

CONCLUSION

AAPM Report 220 proposes that an SSDE calculation method is compliant with a reference method if the root mean square deviation is less than 10 % relative to the reference. According to this criterion, the central slice method and the optimized teamplay and Radimetrics methods agree with the reference method.

CLINICAL RELEVANCE/APPLICATION

As standardized SSDE calculations are not yet readily available from CT scanners, comparisons of available options are needed to choose appropriate methods for accurate patient dose estimates.

SSJ22-05 Equipment Selection: Comparison of Four Different Dose Monitoring Commercial Systems - How the Choice of Different Calculation Methods Could Affect the SSDE in CT Scans of Different Body Areas

Tuesday, Nov. 28 3:40PM - 3:50PM Room: S403B

Participants
Sergio Zucca, Cagliari, Italy (*Presenter*) Nothing to Disclose
Stefano Loi, Cagliari, Italy (*Abstract Co-Author*) Nothing to Disclose
Stefano Massa, Cagliari, Italy (*Abstract Co-Author*) Nothing to Disclose
Giovanni M. Argiolas, MD, Monserrato, Italy (*Abstract Co-Author*) Nothing to Disclose
Luca Saba, MD, Cagliari, Italy (*Abstract Co-Author*) Nothing to Disclose
Paolo Siotto, MD, Cagliari, Italy (*Abstract Co-Author*) Nothing to Disclose
Grazia T. Bitti, MD, Cagliari, Italy (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

sergio.zucca@aob.it

PURPOSE

The dose from a CT scan depends on both patient size and scanner radiation output. Size-specific dose estimate (SSDE) is calculated applying a correction factor based on patient's size to the CTDI value. The purpose of the study was to evaluate SSDE calculation accuracy of four different commercial Radiation Dose Index Monitoring (RDIM) software.

METHOD AND MATERIALS

Two sets of CT acquisitions (GE Discovery HD750), with and without Automatic Tube Current Modulation (ATCM), were performed on an anthropomorphic phantom positioned at the center of the scanning Field-of-View (FOV). Acquisitions were repeated after increasing or decreasing table height by 5 cm. Each set consisted of 6 acquisitions of different scanning length: chest (C) , adbomen (A), neck (N), chest+abdomen (C+A), neck+chest (N+C), head+neck+chest+abdomen (H+N+C+A). A user-developed code (Matlab, Matworks) was applied to calculate Size Specific Dose Estimate (SSDE) from Water Equivalent Diameter (WED) or Effective Diameter (eff), using the image at the center of the scanning region (SSDEc) or the average on all the axial images (SSDEm).Calculated values were compared with those registered by four commercial Radiation Dose Index Monitoring System: Radimetrics, DoseWatch, NexoDose and RDM.

RESULTS

The difference between SSDEm,WED vs SSDEm,eff and SSDEc,WED vs SSDEc,eff were within 5 % on all the scans (RMS=3.17%, max=5.1%). The difference between SSDEm,WED vs SSDEc,WED and SSDEm,eff vs SSDEc,eff were within 7 % on scan C, A and C+A (RMS=5.6%, max=9.2%) and increased on scan H+N+C+A, N and N+C (RMS=17.5%, max=31.2%) due to the diameter variation within the scanning length. The maximum difference between SSDE registered on the RDIM software was lower in C, A and C+A (RMS=15.2%, max=29.4%) and became relevant on scan H+N+C+A, N and N+C A (RMS=37.4%, max=51.7%).

CONCLUSION

Different methods of SSDE calculation are implemented by different RDIM vendor. Relevant differences were found when the scanning region comprehend anatomy with a high variation of patient attenuation (eg neck+shoulder). When comparing result from different evaluation software, the user should be aware of the calculation methods implemented and their limitation.

CLINICAL RELEVANCE/APPLICATION

Differences in SSDE arising from different calculation methods implemented on commercial dose monitoring systems should be carefully considered when comparing data in a multi-institutional framework.

SSJ22-06 Comparison of Clinical and Phantom Image Quality for Low Contrast Liver Lesions in a Prospective Multicenter CT scanner Dose Optimization Program

Tuesday, Nov. 28 3:50PM - 4:00PM Room: S403B

Participants
Hugues G. Brat, MD, Sion, Switzerland (*Presenter*) Nothing to Disclose
Damien Racine, Lausanne, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Stephane Montandon, MSc, Saint-Livres, Switzerland (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Sima Imsand, Epalinges, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Benoit Rizk, MD, Villars-sur-Glane, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Dominique Fournier, MD, Sion, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Federica Zanca, PhD, Digem, Belgium (*Abstract Co-Author*) Employee, General Electric Company

For information about this presentation, contact:

hugobene@gmail.com

PURPOSE

To compare diagnostic performance for low contrast liver lesions on patient and phantom images, in a prospective multicenter CT scanner dose optimization program.

METHOD AND MATERIALS

A CT scanner protocol harmonization process based on clinical indication and BMI (<25 / >25), followed by a 12% stepwise dose reduction program, was implemented in a multicenter medical imaging group (5 units, Philips Healthcare, NL). During the optimization phase, 3035 abdomen CT examinations were prospectively assessed by experienced radiologists with a "positive/negative" diagnostic image quality electronic voting tool and 33 patients who underwent a CT examination for liver tumor or cancer staging before and after optimization were graded for image quality using European image quality guidelines. In parallel, phantom (QRM™ 401 abdomen, Germany) acquisition with 2.5 (size M) and 5cm (size L) fat ring was also performed before and after dose reduction using the liver tumor follow-up protocol. A channelized hotelling model observer was used to assess the lesion detectability using the ROC paradigm with the area under the ROC curve (AUC) as figure of merit.

RESULTS

Median patient CTDIvol value decreased from 6.8 to 5.2mGy (-24%, p<0.005) and from 10.8 to 8.5mGy (-22%, p<0.005) respectively for BMI<25 and >25. For phantom images, mean CTDIvol value decreased from 8.8 to 6.3mGy (-28%) for M-sized and from 15.9 to 11.8mGy (-26%) for L-sized phantom. No negative vote for diagnostic image quality was registered and preliminary results on 33 paired patients showed no loss of image quality according to European image guidelines. Image quality phantom analysis showed a constant low contrast lesion detectability, even after a 26% dose reduction. However, an additional 12% dose reduction started impairing the detectability of 5mm lesions.

CONCLUSION

Combining clinical diagnostic image quality and phantom based analysis enable dose reduction according to the ALARA principle without impairing low contrast liver lesion detectability.

CLINICAL RELEVANCE/APPLICATION

Combining clinical image quality evaluation and phantom analysis for image quality optimization preserves diagnostic confidence and sets a low-level threshold enabling no loss of detectability of low contrast liver lesions.

SSJ23

Physics (Nuclear Medicine)

Tuesday, Nov. 28 3:00PM - 4:00PM Room: S404AB

NM PH

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

FDA Discussions may include off-label uses.

Participants
Osama R. Mawlawi, PhD, Houston, TX (*Moderator*) Research Grant, General Electric Company Research Grant, Siemens AG
Jerome Z. Liang, PhD, Stony Brook, NY (*Moderator*) Nothing to Disclose
Michael A. King, PhD, Worcester, MA (*Moderator*) Nothing to Disclose

Sub-Events

SSJ23-01 MR-Assisted PET Reconstruction in the Presence of Respiratory Motion: A Phantom Study

Tuesday, Nov. 28 3:00PM - 3:10PM Room: S404AB

Participants
Cihat Eldeniz, St. Louis, MO (*Presenter*) Nothing to Disclose
Michael Gach, St. Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Richard Laforest, PhD, Saint Louis, MO (*Abstract Co-Author*) Nothing to Disclose
Hongyu An, DSc, Chapel Hill, NC (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

cihat.eldeniz@wustl.edu

PURPOSE

The simultaneous PET/MR provides an unprecedented opportunity for motion correction. We aimed at developing an integrated MR-assisted PET motion correction method which would allow accurate PET quantification in the presence of respiratory motion. This makes it possible to detect small lesions, which would otherwise become undetectable given the blurring caused by motion. In this study, we also evaluated the performance of the proposed method using a deformable motion phantom with known ground truth.

METHOD AND MATERIALS

For tracking respiratory motion, we developed a self-navigated free breathing MR motion correction method that provides robust and fully-automated respiratory motion detection. Four spheres with FDG activity were placed in a deformable motion phantom to mimic FDG avid lesions. The diameters of the spheres were 4.5 mm, 6.75 mm, 7.5 mm and 9 mm, respectively. List mode PET data and MR motion correction data were acquired simultaneously in the presence and absence of motion. Respiratory motion was first detected using the self-navigated free breathing MR method. This MR derived motion was then used to rebin the simultaneously acquired list mode PET data. Motion-corrected and uncorrected PET images were reconstructed using the same motion-corrupted data. On the other hand, the static (no-motion) PET/MR scan was used as the ground truth for PET activity.

RESULTS

In reference to the static PET, the relative FDG activity measured in the motion uncorrected PET images were 55% (D=4.5 mm, motion range = 9.8 mm), 61% (D=6.75 mm, motion range = 10.7 mm), 75% (D=7.5 mm, motion range = 7.1 mm) and 69% (D=9 mm, motion range = 9.2 mm) for the four spheres. In contrast, the measured activity became, respectively, 95%, 99%, 96% and 96% after applying the MR assisted PET motion correction.

CONCLUSION

Depending on the size and the magnitude of motion, motion-compromised PET images can show up to 45% reduction in FDG activity. Our MR-assisted PET motion correction can recover the activity back to 95%-99% of that measured using the static data set.

CLINICAL RELEVANCE/APPLICATION

High noise and respiratory motion makes it difficult to detect small lesions in PET images. MR-assisted motion correction makes it possible to delineate lesions with significantly higher accuracy.

SSJ23-02 Faster PET Imaging: Evaluation and Optimization of PET Acquisition Overlap on both Solid State Digital PET and PMT PET in FDG and NaF PET/CT

Tuesday, Nov. 28 3:10PM - 3:20PM Room: S404AB

Participants
Jun Zhang, PhD, Columbus, OH (*Presenter*) Nothing to Disclose
Katherine Binzel, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Chadwick L. Wright, MD, PhD, Lewis Center, OH (*Abstract Co-Author*) Nothing to Disclose

Maria I. Menendez, DVM, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose
Piotr J. Maniawski, MSc, Cleveland, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Michael V. Knopp, MD, PhD, Columbus, OH (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

zhang.538@osu.edu

PURPOSE

To improve patient comfort and clinical volume throughput by accelerating PET imaging using optimized PET acquisition overlaps going beyond current accepted boundaries in FDG and NaF TOF PET on both solid state digital photon counting PET (dPET) and conventional PMT PET (cPET).

METHOD AND MATERIALS

An ongoing pre-clinical (beagles) and clinical trial was initiated to investigate the feasibility of minimizing and optimizing PET acquisition overlap in axial on cPET (Gemini TF 64) and dPET (Vereos TF). Four groups of wholebody PET/CT are included: A. preclinical FDG PET (~2.8mCi), B. preclinical NaF PET (~2.8mCi), C. clinical FDG PET (~13mCi) and D. clinical research NaF PET (~3mCi). Intra-individual PET imaging was acquired on both systems under investigational overlaps of 27%, 20%, 12% and 0% besides system defaults (Gemini: 53%; Vereos: 39%). Uniformity phantoms were performed for validation. PET image quality (IQ) and SUV assessment were blinded reviewed by multiple readers.

RESULTS

4 beagles (2 FDG and 2 NaF) and 4 human subjects (2 FDG and 2 NaF) were imaged. dPET images consistently showed better IQ with enhanced contrast and more uniform background than cPET under various overlaps. FDG PET exams showed no impact on visual grades with overlaps of 27%+ for cPET and 20%+ for dPET, compared to PET using default overlaps. NaF PET exams revealed better acceptable range than FDG PET with 20%+ for cPET, and 12%+ for dPET (surprisingly, nice NaF dPET images obtained even without overlap). Reducing overlap to 27% for cPET and to 20% for dPET from default saved ~40% acq time. No significant SUV variances were found between PET using minimized overlaps and default PET for cerebellum, lung, heart, aorta, liver, fat, muscle, bone marrow, thighs and target lesions ($p>0.05$), except kidneys and bladder.

CONCLUSION

The study demonstrated through combined pre-clinical, phantom and clinical exams the feasibility of reducing PET overlaps on both solid state PET and PMT PET scanners to accelerate PET imaging for ~40% from current levels without degradation of image quality. Advantages of solid state PET being capable of enabling faster PET using less PET overlaps than PMT PET was obtained.

CLINICAL RELEVANCE/APPLICATION

Faster PET imaging has substential benifits to patient comfort and clinical volume throughput and the study examed such by optimizing PET acquisition overlaps in FDG and NaF PET on both solid state PET and PMT PET systems.

SSJ23-03 Ultra High Spatial and Energy Resolution PET Detector

Tuesday, Nov. 28 3:20PM - 3:30PM Room: S404AB

Participants
Mokhtar Chmeissani, Bellaterra, Spain (*Presenter*) Nothing to Disclose
Machiel Kolstein, PhD, Bellaterra, Spain (*Abstract Co-Author*) Nothing to Disclose
Jose Gabriel Macias, MENG, Bellaterra, Spain (*Abstract Co-Author*) Nothing to Disclose
Carles Puigdengoles, MENG, Bellaterra, Spain (*Abstract Co-Author*) Nothing to Disclose
Jorge Garcia, MENG, Bellaterra, Spain (*Abstract Co-Author*) Nothing to Disclose
Xavier Prats, BEng, Bellaterra, Spain (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

mokhtar@ifae.es

PURPOSE

Current Positron Emission Tomography (PET) scanners have a limited image resolution which is due both to the intrinsic limits set by PET physics and the design and the material used in state-of-the-art PET scanners. We present a novel 3D gamma sensor, based on pixelated CdTe, to reduce significantly the limitations coming from spatial and energy resolution.

METHOD AND MATERIALS

Each detector module has 4000 voxels (independent channels). Each voxel consists of 1mm x 1mm x 2mm of CdTe bonded to a dedicate pixel channel. The detector module is made of a stack of 10 layers. Each layer has 4 sensors glued to a flex printed circuit board (PCB). The sensor itself is a hybrid pixel CdTe detector, of size 10 mm x 10 mm x 2 mm, bonded to a dedicated pixel ASIC. The pixel ASIC is thinned down to 200um and the flex PCB is 255 um thick. Effectively, each layer has a thickness of 2mm of active material (CdTe), and 0.35mm of passive material. Each detector module has an amount of CdTe equal to 20 mm x 20 mm x 20 mm. A total of 18 of such detector modules will form a PET ring with an inner radius of 6.5 cm and an axial FOV of 2.6 cm. The full ring has 72000 independent channels. Each ASIC (of 100 channels) has one TDC with a time resolution of 1 nano-second. Each channel has its own pre-amp, shaper, discriminator, and 11 bit ADC. Each triggered voxel sends its digitized energy signal plus a time stamp. Currently, 11 out of the 18 detector modules have been assembled and tested using a Na22 source with a bias voltage of 250V/mm.

RESULTS

Overall 90% of the channels are operational. The other 10% have defects due to electronics or detector leakage current. With these working conditions, the energy resolution obtained for PET events is 2.4% at FWHM. The energy resolution for Compton events, reconstructed from two different sensors, is 3.4% at FWHM.

CONCLUSION

With a full PET ring and operating the CdTe at 500V/mm, we expect to achieve the intrinsic spatial resolution set by physics

With a full PET ring and operating the CdTe at 300V/mm, we expect to achieve the intrinsic spatial resolution set by physics, thanks to the excellent 3D detector granularity and with a negligible scattered fraction (4%) thanks to the excellent energy resolution. This translates into a possible detection of cancer lesions as small as 2mm in diameter.

CLINICAL RELEVANCE/APPLICATION

This novel PET make it possible to detector cancer lesion as small as 2mm in diameter with TNR 4:1

SSJ23-04 Evaluation of CZT Gamma Cameras for Whole-Body SPECT and Small FOV Imaging

Tuesday, Nov. 28 3:30PM - 3:40PM Room: S404AB

Participants
James W. Hugg, PhD, Saxonburg, PA (*Presenter*) Sr. Vice President, Kromek Group plc
Brian W. Harris, PhD, Saxonburg, PA (*Abstract Co-Author*) Employee, Kromek Group plc
Hidefumi Tomita, PhD, Saxonburg, PA (*Abstract Co-Author*) employee, Kromek USA / eV Products

For information about this presentation, contact:

james.hugg@kromek.com

CONCLUSION

Continual improvements in CZT detector arrays for molecular imaging, coupled with optimal collimator and image reconstruction, result in minimized dose and exam time. With CZT cost and performance improving, more clinical applications are expected.

Background

The semiconductor CdZnTe (CZT) direct-conversion gamma photon detector has been used in several molecular imaging applications, including small-animal and whole-body human SPECT, cardiac SPECT, and molecular breast imaging (MBI). We designed a modular gamma detector (4.4 cm square with 2 mm pixel pitch) and tiled it in two array sizes: a small FOV camera (8.8 cm square, 44 x 44 pixels) and a whole-body SPECT camera (39.6 cm x 52.8 cm, 198 x 264 pixels) that we mounted on a refurbished SPECT gantry for demonstration. We evaluated the performance of these gamma cameras.

Evaluation

Integration of pixelated CZT detectors with advanced ASICs and readout electronics improves system performance. We measured energy resolution of 3.0% FWHM at 140 keV, intrinsic flood field uniformity of ±0.8% integral and ±0.4% differential, system spatial resolution at 10 cm with an LEHR collimator of 6.8 mm and 7.5 mm without and with scatter, and intrinsic detector count rate performance of 1.4 M cps at 20% loss and 6.1M cps maximum observed. These metrics are significantly better than scintillator SPECT systems.

Discussion

Very good energy resolution enables better scatter rejection and image contrast, further enhanced by excellent uniformity. Smaller pixels improve partial-volume dilution and quantitation. Spatial resolution is improved, even with hexagonal-hole collimators, but registered square-hole collimators provide significantly better resolution and a boost of about 30% in sensitivity which can lower dose and/or exam time. The non-paralyzable CZT cameras count at much higher count rates, enabling new first-pass and pharmacokinetic studies. Advances in detectors, collimators, and image reconstruction have significantly improved efficiency of CZT-based molecular imaging systems and the cost of CZT detectors has steadily declined.

SSJ23-05 TV-Constrained Image Reconstruction from List-Mode TOF-PET Data

Tuesday, Nov. 28 3:40PM - 3:50PM Room: S404AB

Participants
Zheng Zhang, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
Sean Rose, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Jinghan Ye, San Jose, CA (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Amy Perkins, Philadephia, PA (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Chi-Hua Tung, Cleveland, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Chien-Min Kao, PhD, Chicago, IL (*Abstract Co-Author*) Stockholder, Walgreens Boots Alliance, Inc
Emil Y. Sidky, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Xiaochuan Pan, PhD, Chicago, IL (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV ; Research Grant, Toshiba Medical Systems Corporation; Research Grant, Varian Medical Systems, Inc

For information about this presentation, contact:

zhangzh@uchicago.edu

PURPOSE

We investigate an innovative image reconstruction for advanced digital time-of-flight (TOF) positron-emission tomography (PET) and demonstrate its potential for improving image quality in digital TOF PET, in terms of enhanced spatial resolution, signal-to-noise ratio, and axial coverage.

METHOD AND MATERIALS

We employ a digital SiMP TOF PET clinical scanner to collect list-mode TOF-PET data from the Jaszczak and IEC phantoms. The Jaszczak phantom contains six types of cylindrical-shaped cold rods of diameters 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm, whereas the IEC phantom includes 6 spheres of 10, 13, 17, 22, 28, and 37 mm diameter. The activity in the four smallest spheres is 4 times of the background, and the other two spheres have zero concentration. We developed an iterative algorithm based on Chambolle-Pock framework to reconstruct images. Images reconstructed by use of the standard ordered-subset-expectation-maximization (OSEM) algorithm are used as references. Reconstructions are evaluated visually and quantitatively. In particular, the IEC-phantom reconstructions are assessed following the instruction in NEMA NU 2-2012.

RESULTS

TOF-PET images reconstructed with the proposed algorithm exhibit appreciably lower background noise and enhanced contrast relative to that of the reference images. In particular, the reconstructions are with much improved image quality especially in regions near the axial edges where the reference images are observed to have significant artifacts. For the Jaszczak phantom, the smallest revealed cold rods reconstructed by the proposed algorithm are of 7.9mm diameter, whereas those are of 12.7 mm in the reference image. This underscores a considerable improvement on the spatial resolution in reconstructed images. For the IEC phantom, the reconstructions with the proposed algorithm reveal 7%~20% increased contrast for hot spheres, 4%~6% increased contrast for cold spheres, and 27%~46% decreased noise for background over that of the references.

CONCLUSION

The novel algorithm proposed can yield reconstructions from TOF-PET data with considerably improved spatial and contrast resolution and signal-to-noise ratio over the standard algorithms in TOF-PET imaging.

CLINICAL RELEVANCE/APPLICATION

The PET-image quality may be improved by use of advanced algorithms. The algorithm-enabled quality improvement may be of clinical implication for enhanced lesion detectability at low count statistics.

SSJ23-06 Deep Learning Enables at Least 100-fold Dose Reduction for PET Imaging

Tuesday, Nov. 28 3:50PM - 4:00PM Room: S404AB

Awards
Student Travel Stipend Award

Participants
Enhao Gong, MS, Stanford, CA (*Presenter*) Research support, General Electric Company
Jia Guo, PhD, Stanford, CA (*Abstract Co-Author*) Research support, General Electric Company
Junshen Xu, Stanford, CA (*Abstract Co-Author*) Nothing to Disclose
John Pauly, Stanford, CA (*Abstract Co-Author*) Research support, General Electric Company
Greg Zaharchuk, MD, PhD, Stanford, CA (*Abstract Co-Author*) Research Grant, General Electric Company; Consultant, General Electric Company;

For information about this presentation, contact:

enhaog@stanford.edu

PURPOSE

Lowering injected dose in PET can reduce the risk to patients, lower imaging costs and potentially improve imaging efficiency. In addition, it may help imaging logistics when fast-decaying tracers are used. However, lowered dose adversely affects PET image quality. Previous methods typically use complicated and slow iterative reconstruction, yet still cannot yield satisfactory results at significantly low dose.

METHOD AND MATERIALS

We developed a deep network(convolutional encoder-decoder residual network) to recover PET images acquired at ultra-low-dose. This network conducts patch-to-patch regression tasks, taking a noisy low-dose PET image patch as input and outputting a high-quality patch to approximate the corresponding patch in full-dose PET. The final reconstruction is generated by concatenating and averaging overlapping patches. Using bypass connections and patch-based training, we reduced the regression task complexity and achieved robust training performance. To avoid over-fitting, we trained the network with data augmentations(~10000patches×2flips×4rotations). Brain PET-MR datasets(GE Signa 3T) were collected from 7 patients with recurrent glioblastoma(65±6 yrs, 4 males), who received 10mCi FDG. We used the full-dose reconstruction(3D-OSEM, 2 iterations and 28 subsets) as gold-standard. For input, we created low-dose images by removing counts from the listmode data, reconstructing with various dose-reduction factors(DRF). We tested on DRFs up to 200-fold, showing we can acheive satisfactory results at least with 100-fold (1% of original counts).

RESULTS

To show the method can generalize on different data/subjects, we trained the model on subsets of slices from 3 patients and evaluated on all slices which were not used for training from all 7 patients. The proposed method reduces over 50% Root-Mean-Square-Error(RMSE) and gains 7dB in Peak-Signal-Noise-Ratio(PSNR) compared with the conventional method and achieves similar Contrast-Noise-Ratio(CNR) as the gold-standard.

CONCLUSION

Using a deep learning algorithm, we can reconstruct ultra-low-dose (at least 100 fold) PET images and achieve comparable image quality as the full-dose images.

CLINICAL RELEVANCE/APPLICATION

This method could dramatically reduce the radiation dose in PET imaging: a 100-fold-low-dose reduces the effective radiation in PET imaging to a similar level as a NYC-LA flight.

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RC421

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

Tuesday, Nov. 28 4:30PM - 6:00PM Room: S103AB

CT PH SQ

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

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

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC421A Statistical and Iterative Reconstruction and Image Domain Denoising

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

LEARNING OBJECTIVES

1) Learn, at a high, intuitive, and non-mathematical level, how statistical and iterative reconstruction methods work. 2) Understand the differences between conventional reconstruction and statistical/iterative methods. 3) Appreciate the benefits and possible drawbacks of advanced processing methods. 4) Be able to anticipate when the new methods may be useful clinically and what image quality differences to expect.

RC421B Protocol Optimization and Management

Participants
Mannudeep K. Kalra, MD, Boston, MA (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

mkalra@mgh.harvard.edu

LEARNING OBJECTIVES

1) CT protocol optimization begins with justification of clinical indication and proceeds to tailoring of scan parameters according to clinical region of interest, clinical indication, and patient size. Taking a nuanced and stratified approach to protocol stratification helps in the optimization process. 2) CT protocol management is a team effort involving attention to CT image quality and associated radiation doses. Medical physicists, radiologists, and CT technologists have a common responsibility in CT protocol optimization and management.

ABSTRACT

Optimization and management of CT protocols are joint responsibilities of medical physicists, radiologists and CT technologists. Attributes ofoptimized CT protocols include adaptation of image quality and radiation dose through suitable choice of scan parameters based on body areaof interest, clinical indication, presence of prior imaging,patient size, and need for contrast enhancement. In an ideal practice, scan protocols must be divided according to the area of interest, and then clinical indication for which CT has been requested. Management of CT protocols must include frequent audits of image quality and radiation dose monitoring to ensure that good practices are maintained.

RC421C Dose Monitoring and Analytics

Participants
Joshua Wilson, PhD, Durham, NC (*Presenter*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

For information about this presentation, contact:

joshua.wilson@duke.edu

samei@duke.edu

LEARNING OBJECTIVES

1) Describe conventional radiation dose monitoring workflows and analytics. 2) Critique the current shortcomings and future potential value of dose monitoring solutions. 3) Identify opportunities for improving clinical operations and consistency with dose monitoring.

ABSTRACT

Recent legislative and accreditation requirements have driven rapid development and implementation of radiation dose monitoring platforms. Multiple solutions are available that require financial commitment and oversight. How can institutions derive added-value, beyond minimum regulatory requirements, from their monitoring program by improving the quality of their clinical performance? Global alert thresholds, the standard in commercial products, naïve to system model and patient size have limited value. Setting a threshold presupposes a clinically-relevant level is known. For an arbitrary level, appropriately-dosed obese patients triggered false alerts, but over-dosed small patients were missed. Numerous study parameters must be retained because chronologic trends, the industry standard, are rarely useful without controlling for other moderators. Dashboards must be interactive enabling dynamic drill-down into cohorts. Dose databases require curation tools and maintenance, largely absent from all solutions, because wrong information will be inadvertently entered, and the utility of the analytics is entirely dependent on the data quality. Dose monitoring can satisfy requirements with global alert thresholds and patient dose records, but a program's real value is in optimizing patient-specific protocols, balancing image quality trade-offs that dose-reduction strategies promise, and improving the performance and consistency of a clinical operation.

Active Handout:Joshua Wilson

http://abstract.rsna.org/uploads/2017/16001066/Active RC421C.pdf

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RC422

Imaging for Personalized Medicine: Abdomen

Tuesday, Nov. 28 4:30PM - 6:00PM Room: N230B

GI PH

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; ;

For information about this presentation, contact:

kkbrock@mdanderson.org

LEARNING OBJECTIVES

1) Describe the processes necessary for the safe and accurate integration of multi-modality imaging for treatment planning. 2) Understand the role of image guidance for abdominal radiotherapy. 3) Illustrate methods to perform functional and anatomical adaptation in the abdomen.

ABSTRACT

The use of imaging and other biomarkers to increase the efficacy of treatment and decrease the risk of toxicity increased in the abdomen. Functional imaging and serum-based biomarkers can enable a more detailed understanding of the tumor, its characteristics, and early indications of its response to therapy. In addition, they can also be utilized to assess an individual patients risk for toxicity, enabling a personalize approach to radiotherapy. These advanced imaging techniques can be combined with anatomical information to generate high precision treatment plans which can be adapted over the course of treatment to account for identified uncertainties, changes, and deviations which may compromise the delivery of the intended treatment or identify the ability to re-optimize treatment to improve the therapeutic ration. In this session, technical and clinical concepts will be described to design and deliver personalized radiotherapy in the abdomen. Technical concepts will include incorporation of multi-modality imaging for treatment planning, image guidance at treatment, and functional and anatomical adaption. Clinical concepts will include functional targeting, clinical goals, and toxicity risks.

SAM

New in 2017: PLEASE NOTE - All courses designated for SAM credit at RSNA 2017 will require attendees bring a personal device e.g. phone, iPad, laptop to complete the required test questions during the live session.

Sub-Events

RC422A Anatomical Imaging for Personalized Medicine in the Abdomen

Participants
Kristy K. Brock, PhD, Houston, TX (*Presenter*) License agreement, RaySearch Laboratories AB; ;

LEARNING OBJECTIVES

View Learning Objectives under main course title

RC422B Functional Imaging for Personalized Medicine in the Abdomen

Participants
Parag Parikh, MD, Saint Louis, MO (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

View Learning Objectives under main course title

RC423

Molecular Imaging Mini-Course: Advanced Molecular Imaging

Tuesday, Nov. 28 4:30PM - 6:00PM Room: S504AB

MI MR NM PH

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

FDA Discussions may include off-label uses.

Sub-Events

RC423A Novel Tracers

Participants
Timothy R. DeGrado, PhD, Rochester, MN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Identify the major considerations when developing a novel molecular imaging probe. 2) Compare the strengths and weaknesses of the various imaging modalities with regard to probe development and implementation. 3) Define appropriate experiments for probe validation. 4) Gain an understanding of the process of translation of a probe to clinical practice.

ABSTRACT

Molecular imaging is rapidly advancing as new imaging biomarkers are invented to allow noninvasive assessment of biochemical function. Those who embark on the process of developing novel probes come to know the excitement of imaging biological processes for the first time, but are also well aware of the great effort and many pitfalls that can impede progress. This introductory lecture will provide an overview of the process of molecular imaging probe conception, development, preclinical validation, and translation. Specific examples will be used to illustrate the presenter's experience with meeting these challenges.

RC423B Novel Instrumentation (PET/MR)

Participants
Ciprian Catana, MD, PhD, Charlestown, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Distinguish the technical approaches that have been proposed for integrating PET and MRI for the purpose of simultaneous data acquisition. 2) Evaluate the latest methodological developments in PET/MRI for improving PET data quantification. 3) Incorporate simultaneous PET/MRI techniques into research and clinical projects.

RC423C Molecular Imaging with MR

Participants
Peter D. Caravan, PhD, Charlestown, MA (*Presenter*) Research Grant, Pfizer Inc;

LEARNING OBJECTIVES

1) To describe the strengths and limitations of molecular MR imaging. 2) To list the different classes of molecular MR imaging probes and provide examples of each. 3) To understand the process for clinical translation of a novel molecular imaging probe.

ABSTRACT

Magnetic resonance imaging is considered by some to be too insensitive a technique for molecular imaging. Despite some limitations, molecular MR imaging offers a number of advantages compared to other molecular imaging modalities in terms of temporal and spatial resolution, deep tissue imaging, lack of ionizing radiation, shelf-stable molecular probes, complementary functional and anatomic information, and in some cases, equisite sensitivity. Here, we will describe with examples the strengths and limitations of molecular MR, different classes of molecular MR probes, and opportunities for clinical translation of promising preclinical data.

RC425

Radiomics Mini-Course: Informatics Tools and Databases

Tuesday, Nov. 28 4:30PM - 6:00PM Room: S103CD

BQ IN 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; ; ; ; ;
Sandy Napel, PhD, Stanford, CA (*Coordinator*) Medical Advisory Board, Fovia, Inc; Consultant, Carestream Health, Inc; Scientific Advisor, EchoPixel, Inc; Scientific Advisor, RADLogics, Inc

For information about this presentation, contact:

snapel@stanford.edu

Sub-Events

RC425A The Role of Challenges and Their Requirements

Participants
Jayashree Kalpathy-Cramer, MS, PhD, Charlestown, MA (*Presenter*) Consultant, Infotech Software Solution

LEARNING OBJECTIVES

1) Understand the role of challenges and benchmarks in image analysis, radiomics and radiogenomics. 2) Learn about challenge infrastructure and requirements to host and participate in challenges. 3) Learn about past and upcoming challenges that focus on topics in radiology, radiomics and radiogenomics.

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 provide a common dataset and common set of evaluation metrics, they also facilitate a fair and rigorous evaluation of algorithms. Challenge organizers often sequester the test data from the training data, further enhancing the rigor of the evaluation. These efforts can introduce experts in machine learning and data science to problems in medical imaging. They also serve to allow computer scientists access to clinical data which they may not otherwise have. Many challenges have also highlighted the need for collaboration as the best results are often obtained by combining a range of complementary techniques. We will discuss recent challenges from a number of domains including imaging and bioinformatics, explore the informatics infrastructure to host and participate in challenges and discuss the needs for future challenges including those in radiomics and radiogenomics.

RC425B Quantitative Image Analysis Tools: Communicating Quantitative Image Analysis Results

Participants
Andriy Fedorov, PhD, Boston, MA (*Presenter*) Research support, Siemens AG

For information about this presentation, contact:

andrey.fedorov@gmail.com

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 analysis results using DICOM standard.

ABSTRACT

Quantitative imaging holds tremendous but largely unrealized potential for objective characterization of disease and response to therapy. Quantitative imaging and analysis methods are actively researched by the community. Certain quantitation techniques are gradually becoming available both in the commercial products and clinical research platforms. As new quantitation tools are being introduced, tasks such as their integration into the clinical or research enterprise environment, comparison with similar existing tools and reproducible validation are becoming of critical importance. Such tasks require that the analysis tools provide the capability to communicate the analysis results using open and interoperable mechanisms. The use of open standards is also of utmost importance for building aggregate community repositories and data mining of the analysis results. The goal of this talk is to improve the understanding of the interoperability, as applied to quantitative image analysis, with the focus on clinical research applications.

RC425C Public Databases for Radiomics Research: Current Status and Future Directions

Participants
Justin Kirby, Bethesda, MD (*Presenter*) Stockholder, Myriad Genetics, Inc

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 actually driven by biology. A number of public tools and databases 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. Significant 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.

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MSSR41

RSNA/ESR Hybrid Imaging Symposium: The ABCs of Hybrid Imaging (An Interactive Session)

Wednesday, Nov. 29 8:30AM - 10:00AM Room: S402AB

MR NM PH

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

FDA Discussions may include off-label uses.

Participants
Alexander Drzezga, MD, Cologne, Germany (*Moderator*) Consultant, Siemens AG; Consultant, Bayer AG; Consultant, General Electric Company; Consultant, Eli Lilly and Company; Consultant, The Piramal Group; Speakers Bureau, Siemens AG; Speakers Bureau, Bayer AG; Speakers Bureau, General Electric Company; Speakers Bureau, Eli Lilly and Company; Speakers Bureau, The Piramal Group
Katrine Riklund, MD, PhD, Umea, Sweden (*Moderator*) Nothing to Disclose

For information about this presentation, contact:

katrine.riklund@umu.se

LEARNING OBJECTIVES

1) What you need to know about PET-physics. 2) How MR physics influence image quality in hybrid imaging.

Sub-Events

MSSR41A What You Need to Know about PET-Physics

Participants
Jan Axelsson, Umea, Sweden (*Presenter*) Founder, Dicom Port AB

LEARNING OBJECTIVES

1) To understand the basics of physics in PET imaging. 2) To learn about the different approaches of PET attenuation correction. 3) To learn about potential artefacts in hybrid imaging.

ABSTRACT

This lecture gives a basis to understand the underlying mechanism to why PETCT image quantitation sometimes fails. Examples and false PET uptakes, explanation on the underlying mechanism, and rules of thumb how you may reveal if an uptake is physiological will be given.

MSSR41B How MR Physics Influence Image Quality in Hybrid Imaging

Participants
Ciprian Catana, MD, PhD, Charlestown, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn about MR artefacts influencing PET image quality. 2) Understand the complexity of physics in MR-PET. 3) Learn about MR for attenuation and motion correction.

MSSR41C Interactive Case Discussion

Participants
Jan Axelsson, Umea, Sweden (*Presenter*) Founder, Dicom Port AB
Ciprian Catana, MD, PhD, Charlestown, MA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Learn how to identify common MR artefacts. 2) Learn how to identify common PET artefacts. 3) Learn how to identify common CT artefacts.

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RC521

Advances in CT: Technologies, Applications, Operations-Special Purpose CT

Wednesday, Nov. 29 8:30AM - 10:00AM Room: N229

BR MK CT IR PH

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

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

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC521A Breast

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

LEARNING OBJECTIVES

1) Demonstrate the technology associated with cone-beam CT of the breast. 2) Show performance metrics of the cone-beam CT system. 3) Demonstrate the potential of breast CT for breast cancer screening and diagnosis.

RC521B MSK

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) Describe the special prupose CT systems for musculoskeletal (MSK) imaging. 2) Compare the capabilities of special purpose MSK CT systems to conventional modalities. 3) Identify diagnostic applications enabled by special purpose MSK CT.

RC521C Interventional

Participants
Charles M. Strother, MD, Madison, WI (*Presenter*) Research Consultant, Siemens AG; Research support, Siemens AG; License agreement, Siemens AG

RC522

MRI: Imaging for Radiation Treatment Guidance and Verification

Wednesday, Nov. 29 8:30AM - 10:00AM Room: S105AB

MR RO PH

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

Participants
John E. Bayouth, PhD, Madison, WI (*Moderator*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand the main concepts of MRI-guided radiation therapy. 2) Understand the advantages and limitations of MRI-guided radiotherapy systems currently in use or under development. 3) Understand the use of in-room MRI guidance for management of intr- and inter-fraction variations in anatomy.

SAM

New in 2017: PLEASE NOTE - All courses designated for SAM credit at RSNA 2017 will require attendees bring a personal device e.g. phone, iPad, laptop to complete the required test questions during the live session.

Sub-Events

RC522A In-Room MRI for Treatment Guidance

Participants
John E. Bayouth, PhD, Madison, WI (*Presenter*) Nothing to Disclose

RC522B Integrating MRI: The Clinician Perspective

Participants
Caroline Chung, MD, FRCPC, Houston, TX (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understand how MRI can be integrated into the clinical workflow of radiation treatment delivery. 2) Learn about the potential benefits of integrating MRI at each step of radiotherapy: treatment planning, radiation delivery and response assessment. 3) Appreciate the challenges of using MRI for radiation treatment guidance and ongoing research to overcome these challenges.

RC523

Clinical Applications of Molecular Imaging: Neuro MRS and PET

Wednesday, Nov. 29 8:30AM - 10:00AM Room: S502AB

NR MI OI PH

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

Sub-Events

RC523A Oncology Applications

Participants
Hyunsuk Shim, PhD, Atlanta, GA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) To learn the capability/potential of MR spectroscopy in brain tumor patient management. 2) To learn the limitation of the current standard MRIs that guide surgery and radiation therapy. 3) To learn about the potential of combining an advanced spectroscopic MR imaging with standard MR images to reduce the recurrence rate in glioblatomas.

ABSTRACT

Radiation therapy (RT) is as good as the images that guide RT planning. RT based on conventional MRIs may not fully target tumor extent in glioblastomas (GBM), which may, in part, account for high recurrence rates (60-70 percent at 6 months). Magnetic resonance spectroscopy, a molecular imaging modality that quantifies endogenous metabolite levels without relying on perfusion, leakage and diffusion of injected material, may better define extent of actively proliferating tumor. In addition, advances in this technology now permit acquisition of whole-brain high-resolution 3D spectroscopic MRI (sMRI) in 12-14 minutes. We correlated state-of-the-art sMRI metabolite maps and their ratio maps with tissue histopathology to validate further its use for identifying non-enhancing and infiltrating tumors that may not be fully imaged by conventional MRI sequences and provide support for its adjunctive use in tumor contouring for RT planning. Integration of histologically-verified, whole brain 3D sMRI into RT planning is feasible and may considerably modify target volumes. Thus, RT planning for GBMs may be augmented by sMRI potentially leading to reduced or delayed recurrence rates.

RC523B Functional Applications

Participants
Satoshi Minoshima, MD, PhD, Salt Lake City, UT (*Presenter*) Research Consultant, Hamamatsu Photonics KK; Research Grant, Hitachi, Ltd; Research Grant, Nihon Medi-Physics Co, Ltd;

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RC525

Quantitative Imaging Mini-Course: Promise and Challenges

Wednesday, Nov. 29 8:30AM - 10:00AM Room: S504AB

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; ; ; ; ;

Sub-Events

RC525A The Perspective of the RSNA Quantitative Imaging Biomarkers Alliance (QIBA)

Participants
Edward F. Jackson, PhD, Madison, WI (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

efjackson@wisc.edu

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.

ABSTRACT

The added value of quantification in both research and clinical environments is likely to increase as health care initiatives place increased pressure on radiologists to provide decision support for evidence-based care. There remain substantial barriers to the widespread use of quantitative measures in clinical radiology, including an inherently large number of variables that impede validation of specific metrics, diversity of proprietary industry platforms, and lack of acceptance by radiologists. A critical barrier to the implementation of quantitative imaging in radiology is the lack of standardization among vendor platforms. Collaboration in the pre-competitive space is challenging yet crucial to address standardization, and integrating quantitative measurement into workflow will be necessary for wide adoption. The Quantitative Imaging Biomarkers Alliance (QIBA, www.rsna.org/qiba) was launched in 2007 as a means to unite researchers, healthcare professionals, and industry stakeholders in the advancement of quantitative imaging. QIBA's mission is to improve the value and practicality of quantitative imaging biomarkers (QIBs) by reducing variability across devices, imaging centers, patients, and time. The four QIBA modality-driven Coordinating Committees (CT, MR, Nuclear Medicine, Ultrasound) currently oversee 12 Biomarker Committees and 16 Task Forces. Selected QIBs that are considered to be transformational, translational, feasible, practical, and collaborative are addressed by Profiles, which are technical standards that include one or more clinical context-specific claims and inform users what quantitative results can be achieved by following the Profile. Sources of bias and variance, and methods to minimize each, are considered in Profile development. This presentation will summarize the goals and objectives of QIBA, including international efforts. The QIBA perspective on opportunities for QIB applications in the practice of precision medicine, challenges to be overcome, and approaches to addressing such challenges will be presented.

RC525B 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 current status of the Quantitative Imaging Network and the nature and purpose of the most recent program announcement for research efforts in this area will be discussed.

ABSTRACT

The Quantitative Imaging Netwo9rk, created in 2008 by NCI, is now entering its ninth year. Its purpose ciontinues to be tto develop, optimize and validate quantitative imaging tools for measurement or prediction of therapy response in clinical trials. To date a large numer of tools and methods have been developed and are under test and validation in clinical trials across the country. To streamline this process from development to validation, the NCI is using a phased mechanism to support research in this area. The first phase (called teh UG3 phase) will focus on development and optimization, while the second phase (the UH3 phase) will emphasize clinical validation in single-site or multisite clinical trials. Th purpose of teh phased approach is to separate the development efforts from validation efforts. This will be discussed in this presentation.

RC525C Clinical Trials Perspective

Participants
Michael V. Knopp, MD, PhD, Columbus, OH (*Presenter*) Nothing to Disclose

SSK17

Physics (MR: New Techniques, System Evaluation)

Wednesday, Nov. 29 10:30AM - 12:00PM Room: S404AB

MR PH SQ

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

Participants
R. Jason Stafford, PhD, Houston, TX (*Moderator*) Nothing to Disclose
Seth A. Smith, PhD, Nashville, TN (*Moderator*) Nothing to Disclose

Sub-Events

SSK17-01 Blipped Radial CAIPIRINHA for Simultaneous Multislice pseudo-SSFP Magnetic Resonance Fingerprinting

Participants
Nikolai Mickevicius, Milwaukee, WI (*Presenter*) Nothing to Disclose
Eric Paulson, PHD, Milwaukee, WI (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

nmickevicius@mcw.edu

PURPOSE

The purpose of the present work is to accelerate pseudo steady-state free-precession magnetic resonance fingerprinting (pSSFP-MRF) T1 and T2 mapping sequences with simultaneous multislice (SMS) imaging methods.

METHOD AND MATERIALS

Controlled aliasing (CAIPI) techniques are useful for improving the image quality from SMS acquisitions. For multi-shot non-Cartesian k-space trajectories, as is the case for most MRF acquisitions, CAIPI takes the form of modulating the phase of one or more SMS slices relative to the others from readout-to-readout. This is usually accomplished by means of RF phase cycling. An underlying assumption of the pSSFP-MRF method, however, is that all slices experience a sign change of RF phase in consecutive excitations, thus prohibiting the use of RF phase cycled CAIPI. Gradient blips along the slice-selection axis allow similar CAIPI phase modulation without the use of RF phase patterns. This work employs a blipped-CAIPI acquisition with a radial trajectory for pSSFP-MRF. The SMS pSSFP-MRF sequence was implemented on a Siemens 3T scanner. The gradient blips were applied to induce a phase difference of pi/2 between two simultaneously excited slices. The sign of the gradient blip changed in each subsequent spoke which rotates with the golden angle of ~111.246 degrees. A total of 881 spokes were acquired in approximately 5 seconds. To reconstruct images of each slice, the conjugate of the blip-induced phase of the slice-of-interest was added to each spoke. A dictionary was simulated, and T1 and T2 maps were reconstructed using the low rank (R=5) alternating direction method of multipliers (ADMM) technique. The brain of a glioblastoma patient who consented to be a part of an institutional review board approved study was scanned.

RESULTS

The T1 and T2 maps of two simultaneously excited slices are shown in the figure. Total acquisition time was 5 seconds. No slice-leakage is apparent. The relaxation times outside of the tumor agree with literature values for healthy brain tissue. Lengthened T1 and T2 values can be seen within the lesion.

CONCLUSION

A blipped radial CAIPI pSSFP-MRF sequence permits rapid T1 and T2 mapping for use in disease diagnosis, treatment planning, and response assessment.

CLINICAL RELEVANCE/APPLICATION

This work aims to further push the acceleration of pSSFP magnetic resonance fingerprinting scans to aid in the clinical adoption of fully quantitative imaging protocols.

SSK17-02 First Clinical Assessment of kT-Points Dynamic RF Shimming on Abdominal DCE-MRI in a Commercial 3T MRI Scanner

Wednesday, Nov. 29 10:40AM - 10:50AM Room: S404AB

Participants
Raphael Tomi-Tricot, MSc, Gif-Sur-Yvette, France (*Presenter*) Nothing to Disclose
Vincent Gras, Gif-sur-Yvette Cedex, France (*Abstract Co-Author*) Nothing to Disclose
Franck Mauconduit, Saint-Denis, France (*Abstract Co-Author*) Employee, Siemens AG
Francois Legou, MD, Creteil, France (*Abstract Co-Author*) Nothing to Disclose
Nicolas Boulant, Gif-sur-Yvette Cedex, France (*Abstract Co-Author*) Nothing to Disclose
Matthias Gebhardt, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Dieter Ritter, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG

Berthold Kiefer, PhD, Erlangen, Germany (*Abstract Co-Author*) Employee, Siemens AG
Pierre Zerbib, Creteil, France (*Abstract Co-Author*) Nothing to Disclose
Alain Rahmouni, MD, Nogent Sur Marne, France (*Abstract Co-Author*) Nothing to Disclose
Alexandre Vignaud, PhD, Gif Sur Yvette, France (*Abstract Co-Author*) Consultant, Siemens AG
Alain Luciani, MD,PhD, Creteil, France (*Abstract Co-Author*) Research Consultant, Bracco Group; Research Grant, Bracco Group; Research Consultant, General Electric Company; Research Consultant, Siemens AG
Alexis Amadon, Gif-sur-Yvette Cedex, France (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

raphael.tomi-tricot@cea.fr

PURPOSE

The 'B1 artefact' is an important challenge for abdominal MRI at 3T. Our aim was to assess excitation homogeneity and image quality achieved in the liver by kT-points pulses, compared to patient-tailored static RF-shimming.

METHOD AND MATERIALS

The prototypical non-selective kT-points pulse design was compared with patient-tailored static RF shimming for 3D breath-hold liver DCE-MRI on a product dual-transmit MAGNETOM Skyra MRI (Siemens Healthcare). 50 consecutive patients referred for liver MRI at a single institute were included in this IRB-approved study. Quantitative analysis was carried out via simulation to estimate flip angle homogeneity. Signal homogeneity, T1 contrast, enhancement quality, structure details and global degree of trust provided by each technique were qualitatively assessed on a 4-level scale (0 to 3) by 2 radiologists on in vivo pre-injection and late-phase images from 20 acquisitions selected from the pool. An exact matched-pairs one-tailed Wilcoxon signed-rank test was used to compare the methods.

RESULTS

Average excitation inhomogeneity was significantly reduced with kT-points compared to static RF-shimming (mean flip angle error ± standard deviation: 8.5±1.5% vs 20.4±9.8% respectively; $p<0.0001$). The worst case (heavy ascites) was 13.0% (kT-points) vs 54.9% (RF-shim). KT-points qualitative grades were higher for all criteria. Global image quality was significantly higher for kT-points than for RF-shimming (mean grade ± standard deviation: 2.3±0.5 vs 1.9±0.6; $p=0.008$). One subject's examination was judged unusable (0/3 for all criteria) with RF-shim by one reader and none with kT-points. 85% of kT-points acquisitions were graded at least 2/3, compared to only 55% in the static RF-shim case.

CONCLUSION

KT-points significantly reduce excitation inhomogeneity both quantitatively and qualitatively, especially in patients with ascites and prone to 'B1 artefact'.

CLINICAL RELEVANCE/APPLICATION

Proper excitation homogeneity is crucial to take advantage of the high signal-to-noise ratio available at 3T. KT-points improve 3T MRI for abdominal imaging of all patients.

SSK17-03 Multi-Compartmental Analysis Using a Fast Multi-Echo TSE Sequence for Prostate Cancer Diagnosis

Wednesday, Nov. 29 10:50AM - 11:00AM Room: S404AB

Participants
Shiyang Wang, PhD, Chicago, IL (*Presenter*) Nothing to Disclose
Ajit Devaraj, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Roger Bourne, PhD, Sydney, Australia (*Abstract Co-Author*) Nothing to Disclose
Aritrick Chatterjee, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Tatjana Antic, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Aytekin Oto, MD, Chicago, IL (*Abstract Co-Author*) Research Grant, Koninklijke Philips NV; Research Grant, Guerbet SA; Research Grant, Profound Medical Inc; Medical Advisory Board, Profound Medical Inc; Speaker, Bracco Group; ;
Gregory S. Karczmar, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Harsh K. Agarwal, PhD, Briarcliff, NY (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Ambereen Yousuf, MBBS, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

shiyang@uchicago.edu

PURPOSE

Prostate tissue has three major histological components: stroma, glandular lumen and epithelial cells. These volume fractions change when cancer is present. This study evaluates the feasibility of measuring the volume fractions of these compartments quantitatively in normal prostate and prostate cancer (PCa) using multi-compartment T2 decay modeling. A fast multi-echo TSE T2 MRI (k-t-T2) was applied to obtain high resolution T2 maps in clinically feasible scan time. Signal contributions from the three compartments were compared with pathological slices as a gold standard.

METHOD AND MATERIALS

k-t-T2 data were acquired on 17 patients on Philips 3T Achieva scanner; this method uses k-space under sampling for image acquisition to accelerate the scan. TR=3.1-10s; 32 echoes; ΔTE=12ms (TE=24-396ms); 1.0x1.0x3 mm3 in-plane resolution, scan time=4.5-9.6min. Regions of-interest (ROIs) including PCa (n=28) and normal prostate (n=43) were identified through histologic and MRI consensus review. Voxel-based three compartment analysis was used to extract the epithelial, lumen and stromal volume fractions, and T2 value of each compartment, in each ROI. Kruskall-Wallis test and Welch two sample t-test were used to evaluated the statistical significance between ROI groups. Spearman correlation coefficient was calculated between the image features and ROI-specific Gleason scores (GS).

RESULTS

ROI based analysis results showed the volume fraction of epithelium (50±12% vs. 37±10%) and lumen (11±6% vs. 21±7%) are

significantly different between PCa and normal prostate (p<0.01). There is no significant difference in stromal volume fraction (39±9% vs. 41±8%) between PCa and normal prostate (p>0.5). The volume fractions measured by MRI are close to those reported in previous histological studies. The volume fractions of epithelial cells and lumen are strongly correlated with GS (ρ =0.53; -0.41, p<0.05). Epithelial volume fraction in PCa correlates better with GS compared to T2 values (ρ=-0.41, p=0.02).

CONCLUSION

Multi-echo k-t-T2 sequence is feasible in clinical setting. Volume fractions obtained from three compartment model fitting of spin echo signal decay sampled at multiple TE's may help to characterize prostate lesions and may be sensitive to Gleason grade.

CLINICAL RELEVANCE/APPLICATION

New features extracted from multi-echo TSE images are more sensitive to prostate cancer and Gleason score than T2 values alone which may improve prostate cancer diagnosis.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Aytekin Oto, MD - 2013 Honored EducatorAytekin Oto, MD - 2017 Honored Educator

SSK17-04 Comparison between Readout Segmented Diffusion Weighted Imaging and Single Shot Echo Planar Imaging in Image Quality

Wednesday, Nov. 29 11:00AM - 11:10AM Room: S404AB

Participants
Chuangbo Yang, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Hui Zhong, Xianyang, China (*Presenter*) Nothing to Disclose
Nan Yu, MD, Xian Yang, China (*Abstract Co-Author*) Nothing to Disclose
Guangming Ma, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Haifeng Duan, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Qi Yang, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Chenglong Ren, Shanxi, China (*Abstract Co-Author*) Nothing to Disclose
He Taiping, MMed, Xian Yang City, China (*Abstract Co-Author*) Nothing to Disclose
Yuhuan Chen, MD, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

937874041@qq.com

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 MAGNETOM Skyra 3T MR scanner (Siemens AG, 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 information. 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.

SSK17-05 Magnetic Resonance Water-Fat Separation using Deep Machine Learning

Wednesday, Nov. 29 11:10AM - 11:20AM Room: S404AB

Participants
James W. Goldfarb, PhD, Roslyn, NY (*Presenter*) Nothing to Disclose

PURPOSE

The goal of this study was to develop, train and evaluate a convolutional neural network for decomposition of cardiovascular MR images into separate water and fat images with additional calculation of R2* and off-resonance.

METHOD AND MATERIALS

1204 cardiac images in multiple anatomical orientations from 90 imaging sessions acquired at 1.5T using a dark blood double inversion recovery multiple spoiled gradient-echo sequence (TR=20ms; 12 TEs=2.4-15.5ms (1.2ms spacing), bipolar gradient acquisition) were included in this study. This included 15 acute myocardial infarction (MI), 24 sub-acute MI, 34 chronic MI subjects and 17 normal subjects. Water-fat separation was initially performed with a conventional model based technique providing water, fat, R2* and off-resonance images for deep learning training. A U-Net convolutional neural network (CNN) was used for deep learning. The input to the CNN was 24 real and imaginary images from 12 TEs. The output of the CNN was four images (water, fat, R2* and off-resonance). The implementation was done using open source software written in Python v2.7 with the TensorFlow v1.1 and Keras v2.0 machine learning libraries. Training on 900 (x12 echo-times) complex images with 50 epochs was performed using the Adam optimizer with Nestrov momentum. Water and fat images from the data not used for training (n=304) were predicted using the trained CNN. Water-fat fraction images were constructed for both the conventional and deep learning approaches.

RESULTS

Water-fat separation performed well across all image slice orientations. Signal-to-noise was better in the deep learning images when compared to conventional images, $p<0.001$. Fine details were preserved in the deep learning images when compared to conventional images. There was an excellent correlation ($R2=0.97$, $p<0.001$) between the conventional and deep learning fat fraction measurements. Multiple pathologies were visualized with deep learning, including fatty metaplasia (Fig 1a) and intramyocardial hemorrhage (IMH) Fig 1b.

CONCLUSION

Deep learning is a robust, efficient, feasible method for water-fat separation. After the learning phase, utilization is computationally efficient and can make use of echoes with bipolar gradients.

CLINICAL RELEVANCE/APPLICATION

Deep machine learning can provide fat suppressed images and quantitative fat fraction maps with R2* and off-resonance corrections in challenging situations such as cardiovascular imaging.

SSK17-06 Analysis of Different Image Registration Algorithms for Fourier Decomposition MRI in Functional Lung Imaging

Wednesday, Nov. 29 11:20AM - 11:30AM Room: S404AB

Participants
Alexandra Ljimani, MD, Duesseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Rotem S. Lanzman, MD, Duesseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Gerald Antoch, MD, Duesseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Hans-Jorg Wittsack, Duesseldorf, Germany (*Abstract Co-Author*) Nothing to Disclose
Julian Kirchner, Dusseldorf, Germany (*Presenter*) Nothing to Disclose

PURPOSE

To evaluate different image registration algorithms for Fourier decomposition MRI (FD-MRI) in functional lung imaging in healthy subjects.

METHOD AND MATERIALS

Fifteen healthy volunteers (mean age 33.0±10.1 years) were examined on a 1.5 T whole-body MR-scanner (Magnetom Avanto, Siemens AG) with a non-contrast enhanced 2D-TrueFISP pulse sequence in coronal view (TR/TE 2.06/0.89 ms, acquisition time 180 ms/image, 250 images). No ECG or respiratory triggering was used. Three different image registration algorithms (fMRLung 3.0, Siemens Corporate Research; diffeomorphism based ANTs by Avants et al. NeuroImage 2011; Elastix by Staring et al. Medical Physics 2007) were used to compensate the spatial variation of the lung structure. Quality control for the image registration was performed by quotient images (ΔQ) and dice similarity coefficient (ΔD). The impact of the used registration algorithms on the calculated perfusion and ventilation values by Fourier decomposition method was evaluated.

RESULTS

The average time for motion correction by the different image registration algorithms were for fMRILung 1.0±1.6 min, ANTs 38±13.5 min and Elastix 5.9±1.3 h, respectively. No significant ($p>0.05$) difference in the quality of the motion correction provided by different image registration algorithms (ΔQ fMRILung 0.12, ANTs 0.11, Elastix 0.11; ΔD fMRILung 0.06, ANTs 0.07, Elastix 0.06) occurred. Further no significant difference of the calculated ventilation and perfusion values between the different registration algorithms ($p>0.05$) were determined. The calculated ventilation values were 119±12 for fMRILung, 110±14 for ANTs and 118±12 ml/min/100 ml for Elastix, respectively. The perfusion values for fMRILung, ANTs and Elastix were 156±41, 166±46 and 185±66 ml/min/100 ml, respectively.

CONCLUSION

The mandatory motion correction for the calculation of perfusion and ventilation images by FD-MRI is possible with different image registration algorithms without significant influence on the quality of the motion correction or changes of the calculated functional lung values. fMRILung 3.0 (Siemens Corporate Research) provides the fastest way of motion correction.

CLINICAL RELEVANCE/APPLICATION

Motion correction for FD-MRI is possible with different image registration algorithms without loss of accuracy of perfusion and ventilation results.

SSK17-07 MRI Quantitative Quality Control and Calibrated Measurement with DTI and Reference Fluid Phantom Novel Phantom for Quantitate Assessment of DTI Inters Canner Variability

Wednesday, Nov. 29 11:30AM - 11:40AM Room: S404AB

Participants
Walter Schneider, PhD, Pittsburgh, PA (*Abstract Co-Author*) Consultant, Psychology Software Tools, Inc

James M. Provenzale, MD, Durham, NC (*Abstract Co-Author*) Consultant, ArmaGen; Research Grant, Bayer AG; Consultant, Bayer AG; Consultant, Biomedical Systems; Consultant, Laboratory Corporation of America Holdings; Consultant, CurAccel, LLC; Research Grant, General Electric Company; Consultant, sanofi-aventis Group; Consultant, Guerbet SA; Consultant, Takeda Pharmaceutical Company Limited; Consultant, F. Hoffmann-La Roche Ltd
Michael Boss, PhD, Boulder, CO (*Presenter*) Nothing to Disclose
Elisabeth Wilde, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose
Brian A. Taylor, PhD, Houston, TX (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

wws@pitt.edu

CONCLUSION

Current DTI scanning has substantial systematic error, distorting measurement and impairing clinical diagnostic stability. Phantom calibration can quantify such errors and may provide a means for a correction factor to reduce variability across scanners.

Background

We used a novel DTI and isotropic fluid phantom funded by the Chronic Effects of Neurotrauma Consortium, VA, DoD & NIH QIBA programs to provide "ground truth" reference measurement and quality assurance metrics.

Evaluation

The phantom contains anisotropic diffusion components of hollow textiles termed Taxons (axon-shaped tubes, 12-µm inner diameter diffusion chambers) arranged in water-filled bundles of > 100,000. To quantify loss of tract integrity and size, we created tracts with densities of 12.5%- 100% and tract cross-sections of 4-100 mm2. The phantom includes 32 NIST reference fluids (T1, T2, PD, ADC) for isotropic reference metric correction. We imaged on 11 scanners (1.5T and 3T, Siemens, GE & Phillips) with head coils 12-64 channels. Scans detected tracts with high spatial detail at all sizes (average correlation of FA to tract density r=0.992). We found tight repeat measurements, with small changes between scans on the same magnet within a few weeks. However, substantial (35%) inter-scanner systematic error/biases in measurements of FA were seen, greatly exceeding presumed effect size of TBI-induced FA change and 2.85 times the variance within scanner. We applied a reference measurement correction by estimating scanner-specific systematic error on one scan and applying that correction to a second scan weeks later to calculate calibrated FA relative to the mean cross-scanner FA to reference density metrics. The correction reduced the across-scanner spread error by 94%.

Discussion

The phantom provides a reliable and reproducible method to determine degree to which DTI scans on a MR scanner differ from a reference standard that simulates the microstructure of brain white matter. The phantom also allows a means to determine the degree to which DTI scans from multiple scanners differ from one another and, potentially, a method to correct for inter-scanner differences.

SSK17-08 A Quality Improvement (QI) Initiative to Evaluate MR QA Training Strategies for MR Technologists to Enable Them to Undertake Quality Assurance (QA) Testing in MRI

Wednesday, Nov. 29 11:40AM - 11:50AM Room: S404AB

Participants
Walaa M. Alsharif, MSc, dublin, Ireland (*Presenter*) Nothing to Disclose
Michaela Davis, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Patrick Kenny, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
David P. Costello, BSC,MSc, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Andrea Cradock, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Ciara M'Centee, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Allison Mc Gee, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

WALAA_ALSHARIF@HOTMAIL.COM

PURPOSE

The American College of Radiology (ACR) standard recommends that quality assurance (QA) testing of MR systems is the responsibility of both technologists and medical physicists to ensure efficient scanner performance. However, in the Kingdom of Saudi Arabia (KSA), meeting this standard is challenging due to a shortage of medical physicists, variable MR-specific education amongst technologists, and difficulties in achieving standardisation across centres providing MR imaging services. These factors have contributed to low compliance with recommendations for the performance of MR QA tests. This study explored the development of an education-based Quality Improvement (QI) initiative to enable MR technologists across multiple clinical sites to consistently perform MR system QA testing. The authors aimed to develop an educational tool to provide MR QA training to technologists enabling them to undertake this activity in their departments.

RESULTS

There was 95% agreement between the expert-determined and technologist-determined MR QA test results. Interview findings revealed that all technologists reported that the test methods presented in the training video were clear and logical, and enabled them to perform practical QA testing of their scanner. 12% of technologist participants (n=1) acknowledged some difficulty positioning the QA phantom, and 50% (n=4) indicated challenges interpreting the test pattern appearances due to the inherent subjectivity of the low contrast detectability QA test. All participants indicated that their experience of MR QA training was positive, using expressions such as "I enjoyed it", "It was a positive experience", and "very good experience", "It showed me what I can do with the right training". Technologists indicated they had learned a new skill to help them improve the quality of the MR imaging service they provide, and were willing to continue undertaking QA testing, seeing this as one way to expand their professional role.

CONCLUSION

With the ongoing shortage of medical physicists in KSA and other countries, the training video introduced as a QI initiative

With the ongoing shortage of medical physicists in KSA and other countries, the training video introduced as a QI initiative demonstrated the effectiveness of an appropriately designed educational resource combining both technical information and practical skills demonstration. The ease of access and display means that this educational tool can readily be made available to MR technologists across multiple centres in KSA, as a strategy to prevent a shortage in expert personnel limiting the implementation of practices to optimise MR service quality. The broader application of the methods applied during this education-based QI is apparent.

METHODS

Educational Tool Design: A training video was designed to demonstrate MR QA test methods and provide background explanatory information. sing a focus group discussion framework, the research team, comprising two medical physicists and four MR technologists, reached consensus regarding the essential content and presentation format, drawing on ACR MR QA guidelines and the expertise of group members. Based on ACR recommendations, the method for the following QA tests was planned: central frequency, geometric accuracy, high-contrast spatial resolution, low-contrast detectability, image intensity uniformity and signal-to-noise ratio (SNR). Each test was broken down into logical steps which included: MR QA phantom design features, set-up and positioning, pulse sequence and parameters and use of MR images to provide numerical indicators of MR system performance. The performance of these steps by the research team members for each QA test was videoed in sequential order to make it easy for the MR technologists to follow the test method. Editing of the video footage and overlay of audio content was performed by a videographer in consultation with the research team. Educational Tool Evaluation: MR technologists (n=8) in one public (n=4) and one semi-public (n=4) hospital in KSA evaluated the QA training video. Technologists were given supervised access to this resource for two 30-minute sessions per day over one week. A supporting booklet outlining the test methods was also provided. On completion of the educational intervention, each technologist was asked to implement the QA test process in their MRI department for a three-month period by individually conducting weekly QA testing on the MR scanner and documenting the images and numerical results for each test. These findings were compared to images and values independently determined for the same QA tests on each MR scanner as performed by an expert in MR QA following the methodology outlined in the training video. Face-to-face semi-structured interviews were conducted with each technologist to ascertain their opinion regarding the effectiveness of the QA training video and their experiences undertaking the QA tests.

PDF UPLOAD

https://abstract.rsna.org/uploads/2017/17016601/17016601_ox5k.pdf

SSK17-09 A Microwave Imaging System and Real-Time Image Reconstruction Algorithm for Intraoperative 3D Monitoring of Thermal Ablation Therapies

Wednesday, Nov. 29 11:50AM - 12:00PM Room: S404AB

Participants
guanbo chen, los angeles, CA (*Presenter*) Nothing to Disclose
John Stang, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Pratik Shah, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Sang Cho, PharmD,MPH, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Eric Leuthardt, Saint Louis, MO (*Abstract Co-Author*) Stockholder, NeuroLutions, Inc Stockholder, General Sensing Ltd Stockholder, OsteoVantage, Inc Stockholder, Pear Therapeutics Inc Stockholder, Face to Face Biometrics
Mahta Moghaddam, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

guanboch@usc.edu

guanboch@usc.edu

CONCLUSION

We proposed a 3D real-time microwave monitoring method and synthetically validated it for interstitial thermal therapy monitoring. We will further validate on animal models before moving to clinical trials. With this intraoperative temperature monitoring, radiologists will be able to more selectively target tumors, extend the application of thermal ablation to new therapeutic areas, and reduce surgery time.

Background

Thermal ablation is a minimally invasive surgery that is gaining increasing popularity as first-line therapy for soft-tissue tumors. However, its application has been limited by inadequate thermal image guidance. Fiber optic sensors measure temperature only at their tips. B-mode ultrasound is limited to 2D. MRI is not available within the operating room and adds 30-40 minutes to surgery time. To address these challenges, we have developed a microwave monitoring system that can intraoperatively provide a 3D real-time temperature map. The system consists of a multi-antenna imaging cavity, where microwave measurements are collected with a network-analyzer-based measurement system. The data is processed with a differential inverse scattering algorithm, which generates real-time 3D temperature images through a mapping between tissue dielectric change and temperature. In our prior work, the system has been experimentally validated using laboratory phantoms heated with an ablation probe.

Evaluation

To synthetically test the monitoring of the ablation process in the case of brain tumor treated with thermal therapy, we derived a 3D dielectric brain phantom from MRI and simulated the heating of the target region with a multi-physics model of an interstitial ablation probe. In the test, the target region is heated from 37 °C to 70 °C, and 3D temperature maps are generated throughout the procedure.

Discussion

Sample validation results are shown in the figure attached. The 3D temperature maps can be generated as fast as 1 frame/second, provide a resolution of 1 cm, and can track temperature change as small as 1 °C. To further improve temperature accuracy, the mapping model between dielectric and temperature change is currently being refined with empirical studies using *in vitro* tissue samples.

SSK18

Physics (CT: Radiation Dose II)

Wednesday, Nov. 29 10:30AM - 12:00PM Room: S503AB

CT PH SQ

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

FDA Discussions may include off-label uses.

Participants
Shuai Leng, DPHIL, Rochester, MN (*Moderator*) License agreement, Bayer AG
Xinming Liu, PhD, Houston, TX (*Moderator*) Nothing to Disclose

Sub-Events

SSK18-01 Experience with Different Automatic Tube Voltage Selection Software (kV Assist and Care kV) on Four CT Platforms

Participants
Manuel Patino, MD, Boston, MA (*Presenter*) Nothing to Disclose
Anushri Parakh, MBBS, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Avinash R. Kambadakone, MD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose
Dushyant V. Sahani, MD, Boston, MA (*Abstract Co-Author*) Research support, General Electric Company; Medical Advisory Board, Allena Pharmaceuticals, Inc

For information about this presentation, contact:

mpatino@mgh.harvard.edu

PURPOSE

To assess the effect of ATVS on the applied tube voltage, tube current, image quality and radiation exposure across four scanners from two vendors.

METHOD AND MATERIALS

In this IRB approved study, 341 subjects (age: 58 ± 17 years) underwent abdominopelvic CT exams with ATVS technique set at a reference value of 120kVp on four recently introduced CT platforms. kV assist: Revolution CT, GEHC (Group A, n=90); CarekV: Somatom Definition Flash, Siemens (group B, n=16), Somatom Definition Force, Siemens (group C n=82) and Somatom Definition Edge, Siemens (group D n=153). Subjects were categorized based on body weight (<150lb, 151-200lb, >201lb). Images were reconstructed using ASIR-V 40% for group A, SAFIRE 3 for groups B and D, and ADMIRE A3 for group C. In 86 additional subjects, 100 kVp was selected as reference for ATVS (Group E; Revolution CT). Applied scan parameters (tube voltage and mean tube current) and radiation dose (SSDE) were compared for all body weight categories among the groups; ANOVA was performed.

RESULTS

There was no significant difference in body weight among subjects in groups A-E within each category ($p>0.05$). Across all groups and weight categories, low tube voltage (<120 kVp) was selected in 48% of exams (165/341). 5% of exams (19/341) were scanned using 90kVp (<200lb). Majority of low kVp scans were performed in subjects <200lb (147/165). Low kVp was selected in 21.6% of subjects (18/83) >201lb. Highest number of low kVp acquisitions were found in Group D (70%) followed by group C (61%) and Group B (31%). Only 3.3% of exams (3/90) in group A (all <200lb) were performed using 100kVp. However, 86% of exams (74/86) were acquired at 100 kVp in group E. SSDE (mGy) was 12.9 ± 3.3 in group A, 10.9 ± 2.4 in group B, 11.5 ± 3 in group C, 11.2 ± 3.2 in group D, and 7.7 ± 2.2 in group E ($p<0.01$).

CONCLUSION

The kVp selection with ATVS not only depends on body composition but on the reference kVp setting and tube current capacity. Using reference of 120kVp, careKV (Siemens) selected low kVp in 31-70% of exams. Using a reference of 100kVp on kV assist (GE), low kVp selection increased to 86% of exams independently of the body weight.

CLINICAL RELEVANCE/APPLICATION

Due to higher image contrast and lower radiation dose, clinical practice is drifting towards low kVp CT acquisitions. Knowledge of ATVS software selection of kV options can facilitate implementation in clinical practice without degrading image quality or CT workflow.

SSK18-02 Automatic Mapping of CT scan Locations on Computational Human Phantoms for Accurate Organ Dose Estimations for a Large Number of Patients

Wednesday, Nov. 29 10:40AM - 10:50AM Room: S503AB

Participants
Choonsik Lee, PhD, Rockville, MD (*Abstract Co-Author*) Nothing to Disclose
Gleb Kuzmin, MS, Rockville, MD (*Presenter*) Nothing to Disclose

Elizabeth Mosher, Rockville, MD (*Abstract Co-Author*) Nothing to Disclose
Elizabeth C. Jones, MD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

choonsik.lee@nih.gov

PURPOSE

Using Monte Carlo simulations of CT scanners and computational human phantoms, there are several computational solutions available for organ dose estimation from CT. Although most scan parameters can be extracted from DICOM, it is still necessary to manually map the scan locations of patients on phantoms which may cause significant dose difference for organs near the scan boundaries. We developed a method to automate the mapping process and applied it to organ dose estimation for 60 chest CT patients.

METHOD AND MATERIALS

We generated a two-dimensional antero-posterior projection image of the skeleton from given patient CT images. We compared the patient skeleton image with a pre-generated skeleton image from a reference whole body phantom from the top of the head to the bottom of the feet with 1 cm increment to find the best Dice matching score. The mapping algorithm was tested for five partial torso CT sets (22 image sets from the top clavicle with 20 cm scan length with 2 cm increment for each patient) simulated using five full torso CT sets. Illustrative organ doses were calculated for 60 chest CT patients using the algorithm combined with an in-house CT dose calculator. Automatic mapping algorithm-based organ doses were compared with the data based on the scan location manually mapped by experienced medical physicists.

RESULTS

Comparison of the scan location of simulated partial torso CT with the values of automatically-mapped location in phantoms showed very good agreement (less than 10%) with the Dice score of 57% on average. The automatic detection of the scan location took about a minute per CT. The illustrative organ dose for 60 chest CT patients showed significant difference up to 5-fold for some organs located atnthe scan boundaries across the 60 patients. The organ doses from the automati. Mapping algorithm agreed within 5% with the values calculated from manual mapping of scan locations.

CONCLUSION

Our method will provide faster and more accurate organ dose estimation compared to existing approaches in cases requiring organ dose for a large number of patients such as patient dose monitoring, clinical trials, and epidemiological studies.

CLINICAL RELEVANCE/APPLICATION

The new methods we developed in this study will provide with more accurate patient-specific organ doses, which will help radiologists and patients to better understand the health impact of CT scans.

SSK18-03 A Personal Organ Dose Archive System for Patient Safety in Radiotherapy

Wednesday, Nov. 29 10:50AM - 11:00AM Room: S503AB

Participants
Ying Liang, PhD, New Haven, CT (*Presenter*) Nothing to Disclose
Wazir Muhammad, PhD,MS, New Haven, CT (*Abstract Co-Author*) Nothing to Disclose
Jun Deng, PhD, New Haven, CT (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

ying.liang@yale.edu

PURPOSE

Although state-of-the-art radiotherapy techniques have improved local tumor control over the years, normal tissue complication is still of concern in the clinic. Estimation of normal tissue doses depend primarily on treatment planning system (TPS). However, leakage and scatter doses, imaging doses and doses to non-contoured organs are not well considered by modern TPS. In this work, we aim to develop a personal organ dose archive (PODA) system for individual patients undergoing radiotherapy to track doses of all relevant organs from all radiation events.

METHOD AND MATERIALS

CT images, contours and treatment parameters are exported and extracted from TPS via DICOM format. Deformable image registration and dose mapping are performed with MIM with 3D volumetric imaging. GPU-based Monte Carlo dose engine is used for super-fast 3D dose calculation in patient anatomy. A SQLite database is deployed to manage the data registration and inquiry.

RESULTS

Our PODA system includes four parts: (1) DICOM library; (2) PODA database; (3) GPU-based Monte Carlo dose engine; (4) functional modules. DICOM library hierarchically stores all the raw data for each individual patient. PODA database organizes and manages the general information of all patients. GPU-base dose engine computes organ doses and outputs to PODA database for each event involving ionizing radiation. Major functional modules include Update Organ Dose, Report & Alert and Database Backup & Recovery. The four components work together to track patient organ doses on a daily basis. A proactive early warning is issued if organ dose will exceed pre-set dose criteria by prediction.

CONCLUSION

We have developed a PODA system that can be used to track and accumulate each patient's organ doses associated with the use of sophisticated treatment technologies and image-guidance procedures in modern radiotherapy.

CLINICAL RELEVANCE/APPLICATION

With PODA we can provide an important safety mechanism to help prevent irreversible radiation damage to normal tissues and provide a comprehensive organ dose database to help clinicians make informed decisions for individual patients including pre and

post care management.

SSK18-04 Comparison of Image Quality and Radiation Dose of Female Chest CT Using Organ Dose Modulation with Different Detector Coverage on 16cm Wide-detector CT

Wednesday, Nov. 29 11:00AM - 11:10AM Room: S503AB

Participants
Yanan Li, Xian, China (*Presenter*) Nothing to Disclose
Niu Gang, MD, Xi'an, China (*Abstract Co-Author*) Nothing to Disclose
Fan Ganglian, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Jingjing Bai, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Xijun Jiao, Xian, China (*Abstract Co-Author*) Nothing to Disclose
Jian Yang, MD, PhD, Xian, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

liyanan976@163.com

PURPOSE

To evaluate the impact of two different detector coverages (80mm and 40mm) on image quality and radiation dose of the female chest CT using organ dose modulation (ODM).

METHOD AND MATERIALS

Forty female patients undergoing chest CT with clinical justifications were prospectively and randomly assigned to two groups: Group A (n=20) with 80mm detector coverage and pitch 0.992:1; Group B (n=20) with40mm detector coverage and pitch 0.984:1. Both groups used the 0.5s rotation speed and the SmartmA and ODM technique for the breasts. The standard deviation (SD) in the aortic arch, carina, and inferior pulmonary vein in both the anterior and posterior lungs were measured. Image quality was evaluated by two experienced radiologists using a 5-point scoring system. The tube current in different directions (A/L/P/R) were recorded from mA Table. The CTDIvol and DLP values were recorded from dose report and effective dose calculated. The above parameters for the two groups were analyzed using SPSS 20.0.

RESULTS

There was no difference in the anatomic coverage between the two groups (258.75 ±27.85mm vs. 253.00 ±24.51mm). However, Group B with 4mm collimation had lower tube current in all four directions and reduced over-scan range than Group A (29.50±0.60mm vs. 59.40±7.47mm, $P<0.05$), resulting in 25% lower radiation dose in Group B compared with Group A (0.74±0.13mSv vs. 0.99±0.33mSv). . The ODM feature worked in both groups, and the tube current in the anterior was lower than that in the posterior in both groups ($P<0.05$), and produced about 30% radiation reduction for the breasts in both groups. There was no significant difference in SD for the aortic arch, carina, and inferior pulmonary vein level between the two groups. The image quality of two group were judged to be clinically acceptable. There was no significant difference in subjective image quality grading ($p>0.05$) with excellent agreement between the two radiologists (Kappa=0.77, $P<0.001$).

CONCLUSION

The use of helical scan with 40mm collimation and ODM chest CT ensures good image quality with 25% reduced radiation dose, compared with chest CT that uses helical scan with 80mm collimation and ODM.

CLINICAL RELEVANCE/APPLICATION

The use of helical scan with 40mm collimation and ODM chest CT can dramatically reduce radiation dose while maintaining image quality compared with helical scan with 80mm collimation and ODM.

SSK18-05 Efficacy of Organ Dose Modulation and Metal Artifact Reduction Techniques on Reducing Exposed Radiation Dose on Abdominopelvic Computed Tomography Scans With Metal Hip Prosthesis

Wednesday, Nov. 29 11:10AM - 11:20AM Room: S503AB

Participants
Ok Kyu Song, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
Yong Eun Chung, MD, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

songokkyu@yuhs.ac

PURPOSE

To evaluate the effect of metal hip prosthesis on exposed radiation dose and assess the efficacy of organ dose modulatation (ODM) and metal artifact reduction (MAR) protocols on dose reduction.

METHOD AND MATERIALS

Six patients with history of total hip arthroplasty who had both preoperative and postoperative abdominopelvic CT scans using an identical protocol were selected and their preoperative and postoperative CT dose index (CTDI, mGy) were compared. An anthropomorphic phantom was scanned with and without bilateral metal prostheses and exposed surface and deep doses (mGy) at pelvic and extrapelvic cavities were measured using nanoDot dosimetry system. Finally, exposed radiation doses using reference scans, ODM, and two MAR protocols (GSI32 and GSI3; CTDI equivalent to reference scan without and with metal prosthesis respectively) in pelvic and extrapelvic cavities were compared.

RESULTS

Among six patients, the mean CTDI (mGy) increased by 18.1% after metal hip prosthesis implantation ($p=0.028$, Preoperative CTDI: 8.64±2.47, Postoperative CTDI 10.20±3.51). On phantom experiment, adding unilateral or bilateral metal prosthesis in pelvis increased CTDI (mGy) by 14.4% and 30.5% respectively. The tube currents were also increased in pelvic cavity but the metal hip

prosthesis had no effect on the tube currents of extrapelvic area. The utilization of MAR and ODM protocols decreased both the surface and the deep organ doses in pelvis. GSI32 showed the most significant dose reduction in the deep pelvic cavity followed by GSI3 and ODM. However, MAR (GSI32, GSI3) protocols increased radiation doses in extrapelvic cavity compared to the reference scan. ODM showed significant reduction of both the surface and deep organ doses in the extrapelvic cavity.

CONCLUSION

Metal hip prosthesis implantation increased exposed radiation doses in abdominopelvic CT scans. MAR protocol can be utilized to reduce the exposed radiation doses in pelvic cavity while improving image quality. When MAR protocol is not applicable, ODM is an alternative protocol that can be utilized to reduce exposed radiation doses of both pelvic and extrapelvic cavities.

CLINICAL RELEVANCE/APPLICATION

Metal artifact reduction and organ dose modulation techniques reduce radiation doses in patients with metal prosthesis implantation.

SSK18-06 Impact of Adjusting the Pulmonary-Embolism CT-protocol on Female Fertility Preservation by Reducing the Radiation Exposure of the Ovaries

Wednesday, Nov. 29 11:20AM - 11:30AM Room: S503AB

Participants
Roland C. Aydin, MD,MS, Garching, Germany (*Presenter*) Nothing to Disclose
Karoline S. Barth, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Dominik Zinsser, MD, Tuebingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Klaus Herz, Tubingen, Germany (*Abstract Co-Author*) Nothing to Disclose
Christian J. Cyron, PhD, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Konstantin Nikolaou, MD, Tuebingen, Germany (*Abstract Co-Author*) Speakers Bureau, Siemens AG; Speakers Bureau, Bracco Group; Speakers Bureau, Bayer AG
Mike Notohamiprodjo, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Roy Marcus, MD, Tubingen, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

roy.marcus@med.uni-tuebingen.de

PURPOSE

To assess in female patients undergoing a clinical pulmonary-embolism CT-protocol the relative and absolute reduction of the radiation exposure on the gonads by using a modified protocol that imposes a caudal imaging limit of the costodiaphragmatic recesses, in lieu of the common imaging window which also captures the supraadrenal glands. Cumulative exposure to radiation remains a concern due to the rising maternal age at primigravida, and the often unavailable exposure during emergencies such as suspected pulmonary embolisms.

METHOD AND MATERIALS

Thirty non-pregnant female patients with suspected pulmonary embolism underwent a contrast enhanced CT of the chest on a 3rd generation dual source CT (SOMATOM Force, Siemens Healthcare) in single-energy mode with automatic tube voltage selection and tube current modulation. Organ dose of the ovaries was automatically calculated using a commercial dose tracking software (Radimetrics, Bayer Schering). Full assessability of the thoracic cavity was assured with the modified imaging window, although incidental findings of e.g. suprarenal growths were precluded.

RESULTS

Median age of the patients analyzed in the retrospective study was 35 years [17 - 42]. The median equivalent dose of the gonads was 0.031 [0.009 - 0.190] mSv for the adapted (shrunk imaging window) and for the non-adapted protocol (typical size imaging window) 0.060 [0.013 - 0.266] mSv. The reduction in radiation dose was statistically significant ($p<0.0001$). The mean absolute difference in the ovarial radiation dose amounted to 0.041 ± 0.031 mSv, corresponding to a relative reduction in gonadic exposure of 43.8%.

CONCLUSION

For female patients prior to menopause in general, and their subgroup with a history of suspected pulmonary embolisms and thus repeated thoracic CT imaging specifically, an adaption of the CT protocol as outlined conveys a significant cumulative reduction of the radiation exposure on the ovaries.

CLINICAL RELEVANCE/APPLICATION

Shortening the scan range of pulmonary CTA positively affects the ovarian radiation exposure, important in pre-menopausal women undergoing repetitive scans.

SSK18-07 CT-Guided Periradicular Infiltration Therapy: How IR and Protocol Modifications Contribute to Achieving Ultra-Low-Dose

Wednesday, Nov. 29 11:30AM - 11:40AM Room: S503AB

Participants
Fabian Elsholtz, Berlin, Germany (*Presenter*) Nothing to Disclose
Julia Kamp, MD, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose
Janis L. Vahldiek, MD, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose
Bernd K. Hamm III, MD, Berlin, Germany (*Abstract Co-Author*) Research Consultant, Toshiba Medical Services Corporation ; Stockholder, Siemens AG; Stockholder, General Electric Company; Research Grant, Toshiba Medical Services Corporation Research Grant, Koninklijke Philips NV; Research Grant, Siemens AG ; Research Grant, General Electric Company; Research Grant, Elbit Imaging Ltd; Research Grant, Bayer AG ; Research Grant, Guerbet SA; Research Grant, Bracco Group; Research Grant, B. Braun Melsungen AG; Research Grant, KRAUTH medical KG ; Research Grant, Boston Scientific Corporation; Equipment support, Elbit Imaging Ltd; Investigator, CMC Contrast AB

Stefan M. Niehues, MD, Berlin, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

fabian.elsholtz@charite.de

PURPOSE

To evaluate robustness and safety of ultra-low-dose protocols for CT-guided periradicular infiltration of the cervical and lumbosacral spine on a CT scanner with iterative reconstruction software.

METHOD AND MATERIALS

This retrospective study included a total of 366 patients who underwent periradicular infiltration therapy of the cervical (n=191) and lumbar (n=175) spine. Respective study group (90 each cervical and lumbosacral) was treated on a new CT scanner with a new intervention protocol using an iterative reconstruction algorithm. Spot scanning was implemented for planning purposes and a basic low setup of 80 kV (cervical) or 100 kV (lumbosacral) and 5 mAs was established during intermittent fluoroscopy. The comparison group comprised 101 (cervical) and 85 (lumbosacral) prior interventions on a scanner without iterative reconstruction software. Dose-length product, number of acquisitions, pain reduction on a numeric analogue scale and protocol changes to achieve a safe intervention were recorded.

RESULTS

Median DLP for the whole intervention was 24.3 mGy*cm in the cervical and 49.3 mGy*cm in the lumbosacral comparison group towards 1.8 mGy*cm in the cervical and 3.2 in the lumbosacral study group. Pain reduction was median -2 in all the cervical and lumbosacral study and comparison group. Raise of the tube current-time product by 5 mAs was needed in 5 patients of the cervical and 3 patients in the lumbosacral study group.

CONCLUSION

Implementation of a new ultra-low-dose intervention protocol resulted in a reduction of dose by 92.6% (cervical) and 64.0% (lumbosacral) without limitation of safety and pain relief.

CLINICAL RELEVANCE/APPLICATION

Dose reduction in CT imaging is of relevant interest from patients and physicians perspective. Changes of the scanner parameters and implementation of IR can significantly reduce overall dose also of interventional procedures. This dose reduction does not impact the procedure itself nor the outcome as seen in periradicular infiltration.

SSK18-08 Prospective Evaluation of Ultra-Low Dose Enhanced Abdominal Computed Tomography (MDCT) Using 100 kV with Tin Filter as Spectral Shaping: Effect on Radiation Dose Reduction and Image Quality with a Third-Generation Dual-Source CT System

Wednesday, Nov. 29 11:40AM - 11:50AM Room: S503AB

Participants
Pierre G. Leyendecker, MD, Strasbourg, France (*Presenter*) Nothing to Disclose
Vanina Faucher, MD, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Paul R. Magotteaux Sr, MD, Liege, Belgium (*Abstract Co-Author*) Nothing to Disclose
Aissam Labani, MD, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Mickael Ohana, MD, PhD, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose
Catherine Roy, MD, Strasbourg, France (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

pierre.leyendecker@chru-strasbourg.fr

PURPOSE

The purpose of this prospective study was to investigate the radiation dose exposure and image quality of enhanced abdominopelvic single-energy MDCT using a tin filter at 100Kv tube voltage in comparison to the standard enhanced acquisition.

METHOD AND MATERIALS

110 medium size oncologic patients (BMI:25±3.2kg/m2) over 60 years old (mean age:73.2±10.2 years) referred for an enhanced abdominopelvic MDCT examination underwent in addition to our conventional protocol an ultralow dose acquisition with tin filter (TF) in portal venous phase. Our institutional ethical committee reviewed and approved our investigation. The examinations were performed in single energy helical mode with a third-generation dual-source CT (Somatom Force). Both standard acquisition (SP) with an automatic individually-adapted kV (90-110) and tin filter (TP) (100 Sn kV/300mAs) were acquired with automatic milliamperage modulation and identical length of coverage, pitch, reconstructed slice thickness of 2mm, acquisition time and ADMIRE strength : 4. Radiation dose was recorded as dose-length product (DLP), volume CT index (CTDIvol). Effective dose (ED) was calculated. Subjective image quality was evaluated on a 5-grade scale by two blinded independent radiologists and interobserver agreement was calculated. Objective image quality was calculated by signal-to-noise ratio (SNR). The attenuation with standard deviation in liver and psoas muscle were assessed.

RESULTS

Radiation dose was reduced by 82-84% withTF compared to SP (DLP : 290±12.0 vs 49.6± 3.2 mGy.cm; p<0.0006, CTDIvol:1.32±0.36 vs 7.25±1.64 mGy; p<0.0001, ED : 4.93±0.2 vs 0.84±0.1 mSv ; p<0.0005). The image quality was rated as excellent for both (4.5 for TF, 5 for SP) with an excellent interobserver agreement (Kappa =0.87). All abnormalities discovered on SP were identified on TF. SNR was not significantly different with TF in liver (9.53±0.9 vs 8.10±1.1; p : 0.08) or psoas (6.03±1.5 vs 5.46±0.2 ; p : 0.06), respectively. Attenuation values were slightly lower with TF (91±14HU vs 102±12HU, 52±16HU vs 65±10HU; p= 0.06) for liver and psoas muscle, respectively

CONCLUSION

An ultralow radiation dose (ED<1mSv) for abdominopelvic CT is achieved using a tin filtration as spectral shaping at 100 kV without

degradation of image quality and diagnosis confidence in medium size patients.

CLINICAL RELEVANCE/APPLICATION

The TF acquisition should be proposed for enhanced abdominal CT follow up examinations in oncologic patients.

SSK18-09 Reducing Variability of Radiation Doses in CT

Wednesday, Nov. 29 11:50AM - 12:00PM Room: S503AB

Participants
Ryan K. Lee, MD, Philadelphia, PA (*Presenter*) Nothing to Disclose
Joel Y. Sun, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Terence A. Matalon, MD, Philadelphia, PA (*Abstract Co-Author*) Speaker, Koninklijke Philips NV
Samantha Lockerby, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Eric Soltycki, MS, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

leeryan1@einstein.edu

CONCLUSION

Significant decrease of variance in head, chest, and abd/pelvis CT was achieved using a combination of standardizing protocols across the network and implementing advanced software that effectively managed radiation dose.

Background

While reducing radiation is an important goal, also important in the management of radiation dose is ensuring consistency in the amount of radiation administered for each type of study. Being able to consistently administer the same dose everytime a study is performed is the hallmark of high quality in radiation management. We implemented an approach to reducing variance in CT dose by standardizing protocols and employing software at the scanner to provide consistency across the network.

Evaluation

We measured variance of dose administered to head, chest, and abd/pelvis CT in two periods. The first period is pre-intervention: 1/1/13-7/31/14. We then measured the period after intervention: 1/1/16-12/31/16. Statistical analysis for differences in variability of radiation dose pre- and post-intervention used Bartlett's test. Pre-intervention dose and SD: head CT (n= 12,002): 26.4 CTDI with SD of 4.3; chest CT (n=3,149): 8.6 CTDI with SD of 5.2; abd/pelvic CT (n=9833) :12.5 CTDI with SD of 5.2. Post-intervention dose and SD: head CT (n=13,274): 20.1 CTDIvol with SD of 3.4; chest CT (n=3,746): 5.4 CTDI with SD of 2.7; abd/pelvis Ts (n=12,121): 7.7 CTDI with SD 3.3. Post intervention SD was significantly decreased for all studies ($p<0.001$).

Discussion

Our approach to reducing variability in radiation CT was a multifaceted approach: 1. Establishing the Radiation Dose Optimization Committee, 2. Standardizing Protocols, and 3. Implementing scanner software which reduces variance of dose. We implemented software in scanners that increases tube current to a lesser degree than would be obtained by hold noise constant. The software increases tube current for increasing diameter size at a rate less than would be needed to hold noise constant. Thus for larger patients,allowing for controlled increase in dose to improve signal to noise yet also accepting more noise allowed for better dose management avoiding exponential increase in radiation that occurs with conventional dose modulation.

RSNA 2017 Explore. Invent. Transform.
103rd Scientific Assembly and Annual Meeting
November 26 to December 1
McCormick Place, Chicago
Explore Invent Transform

PHS-WEA

Physics Wednesday Poster Discussions

Wednesday, Nov. 29 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Participants
Thomas Oshiro, PhD, Los Angeles, CA (*Moderator*) Nothing to Disclose

Sub-Events

PH245-SD-WEA1 Novel Technique to Generate Computed Diffusion Weighted Brain MRI with Ultra-High B-Values

Station #1

Participants
Toru Higaki, PhD, Hiroshima, Japan (*Presenter*) Nothing to Disclose
Fuminari Tatsugami, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoko Kaichi, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuji Akiyama, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Masaaki Umeda, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;

CONCLUSION

Our cDWI generation method contributes to the quality improvement of ultra-high b-value DWIs of the brain.

Background

Computed diffusion-weighted images (cDWIs) are virtual- calculated from actual DWIs using a few arbitrary low b-values. cDWI is advantageous because images can be generated on scanners that disallow the acquisition of high b-value DWIs. cDWI can reduce the image noise when DWIs are acquired with routinely-used b-values. However, it is not possible to generate ultra-high b-value cDWIs (uh-cDWIs) with conventional calculation methods. We propose a solution to generate such brain images.

Evaluation

A mono-exponential model is used in conventional methods. We applied a bi-exponential model: $Sbx = Sb1 \{ f \exp(-(bx-b1)D1) + (1-f) \exp(-(bx-b1)D2) \}$, where, $Sb1$ and Sbx are the signal intensity, $b1$ and bx the b-values, $D1$ and $D2$ the diffusion coefficients, and f is the weighting factor. Input DWIs for cDWI calculation were acquired from 6 normal volunteers (F:1, M:5, age 32 ± 6 years) on a 3T scanner (Titan 3T, TMSC, Japan). Images with b-values of 250, 500, 750, 1000, 1250, 1500, 1750, and 2000 [s/mm2] were obtained with 6 axes of the MPG vector. To solve the equation, a combination of 4 b-values was required. We applied all combinations to identify the best ultra-high cDWIs. In the conventional method, isotropic diffusion images were the cDWI input. As the white matter is diffusion anisotropic, we calculated cDWIs on images of each MPG axis. We set b=4000 as the target b-value and compared the image quality of cDWIs and actual DWIs.

Discussion

We generated highly accurate cDWIs compared to actual DWIs (Fig. 1). The best combination of input b-values was 250, 750, 1250, and 2000; it yielded the least noise and the highest quality. The conventional mono-exponential model performed poorly in the generation of ultra-high cDWIs (Fig. 2). As cDWIs obtained by our method shortened TE compared to actual DWIs, their low image noise and true diffusion contrast are advantageous.

PH246-SD-WEA2 Improved Spatial Resolution of High-contrast Structures with Ultra-high-resolution CT Scanner: Phantom and Clinical Pilot Studies

Station #2

Participants
Wataru Yamamura, Tokyo, Japan (*Presenter*) Nothing to Disclose
Takuya Adachi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuta Shimizu, MItaka-shi, Japan (*Abstract Co-Author*) Nothing to Disclose
Keita Fukushima, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Masamichi Koyanagi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Haruhiko Machida, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshiya Kariyasu, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Akihito Nakanishi, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Kenichi Yokoyama, MD, Mitaka-Shi, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshiaki Nitatori, MD, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Koji Yamashita, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
Hiromi Enomoto, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose
takahiro arai, Tokyo, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The latest ultra-high-resolution CT (UHRCT) scanner with slice collimation of 0.25 mm x 160 and a matrix size of 10242 in super-high-resolution (SHR) reconstruction mode has recently become clinically available. We performed phantom and clinical pilot studies to compare the spatial resolution of high-contrast structures using various reconstruction modes in UHRCT.

METHOD AND MATERIALS

We performed helical scanning (2 cm off center) and filtered-back-projection reconstruction (5-cm field of view, bone kernel) of wire (0.05-mm diameter) and micro-coin (0.05-mm thickness) phantom images using a UHRCT scanner (Aquilion Precision, Toshiba) in SHR mode and normal-resolution (NR) mode (slice thickness: 0.5 mm, matrix size: 5122). Using the modulation transfer function (MTF), we quantified in-plane (10% MTFxy) and through-plane spatial resolution (10% MTFz) in the wire and coin images, respectively. We retrospectively enrolled 11 patients (6 men, mean age: 52±18 years) who had undergone temporal bone CT using this scanner and reconstructed 0.5-mm-thick multiplanar reformation coronal images and volume-rendered images of the ossicles in both SHR and NR modes for each patient. Two independent readers visually graded sharpness and delineation of the stapes in the coronal and volume-rendered images using a 5-point scale (1 = poor, 5 = excellent), respectively. We compared 10% MTFxy and MTFz and the visual grades by each reader between the two modes using the Wilcoxon signed rank test. We assessed inter-reader agreement of the visual grades using κ-statistics.

RESULTS

While 10% MTFxy was higher for SHR mode (2.64) than NR mode (1.11), 10% MTFz was higher for SHR mode (1.77) than NR mode (0.98). Both sharpness and delineation of the stapes were significantly better for SHR mode (reader 1: 3.8±0.9 and 3.1±1.2; reader 2: 4.1±0.7 and 3.2±1.3, respectively) than NR mode (reader 1: 2.9±1.0 and 1.0±0.0; reader 2: 2.9±0.8 and 1.0±0.0) ($P < 0.05$). The inter-reader agreement was excellent ($\kappa = 0.86$ and 1.00).

CONCLUSION

The use of UHRCT with SHR reconstruction mode quantitatively and qualitatively improves the spatial resolution of high-contrast structures.

CLINICAL RELEVANCE/APPLICATION

The state-of-the-art ultra-high-resolution CT scanner can improve the sharpness and delineation of fine high-contrast structures or lesions and the quality of CT diagnosis as compared to standard CT.

PH247-SD-WEA3 A Novel Perfusion Map for Assessment of Brain Ischemia in 4D-CT: Comparison with PET Image

Station #3

Participants
Tomomi Omura, Akita, Japan (*Presenter*) Nothing to Disclose
Noriyuki Takahashi, Akita, Japan (*Abstract Co-Author*) Nothing to Disclose
Yongbum Lee, PhD, Niigata, Japan (*Abstract Co-Author*) Nothing to Disclose
Mamoru Kato, PhD, Akita, Japan (*Abstract Co-Author*) Nothing to Disclose
Hideto Toyoshima, BSc, Akita, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshibumi Kinoshita, MD, PhD, Akita, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

t-omu@akita-noken.jp

PURPOSE

CTP quantitative maps such as CBF, CBV and MTT are helpful for assessment of brain ischemia. However, they are different depending on deconvolution analysis even when using identical CTP datasets. The enhancement effect of the contrast agent of the brain tissue in the ischemic hemisphere appears later than the normal hemisphere because severe ischemia makes intracranial hemodynamics be worse. If the difference of hemodynamic state can be represented without deconvolution analysis, it will provide more robust information in the diagnosis of ischemia. The purpose of this study is to propose a novel perfusion mapping method independent of the deconvolution algorithm and to verify the accuracy of the proposed method compared with positron emission tomography (PET) images.

METHOD AND MATERIALS

The patient's brain was scanned using an area detector CT scanner (Aquilion ONE; Toshiba Medical). CT images were acquired at 80 kV and 80 mA. CTP source images (CTP-SI) were obtained at 1-s intervals using dynamic multiphase imaging. An early-phase image was generated by computing the average of CTP-SI for 5 s in the vicinity of the peak enhancement curve of the normal hemisphere. Similarly, a late-phase image was generated by computing the average of CTP-SI for 5 s immediately after the early phase. Finally, a new perfusion image (PI map) was generated dividing the late-phase image by the early-phase image. Twenty patients (12 men, 8 women; mean age: 66.8 years) with unilateral cervical and intracranial steno-occlusive disease underwent CTP. To investigate the validity of the PI map, PET-CBF was used as the gold-standard map. In addition, two conventional CTP maps (CBF) using deconvolution and PET-CBF were also compared for the lesion-to-normal rations. Standard singular value decomposition (SVDst) and block circulant singular value decomposition (SVDbc) were used to generate the conventional CTP maps.

RESULTS

The correlation between PET-CBF and the PI map was strongest in the three comparisons (PET-CBF vs. PI map: R = 0.82, PET-CBF vs. SVDst: R=0.62,PET-CBF vs. SVDbc: R=0.23)

CONCLUSION

The results suggested that the PI map would provide more robust information than conventional CTP maps in the diagnosis of ischemia.

CLINICAL RELEVANCE/APPLICATION

The simplicity and quantitativeness of PI mapping in ischemic stroke are advantageous compared to other perfusion evaluations for prognosis prediction and Propriety of revascularization.

PH249-SD-WEA5 Comparison of Three Different Protocols of CT Cardiac Imaging and CT Angiography as Pre-Procedural Assessment of Trans-Catheter Aortic Valve Implantation (TAVI): A Prospective Study

Station #5

Participants
George Masouris, Athens, Greece (*Presenter*) Nothing to Disclose
Euthimios Agadakos, Athens, Greece (*Abstract Co-Author*) Nothing to Disclose
Stavros Spiliopoulos, MD, PhD, Patra, Greece (*Abstract Co-Author*) Consultant, C. R. Bard, Inc Research funded, C. R. Bard, Inc
Konstantinos Flessas, Athens, Greece (*Abstract Co-Author*) Nothing to Disclose
Manolis Vavuranakis, Athens, Greece (*Abstract Co-Author*) Nothing to Disclose
Konstantinos Revenas, Athens, Greece (*Abstract Co-Author*) Nothing to Disclose
Alexandra Zormpala, Vrilissia, Greece (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

masouris_g@hotmail.com

CONCLUSION

We believe that for elderly patients with low risk of complications to CM, the ideal option is protocol 3 as it presents the most accurate assessment. For elderly patients with poor kidney function, we suggest protocol 2, which offers satisfactory heart imaging with a minimal dose of CM. In younger patients, where low radiation dose is vital, we suggest the protocol 1 for superior imaging of the vasculature or the protocol 2 in cases of renal impairment.

Background

TAVI has emerged as a technique for patients with high surgical risk. MSCT is increasingly employed for assessing the size of the vasculature, for assessing the landing zone of the trans-catheter valve and for the prevention of complications. We prospectively evaluated three different scanning protocols.

Evaluation

This is a prospective study in 10 patients. All CT acquisitions were conducted using a 128+ scanner. As per the protocol 1, ECG gating was applied for the CCTA but not for the CTA and a volume of 160ml CM. The acquisition method for the protocol 2 remained unchanged however the volume of the CM was reduced to 40ml. The protocol 3 was performed with ECG gating for both the CCTA and CTA and an 90-120ml volume of CM. We comparatively assessed the protocols in respect to the quality of the images and the radiation dose. The measurements were executed during the systolic and diastolic cardiac phase. Quantification of calcium in the landing zone and the coronary arteries was performed.

Discussion

Regarding the quality of the images, the radiation dose and the parameters of the aortic root between the systolic and diastolic phase, we found no statistically significant difference, except for the diameter of the aortic root, which was increased during the systolic phase. When we compared the distance between the lower edge of the coronary arteries and the aortic annulus with or without the stretched projection, we detected statistical significant difference in the size of the right coronary artery. We found no correlation between the calcium burden of the coronary arteries and that of the aortic root. Concerning the assessment of the vasculature, the usage of the stretched projection was not feasible for the second protocol.

PH250-SD-WEA6 Contribution of Mono-Exponential, Bi-Exponential and Stretched Exponential Model-Based Diffusion-Weighted MR Imaging in the Diagnosis of Prostate Cancer

Station #6

Participants
Wu Hui, Hohht, China (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

terrywuhui@sina.com

CONCLUSION

DDC, a and D may provide additional information and could lead to improved differentiation between PC and SH compared with conventional ADC .

Background

To investigate the potential of various diffusion parameters obtained from monoexponential, biexponential, and stretched exponential diffusion-weighted imaging (DWI) models in differentiating prostate cancer (PCa) and stromal prostate hyperplasia(SH).

Evaluation

Forty four patients with pathologically confirmed PC (n 24) or SH(n 20) underwent multi-b value DWI (13 b values : 0,10,25 ,50,75,100,150 200 ,400, 800,1200 ,1500 ,2000 s/mm2.) imaging MRI examinations were performed on a 3-T pelvic scan (Discovery 750, GE Healthcare, US). An apparent diffusion coefficient (ADC) was calculated from diffusion-weighted images by using monoexponential model. A pure diffusion (D), pseudo-diffusion (D*), and perfusion fraction (f) were calculated from diffusion-weighted images by using a biexponential model. A water molecular diffusion heterogeneity index (a) and distributed diffusion coefficient (DDC) were calculated from diffusion-weighted images by using a stretched exponential model. All parameters were compared between PC and SH by using independent t test. Receiver operating characteristic (ROC) to differentiate the diagnostic efficacy and correlation coefficient analysis were used for statistical evaluations.

Discussion

1. ADC, D,DDC and a values were significantly lower in the PC group than in the SH group ($P < 0.001$). D* value was significantly higher in the PC group than in the SH group ($P < 0.001$); however,f value was not statistically significant($P=0.507$);2. D, DDC, a, ADC have higher diagnostic performance, the area under the curve (AUC) values were 0.998, 0.994, 0.986, 0.985 respectively; the diagnostic threshold were 0.000765, 0.000978, 0.564, 0.000874; 3.ADC, D, DDC have a good correlation.

Participants
WEA7

Arm Artifact Reduction Techniques for Computed Tomographic Images: Has the Problem Been Overcome by Existing Techniques?

Station #7

Hiroki Kawashima, Kanazawa, Japan (*Presenter*) Nothing to Disclose
Katsuhiro Ichikawa, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Tadanori Takata, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

kawa3@med.kanazawa-u.ac.jp

TEACHING POINTS

1. To review current issues involving arm artifacts in computed tomography (CT) images of polytrauma patients with arms-down positioning. 2. To discuss existing artifact reduction techniques, including iterative reconstruction (IR) and demonstrate their limited effects. 3. To demonstrate causes of arm artifacts (arm-induced raw data noise: arm-noise). 4. To discuss and compare the usefulness of arm artifact reduction techniques in an algorithm with arm-noise filtering and in the latest IRs in terms of streak artifact reduction and side-effects of artifact reduction.

TABLE OF CONTENTS/OUTLINE

1. Arm artifacts in abdominal CT images of patients with arms-down positioning - Artifact appearance features - Influences of the artifacts on abdominal CT image quality - Existing artifact reduction techniques and IRs and their limitations 2. Cause of arm artifacts - Increased noise on arm trajectories and data errors by excessive attenuation in the projection data - Need for an algorithm that selectively reduces arm-noise 3. Arm artifact reduction algorithm combined with arm recognition - Explanation of the arm-noise filtering - Examples of original and processed images 4. Comparison of the usefulness of arm-noise filtering and the latest IRs - Streak artifact index - Comparison of side effects (image blurring)

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Participants
Thomas Oshiro, PhD, Los Angeles, CA (*Moderator*) Nothing to Disclose

Sub-Events

PH251-SD-WEB1 Calculation of Aortic Regurgitation Rate by Differential Analysis of Multi Location Time Enhancement Curve Using Test Injection in CT Examination

Station #1

Participants
Takuya Akagawa, MSc,RT, Komatsushima, Japan (*Presenter*) Nothing to Disclose
Sachiko Goto, PhD, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Ryutaro Matsuura, MSc, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiharu Azuma, PhD, Okayama, Japan (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

We consider that it is possible to quantitatively evaluate the aortic regurgitation ratio using comparison between maximum CT value of change speed of left atrium and ascending aorta by differential analysis of MLTEC (Multi Location Time Enhancement Curve) using application of TI (Test Injection) in CT examination.

Background

Usually, Aortic regurgitation is evaluated by echocardiography and Sellers classification. We propose the method of calculating an aortic-regurgitation rate by the derivative analysis of Multi Location Time Enhancement Curves (MLTEC) obtained from the test injection (TI) of CT examination. In this study aortic regurgitation rates before and after operation for the same patient of aortic regurgitation were calculated by using the differential analysis and the echo examination, and then the rates were compared.

Evaluation

CT examinations were performed with MDCT scanner (Aquilion ONE; TOSHIBA). The contrast material was injected 10 mL with the injection ratio 5 ml/s. The TI was scanned at 0.5 second intervals until the contrast agent reached the descending aorta before reaching the pulmonary artery. Fig. a shows the location of 4 ROIs simultaneously obtained in TI. Fig. b and Fig. d show the time enhancement curve in each ROI. Furthermore, the curves were differentiated to obtain the velocity variety curve of the blood concentration of a contrast material (Fig. c and e).

Discussion

It was suggested that the aortic regurgitation rate could be calculated by differential analysis of TECs of left atrium and ascending aorta, because increasing rate of CT value in ascending aorta is related to aortic regurgitation. Preoperative and postoperative results in the same patient with aortic regurgitation were compared in this study. In the pre-operative differentiated graph, the maximum CT value of change speed of ascending aorta was 48.2% lower than the left atrium indicated by the arrow (Fig. c). However, in the post-operative, the maximum CT value of change speed of ascending aorta was 18.1% lower than left atrium indicated by the arrow (Fig. e). It has been proved that the concentration of the contrast material injected bolus does not decrease because the blood reflux has disappeared.

PH252-SD-WEB2 Myocardial T1 Measurement and Relationship with Myocardial T2* at 3.0T MRI for Thalassemia Major Patients

Station #2

Participants
Aamish Kazi, MD, Mumbai, India (*Presenter*) Research collaboration, Koninklijke Philips NV
Bhavin Jankharia, MD, Mumbai, India (*Abstract Co-Author*) Nothing to Disclose
Stanley K. Pichai, Mumbai, India (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Tejas Shah, Bangalore, India (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Kurian Thomas, Gurgaon, India (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Jaladhar Neelavalli, Bangalore, India (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Indrajit Saha, PhD, Gurgaon, India (*Abstract Co-Author*) Employee, Koninklijke Philips NV

For information about this presentation, contact:

bhavin@jankharia.com

CONCLUSION

Native myocardial T1 at 3.0T is linearly correlated with myocardial T2* at 3.0T for patient population with TM.

Background

Use of myocardial T2* mapping at 1.5T MRI for indirect detection of iron deposition in thalassemia patients due to blood transfusional therapy and sickle cell disease has been clinically evaluated (Tanner et al. 2006). Previously, in a gerbil iron overload model, it has been demonstrated that myocardial T1 could serve as an alternative and probably more sensitive method for cardiac iron overload assessment (Wood et al. 2005). While studies at 1.5T (Feng et al. 2013) have already demonstrated a linear relationship between native T1 and T2* among thalassemia patients; a recent study has established the relationship between T1 at 3.0T and T2* at 1.5T (Alam et al. 2015). In this study, we aim to evaluate the relationship between native myocardial T1 and T2* at 3.0T among patients with Thalassemia Major (TM).

Evaluation

Myocardial T1 and T2* maps of 35 patients with TM (age 21 ± 16 years, 18 females), obtained at a 3.0T MRI scanner (Ingenia, Philips Health Systems, The Netherlands), were retrospectively analyzed for this study. The quantitative cardiac imaging protocol included standard ECG gated, multi-transmit RF enabled single breath-hold Modified Look-Locker Inversion recovery (MOLLI) sequence (5s(3s)3s) for native T1 quantification and a multi-echo gradient echo sequence for T2* quantification. T1 and T2* values were measured by manually selecting ROI on cardiac septum in a single short axis slice. Relation between the parameters was statistically evaluated through linear regression analysis with p-value < 0.05 set as significant.

Discussion

To our knowledge, this is the first report demonstrating a linear correlation between native myocardial T1 and T2* at 3.0T in the in vivo human heart of TM patients (r2 = 0.72, p-value < 0.05). This is similar to the behavior observed in studies carried out at 1.5T and indicates that myocardial T1 mapping at 3.0T MRI may serve as a complimentary metric to T2* mapping in assessing cardiac iron overload.

PH253-SD-WEB3 Reducing Variability of Radiation Doses in CT

Station #3

Participants
Ryan K. Lee, MD, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Joel Y. Sun, MD, Philadelphia, PA (*Presenter*) Nothing to Disclose
Terence A. Matalon, MD, Philadelphia, PA (*Abstract Co-Author*) Speaker, Koninklijke Philips NV
Samantha Lockerby, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose
Eric Soltycki, MS, Philadelphia, PA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

leeryan1@einstein.edu

CONCLUSION

Significant decrease of variance in head, chest, and abd/pelvis CT was achieved using a combination of standardizing protocols across the network and implementing advanced software that effectively managed radiation dose.

Background

While reducing radiation is an important goal, also important in the management of radiation dose is ensuring consistency in the amount of radiation administered for each type of study. Being able to consistently administer the same dose everytime a study is performed is the hallmark of high quality in radiation management. We implemented an approach to reducing variance in CT dose by standardizing protocols and employing software at the scanner to provide consistency across the network.

Evaluation

We measured variance of dose administered to head, chest, and abd/pelvis CT in two periods. The first period is pre-intervention: 1/1/13-7/31/14. We then measured the period after intervention: 1/1/16-12/31/16. Statistical analysis for differences in variability of radiation dose pre- and post-intervention used Bartlett's test. Pre-intervention dose and SD: head CT (n= 12,002): 26.4 CTDI with SD of 4.3; chest CT (n=3,149): 8.6 CTDI with SD of 5.2; abd/pelvic CT (n=9833) :12.5 CTDI with SD of 5.2. Post-intervention dose and SD: head CT (n=13,274): 20.1 CTDIvol with SD of 3.4; chest CT (n=3,746): 5.4 CTDI with SD of 2.7; abd/pelvis Ts (n=12,121): 7.7 CTDI with SD 3.3. Post intervention SD was significantly decreased for all studies (p<0.001).

Discussion

Our approach to reducing variability in radiation CT was a multifaceted approach: 1. Establishing the Radiation Dose Optimization Committee, 2. Standardizing Protocols, and 3. Implementing scanner software which reduces variance of dose. We implemented software in scanners that increases tube current to a lesser degree than would be obtained by hold noise constant. The software increases tube current for increasing diameter size at a rate less than would be needed to hold noise constant. Thus for larger patients,allowing for controlled increase in dose to improve signal to noise yet also accepting more noise allowed for better dose management avoiding exponential increase in radiation that occurs with conventional dose modulation.

PH254-SD-WEB4 TSE-Based DWI of the Prostate as an Alternative to SS-SE-EPI DWI

Station #4

Participants
Antonio Luna, MD, Jaen, Spain (*Presenter*) Consultant, Bracco Group; Speaker, General Electric Company; Speaker, Toshiba Medical Systems Corporation
Javier Sanchez, MD, PhD, Madrid, Spain (*Abstract Co-Author*) Nothing to Disclose
Teodoro Martin, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Lidia Alcala Mata, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Jordi Broncano, MD, Cordoba, Spain (*Abstract Co-Author*) Nothing to Disclose
Paula Montesinos de la Vega, Madrid, Spain (*Abstract Co-Author*) Employee, Koninklijke Philips NV

CONCLUSION

DWI TSE has a potential role as an alternative to SS-SE-EPI DWI in MR protocols for prostate cancer detection.

Background

DWI is a key MR imaging contrast for prostate cancer detection. In clinical practice, a SS-SE-EPI sequence is used. EPI readout is prone to geometrical distortion and susceptibility artifact due to the presence of air content within the rectum or metallic implants. These limitations make more difficult the proper spatial localization of the lesions. Also, the use of DWI to localize suspicious areas in targeted MR/ultrasound fusion guided biopsy is limited. Turbo Spin Echo-based DWI is proposed as a potential alternative to eliminate geometric distortion and local susceptibility artefacts. In this presentation, its geometric validation is performed to demonstrate spatial accuracy of DWI-TSE images compared with conventional DWI-SE-EPI sequence.

Evaluation

All images were acquired in a 3.0 T Achieva scanner (Philips Healthcare, The Netherlands) with a 16ch body coil on 15 patients with prostate cancer in targeted MR/ultrasound guided biopsy. On these patient, two DWI sequence were performed with equal b values (0, 1000 and 1500 s/mm2) wit DWI-SE-EPI (TR/TE=4500/90ms) and DWI-TSE (TR/TE=11173/131ms) sequences. DWI images were acquired in the same orientation of conventional TSE T2-weighted sequence. Both acquisitions shared equivalent spatial resolution (2.6x2.8x4.5 mm3) with no gap between slices. Total scan time was 118s and 290s for SS-SE-EPI and TSE respectively. ADC maps were calculated using b0 and b 1000 s/mm2 for both sequences. SNR and CNR were compared for all b values and ADC maps. Also, the presence of geometric distortion and susceptibility artifacts was recorded. Both sequences were also compared to target prostate biopsy using an specific MR/ultrasound fusion device.

Discussion

TSE-based DWI presented free geometric distorted images in all cases with similar CNR, although with a moderate increase in acquisition time. Also, this approach permits to delineate lesions for targeted biopsy with advantage over SS-SE-EPI DW-sequence due to good geometrical performance.

PH006-EB-WEB Ultra-Short Pulse Operation of Digital X-Ray Tubes with Carbon Nanotube Electron Emitters for High-Performance Medical Imaging

Hardcopy Backboard

Participants
Jin-Woo Jeong, PhD, Daejeon, Korea, Republic Of (*Presenter*) Nothing to Disclose
Jae-Woo Kim, PhD, Dae-Jeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Sora Park, PhD, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Jun-Tae Kang, MS, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Young Chul Choi, PhD, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Yoon-Ho Song, Daejeon, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

jinu@etri.re.kr

CONCLUSION

We could obtain ultra-short x-ray pulses from the digital x-ray tube based on CNT emitters. Applying this tube to CT, C-arm, or angiography will result in a clear image without motion blur while reducing unnecessary exposure to the patient.

FIGURE

https://abstract.rsna.org/uploads/2017/17017549/17017549_u9ps.jpg

Background

In order to minimize the motion blur in x-ray images of the object in continuous motion like a heart, it is necessary to increase frame rates for obtaining images. In addition, if it is difficult to remain without moving of object for a long time such as in the medical CT, x-ray imaging should be performed with a high frame rates for fast x-ray image acquisition. If x-ray is emitted strongly in a shorter time, a clearer image can be obtained with the same dose. It is also possible to minimize the radiation exposure to the patient if x-ray could be rapidly turned-on and off. Field emission x-ray tubes can easily implement these functions. This paper introduces ultra-short pulse operation, with a high current, of fully vacuum sealed x-ray tubes based on carbon nanotube (CNT) electron emitters.

Evaluation

We fabricated a stationary anode x-ray tube based on CNT emitters by using a vacuum brazing method. By controlling the cathode current, a sub-microseconds current pulse can be emitted from the CNT cathode, wherein the anode, focus and gate voltages are applied with constant voltages. In order to prevent the heat damage to the surface of tungsten target due to the accelerated focused electron beam, the cathode current is produced as a pulse packet consisting of ultra-short pulses with below microsecond, for example, a pulse packet of 1 ms composed of 1,000 ultra-short pulses with a width of 0.5 us.

Discussion

Figure 1 shows the variation of x-ray images of a lead wire of 1 mm diameter, rotating 3.6 degrees per second when x-ray pulse widths are 32, 16, 8 and 1 ms. As shown in the figure, the blurring due to the rotation of the lead wire decreases as the x-ray exposure time decreases. The decrease in the x-ray dose due to shorter pulse emission could be compensated by increasing the CNT cathode current, up to 200 mA for the x-ray tube. Furthermore, ultra-short pulse operation makes it possible to prevent the overheating of target surface.

PH007-EB-WEB A New Quantitative Index For the Noise Power Spectrum at CT: Correlation with Subjective Nodule Detectability on CT Images

Hardcopy Backboard

Participants
Toru Higaki, PhD, Hiroshima, Japan (*Presenter*) Nothing to Disclose
Fuminari Tatsugami, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuko Nakamura, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Chikako Fujioka, RT, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose

So Tsushima, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;
Makoto Iida, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

Even at the same image noise, when the NPS is changed on hybrid-IR, the diagnostic ability may be affected. The centroid of the NPS curve may be helpful for assessing image quality.

FIGURE

https://abstract.rsna.org/uploads/2017/17000849/17000849_3h4b.jpg

Background

Image noise (IN) on CT images is defined as the standard deviation from a CT number of a structurally uniform region. Although IN is often used to evaluate image quality, the evaluation of low-contrast detectability by IN is difficult because IN does not include information on the noise frequency. The noise power spectrum (NPS) is used for image quality assessment. We propose a new quantitative index for NPS and correlate it with quantitative analysis results for detecting hyperdensity nodules at CT.

Evaluation

We used a 3D printer (Agilista 3200, KEYENCE, Japan). Our phantom featuring a 3-, 6-, 9-, 12-, and 15-mm diameter cylindrical cavity filled with diluted contrast material (CM) (Iohexol) simulated hypervascular nodules. The contrast between the phantom base and diluted CM was adjusted to 5-, 10-, 15-, 20-, 25-, 50-, 75-, 100-, 150-, and 200 HU. The phantom was scanned on a 320-raw detector CT instrument (Aquilion ONE, TMSC, Japan) at 120 kV. We combined the tube current and reconstruction method so that the IN of reconstructed images was about 15 HU (100 mA with filtered back projection (FBP), 50 mA with hybrid-iterative reconstruction [h-IR, AIDR 3D (TMSC) level (LV) 1], 25 mA with h-IR LV2, and 10 mA with h-IR LV3 (Fig. 1). We measured NPSs for all reconstructed images (Fig. 2), and calculated the centroid of the NPS curves as a quantitative NPS value. Seven board-certified radiologists took observer performance tests to evaluate the detectability of the simulated nodules.

Discussion

The IN on images reconstructed with FBP, h-IR LV1, -LV2, and -LV3 was similar (15.7, 16.1, 15.5, and 15.9 HU, respectively). The NPSs were very different; the centroid of the NPS curves was 0.41, 0.32, 0.25 and 0.20, respectively. The ROC test showed that the area under the curve (AUC) of each reconstructed image was 0.81, 0.76, 0.74 and 0.72 (Fig. 3). Although the IN was similar, detectability varied widely. The correlation between the centroid of the NPS curve and the AUC for detectability was high (R2=0.99) (Fig. 4).

SSM20

Physics (MR: New Techniques)

Wednesday, Nov. 29 3:00PM - 4:00PM Room: S403A

MR PH

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

FDA Discussions may include off-label uses.

Participants
Timothy J. Carroll, PhD, Chicago, IL (*Moderator*) Nothing to Disclose
Geoffrey D. Clarke, PhD, San Antonio, TX (*Moderator*) Nothing to Disclose

Sub-Events

SSM20-01 Hyperpolarized Water as an Alternative MRI Contrast Agent

Wednesday, Nov. 29 3:00PM - 3:10PM Room: S403A

Participants
Sebastian Fischer, MD, Frankfurt, Germany (*Presenter*) Nothing to Disclose
Richard D. Maeder, Frankfurt, Germany (*Abstract Co-Author*) Nothing to Disclose
Maxim Terekhov, Mainz, Germany (*Abstract Co-Author*) Nothing to Disclose
Stefan Zangos, MD, Frankfurt Am Main, Germany (*Abstract Co-Author*) Nothing to Disclose
Thomas Prisner, Frankfurt, Germany (*Abstract Co-Author*) Nothing to Disclose
Thomas J. Vogl, MD, PhD, Frankfurt, Germany (*Abstract Co-Author*) Nothing to Disclose
Vasyl Denysenkov, Frankfurt, Germany (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

sebastian.fischer@kgu.de

CONCLUSION

Hyperpolarized water might be a promising future alternative to Gadolinium based contrast agents in MR angiography or even further diagnostics without risking the potential adverse effects or intracorporal remnants of Gadolinium based contrast agents.

Background

The administration of Gadolinium based contrast agents is associated with the risk of allergic reactions and the development of a systemic nephrogenic fibrosis (NSF). Current research showed remnants of some types of Gadolinium based MR contrast agents in the brain - with unknown long-term effects. Purpose of our work is the development of an alternative method to create MRI contrast by using dynamic nuclear polarization (DNP). The tested liquid-state Overhauser DNP is a technique to achieve hyperpolarization by microwave irradiation of electron spins in TEMPOL radicals, which are coupled with the nuclear spins of water molecules.

Evaluation

Our setup comprises a 42 GHz microwave source and an in-bore DNP polarizer, equipped with a multimode resonator inside a standard clinical 1.5 T scanner, which allows a continuous hyperpolarization of water molecules with a flow rate about 1.2 ml/min. In this work we characterized the performance of the DNP setup for MR imaging in various vascular models by comparing it to standard Gadolinium-based contrast media. We used 2D and 3D scan protocols with GRE- and VIBE-sequences for measurements, which feature up to a 30-fold signal enhancement of the hyperpolarized aqueous solution. A comparison to Gadolinium enhanced signals of physiologic intravascular conditions shows 12-fold enhancement rates and an increased absolute sensitivity.

Discussion

The used liquid state in-bore DNP setup creates hyperpolarized water, which features high T1 MR signal enhancements and a short relaxation time. SNR and CNR values were substantially improved by DNP and capillary diameters down to 75µm could be visualized. In our comparing experiments the hyperpolarized water showed an enhancement higher than gadolinium, which allows imaging down to small vascular structures in a standard clinical 1.5 T scanner.

SSM20-02 Intravoxel Incoherent Motion Diffusion-weighted Imaging of Bone Marrow Microstructure in Patients with Acute Leukemia

Wednesday, Nov. 29 3:10PM - 3:20PM Room: S403A

Participants
Jinliang Niu, MD, PhD, Taiyuan, China (*Presenter*) Nothing to Disclose
Hong Zhu, Taiyuan, China (*Abstract Co-Author*) Nothing to Disclose
Wenqi Wu, Taiyuan, China (*Abstract Co-Author*) Nothing to Disclose
Yang Wang, Taiyuan, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

wuwenqi198@163.com

PURPOSE

Intravoxel Incoherent Motion Diffusion-weighted Imaging of Bone Marrow Microstructure in Patients with Acute Leukemia

METHOD AND MATERIALS

28 patients with AL underwent MRI scans at 1.5T using conventional diffusion weighted imaging (DWI) and IVIM (b= 0, 10, 25, 50, 100, 200, 400, 600, 800, 1000, 1200s/mm2) in the sagittal plane covering the lumbar bone marrow before standard chemotherapy. The IVIM parameters (perfusion fraction [f], molecular diffusion coefficient [D], and perfusion-related D [D*] and apparent diffusion coefficient (ADC) were extracted from the bone marrow images. The microvessel density (MVD) and vascular endothelial growth factor(VEGF) was confirmed by bone marrow biopsy of the iliac crests, whichwere used to evaluate bone marrow microstructure. All patients were divided into complete remission (CR) and non-remission (NR) group according to the treatment response.

RESULTS

All patients underwent the first remission induction chemotherapy, with 19 patients achieved CR and 9 patients achieved NR.The ADC and D* values were not significant different between the two groups. However, D value of CR group was significantly higher (p=0.003), and f value of CR group was significantly lower (p=0.039) than those of NR group. Using receiver operator characteristic (ROC) analysis, the area under the curve (AUC) of D and f were 0.848 and 0.746 respectively in evaluating prognosis of AL before treatment. The fshowed significantly statistical correlations with MVD (r= 0.384) and VEGF (r= 0.439).

CONCLUSION

The D , f value ofbone marrow could play a potential role in prognosticating patients with AL. The f value could be used as noninvasive biomarkers to evaluate the microstructure bone marrow.

CLINICAL RELEVANCE/APPLICATION

Evaluation of bone marrow microstructure and prognosis of leukemia patients

SSM20-03 Auto-Calibrated Correlation Time Diffusion Brain qMRI and the Principle of Diffusional Homeostasis

Wednesday, Nov. 29 3:20PM - 3:30PM Room: S403A

Participants
Hernan Jara, PhD, Boston, MA (*Presenter*) Patent holder, qMRI algorithms; Royalties, World Scientific Publishing Co; ; ;
Stephan W. Anderson, MD, Cambridge, MA (*Abstract Co-Author*) Nothing to Disclose
Osamu Sakai, MD, PhD, Boston, MA (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

hjara@bu.edu

CONCLUSION

A fully automated and auto-calibrating DCT mapping algorithm has been developed and could be useful for aiding in the diagnosis of pathologic entities that disrupt diffusional homeostasis such as acute ischemic stroke.

Background

Standard diffusion MRI is based on the pulsed field gradient (PFG) experiment and probes molecular water motions at the 10-100millisecond time scale depending on experimental conditions. Despite the very different water micro-environment in gray matter (GM) and white matter (WM), one of the most remarkable findings of DPFG MRI is the near equality of the mean diffusivities of water in both tissues at diffusion times reported in the literature. Correlation time diffusion (DCT) MRI is based on T1 relaxometry and therefore probes water diffusion at the very short time scale of the correlation time: approximately 20ps for brain tissue. We hypothesize that the herein termed "*principle of diffusional homeostasis*" is valid at such short time scales and apply it to develop a self-calibrating DCT mapping algorithm whereby the one external model parameter -specifically, the magnetization transfer coupling constant (kappa in Fig. 1)-- is auto-determined by minimizing the WM-to-GM diffusional differences to within one half the standard deviation.

Evaluation

This is a HIPAA compliant prospective study approved by the local IRB that included ten patients without major abnormalities ranging in age from 2 to 87years. MR images acquired with the mixed turbo spin echo pulse (mixed-TSE) sequence were qMRI processed generating maps of T1, T2, and PD. These maps were used to generate DCT maps using an algorithm which calculates the pure correlation time without magnetization transfer effects. In all ten cases, the DCT maps were in quantitative agreement (<5%) with the DPFG maps for GM, WM, and cerebrospinal fluid.

Discussion

The developed fully auto-calibrating DCT mapping algorithm is based on the assumption of diffusional homeostasis, which is supported by a wealth of DPFG evidence in the healthy brain. Differences between DCT and DPFG may arise in pathologic conditions whereby the long time scale diffusion tissue properties may be abnormal via restricted diffusion.

SSM20-04 Metal Artifact Reduction for Myocardial Scar Assessment in Patients with Cardiac Implanted Electronic Devices Using Cardiac Magnetic Resonance

Wednesday, Nov. 29 3:30PM - 3:40PM Room: S403A

Participants
Jadranka Stojanovska, MD, MS, Ann Arbor, MI (*Presenter*) Consultant, Guerbet SA
El-Sayed H. Ibrahim, PhD, MSc, Ann Arbor, MI (*Abstract Co-Author*) Employee, General Electric Company
Yuxi Pang, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Maryam Ghadimi Mahani, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

Anil K. Attili, MD, Saline, MI (*Abstract Co-Author*) Nothing to Disclose
Thomas L. Chenevert, PhD, Ann Arbor, MI (*Abstract Co-Author*) Consultant, Koninklijke Philips NV

For information about this presentation, contact:

jstoanov@umich.edu

CONCLUSION

The developed wideband IR technique minimizes the CIED-generated hyperintensity artifacts without increasing scan time, and allows for accurate identification of arrhythmogenic substrate in VT patients.

Background

An important application of late gadolinium enhancement (LGE) cardiac magnetic resoncance (CMR) is assessment of myocardial scar in patients with ventricular tachycardia (VT) before ablation. LGE imaging in patients with cardiac implanted electronic devices (CIEDs) is challenging because of device-generated metal artifacts that compromise the effect of the inversion recovery (IR) pulse and obscure the region of interest. In 2016 we have performed 180 CMRs in patients with CIED at our institution. In this abstract we will discuss the use of modified IR technique to alleviate metal artifacts and improve diagnostic image quality.

Evaluation

The modified sequence includes a wideband IR pulse with adjustable frequency offset and bandwidth, which allows for optimal myocardial signal nulling in the presence of off-resonance effects. A phantom experiment was conducted on a 1.5T scanner using conventional and wideband IR sequences with different frequency offset and bandwidth (BW) values. Then, 20 patients (18 males, age=62±17) with CIEDs (8 Boston Scientific, 10 Medtronic, and 2 St Jude) were imaged on the same scanner using the conventional and optimized wideband LGE techniques prior to ablation. The imaging parameters were optimized for each patient. Conventional IR sequence resulted in severe artifacts that obscured ventricular segments in 15 out of 20 patients. The wideband IR sequence significantly minimized the artifacts. Optimal BW was in the range of 2000-3000Hz with optimal frequency shift up to 1000Hz.

Discussion

Increasing the IR frequency BW results in better artifact reduction, although this comes at the cost of incomplete myocardial nulling. So, BW should be set to the minimum value that eliminates the artifact, which is affected by the device type and location. Similarly, the frequency offset of the IR pulse affects the artifact appearance, so proper setting of the frequency offset could allow for removing the artifact without the need to increase the frequency BW.

SSM20-05 TSE-Based DWI of the Prostate as an Alternative to SS-SE-EPI DWI

Wednesday, Nov. 29 3:40PM - 3:50PM Room: S403A

Participants
Antonio Luna, MD, Jaen, Spain (*Presenter*) Consultant, Bracco Group; Speaker, General Electric Company; Speaker, Toshiba Medical Systems Corporation
Paula Montesinos de la Vega, Madrid, Spain (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Lidia Alcala Mata, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Teodoro Martin, MD, Jaen, Spain (*Abstract Co-Author*) Nothing to Disclose
Jordi Broncano, MD, Cordoba, Spain (*Abstract Co-Author*) Nothing to Disclose
Javier Sanchez, MD, PhD, Madrid, Spain (*Abstract Co-Author*) Nothing to Disclose

CONCLUSION

DWI TSE has a potential role as an alternative to SS-SE-EPI DWI in MR protocols for prostate cancer detection.

Background

DWI is a key MR imaging contrast for prostate cancer detection. In clinical practice, a SS-SE-EPI sequence is used. EPI readout is prone to geometrical distortion and susceptibility artifact due to the presence of air content within the rectum or metallic implants. These limitations make more difficult the proper spatial localization of the lesions. Also, the use of DWI to localize suspicious areas in targeted MR/ultrasound fusion guided biopsy is limited. Turbo Spin Echo-based DWI is proposed as a potential alternative to eliminate geometric distortion and local susceptibility artefacts. In this presentation, its geometric validation is performed to demonstrate spatial accuracy of DWI-TSE images compared with conventional DWI-SE-EPI sequence.

Evaluation

All images were acquired in a 3.0 T Achieva scanner (Philips Healthcare, The Netherlands) with a 16ch body coil on 15 patients with prostate cancer in targeted MR/ultrasound guided biopsy. On these patient, two DWI sequence were performed with equal b values (0, 1000 and 1500 s/mm2) wit DWI-SE-EPI (TR/TE=4500/90ms) and DWI-TSE (TR/TE=11173/131ms) sequences. DWI images were acquired in the same orientation of conventional TSE T2-weighted sequence. Both acquisitions shared equivalent spatial resolution (2.6x2.8x4.5 mm3) with no gap between slices. Total scan time was 118s and 290s for SS-SE-EPI and TSE respectively. ADC maps were calculated using b0 and b 1000 s/mm2 for both sequences. SNR and CNR were compared for all b values and ADC maps. Also, the presence of geometric distortion and susceptibility artifacts was recorded. Both sequences were also compared to target prostate biopsy using an specific MR/ultrasound fusion device.

Discussion

TSE-based DWI presented free geometric distorted images in all cases with similar CNR, although with a moderate increase in acquisition time. Also, this approach permits to delineate lesions for targeted biopsy with advantage over SS-SE-EPI DW-sequence due to good geometrical performance.

SSM20-06 Measuring Frequency Drift in MR Spectroscopy on a 3 T MRI

Wednesday, Nov. 29 3:50PM - 4:00PM Room: S403A

Participants

Gregory A. Book, MS, Hartford, CT (*Presenter*) Nothing to Disclose
Alecia D. Dager, PhD, Hartford, CT (*Abstract Co-Author*) Nothing to Disclose
Malgorzata Marjanska, PhD, Minneapolis, MN (*Abstract Co-Author*) Nothing to Disclose
Godfrey Pearlson, MD, Hartford, CT (*Abstract Co-Author*) Consultant, Astellas Group

For information about this presentation, contact:

gregory.book@hhchealth.org

gregory.book@hhchealth.org

CONCLUSION

Change in gradient temperature from heavy usage negatively impacts scanning quality for MRS sequences. Methods exist to compensate for frequency drift, but significant drift can still negatively impact quantification of the metabolite concentrations due to the poor water suppression. Quantifying the time required for gradients to stabilize after intense use, in this example of a Siemens Skyra 3 T, can inform scheduling of MRS studies to maximize their stability, and reduce the need for drift correction tools.

Background

MR spectroscopy (MRS) is susceptible to frequency drift caused by gradient warming, more so than other MR imaging modalities. Frequent switching of gradients in fMRI and DTI causes heating and the frequency of the magnet to change in an unpredictable way. Frequency drift in functional brain imaging can cause spatial drift over time, especially in the z direction, but is easily corrected by realignment. Frequency drift in MRS degrades the water suppression and quality of the spectrum through increased linewidth. We examine the effects of gradient heating on frequency drift and map the time required for gradients to stabilize on a specific magnet.

Evaluation

Drift was tested on a Siemens 3 T Skyra MRI, with a 32-channel receive-only head-coil, standard gradients, and an MRS phantom. Using a PRESS sequence, transmitter voltage and water suppression flip angle were adjusted to produce optimal water suppression. At 10 minute intervals over a period of 3 hours, magnet frequency was adjusted to convergence and the new frequency recorded. Two 9 min fMRI sequences (TR = 700ms) were run starting 20 minutes after initial frequency measurement.

Discussion

Frequency drift was negligible prior to perturbation of gradients from fMRI, but increased 5.6Hz/min to a peak of 70 Hz above baseline after the second fMRI sequence. Frequency returned to baseline 120 minutes after completion fMRI at a rate of 0.83 Hz/min for the first 60 minutes. Spectra collected using LASER sequence after perturbation showed significant drift, and spectra collected before perturbation showed no drift.

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RC621

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

Thursday, Nov. 30 8:30AM - 10:00AM Room: N229

CT PH SQ

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

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

For information about this presentation, contact:

samei@duke.edu

LEARNING OBJECTIVES

1) Understand the basic components of CT performance evaluation. 2) Understand the difference between basic and operational performance of CT. 3) Understand the methods to characterize iterative reconstruction, tube current modulation, and task specific noise and resolution.

Sub-Events

RC621A Dose and Risk Characterization

Participants
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

For information about this presentation, contact:

samei@duke.edu

LEARNING OBJECTIVES

1) Understand the metrics of dose and risk in CT imaging. 2) Understand methods to estimate organ dose. 3) Understand the relevance of CT dosimetry to operational performance.

RC621B Image Quality Estimation

Participants
Guang-Hong Chen, PhD, Madison, WI (*Presenter*) Research funded, General Electric Company Research funded, Siemens AG

For information about this presentation, contact:

gchen7@wisc.edu

LEARNING OBJECTIVES

1) To understand the potential consequences of the nonlinear model based image reconstruction on image quality assessment in terms of spatial resolution assessment, noise power spectra, task-based CT protocol optimization.

RC621C Performance Evaluation, TG233

Participants
Ehsan Samei, PhD, Durham, NC (*Presenter*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC

For information about this presentation, contact:

samei@duke.edu

LEARNING OBJECTIVES

1) Understand the basic components of CT performance evaluation in terms of basic as well as operational performance. 2) Understand the methods to characterize task based performance of CT. 3) Understand methods to characterize tube current modulation.

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RC622

Imaging for Proton Treatment Planning

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

RO PH

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

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

ABSTRACT

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

Sub-Events

RC622A Uncertainties in Imaging for Proton Therapy Dose Calculations

Participants
Andrew Wroe, PhD, Loma Linda, CA (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Describe the Bragg peak and the impact this has on treatment delivery. 2) Understand proton therapy clinical workflow. 3) Discuss imaging modalities used for proton therapy treatment planning. 4) Describe the CT number to proton stopping power calibration. 5) Understand sources of range uncertainty in proton therapy. 6) Discuss alternate imaging modalities that may impact proton range uncertainty.

RC622B Uncertainties in Motion for Treatment Planning

Participants
Heng Li, Houston, TX (*Presenter*) Research funded, Varian Medical Systems, Inc

LEARNING OBJECTIVES

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

RC623

Evolving Perspectives on Ultrasound Safety

Thursday, Nov. 30 8:30AM - 10:00AM Room: S504AB

PH SQ US

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

Participants
J. Brian Fowlkes, PhD, Ann Arbor, MI (*Director*) Equipment support, Koninklijke Philips NV; Equipment support, General Electric Com;pany; Equipment support, Toshiba 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

RC623A Ultrasound Safety: Understanding the Potential Bioeffects

Participants
J. Brian Fowlkes, PhD, Ann Arbor, MI (*Presenter*) Equipment support, Koninklijke Philips NV; Equipment support, General Electric Com;pany; Equipment support, Toshiba 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/2017/17000402/Active RC623A.pdf

RC623B Ultrasound Safety: What You Should Tell the Clinicians

Participants
Jacques S. Abramowicz, MD, Chicago, IL (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

jabramowicz@bsd.uchicago.edu

LEARNING OBJECTIVES

View Learning Objectives under main course title

Active Handout:Jacques S. Abramowicz

http://abstract.rsna.org/uploads/2017/17000403/Active RC623B.pdf

RC623C Diagnostic Ultrasound Regulation: Substantial Equivalence, Novel Technologies, and Reasonable Assurance of Safety and Effectiveness

Participants
Shahram Vaezy, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) Understanding the mission of the Center for Devices and Radiological Health (CDRH). 2) protection and promotion of the public health: Access to safe and effective medical devices, Facilitating medical device innovation. 3) Understanding diagnostic ultrasound premarket review of safety and effectiveness. 4) Elements of regulatory review: Intended use, Technological characteristics, Performance data, Labeling. 5) Class II medical devices and premarket notification (510(k) submissions): Safety and effectiveness for establishing substantial equivalence, Clearance for marketing. 6) Class III medical devices and premarket approval (PMA submissions): Safety and effectiveness, classification regulation, level of risk, Approval for marketing. 7) The de-novo classification

for devices with novel technologies: Not substantially equivalent, Risk-based classification. 8) Understanding post-market activitie. 9) Compliance: Medical device report (MDR), Recalls, Facility inspections. 10) Understanding FDA resources/information. 11) Code of Federal Regulation (CFR). 12) Consensus standards. 13) General controls and Special Controls. 14) FDA communications and website. 15) Pre-submissions.

Active Handout:Shahram Vaezy

http://abstract.rsna.org/uploads/2017/17000405/Active RC623C.pdf

RC625

Quantitative Imaging Mini-Course: Image Modality Specific Issues

Thursday, Nov. 30 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; ; ; ; ;

Sub-Events

RC625A Quantitative Imaging for Computed Tomography: Applications and Future Directions

Participants
Samuel G. Armato III, PhD, Chicago, IL (*Presenter*) Consultant, Aduro Biotech, Inc

RC625B Quantitative Imaging for PET-CT: Applications and Future Directions

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

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.

RC625C Quantitative Imaging for DCE-MRI: Applications and Future Directions

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

LEARNING OBJECTIVES

1) To understand QA, acquisition and quantification processes of DCE MRI to derive physiological parameters. 2) To understand clinical applications of quantitative DCE MRI. 3) To understand limitations of quantitative DCE MRI and future directions.

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SSQ18

Physics (Quantitative Image Analysis)

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

BQ CT PH

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

FDA Discussions may include off-label uses.

Participants

Maryellen L. Giger, PhD, Chicago, IL (*Moderator*) Stockholder, Hologic, Inc; Stockholder, 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, Toshiba Medical Systems Corporation
Bram Van Ginneken, PhD, Nijmegen, Netherlands (*Moderator*) Stockholder, Thirona BV Co-founder, Thirona BV Research Grant, MeVis Medical Solutions AG Research Grant, Delft Imaging Systems Research Grant, Toshiba Corporation

Sub-Events

SSQ18-01 Feasibility of Multi-Reference-Tissue Normalization of T2-Weighted Prostate MRI

Thursday, Nov. 30 10:30AM - 10:40AM Room: S403B

Participants
Laura I. Stoilescu, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Henkjan Huisman, PhD, Nijmegen, Netherlands (*Presenter*) Shareholder QView Medical

For information about this presentation, contact:

henkjan.huisman@radboudumc.nl

PURPOSE

To explore a novel multi-reference-tissue normalization method applied to t2-weighted prostate MRI.

METHOD AND MATERIALS

Assuming the availability of a set of distinct reference tissue segmentations, the hypothesis is that it allows computing a patient specific sequence model that can normalize MRI. The normalization should produce similar scalar values in the same reference regions for different patients/scanners/sequences and interpolate in between reference values for other tissue areas. Regions of interest (ROI) were drawn in four distinct tissue types in a cohort of sixty-five t2-weighted images from regular multiparametric prostate MRI (mpMRI). The four reference tissue types were: skeletal muscle, body fat, femur head, bladder lumen. Four average ROI signals were computed per patient. Each reference tissue was assigned a fixed reference value (t2 relaxation found in literature). Per patient, a smooth sequence model was fitted to the (average, reference) pairs. The estimated sequence model was then inverted to map patients' raw t2-weighted image scalar values to normalized values. To test the method, the effect of normalization on observed variance and tissue discriminability was analyzed. A leave-one-out experiment was performed in which for each ROI its normalized value was computed using the sequence model estimate using the three remaining reference ROIs. The difference between original t2-weighted and normalized scalar MRI was analyzed by means of variability and ROC analysis.

RESULTS

Multi-reference-tissue normalization significantly ($p<0.05$) decreased variability and increased the area under the ROC curve for discriminating each reference tissue combination. The ROC curves in the figure show the effect of the normalization (T2-n) on the discrimination between body fat and femur head tissue.

CONCLUSION

Semi-automatic multi-reference-tissue normalization shows reduced inter-patient variability and may allow better quantitative discrimination between tissue types.

CLINICAL RELEVANCE/APPLICATION

Multi-reference-tissue t2-weighted MRI normalization seems feasible. In combination with automatic segmentation, this could be providing clinical quantitative imaging support to mpMRI diagnosis of prostate cancer. This result motivates us to continue to explore the ability of this novel method to help detect and discriminate prostate cancer in mpMRI.

SSQ18-02 Automatic Algorithm for Joint Morphology Measurements in Volumetric Musculoskeletal Imaging

Thursday, Nov. 30 10:40AM - 10:50AM Room: S403B

Participants
Michael Brehler, Baltimore, MD (*Presenter*) Research Grant, Carestream Health, Inc
Gaurav K. Thawait, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Qian Cao, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose

Jonathan Kaplan, Natick, MA (*Abstract Co-Author*) Nothing to Disclose
John Ramsay, Natick, MA (*Abstract Co-Author*) Nothing to Disclose
John Yorkston, PhD, Penfield, NY (*Abstract Co-Author*) Employee, Carestream Health, Inc
Shadpour Demehri, MD, Baltimore, MD (*Abstract Co-Author*) Research support, General Electric Company; Research Grant, Carestream Health, Inc; Consultant, Toshiba Corporation;
Jeffrey H. Siewerdsen, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Siemens AG; Research Grant, Carestream Health, Inc; Advisory Board, Siemens AG; Advisory Board, Carestream Health, Inc; License agreement, Carestream Health,Inc; License agreement, Precision X-Ray, Inc; License agreement, Elekta AB; ; ;
Wojciech Zbijewski, PhD, Baltimore, MD (*Abstract Co-Author*) Research Grant, Carestream Health, Inc; Research Grant, Siemens AG

PURPOSE

An automated algorithm was developed for measurements of bone morphology and joint alignment in volumetric musculoskeletal imaging. The algorithm was applied to evaluation of the weight-bearing tibiofemoral and patellofemoral joints using a dedicated extremity cone-beam CT (CBCT) system.

METHOD AND MATERIALS

Weight-bearing CBCT scans were acquired from 24 healthy subjects at ~12 mGy dose; reconstructed field of view was 20x20x30 cm3 with 0.56 mm isotropic voxels. Anatomical landmarks on tibia, femur, and patella were set by an expert radiologist for the following metrics: Medial Tibial Depth (MTD), Tibial Tuberosity-Trochlear Groove (TTTG) distance, and Insall-Salvati-Ratio (ISR). The automated algorithm uses three sets of atlas volumes, one for each of the bones. The atlases are annotated with pertinent anatomical landmarks according to expert reader consensus. The atlas volumes are first registered (individually for each bone) to the analyzed volume using Mattes mutual information and similarity transforms. The best fitting atlas images are then selected, and their bone surfaces are deformably registered to the corresponding bones in the analyzed volume. No segmentation of the analyzed volume is necessary. The transforms found in the registration are then applied to the atlas landmarks to compute the anatomical metrics.

RESULTS

The deviation of the anatomical landmarks found by the algorithm from the locations selected by the expert reader are within the range of intra-reader variability (~1 mm). The automated algorithm achieved high level of agreement with expert radiologist readings in leave-one-out evaluation of the anatomical metrics, with ICC of 1.0, 0.93, and 0.97 for TTTG, ISR, and MTD, respectively. The RMSE of the metrics sharply decreases with increasing number of atlas images, achieving RMSE of less than 0.5 mm for TTTG and MTD less than 0.2 [a.u.] for ISR when 15 atlas images are used for each bone.

CONCLUSION

The algorithm achieved high correlation with expert radiologist readings, providing quantitative assessment of the complex, multi-body anatomy of the joints in support of orthopedic diagnosis and surgical planning.

CLINICAL RELEVANCE/APPLICATION

An automatic algorithm for image-based anatomical measurements in musculoskeletal radiology supports quantitative assessment of joint morphology in diagnostic and surgical applications.

SSQ18-03 A Contrast-to-Noise Ratio for Clinical Mammographic Images

Thursday, Nov. 30 10:50AM - 11:00AM Room: S403B

Participants
Melissa L. Hill, PHD, Issy les Moulineaux, France (*Presenter*) Consultant, Volpara Health Technologies Limited
Nabeel Khan, PhD, Wellington, New Zealand (*Abstract Co-Author*) Employee, Volpara Health Technologies Limited
Kaier Wang, PhD, Wellington, New Zealand (*Abstract Co-Author*) Employee, Volpara Health Technologies Limited
Alistair Mackenzie, PHD, Guildford, United Kingdom (*Abstract Co-Author*) Research collaboration, Volpara Health Technologies Limited
Ralph P. Highnam, PhD, Wellington, New Zealand (*Abstract Co-Author*) CEO, Matakina Technology Limited CEO, Volpara Solutions Limited

For information about this presentation, contact:

melissa.hill@volparasolutions.com

PURPOSE

Image quality estimation directly from clinical mammograms rather than from phantom images would allow for patient-specific and 'real-time' monitoring of complete system performance. This study evaluates a novel method to estimate a contrast-to-noise ratio (CNR) directly from mammograms.

METHOD AND MATERIALS

The novel CNR uses a noise estimation from the compressed breast region that minimizes the influence tissue characteristics, while a signal difference between pixels with known tissue compositions serves as an alternative to the difference between a phantom contrast feature and uniform background. For initial validation, a phantom with 0.2 mm Al and 2-8 cm PMMA was imaged with technique factors to match automatic exposure control (AEC)-acquisition on the GE Senographe Essential, and in combo-mode (FFDM & DBT) on the Hologic Selenia Dimensions. CNR measured from phantom images per EUREF guidelines was compared to CNR determined using noise estimated by the proposed method. The novel CNR was calculated for AEC-acquired clinical images and plotted against compressed thickness following typical analysis of AEC performance. The dataset included 274 Hologic Selenia Dimensions combo-mode images and 80 GE Senographe Essential FFDM images. Phantom and clinical images were acquired on different machines. Version 1.5.3.0 of the VolparaDensity algorithm was applied to measure tissue composition.

RESULTS

The correlation was excellent between the EUREF-derived and novel CNR for phantom images, with Pearson coefficients over 0.99. The trends between mammographic image CNR and thickness correspond well to the phantom-verified relationships, with differences in phantom and mammographic CNR magnitudes largely resulting from the different contrast materials and methodologies, along with some variability from machine-specific performance.

CONCLUSION

A novel CNR measure was assessed using phantom and clinical mammographic images. The validation results show promise for the ability to avoid signal variations due to tissue structure, while extracting system-dependent data to make objective CNR estimates. Future work will assess clinical image CNR sensitivity to variations in acquisition parameters.

CLINICAL RELEVANCE/APPLICATION

To our knowledge this is the first description of an objective CNR measure that can be made directly from mammographic images, thereby enabling real-time and patient-specific image quality evaluation.

SSQ18-04 Framework for Automatic 3D Coronary Artery Vessel Wall Segmentation from Coronary CT Angiography

Thursday, Nov. 30 11:00AM - 11:10AM Room: S403B

Participants
Ahmed M. Ghanem, PhD, Bethesda, MD (*Presenter*) Nothing to Disclose
Ahmed H. Hamimi, MD , Chevy Chase, MD (*Abstract Co-Author*) Nothing to Disclose
Jatin R. Matta, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Reham M. Elgarf, BDS, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Ahmed M. Gharib, MBChB, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose
Khaled Z. Abd-Elmoniem, PhD, Bethesda, MD (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To develop a framework for automated 3D segmentation of the coronary vessel wall and atherosclerotic plaque in the three major coronary artery vessels using level sets and centerline as a guide. To overcome premature termination of coronary segmentation caused by poor contrast, motion artifacts, and severe stenosis.

METHOD AND MATERIALS

The proposed framework computes the vesselness and, with the original 3D coronary image, obtains an initial lumen contour via region growing. Next, a level set energy function is minimized to segment the lumen boundaries. Subsequently, the segmented lumen is utilized as the initial vessel outer boundaries. A second level set energy function segments the final outer wall using a specific sigmoid feature image. The lumen and vessel boundaries are joined to create the coronary wall. Once the wall is segmented, curved multiplanar reformation is used to straighten the segmented lumen and wall using the lumen centerline. Coronary CTA data were acquired from 41 asymptomatic CAD subjects. Images were read by a radiologist to identify the segments of adequate diagnostic image quality and the extent of atherosclerosis plaque burden therein including plaque presence, type, volume, and luminal stenosis severity. Wall and plaque volumes were segmented using the framework and compared to an expert radiologist's manual delineation. The evaluation dataset contained 122 plaques of different characteristics.

RESULTS

Agreement between automatic and radiologist segmentation improved was a function of plaque. For small, mild, medium, and large plaques, mean±SD similarity DICE coefficient between segmented and radiologist's delineation was 86±13%, 90±10%, 95±5%, and 95±6%, respectively. Relative volume difference was 7.3±7.3%, 5.2±5.2%, 4.9±3.9%, and 4.1±5.4%, respectively. The p-values from a paired t-test comparing the radiologist to framework segmentation volumes were p=0.72 for small, p=0.76 for mild, p=0.89 for medium, and p<<0.93 for large plaques.

CONCLUSION

Automatic CTA coronary wall segmentation that is highly similar to radiologist's manual delineation is feasible, which thus is promising for accelerated, reliable, and reproducible atherosclerotic plaque characterization.

CLINICAL RELEVANCE/APPLICATION

Automatic segmentation of CTA coronary wall improves objective quantification of coronary atherosclerotic plaque beyond subjective assessment of stenosis and potentially applicable for monitoring response to therapy.

SSQ18-05 CT Coronary Calcium Scoring with Tin Filtration Using Iterative Beam-Hardening Calcium Correction Reconstruction

Thursday, Nov. 30 11:10AM - 11:20AM Room: S403B

Participants
Marwen Eid, MD, Charleston, SC (*Presenter*) Nothing to Disclose
Christian Tesche, MD , Charleston, SC (*Abstract Co-Author*) Nothing to Disclose
Moritz H. Albrecht, MD, Charleston, SC (*Abstract Co-Author*) Nothing to Disclose
Carlo N. De Cecco, MD, PhD, Charleston, SC (*Abstract Co-Author*) Research Grant, Siemens AG
Domenico De Santis, MD, Charleston, SC (*Abstract Co-Author*) Nothing to Disclose
U. Joseph Schoepf, MD, Charleston, SC (*Abstract Co-Author*) Research Grant, Astellas Group; Research Grant, Bayer AG; Research Grant, General Electric Company; Research Grant, Siemens AG; Research support, Bayer AG; Consultant, Guerbet SA; ; ;
John W. Nance JR, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Akos Varga-Szemes, MD, PhD, Charleston, SC (*Abstract Co-Author*) Research Grant, Siemens AG
Taylor M. Duguay, Charleston, SC (*Abstract Co-Author*) Nothing to Disclose
Thomas Allmendinger, Forchheim, Germany (*Abstract Co-Author*) Employee, Siemens AG
Christian Canstein, Charleston, SC (*Abstract Co-Author*) Employee, Siemens AG
Domenico Mastrodicasa, MD, Charleston, SC (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

schoepf@musc.edu

PURPOSE

To investigate the diagnostic accuracy of CT coronary artery calcium scoring (CACS) with tin pre-filtration (Sn100kVp) using

To investigate the diagnostic accuracy of CT coronary artery calcium scoring (CACS) with tin pre-filtration (Sn100kVp) using iterative beam-hardening correction (IBHC) calcium material reconstruction compared to the standard 120kVp acquisition.

METHOD AND MATERIALS

In an IRB-approved, HIPAA compliant prospective study, 62 patients (56% male, age 63.9±9.2years) underwent a clinically-indicated CACS acquisition using the standard 120kVp protocol and an additional Sn100kVp CACS research scan. Datasets of the Sn100kVp scans were reconstructed using a dedicated spectral IBHC CACS reconstruction to restore the spectral response of 120kVp spectra. Agatston scores were derived from 120kVp and IBHC reconstructed Sn100kVp studies. Pearson`s correlation coefficient was assessed and Agatston score categories and percentile-based risk categorization were compared.

CONCLUSION

Low voltage CACS with tin filtration using a dedicated IBHC CACS material reconstruction algorithm shows excellent correlation and agreement with the standard 120kVp acquisition regarding Agatston score and cardiac risk categorization, while radiation dose is significantly reduced by 75% to the level of a chest x-ray.

CLINICAL RELEVANCE/APPLICATION

Low x-ray tube voltage third generation dual-source CT CACS paired with tin pre-filtration and iterative beam-hardening correction calcium material reconstruction allows for coronary artery calcium quantification in excellent correlation with standard protocols, albeit at a fraction of the radiation dose. This approach thus seems well suited for a screening test in a priori healthy individuals.

SSQ18-06 Robustness Evaluation of RA-950 Scoring in a Cohort of CT Lung Screening Patients Across a Large Range of CT Acquisition and Reconstruction Conditions

Thursday, Nov. 30 11:20AM - 11:30AM Room: S403B

Participants
John M. Hoffman, BS, Los Angeles, CA (*Presenter*) Nothing to Disclose
Hyung J. Kim, PhD, Los Angeles, CA (*Abstract Co-Author*) Research Consultant, MedQIA
Jonathan G. Goldin, MBChB, PhD, Los Angeles, CA (*Abstract Co-Author*) Nothing to Disclose
Matthew S. Brown, 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; ; ; ; ;

For information about this presentation, contact:

jmhoffman@mednet.ucla.edu

PURPOSE

Interest in quantitative evaluation of images is high, however variation in imaging protocols raises questions about the reliability of utilized metrics. In this study we investigate the multivariate effects of CT acquisition and reconstruction parameters on emphysema scoring in CT lung screening.

METHOD AND MATERIALS

30 clinical lung screening scans were selected from an in-house archive that contains raw projection data. Reduced dose acquisitions were simulated at 50%, 10%, and 5% of clinical dose (~2mGy CTDIvol) by adding noise to the raw data. Full-dose and reduced-dose acquisitions were then reconstructed using the open-source software "FreeCT_wFBP" at slice thicknesses of 0.6, 1, 2, and 5mm using smooth, medium and sharp kernels for a total of 48 reconstructions per patient. To score emphysema, a density mask was applied with -950HU as the threshold (RA-950 score), and for each parameter configuration, change in RA-950 relative to a reference (100% dose, 1.0mm slice thickness, medium kernel; chosen for similarity to clinical protocols) was calculated and averaged across the population.

RESULTS

Only 21 of 48 (44%) configurations produced scores within ±5% of the reference suggesting limitations to the range of acceptable parameters for quantitative emphysema evaluation. Configurations using the sharp kernel, the 0.6 mm slice thickness, or doses below 50% of the clinical reference consistently produced scores very different than reference. Protocols producing higher image noise resulted in higher RA-950 scores. With slice thicknesses >=1.0mm and the smooth or medium kernel, the 50% dose configuration results in RA-950 comparable to reference. Patient-specific surface plots revealed that change in RA-950 as a function of reconstruction parameter strongly depends on the amount of emphysema measured at reference.

CONCLUSION

As quantitative evaluation of COPD increases and efforts to reduce CT dose continue, changes in protocol are likely. This study shows that reliable quantitative emphysema evaluation is possible with further dose reduction (to ~1mGy) when combined with appropriate reconstruction parameters, however care must be taken to prevent parameter-dependent changes in the measured score.

CLINICAL RELEVANCE/APPLICATION

Establishing protocols for reliable quantitative metrics is critical for the use of clinical quantitative imaging. This study assesses and provides guidance on RA-950 scoring for the evaluation of emphysema.

SSQ18-07 Fully Automatic Measurement of the Splenic Volume in CT with U-Net Convolutional Neural Networks

Thursday, Nov. 30 11:30AM - 11:40AM Room: S403B

Participants
Joris Bukala, MSc, Nijmegen, Netherlands (*Presenter*) Nothing to Disclose
Gabriel Efrain Humpire Mamani, Nijmegen, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Ernst T. Scholten, MD, Haarlemmerliede, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Mathias Prokop, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Speakers Bureau, Bayer AG; Speakers Bureau, Bracco Group; Speakers Bureau, Toshiba Medical Systems Corporation; Research Grant, Toshiba Medical Systems Corporation;
Bram Van Ginneken, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Stockholder, Thirona BV Co-founder, Thirona BV Research

Grant, MeVis Medical Solutions AG Research Grant, Delft Imaging Systems Research Grant, Toshiba Corporation
Colin Jacobs, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Research Grant, Varian Medical Systems, Inc

For information about this presentation, contact:

joris.bukala@radboudumc.nl

PURPOSE

To develop a fully automatic deep learning method for 3D segmentation of the spleen on computed tomography (CT) scans and to compare the automatically measured spleen volume with the standard splenic index approximation formula that requires three 2D manual measurements.

METHOD AND MATERIALS

145 CT thorax-abdomen scans were collected from our institute. All scans were contrast enhanced and acquired with a slice thickness of 1 or 2 mm. The spleens were manually segmented in 3D by trained human observers in all scans. We used 100 scans for training and 45 scans as an independent test set. In the test set, the standard approximation formula was applied by a human observer to get an estimation of the splenic volume. The system fully analyzes the entire thorax-abdomen CT scan to segment the exact location of the spleen, without any need for pre-processing. Multiple U-net convolutional neural networks were trained for different orthogonal directions using the training data set. A validation set consisting of 30% of the training data was used to optimize the hyperparameters of the neural network. A dedicated hard mining selection strategy was employed to improve the learning process. The predictions of the U-nets were averaged and subsequently thresholded to obtain a 3D spleen segmentation. The mean absolute error of the splenic volume was used to measure the accuracy of the deep learning approach and the standard approximation formula in comparison to the manual reference standard. The performance of the deep learning approach was also evaluated by computing the Dice similarity coefficient on the test set.

RESULTS

The deep learning approach resulted in a mean absolute error of 8.5% (SD 11.6) in the splenic volume while the approximation formula gave a significantly higher ($p<0.01$) mean absolute error of 17.7% (SD 14.7). The average Dice score between the deep learning segmentations and the reference segmentations was 0.91 (SD 0.08).

CONCLUSION

Splenic volume can be fully automatically assessed using a U-net deep learning approach, with an accuracy that is substantially better than the clinically widely used approximation formula.

CLINICAL RELEVANCE/APPLICATION

An accurate splenic volume measurement can be used for assessing splenomegaly and for detecting changes in splenic volume over time.

SSQ18-08 Newly Developed 3D Computer-Aided Volumetry (CADv) with Pulmonary Nodule Component Evaluation: Capability for Quantitative Prediction of Malignancy and Postoperative Recurrence on Thin-Section CT

Thursday, Nov. 30 11:40AM - 11:50AM Room: S403B

Participants
Yoshiharu Ohno, MD, PhD, Kobe, Japan (*Presenter*) Research Grant, Toshiba Medical Systems Corporation; Research Grant, Koninklijke Philips NV; Research Grant, Bayer AG; Research Grant, DAIICHI SANKYO Group; Research Grant, Eisai Co, Ltd; Research Grant, Fuji Pharma Co, Ltd; Research Grant, FUJIFILM Holdings Corporation; Research Grant, Guerbet SA;
Atsushi Yaguchi, MENG, Kawasaki, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Tomoya Okazaki, MS, Kawasaki, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Kota Aoyagi, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Shigeo Kaminaga, Otawara-shi, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Takeshi Yoshikawa, MD, Kobe, Japan (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation
Wakiko Tani, RT, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Erina Suehiro, RT, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Toshinori Sekitani, MS, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Noriyuki Negi, RT, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuji Kishida, MD, Kobe, Japan (*Abstract Co-Author*) Nothing to Disclose
Shinichiro Seki, Kobe, Japan (*Abstract Co-Author*) Research Grant, Toshiba Medical Systems Corporation
Hisashi Tachizaki, Tustin, CA (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation

For information about this presentation, contact:

yosirad@kobe-u.ac.jp

PURPOSE

To evaluate the quantitative capability of newly developed 3D computer-aided volumetry (CADv) with pulmonary nodule component assessment for predicting malignancy and postoperative recurrence on thin-section CT.

METHOD AND MATERIALS

59 consecutive patients with 101 pulmonary nodules underwent repeated thin-section CT, pathological examination, surgical resection and/ or follow-up examination. Then, all nodules were divided into malignant (n=64) and benign (n=37) nodule groups. In addition, all patients with operated as malignancy were also divided into postoperative recurrence (n=12) and non-recurrence (n=53) groups. In this study, CADv automatically assessed solid, ground-glass opacity, cavity and total nodule volumes from two serial CT data. Then, total volume change per day (TV/day), solid to total volume change ratio per day (S/T ratio/day) and doubling time (DT) were determined. Student's t-test was performed to compare all indexes between malignant and benign groups, and between recurrence and non-recurrence groups. Then, ROC analyses were performed to compare differentiation capabilities of indexes as having significant differences between malignant and benign groups, and between recurrence and non-recurrence groups. Finally, each diagnostic performances was compared by McNemar's test.

RESULTS

TV/day and DT had significant differences between malignant and benign nodule groups ($p<0.05$), although TV/day and S/T ratio/day had significant difference between recurrence and non-recurrence groups ($p<0.05$). On distinguishing malignant from benign groups, area under the curves (Azs) of TV/day (Az=0.94) was significantly larger than that of DT (Az=0.62, $p<0.001$). In addition, specificity (SP) and accuracy (AC) of TV/day were significantly higher than those of DT ($p<0.001$). For distinguishing recurrence from non-recurrence groups, Az of S/T ratio/day (Az=0.92) was significantly larger than that of TV/day (Az=0.68, $p=0.006$). Moreover, SP and AC of S/T ratio/day were significantly higher than those of TV/day ($p<0.001$).

CONCLUSION

Newly developed 3D CADv system has quantitative capability for prediction of malignancy and postoperative recurrence on thin-section CT.

CLINICAL RELEVANCE/APPLICATION

Newly developed 3D CADv system has quantitative capability for prediction of malignancy and postoperative recurrence on thin-section CT.

SSQ18-09 Quantitative Evaluation of Partial Obstruction of the Upper Urinary Tract by Analyzing Sequential Fluoroscopic Images from Antegrade Nephrostograms

Thursday, Nov. 30 11:50AM - 12:00PM Room: S403B

Participants
Isaac Leichter, PhD, Jerusalem, Israel (*Presenter*) Nothing to Disclose
Victor Neeman, PhD, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Ori Gleisner, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Jonathan Patao, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Talia Yeshua, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Richard Lederman, MD, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose
Mordechai Duvdevani, MD, Jerusalem, Israel (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Visual monitoring of fluoroscopy images, following PCNL does not allow for objective assessment of partial obstruction in the upper urinary tract. This study describes an algorithm for a quantitative evaluation of the urine flow rate, by analyzing sequential images from a routine nephrostogram.

METHOD AND MATERIALS

Following PCNL, contrast agent is introduced into the renal collecting system and serial fluoroscopic images of the renal pelvis are visually evaluated to ensure that contrast material is drained through the upper urinary tract. This study examined fluoroscopic images obtained retrospectively from nephrostograms of 40 subjects, 3 days following PCNL. In 16 cases, visual estimation of the images indicated partial obstruction. An algorithm was developed to calculate the amount of contrast agent in the renal pelvis, in each sequential image, by analyzing the integrated gray level values. As the contrast material is drained, its radio-opacity is decreased. The amount of contrast material in each image was calculated as a function of time, to yield a clearance curve of the contrast material from the renal pelvis. From this curve, the urine flow rate in the renal collecting system was calculated.

RESULTS

For each of the 40 cases, the obtained clearance curve highly fitted an exponential regression function with a mean correlation coefficient of 0.96 . The time constant - τ of the exponential decay was automatically calculated for each case. From the known value of τ, the time $t_{1/2}$ at which half of the contrast agent has drained from the renal pelvis was calculated. The mean value of $t_{1/2}$ for the 16 cases with suspected partial obstruction was 9.1 minutes, while for the 24 cases without suspected obstruction it was 2.4 minutes. The difference between the $t_{1/2}$ value of the two groups was statistically significant ($p<0.05$).

CONCLUSION

The described algorithm provides a quantitative assessment for the urine flow rate in the renal collecting system. The calculated time at which half of the contrast agent has drained from the renal pelvis following PCNL, was significantly longer in cases with partial obstruction.

CLINICAL RELEVANCE/APPLICATION

Measuring urine flow rate by processing fluoroscopic images from a routine nephrostogram examination may be used for diagnosing and quantitatively assessing partial obstruction in the upper urinary tract. This early diagnosis will improve patient care and management.

SSQ19

Physics (CT, Tomosynthesis, Fluoroscopy)

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

CT PH

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

FDA Discussions may include off-label uses.

Participants
Ingrid Reiser, PhD, Chicago, IL (*Moderator*) Nothing to Disclose
Charles E. Willis, PhD, Houston, TX (*Moderator*) Medical Advisory Board, General Electric Company

Sub-Events

SSQ19-01 First-Reader Computerized System for Distinction between Malignant and Benign Nodules on Thoracic CT Images By Means of End-To-End Deep Learning: Convolutional Neural Network (CNN) and Neural Network Convolution (NNC) Approaches

Thursday, Nov. 30 10:30AM - 10:40AM Room: S404AB

Participants
Takayoshi Ito, BEng, Ube, Japan (*Presenter*) Nothing to Disclose
Yasushi Hirano, Ube, Japan (*Abstract Co-Author*) Nothing to Disclose
Kenji Suzuki, PhD, Chicago, IL (*Abstract Co-Author*) Royalties, General Electric Company; Royalties, Hologic, Inc; Royalties, MEDIAN Technologies; Royalties, Riverain Technologies; Royalties, Toshiba Medical Systems Corporation; Royalties, Mitsubishi Corporation; Royalties, AlgoMedica, Inc.; ; ; ; ; ; ; ;
Shoji Kido, MD, PhD, Ube, Japan (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

w007vg@yamaguchi-u.ac.jp

PURPOSE

Existing computer-aided detection (CADe) systems have not reached high enough sensitivity to be used as a first reader. In the computer vision field, deep learning achieved overwhelming success with substantially higher performance than existing methods. Our purpose was to develop a first-reader CADe system for distinguishing benign from malignant lung nodules in CT by using deep-learning models, namely, a CNN and our original NNC.

METHOD AND MATERIALS

We developed a CNN with 5 layers: 2 convolution layers and a pooling layer followed by a fully-connected soft-max layer, and NNC consisting of neural network regression (NNR) with 3 layers followed by a scoring layer. In NNC, convolution of the NNR was performed to process the entire 3D volume, but unlike CNN it was done outside the network. The NNC was trained with input volumes containing nodules and "teaching" maps for probability of malignancy. Namely, the desired output volumes for malignant and benign nodules contained a 3D Gaussian distribution and completely dark, respectively. Thus, the NNC was trained to enhance malignant nodules. To obtain a likelihood of malignancy, Gaussian weighting was performed on the output volume in the scoring layer. To test those 2 deep-learning models, we collected 94 lung nodules (34 malignant; 60 benign) from the LIDC-IDRI database. The malignancy and benignancy of the nodules were determined by 3 radiologists. The CT had slice thickness ranging from 0.5-3.0 mm. Tube voltage and current range from 120-140 kVp and 40-570 mA, respectively. We performed a two-fold cross-validation test. Receiver-operating-characteristic (ROC) analysis was used for evaluating the performance.

RESULTS

Our NNC achieved an area-under-the ROC curve (AUC) of 0.997, whereas the CNN achieved 0.986 (p=.083). Our NNC distinguished all malignant nodules correctly from 54 out of 60 benign nodules (10% false positive (FP) rate).

CONCLUSION

Our NNC classified 100% of malignant lung nodules correctly with 10% of FPs in CT. Our system could be used as a first reader where radiologists only check the cases suggested by our "screening" system.

CLINICAL RELEVANCE/APPLICATION

Our high-performance deep-learning-based system would reduce radiologists' workload thus improve the efficiency and potentially improve their diagnostic performance.

SSQ19-02 Development of a New Phantom to Measure Image Quality for Iterative Reconstruction in CT for Abdominal Scanning

Thursday, Nov. 30 10:40AM - 10:50AM Room: S404AB

Participants

Anne C. Martinsen, Oslo, Norway (*Presenter*) Nothing to Disclose
Hilde K. Andersen, MSc, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
Kristin Jensen, Oslo, Norway (*Abstract Co-Author*) Nothing to Disclose
Hildur Olafsdottir, Salem, NY (*Abstract Co-Author*) Research funded, Image Owl, Inc
Ingvi S. Olafsson, BSc, Reykjavik, Iceland (*Abstract Co-Author*) Research supported, Image Owl, Inc
Joshua Levy, Salem, NY (*Abstract Co-Author*) Stockholder, The Phantom Laboratory President, The Phantom Laboratory Stockholder, Image Owl, Inc
David J. Goodenough, PhD, Myersville, MD (*Abstract Co-Author*) Consultant, The Phantom Laboratory

PURPOSE

To develop a novel phantom for abdominal CT image quality measurements feasible for iterative reconstructions.

METHOD AND MATERIALS

An anthropomorphic abdominal phantom, designed for ROC studies and quantitative image quality analyses was tested. The phantom consisted of 4 ROC inserts, one MTF insert, and two iodine test inserts. The iodine inserts contained 6 lesions of different sizes and density (1g and 5 g of iodine). The MTF insert contained two tungsten carbide beads. The ROC inserts contained 12 lesions (16 HU contrast to background difference). The phantom was scanned on Siemens Drive. The four ROC inserts were rotated and interchanged between scans. Scan parameters: 120 kVp, CTDIvol 10, 15 and 20 mGy, 3 mm slices, FBP B30f, Admire 2 and Admire 3 reconstructions. Three readers evaluated all images in a blinded, randomized order upon a 5 point scale, and area under curve (auc) was calculated. MTF, SNR and CNR were measured for all reconstructions and all dose levels, using ImageOwl. Spearman's rank correlation coefficient was used for evaluation of correlation between different image quality measurements.

RESULTS

For all dose levels, the iterative reconstruction techniques, Admire, had higher MTF and improved lesion detectability (significant for 10 and 15 mGy, derived from ROC studies) compared to FBP. Admire 3 had the highest score and FBP the lowest score for CNR and SNR for all dose levels. The Spearman's rank correlation coefficients for the correlation between auc and MTF, SNR and CNR were 0.26 (p=0.497), 0.81 (p=0.011) and 0.92 (p=0.001) respectively. The results indicate a strong correlation beween ROC lesion detectability and SNR and CNR. The correlation between lesion detectability and MTF was not significant.

CONCLUSION

The new phantom enabled a combination of quantitative and qualitative image quality measurements important for optimization of image quality for CT examinations. The correlation between the lesion detectability and SNR and CNR was good, indicating that both quantiative and qualitative measurements give meaningful results for both FBP and the iterative reconstruction, Admire, for abdominal CT.

CLINICAL RELEVANCE/APPLICATION

Optimization of iterative reconstruction demand phantoms designed for qualitive and quantiative image quality analysis. A new abdominal phantom designed for ROC studies showed promising results.

SSQ19-03 Motion Compensated CT Imaging of the Aortic Valve

Thursday, Nov. 30 10:50AM - 11:00AM Room: S404AB

Participants
Tanja Elss, Hamburg, Germany (*Abstract Co-Author*) Doctorate student, Koninklijke Philips NV
Clemens Spink, Hamburg, Germany (*Presenter*) Nothing to Disclose
Rolf Bippus, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Thomas B. Ivanc, MS, Willoughby, OH (*Abstract Co-Author*) Employee, Koninklijke Philips NV
Gerhard B. Adam, MD, Hamburg, Germany (*Abstract Co-Author*) Nothing to Disclose
Gunnar K. Lund, MD, Hamburg, Germany (*Abstract Co-Author*) Nothing to Disclose
Michael Morlock, PhD, Hamburg, Germany (*Abstract Co-Author*) Nothing to Disclose
Michael Grass, PhD, Hamburg, Germany (*Abstract Co-Author*) Employee, Koninklijke Philips NV

PURPOSE

Cardiac CT imaging is used for the planning of transcatheter aortic valve implantation (TAVI). ECG correlated data acquisition and gated reconstruction enables imaging of the valve in the systolic and diastolic phase. Especially in the systolic phase, motion artifacts may occur and interfere with diagnosis and treatment planning. The purpose of the study was to analyze the efficiency of a second pass motion correction method to compensate cardiac motion.

METHOD AND MATERIALS

A time series of cardiac contrast enhanced CT volume images were first reconstructed atdifferent phase points with a temporal distance of 5% cardiac cycle. Edge features of the valve, thevalve leaflets and the neighboring vascular anatomy were enhanced in the reconstructed images by agradient based filter which uses non-maximum-suppression and hysteresis thresholding. Afterwards, a subsequent elastic image registration was applied to estimate dense motion vector fields for thedifferent cardiac phases. The resulting motion vector fields are included in the motion compensatedfiltered back projection and interpolated in the time domain to cover the temporal projection rangerequired for reconstruction. The method was applied to retrospective ECG-gated clinical datasetsacquired with a 256-slice CT scanner (Brilliance iCT, Philips Healthcare) and tested for systolic (30%R-R-interval) and diastolic (70%) imaging of the valve on ten data sets.

RESULTS

The method achieved motion artifact reduction in both heart phases. Especially in late systolea strong improvement in image quality and visibility of the valve leaflets and aortic boundaries couldbe observed, as well as reduced blurring compared to the gated reconstructions.

CONCLUSION

Motion compensated reconstruction of the aortic valve is feasible using edge filtering andimage based registration for motion estimation. Improved CT image quality and reduced motionartifact levels can be achieved thereby facilitating improved visualization

of the aorta as well asimproved planning and device selection for TAVI procedures.

CLINICAL RELEVANCE/APPLICATION

Improved CT visualization of the aorta by new image processing tools is crucial for optimized planning and device selection for TAVI procedures.

SSQ19-04 Body Position's Effect on the Subclavian Vein Artifact in Carotid Artery CT Angiography: Lateral Position vs Supine Position

Thursday, Nov. 30 11:00AM - 11:10AM Room: S404AB

Participants
Fei Fu, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose
Xinlong Ma, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose
Anwei He, Tianjin, China (*Presenter*) Nothing to Disclose
Jiyang Zhang, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose
Yue Zhang, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose
Xin Deng, MD, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose
Yeda Wan Sr, Tianjin, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

13102233561@163.com

PURPOSE

Aim of this study was to assess the body position's effect on the subclavian vein artifact in carotid artery CT angiography by comparing lateral position with supine position.

METHOD AND MATERIALS

80 patients who underwent carotid artery CT angiography imaging were randomly separated into two groups: group A with patient lying with lateral position and B with patient lying with supine position (n=40 for both groups). The other scanning parameters were the same for both groups, including tube voltage of 120kV, tube current of 260mA, pitch of 1.375:1, slice thickness of 5.0mm, large FOV. 70ml contrast agent (omnipaque, 350mgI/ml), 4.0ml/s of flow rate and smart contrast agent monitoring with a threshold of 200Hu were used for both groups. Image noise and CT value of subclavian artery (at the level of subclavian artery origin, vertebral artery origin and subscapular artery origin) and adjacent muscle (trapezius) were measured. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) for subclavian artery were calculated, according the formulas: SNR=CTartery/SD and CNR=(CTartery-CTmuscle)/SD. Subjective image quality was evaluated by two radiologists with a 5-point scale. Measurement data was compared with independent student T test, the image quality score was compared with Mann-Whitney U test.

RESULTS

The SD of group A were lower than that of group B (35.03±14.09 vs 208.21±35.78, $p<0.05$). The SNR and CNR of group A were both higher than those of group B (SNR, 14.19±4.30 vs 6.40±2.3; CNR,10.76±3.62 vs 4.86±1.88, both$p<0.05$). The subjective image quality was also higher in group A than group B (4.30±0.47 vs 3.17±0.70, $p<0.05$).

CONCLUSION

Changed velocity vector of flowing blood via changed body position, could removed the subclavian vein artifacts during carotid artery CT angiography imaging. This technique is useful and very feasible.

CLINICAL RELEVANCE/APPLICATION

Through changed body position to changed velocity vector of flowing blood is a useful and very feasible way to removed the subclavian vein artifacts during carotid artery CT angiography imaging.

SSQ19-05 The Visibility of Peripheral Pulmonary Arteries in Pulmonary Embolism Patients by Free-breathing Combined with High-threshold Bolus Triggering Technique in CT Pulmonary Angiography

Thursday, Nov. 30 11:10AM - 11:20AM Room: S404AB

Participants
Daliang Liu, PhD,MD, Liaocheng, China (*Presenter*) Nothing to Disclose
Xiaowen Lu, Liaocheng, China (*Abstract Co-Author*) Nothing to Disclose
Zhao Li, Liaocheng, China (*Abstract Co-Author*) Nothing to Disclose
Xianghui Wan, Liaocheng, China (*Abstract Co-Author*) Nothing to Disclose
Li Wei, PhD,MD, Liaocheng, China (*Abstract Co-Author*) Nothing to Disclose
Lingling Wang, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

llpldl@163.com

PURPOSE

To investigate the visibility of peripheral pulmonary by computed tomography pulmonary angiography (CTPA) under free breathing mode and to explore the feasibility of this technique in pulmonary embolism patients who can't hold breathing.

METHOD AND MATERIALS

200 patients who were suspected PE underwent CTPA on GE Revolution CT. They were randomly assigned into two groups: free-breathing group (n=100) and breath-holding group (n=100). CTPA were performed with pitch 0.992:1, rotation time 0.28s and 16cm-detector. Automatic bolus-tracking was used with a monitor ROI placed on main pulmonary artery(MPA). For the free-breathing group, scan started immediately as the CT value reached a 250 HU threshold; for the breath-holding group, scan started 5 seconds after reaching an 80 HU threshold. The reconstruction slice thickness and interval were 0.625 mm with standard lung

algorithm and all images were transferred to the ADW 4.6 workstation for diagnosis and evaluation. Mean scanning time was recorded and analyzed by independent-sample t-test; the displayed distal branches of pulmonary artery was recorded and chi-square test was used for statistical analysis.

RESULTS

All CTPA were performed successfully and all the farthest branches reached of 6 or farer. There was no significant difference between the two groups in mean scanning time(0.67±0.09s vs 0.67s±0.10s, p=0.367). The order of distal pulmonary arteries of 6, 7 and 8 in the free and holding groups were 25, 57, 18 vs 17, 61, 22 respectively.There was no significant difference between the two groups ($\chi 2=2.059$, p=0.357), and there was no significant statistical significance ($p > 0.5$).

CONCLUSION

Compared with breath-holding mode, the free breathing mode CTPA by 16cm-wide detector scanner has the same ability to display the peripheral pulmonary arteries.

CLINICAL RELEVANCE/APPLICATION

Free breathing CTPA can be successfully applied in PE patients, especially valuable for the patients who can't hold their breath.

SSQ19-06 Patient Dose Reduction in Tomosynthesis Imaging: Application of a New Computerized Reconstruction Technique

Thursday, Nov. 30 11:20AM - 11:30AM Room: S404AB

Participants
Ryohei Fukui, Yonagoshi, Japan (*Presenter*) Nothing to Disclose
Junji Shiraishi, Kumamoto, Japan (*Abstract Co-Author*) Research Grant, FUJIFILM Holdings Corporation; Research Grant, Nihon Medi-Physics Co, Ltd

PURPOSE

A high radiation dose is one of the problem in tomosynthesis examination. Generally, an increase in the number of projected images results in high image quality of reconstructed tomosynthesis images, but also increases the patient dose. In this study, we developed a new interpolation technique for improving the image quality of reconstructed tomosynthesis images with a reduced number of projection images.

METHOD AND MATERIALS

A full projected images (73 projections) were acquired with Safire17 (Shimadzu Co.) as the original data set (Orig-set). Partially projected image data sets (Sub-set) with 37, 19, and 11 projections were selected from the Orig-set with intervals of 1, 3, and 7 projections. In this study, the Path Framework (PF) method, which was originally developed for a video interpolation technique, was applied to interpolate interval projection images of Sub-set images. The pixel value of the interpolated image was estimated from one of the two input images before and after the target phase; this pixel value was determined using the shifted value between the target phase and the two input images. Using this technique, the frequency content of the original image could be preserved without blurring. Three image data sets with 73 projection images were consisted with real projection images and their interpolated projection images obtained by the PF method (PF-set). Tomosynthesis images were reconstructed by these data sets using filtered back-projection. In order to evaluate the image quality, we adopted the wire method and the two-dimensional fast Fourier transformation method for spatial resolution and noise property, respectively.

RESULTS

Spatial resolution and noise property of tomosynthesis images reconstructed from the PF-set were equivalent to those obtained from the Orig-set., whereas the spatial resolution of tomosynthesis images was clearly degraded by using a conventional interpolation technique.

CONCLUSION

The number of projected images can be reduced more than 50% by using the PF method without degradation of image quality. We believe this proposed method would be utilized for the reduction of patient dose in tomosynthesis.

CLINICAL RELEVANCE/APPLICATION

This proposed method would be applied for various tomosynthesis systems without any modification of system hardware and can realize patient dose reduction effectively.

SSQ19-07 Ex-Vivo Neuro-Imaging of Human and Animal Spinal Cords via X-Ray Phase Contrast CT: Detection of Full Organ Anatomy, Micro-Vessels and Single Motor Neurons

Thursday, Nov. 30 11:30AM - 11:40AM Room: S404AB

Participants
Giacomo E. Barbone, MSc, Garching, Germany (*Presenter*) Nothing to Disclose
Cecilia Ceresa, PhD, Monza, Italy (*Abstract Co-Author*) Nothing to Disclose
Marina Eckermann, Garching, Germany (*Abstract Co-Author*) Nothing to Disclose
Alberto Mittone, Munich, Germany (*Abstract Co-Author*) Nothing to Disclose
Alberto Bravin, PhD, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose
Valentin Djonov, PhD, Bern 9, Switzerland (*Abstract Co-Author*) Nothing to Disclose
Guido Cavaletti, MD, Monza, Italy (*Abstract Co-Author*) Nothing to Disclose
Paola Coan, Grenoble, France (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

giacomo.e.barbone@gmail.com

PURPOSE

Achieving non-invasively both full-organ visualization and cellular-resolution in the imaging of anatomical and pathological CNS tissue structure is beyond both current clinical and preclinical cutting-edge neuroimaging techniques. In fact, the study of vascular and neurodegenerative disorders still relies heavily on sample-invasive imaging protocols, which involve dissections, staining or labeling of nervous tissue, and which in most cases fail to capture complete volumetric information on cell populations and microvasculature within a full-organ sample. In this ex-vivo study, we used a staining- and dissection-free imaging technique, X-ray phase contrast tomography (PCI-CT), to visualize full-organ vascularization and concurrent detection of single neuronal cells in excised spinal cord samples from both human donors and animals.

METHOD AND MATERIALS

Lumbar spinal cord samples, extracted from both healthy rats and human donors, were imaged using a synchrotron PCI-CT setup. We used 20-40 keV monochromatic coherent X-rays, a sCMOS-sensor PCO camera and an optics system with isometric voxels of sizes from 46^3 micron^3 down to 0.3^3 micron^3.

RESULTS

PCI allowed recognition and differentiation of full-organ spinal cord anatomy, including anterior/posterior gray horns, the dorsal/ventral roots and ganglions, the central canal and the meninges. Superficial as well as deep vessel architecture could be extracted without the need of any contrast-agent. Moreover, at the highest resolutions used, single neuronal cells perfused by surrounding vasculature could be recognized: distinct bundles of nerve fibers, single motor neurons and neuro-glial cells, cell bodies and axons, as well as intra-cellular structure (cell nuclei and nucleoli) were successfully detected.

CONCLUSION

CNS PCI micro-CT, with the unique detection of single cells and of single micro-vessels within full-organ samples, enables a volumetric histology-like analysis of neuronal cell populations and micro-vascular networks in extracted spinal cord samples of both human donors and animals.

CLINICAL RELEVANCE/APPLICATION

Non-invasive visualizations of full-organ CNS micro-vascularization and of neuronal cell populations are fundamental in the preclinical study of vascular and neurodegenerative diseases.

SSQ19-08 Evaluation of a New Nonrigid-Registration Method Using Non-Local Spatio-Temporal Priors on Liver Perfusion CT in Patients with Hepatic Cellular Carcinoma

Thursday, Nov. 30 11:40AM - 11:50AM Room: S404AB

Participants
Qingguo Wang, MD, Shanghai, China (*Presenter*) Nothing to Disclose
Han Wang, MD, PhD, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Ting-Yim Lee, MSc, PhD, London, ON (*Abstract Co-Author*) License agreement, General Electric Company
Feng Su, PhD, London, ON (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

wqg98@126.com

PURPOSE

To evaluate the feasibility of the Nonrigid-registration method on free-breathing liver CT perfusion in comparison with standard Rigid-registration method.

METHOD AND MATERIALS

Six studies of three patients with hepatic cellular carcinoma underwent free-breathing liver CT perfusion scanning by using a 128-row CT scanner (Revolution CT, GE Healthcare, Milwaukee, WI). The original axial CT images of all studies were registered by Nonrigid-registration method using Non-local Spatio-temporal Priors (GE Healthcare, Milwaukee, WI) and standard Rigid-registration method (ANALYZE software supplied by Mayo Clinic, Rochester, MN) respectively. The CT perfusion maps (BF, BV, MTT, PS, HAF, HAP and PVP) and motion in tumor regions on images registered by Nonrigid-registration and Rigid-registration were compared.

RESULTS

The Nonrigid-registration method significantly reduced respiratory motion on whole liver region, whereas only focused tumor region can be registered well by using standard Rigid-registration in our study. All the perfusion parameters had no statistically difference between Nonrigid-registration and Rigid-registration (all P values > .05)

CONCLUSION

The new Nonrigid-registration method using Non-local Spatio-temporal Priors gained better alignment on whole liver region than Rigid-registration. The Nonrigid-registration method promotes the application of free-breathing liver CT perfusion in clinical practice.

CLINICAL RELEVANCE/APPLICATION

Nonrigid-registration with non-local spatio-temporal can achieve a stable perfusion CT data and is a powerful method as a first step for image post-processing after CT perfusion scanning.

SSQ19-09 Improved Visibility of Guidewires and Devices for Interventional X-Ray Procedures Using a New Approach to Automatic Exposure Control

Thursday, Nov. 30 11:50AM - 12:00PM Room: S404AB

Participants
Michiel Dehairs, Leuven, Belgium (*Presenter*) Research Grant, Siemens AG
Nicholas Marshall, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose
Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG
Geert Maleux, MD, PhD, Leuven, Belgium (*Abstract Co-Author*) Nothing to Disclose

Sandra A. Cornelissen, MD, Utrecht, Netherlands (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

michiel.dehairs@uzleuven.be

PURPOSE

Current automatic exposure controls (AEC) of fluoroscopy systems adjust acquisition parameters to achieve a constant signal level in the image receptor. This study investigates a new AEC approach that sets parameters which optimize the visibility of specific materials quantified using a figure of merit (FOM). The clinical motivation is to increase efficiency and clinical outcomes in the angio suite while reducing dose.

METHOD AND MATERIALS

A Siemens Artis Q interventional system was used to image a phantom composed of 4, 8 and 12 composite plates, each of 20mm PMMA and 2mm Al, approximating the attenuation of 10, 20 and 30cm human tissue. Seven materials were studied, including iron, iodine contrast and platinum, covering a range of clinically relevant devices and contrast media. Samples were placed at the phantom center and imaged using a new AEC approach based on an FOM composed of a spatial frequency dependent signal difference to noise ratio (SDNR(u)). Standard SDNR was corrected for the influence of focal spot size and object motion blurring by multiplying with MTF based correction factors, which were calculated with access to unprocessed data. The FOM was defined as $SDNR^2(u)$/entrance air kerma rate. The FOM was measured for all samples using a total of 10 new AEC regulation curves, each optimized for a specific material, and the current standard curve. The FOM of the curve matching the correct insert was then compared to the FOM data of the other curves: taking the ratio gave an estimate of the efficiency change.

RESULTS

The new AEC improved the imaging efficiency of metals such as iron, tantalum and platinum: for the 20cm phantom the FOM increased by 16%, 165% and 164% respectively compared to the conventional AEC. There was little or no gain for the 30cm phantom, with increases of 0%, 7% and 4%, respectively, due to restricted parameter selection at large patient thicknesses. The FOM for iodine contrast increased between 15% and 20%, for the 20cm phantom.

CONCLUSION

The new AEC approach shows great potential for increasing the imaging efficiency of a wide range of materials. For a typical patient thickness of 20cm, increases between 15% and 165% were seen compared to the conventional AEC.

CLINICAL RELEVANCE/APPLICATION

Selecting AEC factors by optimizing an FOM instead of keeping X-ray detector signal constant can increase visibility of devices, guidewires and contrast media used during interventional procedures.

RSNA 2017 Explore. Invent. Transform.
103rd Scientific Assembly and Annual Meeting
November 26 to December 1
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PHS-THA

Physics Thursday Poster Discussions

Thursday, Nov. 30 12:15PM - 12:45PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Zheng Feng Lu, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

PH255-SD-THA1 Optimal Beam Quality for Chest Flat Panel Detector System: Realistic Phantom Study

Station #1

Participants
Chie Kuwahara, MD, Kitakyushu, Japan (*Presenter*) Nothing to Disclose
Takatoshi Aoki, MD, PhD, Kitakyushu, Japan (*Abstract Co-Author*) Nothing to Disclose
Nobuhiro Oda, PhD, Kyoto, Japan (*Abstract Co-Author*) Nothing to Disclose
Koichiro Sugimoto, MD, Kitakyushu, Japan (*Abstract Co-Author*) Nothing to Disclose
Yoshiko Hayashida, MD, Fukuoka, Japan (*Abstract Co-Author*) Nothing to Disclose
Yukunori Korogi, MD, PhD, Kitakyushu, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Although chest flat-panel detector (FPD) radiography is typically performed with 120kV shot, there is a lot of room for improvement in the X-ray spectrum. The purpose of this study was to evaluate how beam optimization contributes to the improvement of image quality using a realistic lung phantom.

METHOD AND MATERIALS

Chest FPD radiographs were obtained on a lung phantom (Kyoto Kagaku N-1) with simulated lung opacities using various X-ray tube voltage levels (80-140 kV) with/without copper filter. Entrance skin dose was set to maintain identical for all images (0.1 mGy). For quantitative assessment, contrast-to-noise ratio (CNR) of simulated nodules (10mm; +30, -375, -620 HU) were measured. For qualitative assessment, 3 blinded chest radiologists independently evaluated the image quality of each simulated opacity (nodules and honeycomb opacity) and normal structure (pulmonary vessels and vertebra) using a five-point scale (+2: clearly superior to the standard; +1: slightly superior to the standard; 0: equal to the standard; -1: slightly inferior to the standard; -2: clearly inferior to the standard). The traditional FPD image obtained at a tube voltage of 120 kV without copper filter was used as the standard.

RESULTS

The CNRs of the +30HU and -375HU nodules using 90-100kV shot with copper filter were significantly higher than those using traditional 120-140kV shot without filter ($p < 0.05$). FPD images using 90kV shot with copper filter were superior to the traditional 120kV shot without filter with respect to the visibility of vertebra, pulmonary vessels, and nodules overlapping diaphragm and heart ($p < 0.05$). There was no significant difference with respect to the visibility of all other simulated lung opacities between each tube voltage level with/without copper filter and the traditional 120kV shot without filter.

CONCLUSION

Image quality of FPD images using 90kV with filter is superior to that using traditional beam when exposure dose is identical.

CLINICAL RELEVANCE/APPLICATION

Both in quality and in quantity, 90kV shot with copper filter is recommended for chest FPD images.

PH256-SD-THA2 A New 3D Resolution Gauge for CT

Station #2

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

PURPOSE

The use of 3D and MPR CT techniques lead to the need for phantoms and test methods that reveal to the radiologist and physicist actual 3D resolution, including in-plane (x,y) resolution, an slice width SSP. These "combined" effects can be studied with new 3D resolution gauge amenable to visual or automated analysis.

METHOD AND MATERIALS

To test 3D resolution in CT, a new resolution gauge has been developed that includes not only periodic pattern(s) in the x,y plane, but extends the variation at a 45° angle into the z-axis. Thus, this 45° 3-D resolution gauge, e.g., weighs the z-axis equally with the x or y axis. Other inclination angles, relative to the x-y plane, could be used to augment or diminish z effect versus, x or y. Given current CT slice thickness of 0.5mm or greater, the gauge design ranges from 1-10 line pairs/cm. This particular gauge was scanned using varying in-plane reconstruction filters and varying slice thicknesses. This gauge is used in scans from different CT

scanners to show the influence of slice thickness in the 3-D resolution results.

RESULTS

The 3D gauge scans are shown for various acquisition protocols involving different spatial resolution filters and different slice thicknesses. The limitations of conventional high resolution filters (e.g. greater than 10 lp/cm) with typical slices of 0.5 to 10mm are shown for different CT scanner. Resulting images show the effect of slice thickness on the 3D resolution gauge. In CT scans that use a high in-plane resolution, e.g., 10 line pairs/cm or more, the resulting gauge pattern will be dominated by the slice thickness and are limited to about 10 lp/cm even for 0.5mm slice and are totally dominated as slice thicknesses range from about 1mm to 10mm.

CONCLUSION

Phantoms employing the new 3D gauge reveal useful information for 3D imaging on the combined effects of in-plane resolution and the slice thickness. These results can influence the appropriate choice of resolution filter and slice thickness in acquisition protocols.

CLINICAL RELEVANCE/APPLICATION

These new approaches give the clinician, for the first time, simultaneously, a qualitative (visual) measure of the combined effects of in-plane resolution and slice thickness used in the image acquisition or reconstruction process with a single scan of the 3-D resolution gauge.

PH257-SD-THA3 Deep Learning Super-Resolution Imaging for Enhancing Image Resolution in Digital Mammography

Station #3

Participants
Junko Ota, MS, Suita, Japan (*Presenter*) Nothing to Disclose
Kensuke Umehara, MS, Suita, Japan (*Abstract Co-Author*) Nothing to Disclose
Tokiko Endo, MD, Nagoya, Japan (*Abstract Co-Author*) Institutional Grant support, FUJIFILM Holdings Corporation
Takayuki Ishida, PhD, Suita, Japan (*Abstract Co-Author*) Research funded, Doctor-NET Inc

For information about this presentation, contact:

ota@sahs.med.osaka-u.ac.jp

PURPOSE

Image resolution is an important factor for detecting suspicious low-contrast masses under conditions of breast glandular tissue in digital mammography. In addition, 4K or 8K diagnostic displays become to be implemented, in particular, high-resolution displays are often required in mammography. The purpose of this study was to apply and evaluate a novel deep-learning based super-resolution (SR) method for enhancing image resolution in digital mammography.

METHOD AND MATERIALS

A total of 711 cases with breast masses were sampled from the Digital Database for Screening Mammography (DDSM) database. The 711 cases contained 711 MLO images and 607 CC images. Super-resolution convolutional neural network (SR-CNN), which is state-of-the-art deep-learning based SR method, was trained with millions of natural non-medical images. With the trained SR-CNN, the high-resolution image was reconstructed from the low-resolution one. For quantitative evaluation, peak signal-to-noise ratio (PSNR) and structural similarity (SSIM) were measured for assessing the image noise level and the perceived image quality. The image quality of the SR-CNN was evaluated by two metrics compared with those of conventional interpolation methods (nearest neighbor [NN], bilinear [BL]) by means of one-way ANOVA and Tukey's post-hoc test.

RESULTS

[MLO]: In the SR-CNN scheme, the mean ± SDs of PSNR and SSIM were 43.97 ± 3.87 dB, 0.957 ± 0.030, respectively, which were significantly higher than those of NN (41.83 ± 3.06 dB, [p<.001]; 0.938 ± 0.036, [p<.001], respectively), and BL (42.17 ± 3.34 dB, [p<.001]; 0.938 ± 0.040, [p<.001], respectively). [CC]: In the SR-CNN scheme, the mean ± SDs of PSNR and SSIM were 44.20 ± 3.68 dB, 0.960 ± 0.026, respectively, which were significantly higher than those of NN (41.99 ± 2.84 dB, [p<.001]; 0.942 ± 0.032, [p<.001], respectively), and BL (42.36 ± 3.14 dB, [p<.001]; 0.942 ± 0.035, [p<.001], respectively).

CONCLUSION

SR-CNN can significantly outperform conventional interpolation methods for enhancing image resolution in digital mammography.

CLINICAL RELEVANCE/APPLICATION

SR-CNN can provide substantial highly enhancement in magnifying mammographic images, leading to more accurate diagnosis of small or subtle lesions in breast glandular tissue without additional dose exposure or patient nuisance.

PH258-SD-THA4 Analysis and Optimization of Projection Data Acquisition in CT under the Framework of Sampling on Lattice

Station #4

Participants
Huiqiao Xie, PhD, Atlanta, GA (*Presenter*) Nothing to Disclose
Xiangyang Tang, PhD, Atlanta, GA (*Abstract Co-Author*) Research Grant, SINOVISION Technologies Co, Ltd

For information about this presentation, contact:

xiangyang.tang@emory.edu

PURPOSE

The detector configuration in CT is a two dimensional (2D) cell array with uniform pitch. Due to the 2D array's intrinsic inability of satisfying the Nyquist-Shannon sampling theorem, aliasing artifacts, which manifest themselves as windmill or pinwill in morphology, may appear in the images of multi-detector row CT (MDCT) and/or cone-beam CT (CBCT). We present the framework of sampling

on lattice for data acquisition analysis and propose a number of novel and practical sampling structures for aliasing artifacts suppression to reach an optimal trade-off over artifacts, spatial resolution and noise.

METHOD AND MATERIALS

Based on the framework of sampling on lattice, the data acquisition in CT is analyzed on the reciprocal lattice in the frequency domain. Then interlaced sampling structures are deduced to mitigate sampling aliasing along the longitudinal direction. Experimental evaluation of the interlaced sampling structures is conducted by simulating the scan of a clockwise spiral sphere phantom, a wire phantom and a thin foil phantom, wherein the original micro-detector (i.e., default) cells are binned into interlaced macro-detector cells (lattice), in which latitudinal or longitudinal interpolation is applied prior to the ramp filtering and 3D back-projection in the FDK image reconstruction.

RESULTS

Theoretical analysis of data acquisition in CT suggests that the interlaced sampling structure can substantially mitigate aliasing in the frequency domain along the longitudinal direction. The simulation study shows that a number of interlaced sampling structures can indeed suppress the windmill artifacts efficiently. In addition, the interlaced sampling structures can moderately improve the reconstruction accuracy of the FDK algorithm, while reaching an optimal trade-off between spatial resolution and noise.

CONCLUSION

The interlaced sampling structure deduced from the analysis of data acquisition in CT can substantially suppress aliasing artifacts, moderately improve the accuracy of CB image reconstruction, and optimally achieve a trade-off between spatial resolution and noise.

CLINICAL RELEVANCE/APPLICATION

The methodology of analyzing data acquisition in CT under the framework of sampling on lattice and the proposed interlaced sampling structure may provide a foundation for the architecture design of MDCT and/or CBCT to meet the challenges imposed by extensive preclinical and clinical applications.

PH008-EB-THA CT Imaging Phantom for Mimicking Pulmonary Diseases and Validation Using 3D Printing Technology

Hardcopy Backboard

Participants
Sang-Wook Lee, BS, Seoul, Korea, Republic Of (*Presenter*) Nothing to Disclose
dayeong Hong, ulsan, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Guk Bae Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Myongjoon Kim, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose
Namkug Kim, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Stockholder, Coreline Soft, Inc
Joon Beom Seo, MD, PhD, Seoul, Korea, Republic Of (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

joonbeom.seo@gmail.com

CONCLUSION

A wide range of HU values was achieved through controlling 3d printing materials, the proportions of contrast medium, and utilizing foamed silicone with different pressure applied. The resulting phantom models accurately duplicate actual human lung CT images with similar HU ranges, which could be used for imaging diagnostic software evaluation.

FIGURE

https://abstract.rsna.org/uploads/2017/17016275/17016275_9rzk.jpg

Background

Various kinds of lung diseases including cancer, chronic obstructive pulmonary disease (COPD), and interstitial lung disease (ILD) are the leading cause of deaths worldwide. As the accuracy of CT for non-invasively detecting lung diseases is increasing and the importance of early diagnosis is being emerged, the development of medical imaging software has been rapidly accelerated. Therefore, in this study, 3D printing technology utilizing various 3D printable materials, contrast medium, foamed silicone is used to accurately duplicate and develop disease-specific lung phantoms of complex shapes and with various kinds of pulmonary diseases, which can be used for the evaluation of the CT quality assurance and quantitative imaging software.

Evaluation

Lung parenchyma, disease, and trachea areas acquired from CT were segmented and modeled using an in-house medical image modeling software (Aview, Asan medical center, South Korea). The internal structures were then made utilizing 3D printers and injection molds. The trachea was directly 3D printed, and the five lobes were made with silicone injection molds. The HU values of the actual lobe and the fissure of the patient were simulated by mixing foamed silicone with an appropriate amount of contrast medium. The histogram, size, and texture of the disease areas were replicated by adjusting the porosity and the proportion of the contrast medium. This phantom model was then scanned with CT, verified with radiologists, and checked using a diagnostic software.

Discussion

Foamed silicone samples were produced applying different pressure conditions (0.03 ~ 0.09 MPa). As the pressure decreased, the size of the pores is increased and the HU value of the CT is lowered as a result. (-675~-826 HU) Samples with increasing ratio of contrast medium in the foamed silicone resulted in increasing HU value in the CT images.

PH002-EB-THA Porcine Cardiac Imaging using Prospective Electrocardiogram Gated Stationary Digital Tomosynthesis

Hardcopy Backboard

Participants
Elias T. Gunnell, MS, BS, Chapel Hill, NC (*Presenter*) Nothing to Disclose
Allison E. Hartman, Chapel Hill, NC (*Abstract Co-Author*) Nothing to Disclose

Christy Inscoe, MS, BS, Chapel Hill, NC (*Abstract Co-Author*) Nothing to Disclose
Yueh Z. Lee, MD, PhD, Chapel Hill, NC (*Abstract Co-Author*) License agreement, XinRay Systems Inc
Otto Zhou, PhD, Chapel Hill, NC (*Abstract Co-Author*) Board of Directors, XinRay Systems Inc
Jianping Lu, Chapel Hill, NC (*Abstract Co-Author*) Board of Directors, XinRay Systems Inc

For information about this presentation, contact:

egunnell@med.unc.edu

CONCLUSION

Precise prospective cardiac imaging using a CNT s-DCT is possible with the use of ECG gating. Gating is reproducible and easily adjusted to a particular portion of the cardiac cycle. Using CNT Cardiac Gated s-DCT has allowed us to capture images of a porcine heart that have improved image quality compared to non-gated studies. This experiment suggests that similar studies performed on human patients should yield promising results.

FIGURE

https://abstract.rsna.org/uploads/2017/17005722/17005722_dr11.jpg

Background

Obtaining still images of the heart is technically challenging due to the rapid movement of the heart and the relatively slow imaging times. Using cardiac gating and our stationary digital chest tomosynthesis (s-DCT) system we acquired images of a live pig's heart that showed improved image quality and decreased motion blur compared to non-gated images.

Evaluation

Using our Carbon Nanotube stationary digital chest tomosynthesis (CNT s-DCT) system (80kVp, .0125mAs, detector frame rate of 5fps) and the BioVet ECG gating system we performed cardiac gated tomosynthesis scans of a live pig. Imaging was performed on a sedated, free breathing juvenile pig, with an average heart rate of 120 bpm. Gating was set to capture images of the pig's heart in a 1ms timeframe at a specified rising edge of the R wave of the ECG. Images were acquired when the BioVet signaled the X-ray source that the targeted cardiac period was occurring. If this coincided with the detector ready signal an X-ray was fired. Three trials were performed using a combination of ECG and respiratory gating. A total of 29 projection images per trial were acquired and reconstructed, using iterative reconstruction at 2mm slice thickness, into an imaging set.

Discussion

Cardiac imaging was obtained using our CNT Gs-DCT system. Trial imaging times averaged to be 120s ±.40s compared to an un-gated scanning time of 6.3s ± .6s. The average cross correlation coefficient between the ECG trace at the time of the x-ray pulse was .99 ± .01 for the gated scan compared to .31±.32 for the un-gated scan. Analysis of line profiles at the cardiac border result in a half width half max (HWHM) of 3.9 ± .22 mm for un-gated scans and 2.87 ± .22 mm for gated scans.

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PHS-THB

Physics Thursday Poster Discussions

Thursday, Nov. 30 12:45PM - 1:15PM Room: PH Community, Learning Center

PH

AMA PRA Category 1 Credit ™: .50

Participants
Zheng Feng Lu, PhD, Chicago, IL (*Moderator*) Nothing to Disclose

Sub-Events

PH259-SD-THB1 Improvement of Spatial Resolution of CT Using Model-Based Iterative Reconstruction on CT: A Phantom Study

Station #1

Participants
Toru Higaki, PhD, Hiroshima, Japan (*Presenter*) Nothing to Disclose
Fuminari Tatsugami, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yuko Nakamura, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Kazushi Yokomachi, RT, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
So Tsushima, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Medical Systems Corporation
Kazuo Awai, MD, Hiroshima, Japan (*Abstract Co-Author*) Research Grant, Toshiba Corporation; Research Grant, Hitachi, Ltd; Research Grant, Bayer AG; Research Grant, Daiichi Sankyo, Ltd; Research Grant, Eisai, Ltd; Medical Adviser, GE Healthcare; Research Grant, Fujitsu Ltd; ; ; ; ; ;
Chikako Fujioka, RT, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Makoto Iida, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose
Yasutaka Baba, MD, Hiroshima, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

Higher spatial resolution is important for CT of the temporal bones, lungs and CT angiography (CTA). While recent clinically introduced model-based iterative reconstruction (MBIR) can reduce image artifacts and noise on CT images, it can also theoretically improve spatial resolution. The purpose of this study was to compare spatial resolution of MBIR with hybrid type iterative reconstruction (hybrid-IR) by measuring modulation transfer function (MTF).

METHOD AND MATERIALS

The phantom was made by 3D printer (Agilista 3200, Keyence, Japan) and has a small cylindrical cavity. The outer diameter of the phantom was 20 mm, and diameter of the cavity was 5 mm. To make a different contrast, we filled the cavity with air (-1000 HU) for simulation of the lung; and with diluted contrast material of +350 HU for simulation of CTA, and +1000 HU for simulation of temporal bones. The phantom images were acquired on a 320 detector CT (Aquilion ONE, Toshiba, Japan), with a tube voltage of 120kV, tube current of 50mA. We employed Forward projected Model-Based Iterative Reconstruction Solution (FIRST, Toshiba) for MBIR and Adaptive Iterative Dose Reduction 3D (AIDR 3D, Toshiba) for hybrid-IR. Various clinical situations were simulated using combinations of reconstruction methods and phantom contrast (Table1). Measurement and image analysis was performed using ImageJ (https://imagej.nih.gov/, NIH, US). We measured spatial resolution by 50%, 20%, 10%, and 5% levels of MTF curves (Fig1) from CT images of the cylindrical phantom. We also calculated theoretical MTF (from Aperture Transfer Function: ATF) defined by physical characteristics of the CT scanner such as size of X-ray spot and aperture size of detector.

RESULTS

The measured MTF values are shown in Fig 2-4. In the CTA simulation, the MTF of FIRST was closest to the ATF. In the lung and temporal bone simulations, the MTF of MBIR was closest to ATF, except at 50% MTF. Although MTF of hybrid-IR is higher than that of MBIR at 50% MTF, this might be attributed to over-/undershooting effects of the convolution kernel used in the hybrid IR and spatial resolution might not be actually improved on hybrid IR images.

CONCLUSION

The MBIR can provide higher spatial resolution without artifacts compared to hybrid-IR.

CLINICAL RELEVANCE/APPLICATION

The MBIR achieves higher spatial resolution than hybrid-IR and aggressive use of the MBIR is recommended for diagnosing diseases of lungs, temporal bones and vessels.

PH260-SD-THB2 Image Quality Assessment of Modern Dual Source and Area Detector CT Scanners Using Contrast Dependency Signal-to-Noise Ratio

Station #2

Participants
Shinji Niwa, MS, Nakatsugawa, Japan (*Presenter*) Nothing to Disclose
Takanori Hara, PhD, Nakatsugawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Katsuhiro Ichikawa, PhD, Kanazawa, Japan (*Abstract Co-Author*) Nothing to Disclose
Atsushi Urikura, PhD, Nagaizumi, Japan (*Abstract Co-Author*) Nothing to Disclose

Hideki Kato, MS, Nakatugawa, Japan (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The purpose of this study was to assess the image quality of modern computed tomography (CT) scanners using contrast dependency signal-to-noise ratio (SNRc), which incorporates iodine contrast enhancement.

METHOD AND MATERIALS

The following three modern CT scanners were assessed in this study: a third-generation dual-source CT (3rd DSCT) scanner (SOMATOM Force; Siemens Healthcare); a 256-row area detector CT (256-row ADCT) scanner (Revolution CT; GE Medical Systems); and a 320-row area detector CT (320-row ADCT) scanner (Aquilion ONE ViSION Edition; Toshiba Medical Systems). A phantom was constructed using a plastic-circular cylinder with various iodinated solutions added into a 300-mm cylindrical water bath phantom. The tube voltage was 80-120 kVp, and the tube current was adjusted to obtain the same size-specific dose estimates for the respective tube voltage settings. SNRc was calculated as system performance from iodine contrast enhancement, modulation transfer function, and the noise power spectrum and compared between the three CT scanners.

RESULTS

Iodine contrast enhancement increased with decrease in tube voltage with all three models. Iodine contrast enhancement of the 320-row ADCT scanner was higher than that of other two scanners; the maximum difference in this respect was 18%. The SNRc of the three CT scanners increased with decrease in tube voltage. SNRc of 3rd DSCT were higher than that of the other scanners at all frequencies with the same tube voltage setting. The SNRc curve for the 3rd DSCT showed nonlinear property with change in the tube voltage.

CONCLUSION

SNRc depends on iodine contrast enhancement and the physical image property of the CT scanner. Generally, because sensitivity for tumor detection is closely related to contrast enhancement, appropriate acquisition conditions for clinical applications should be determined based on SNRc, which incorporates iodine contrast enhancement.

CLINICAL RELEVANCE/APPLICATION

SNRc is an effective image quality index to determine scan conditions because it is closely related to signal detectability in contrast-enhanced CT study.

PH261-SD-THB3 A Three-Dimensional Two Material Based Beam Hardening Correction Algorithm for Iterative Reconstruction Computed Tomography

Station #3

Participants
Ilmar A. Hein, PhD, Vernon Hills, IL (*Presenter*) Employee, Toshiba Corporation
Naruomi Akino, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Corporation
Satoru Nakanishi, MS, Otawara, Japan (*Abstract Co-Author*) Employee, Toshiba Corporation
Jian Zhou, PhD, Vernon Hills, IL (*Abstract Co-Author*) Principal Scientist, Toshiba Corporation
Zhou Yu, Waukesha, WI (*Abstract Co-Author*) Employee, Toshiba Corporation

For information about this presentation, contact:

ihein@tmriusa.com

PURPOSE

A 3D, two material beam hardening correction method (BHC3D) for x-ray CT is described for use in iterative reconstruction (IR). A limitation of earlier beam hardening correction methods is that the correction is two dimensional. The water and bone corrections were typically fan beam, thus limiting the accuracy. BHC3D forward projection is 3D, producing a more accurate correction.

METHOD AND MATERIALS

An FBP seed image volume is first reconstructed, which is segmented into bone and water images. Bone and water pathlengths are determined by forward projection. The pathlengths are indexes to lookup tables, which are used to correct projection data. BHC3D was tested with a QRM cranial phantom as well as clinical cranial and cardiac data.

RESULTS

1) Quantitative testing: QRM cranial CT phantom. With single material water beam hardening correction (WBHC) only, significant blooming is still present around the skull edge along with a dark band present between the temporal bones. The measured HU near the skull edge is 46 HU and 23 HU at the dark band. BHC3Dremoves all BHC artifacts, and measured HU values are uniform. 2) Clinical cranial data: With WBHC only, brightening and darkening artifacts are seen in cranial images. Various structures, particularly at the top of posterial cranial fossa, are not distinct. BHC3D removes brightening and darkening artifacts, and structures are distinct and uniform. 3) Clinical cardiac data: Beam hardening in cardiac images with contrast agents typically shows up as a darkening between the left ventricle and descending aorta. With BHC3D and contrast medium table, cardiac beam hardening artifacts are eliminated. 4) Axial HU Uniformity: An axial uniformity contrast phantom consisting of tubes filled with iodine contrast similar to arteries was constructed and the HU as a function of axial position evaluated. Without BHC3D, the HU linearly decreased from top to bottom as a function of axial position. With BHC3D the linear decrease is eliminated and the HU consistent at both ends of the phantom.

CONCLUSION

BHC3D significantly improves CT images with beam hardening artifacts.

CLINICAL RELEVANCE/APPLICATION

Beam hardening artifacts can obscure anatomical information as well as be misinterpreted as true anatomical information, thus increasing the potential for misdiagnosis.

PH262-SD-THB4 Multivariate Radiogenomic Analysis for Molecular Classification of Invasive Breast Cancer Guided by

Synergistic Interactions of microRNA-Gene Network

Station #4

Participants
Ravi K. Samala, PhD, Ann Arbor, MI (*Presenter*) Nothing to Disclose
Heang-Ping Chan, PhD, Ann Arbor, MI (*Abstract Co-Author*) Institutional research collaboration, General Electric Company
Lubomir M. Hadjiiski, PhD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose
Mark A. Helvie, MD, Ann Arbor, MI (*Abstract Co-Author*) Institutional Grant, General Electric Company
Colleen H. Neal, MD, Ann Arbor, MI (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

To study the feasibility of interpreting the association between the radiomic and the genomic features by exploring the synergistic aspects of the interactions between functional elements of a cell, which may provide understanding and guidance for radiogenomics-based molecular classification of invasive breast cancer.

METHOD AND MATERIALS

Ninety 1.5T T1-weighted DCE-MRI scans were obtained from TCIA and the corresponding genomic data from TCGA and RPPA core. The genomic features included microRNA (miRNA) and protein expression. Initial selection of miRNAs was based on the miRNA regulatory network from the KEGG breast cancer pathway. The individual nodes in the miRNA-gene interaction network were revealed by supervised feature selection and the interactions were analyzed based on miRNet with annotations extracted from 11 miRNA databases. Individual genomic features that had high discriminatory power for molecular classification were identified. The miRNAs that have mappings to the genes in the interaction network were candidates for further analysis. For each MRI volume, a volume-of-interest enclosing the mass was segmented using fuzzy *c*-means clustering and level sets. From the segmented objects, radiomic features (morphological, gray-level intensity and texture) were extracted. The patterns of relationships between the radiomic features and the regulatory miRNAs were examined by canonical correlation analysis. The radiomic features having high correlation with miRNAs were identified and used in a two-loop leave-one-out cross-validation (TLOOV) for molecular classification of estrogen receptor (ER) and progesterone receptor (PR) status of breast cancers.

RESULTS

The first canonical correlation was 0.74 (54% overlapping variance) (λ=0.035, p=0.000); the second was 0.70 (48% overlapping variance) (λ=0.076, p=-.005). The TLOOV using stepwise linear discriminant analysis for feature selection and classification resulted in *AUC* of 0.78±0.05 and 0.65±0.07 for ER+/- and PR+/- classification, respectively.

CONCLUSION

Our novel approach that uses the radiogenomic mapping built on the synergistic interactions of miRNA-gene network can help identify and interpret radiomic biomarkers for molecular classification.

CLINICAL RELEVANCE/APPLICATION

Understanding the key radiogenomic associations for breast cancer is the foundation for the discovery of radiomic features as biomarkers for assessing tumor progression and prognosis.

PH263-SD-THB5 A Methodology to Calculate the Water Equivalent Diameter for Chest Radiography: A Step Closer to Personalized Dosimetry with a Dose Monitoring Platform

Station #5

Participants
An Dedulle, MS, Leuven, Belgium (*Presenter*) Researcher, Qaelum NV
Niki Fitousi, Leuven, Belgium (*Abstract Co-Author*) Research Director, Qaelum NV
Hilde Bosmans, PhD, Leuven, Belgium (*Abstract Co-Author*) Co-founder, Qaelum NV Research Grant, Siemens AG
Jurgen Jacobs, MSc, Leuven, Belgium (*Abstract Co-Author*) CEO, Qaelum NV ; Co-founder, Qaelum NV

For information about this presentation, contact:

an.dedulle@qaelum.com

PURPOSE

To estimate the patient body habitus in terms of the Water Equivalent Diameter (WED) for chest posterior-anterior (PA) radiography exams, using readily available parameters in the DICOM header that can be routinely extracted via a dose monitoring platform.

METHOD AND MATERIALS

For a given patient radiograph, Dose-Area Product (DAP) divided by exposed area (Aexp) gives the approximate input air-kerma to the patient, while Exposure Index (EI) is approximately the exit air-kerma and thus we expect the ratio of EI to (DAP/Aexp) to be related to patient thickness. To test this, a group of 179 patients (78 females, 101 males) were selected who underwent both chest PA radiography and a chest Computed Tomography (CT) exam within 100 days. The axial CT images were used to calculate the gold standard WED for each patient. For each chest radiograph, DAP, Aexp and EI were then extracted from the DICOM header using a dose management platform (DOSE, Qaelum NV). The ratio of EI to (DAP/Aexp) was plotted against WED calculated from the CT images and a curve fit was applied. The methodology was then validated on 53 new patients (26 females, 27 males) who also had a CT and chest PA exam, by calculating WED using the curve fit and comparing against the true WED derived from the CT data.

RESULTS

The ratio of EI to (DAP/Aexp) correlated well with the WED of the patients. An exponential equation gave the best fit with R2 = 0.89. When applied to 53 new patients, mean percentage difference between WEDCT and WEDequation was 2%. Maximum percentage difference was within ±15% and for 68% of patients, the difference was within ±5%.

CONCLUSION

Projection radiography (including general x-ray, dynamic fluoroscopic imaging) has been sidelined when it comes to individualized

dosimetry. The methodology proposed here enables the calculation of an attenuation-based metric from 2D projection radiographs using simple parameters captured by a dose management system from the DICOM header. The validation part showed the approach to be promising. Its implementation would allow straightforward application of WED based conversion factors to organ or effective dose.

CLINICAL RELEVANCE/APPLICATION

The proposed methodology delivers a more personalized approach to patient dose assessment in 2D projection imaging and is easily implemented in daily practice via dose monitoring platforms.

PH264-SD-THB6 Four Different Iterative Reconstruction Algorithms on Abdominal CT Image: A Comparative Study on Image Quality of Inferior Vena Cava

Station #6

Participants
chun yu Gu, xian yang, China (*Presenter*) Nothing to Disclose
Taiping He, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Chenglong Ren, Shanxi, China (*Abstract Co-Author*) Nothing to Disclose
Li Shen, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Lanxin Zhang, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

302956109@qq.com

PURPOSE

Objective To compare the image quality of inferior vena cava in abdominal CT with 4 algorithms, filtered back projection (FBP), adaptive statistical iterative reconstruction (ASIR) and model-based iterative reconstruction (MBIR) noise reduction setting (MBIRNR40) and both noise and spatial resolution setting (MBIRSTND)

METHOD AND MATERIALS

40 adult patients underwent conventional upper abdominal enhancement scan with dual energy CT (DiscoveryTM CT750 HD), and the data was collected on 180s delay phase. Those dates were reconstructed by FBP, ASIR (40% ASIR and 60% FBP blends), MBIRNR40 and MBIRSTND algorithms, at thickness of 0.625mm.The CT value and SD value of the subcutaneous fat of the anterior abdominal wall, the left erector spinae muscle, the inferior vena cava the hepatic vein (left branch and right branch) were measured to calculate the signal-to-noise ratio of the inferior vena cava and contrast noise ratio (CNR) as the standard of ASIR image quality. Two radiologists with more than 10 years experience used 5 scores to access the subjective noise and smoothness of the inferior vena cava and hepatic vein.

RESULTS

The CT values of FBP, ASIR, MBIRNR40 and MBIRSTND were not statistically significant, and the inferior vena cava was 31.1 ± 5.15,23.39 ± 3.77,10.75 ± 1.45,6.14 ± 1.32 (P less than 0.05); CNR were 10.53 ± 2.95, 13.29 ± 3.62, 16.25 ± 4.79 and 23.3 ± 17.39, respectively (P <0.05).The subjective scores of image quality MBIRNR40 and MBIRSTND were significantly lower than ASIR (P <0.05).

CONCLUSION

Under the condition of conventional abdominal scanning, MBIRNR40 and MBIRSTND were higher than ASIR subjective noise and vascular smoothness score,The subjective noise score of MBRNR40 image is the highest, and the MBIRSTND image has a higher degree of vascular smoothness than the subjective noise and the smoothness of blood vessel of ASIR image.

CLINICAL RELEVANCE/APPLICATION

MBIRNR40 and MBIRSTND reconstruction algorithm can improve the quality of CT images of inferior vena cava angiography, and the image quality of left hepatic vein and right hepatic vein is also improved.

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RC721

Advances in CT: Technologies, Applications, Operations-Quantitative CT (QIBA)

Thursday, Nov. 30 4:30PM - 6:00PM Room: S102CD

BQ CT PH

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

Participants

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

For information about this presentation, contact:

samei@duke.edu

Sub-Events

RC721A Volumetry

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

LEARNING OBJECTIVES

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

RC721B Material Identification

Participants
Daniele Marin, MD, Durham, NC (*Presenter*) Research support, Siemens AG

For information about this presentation, contact:

daniele.marin@duke.edu

LEARNING OBJECTIVES

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

RC721C Texture Characterization

Participants
Samuel G. Armato III, PhD, Chicago, IL (*Presenter*) Consultant, Aduro Biotech, Inc
Maryellen L. Giger, PhD, Chicago, IL (*Presenter*) Stockholder, Hologic, Inc; Stockholder, 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, Toshiba Medical Systems Corporation

For information about this presentation, contact:

m-giger@uchicago.edu

LEARNING OBJECTIVES

1) Understand the concept of texture-based image characterization. 2) Identify radiologic tasks in CT that could benefit from image texture analysis. 3) Describe the limitations of these techniques.

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RC722

Imaging for Proton Treatment Guidance and Verification

Thursday, Nov. 30 4:30PM - 6:00PM Room: E261

RO PH

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

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

ABSTRACT

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

Sub-Events

RC722A Pre- and Intra-treatment Imaging Strategies for Patient Alignment

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

LEARNING OBJECTIVES

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

RC722B Advanced Imaging Techniques for Range Verification

Participants
Brian A. Winey, PHD, Boston, MA (*Presenter*) Research Grant, Elekta AB; ;

For information about this presentation, contact:

bwiney@mgh.harvard.edu

LEARNING OBJECTIVES

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

RC723

Molecular Imaging Mini-Course: Clinical Applications of Molecular Imaging—Oncology

Thursday, Nov. 30 4:30PM - 6:00PM Room: S403B

MI OI PH

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

FDA Discussions may include off-label uses.

Sub-Events

RC723A Diagnosis

Participants
Terence Z. Wong, MD, PhD, Chapel Hill, NC (*Presenter*) Consultant, Lucerno Dynamics, LLC;

LEARNING OBJECTIVES

1) Discuss the value of combined FDG-PET and CT for diagnosing malignant disease. 2) Discuss selection of PET radiotracers the potential role of non-FDG PET tracers in managing patients with cancer.

RC723B Staging

Participants
Dominique Delbeke, MD, PhD, Nashville, TN (*Presenter*) Nothing to Disclose

LEARNING OBJECTIVES

1) The potential clinical indications of PET and PET/CT in the evaluation of patients with malignancies. 2) The impact on patient care. 3) Recommendations for PET/CT in the NCCN guidelines.

Active Handout:Dominique Delbeke

http://abstract.rsna.org/uploads/2017/15002834/Active RC723B.pdf

RC723C Evaluation of Treatment

Participants
David A. Mankoff, MD, PhD, Philadelphia, PA (*Presenter*) Speaker, Koninklijke Philips NV; Consultant, General Electric Company; Advisory Board, RefleXion Medical Inc; Consultant, Blue Earth Diagnostics

For information about this presentation, contact:

david.mankoff@uphs.upenn.edu

LEARNING OBJECTIVES

1) List applications of quantitative imaigng for clinical trials. 2) Describe the approach to the design of cancer imaging trials. 3) Discuss biomarkers applications of cancer imaging.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ David A. Mankoff, MD, PhD - 2013 Honored Educator

RC725

Quantitative Imaging Mini-Course: Modality Independent Issues

Thursday, Nov. 30 4:30PM - 6:00PM Room: S403A

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; ; ; ; ;

Sub-Events

RC725A The Role of Physical Phantoms in Quantitative Imaging

Participants
William D. Erwin, MS, Houston, TX (*Presenter*) Research Grant, FUJIFILM Holdings Corporation; Research Grant, Leadiant Biosciences SpA;

LEARNING OBJECTIVES

1) To understand the definitions and requirements of quantitative medical imaging. 2) To learn the role of phantoms and tradeoffs in comparison with simulations and patient studies. 3) To review the classes of phantoms available: Commercial, experimental, and virtual (digital reference objects.)

Active Handout:William Daniel Erwin

http://abstract.rsna.org/uploads/2017/17000434/Active RC725A.pdf

RC725B Digital Reference Objects

Participants
Daniel P. Barboriak, MD, Durham, NC (*Presenter*) Advisory Board, General Electric Company

For information about this presentation, contact:

daniel.barboriak@duke.edu

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 are several software packages 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 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.

Honored Educators

Presenters or authors on this event have been recognized as RSNA Honored Educators for participating in multiple qualifying educational activities. Honored Educators are invested in furthering the profession of radiology by delivering high-quality educational content in their field of study. Learn how you can become an honored educator by visiting the website at: https://www.rsna.org/Honored-Educator-Award/ Daniel P. Barboriak, MD - 2013 Honored Educator

RC725C CT Image Analysis and Sources of Variation

Participants
Binsheng Zhao, DSc, New York, NY (*Presenter*) License Agreement, Varian Medical Systems, Inc; Royalties, Varian Medical Systems, Inc; License Agreement, Keosys SAS; License Agreement, Hinacom Software and Technology, Ltd; License Agreement, ImBio, LLC; License Agreement, AG Mednet, Inc; Research Grant, ImBio, LLC;

For information about this presentation, contact:

bz2166@cumc.columbia.edu

LEARNING OBJECTIVES

1) To familiarize the audience with quantitative image analysis methods such as tumor segmentation and feature extraction, using response assessment in oncology as an example. 2) To discuss sources of variation in tumor characterizations, using both in-vivo tumor and phantom study data. 3) To raise awareness of the need for standardization of imaging acquisition parameters and tumor quantification techniques.

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RCA55

Introduction to Computational Fluid Dynamics from Medical Images: A Step by Step Demonstration (Hands-on)

Thursday, Nov. 30 4:30PM - 6:00PM Room: S401AB

IN PH

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

Participants
Dimitris Mitsouras, PhD, Boston, MA (*Presenter*) Research Grant, Toshiba Medical Systems Corporation;

For information about this presentation, contact:

dmitsouras@alum.mit.edu

LEARNING OBJECTIVES

1) Describe each of the steps involved in performing a computational fluid dynamic (CDF) simulation of blood: a) Segment the blood lumen in a 3D volumetric angiography image dataset (e.g., CT or MRI) starting from DICOM images. b) Produce a finite volume mesh on which to perform the CFD computation starting from the segmented lumen. c) Determine appropriate CFD boundary conditions to set up the problem physics on this mesh. d) Perform the blood flow simulation e) Finally, interrogate the resulting solution for quantities of interest such as pressure, fractional flow reserve (FFR) or endothelial shear stress. 2) Identify the different software components required to perform each of the steps. 3) Use these software components to perform their own computational fluid dynamic analyses in their own field of interest.

ABSTRACT

In this exercise, we will be working with the contrast-enhanced coronary CT angiogram (CTA) of a 48-year-old male patient with hypertension and dyslipidemia who presented with atypical chest pain and that had no personal or family history of CAD. Coronary CTA demonstrated a 59% stenosis of the proximal RCA (AHA segment 1). The patient then underwent elective catheter angiography, which demonstrated a 61% stenosis of the corresponding segment and an FFR measurement of 0.85, indicating no hemodynamic significance of this obstructive (>=50 %) lesion.We will first use a semi-automated coronary segmentation tool in Mimics (Materialise NV) to segment the right coronary artery and its two terminal branches, the posterior descending artery (PDA) and posterior left ventricular branch (PLV) from the CTA and create a 3D model. We will then export the 3D model in the Standard Tessellation Language, or STereo Lithography (STL) file format. The STL file will then be imported into the CFD software (Fluent, ANSYS Inc) and we will generate a finite volume mesh to fill the lumen defined by this STL. We will finally solve the Navier-Stokes equations in this mesh simulating blood flow at hyperemic conditions in the steady state, and we will interrogate the solution for pressure and CT-FFR after setting the coronary pressure at the ostium to that measured in the patient using a sphygmomanometer at the time of CTA.The training guide for this course can be downloaded from here: Click to Download PDF automaticallyor if link doesn't work, copy paste this URL to your web browser:http://www.brighamandwomens.org/Departments_and_Services/radiology/Research/documents/RSNASyllabus-final-online.pdf

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RC825

Quantitative Imaging Mini-Course: Statistical Analysis/Metrology Issues

Friday, Dec. 1 8:30AM - 10:00AM Room: E263

BQ PH RS

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; ; ; ; ;

Sub-Events

RC825A The Role of Metrology in Quantitative Imaging

Participants
Hyung J. Kim, PhD, Los Angeles, CA (*Presenter*) Research Consultant, MedQIA

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. Many applications of using QI biomarkers or in the field of 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 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. To estimate a variation of measureland, the study design is a critical basis for the each stage of development, evaluation, and validation of a QI biomarker or measurement from radiomics using a standard metric of variation. Reporting an estimated measureland universally is an initial step for combining the knowledge across studies and centers as part of evaluation and validation by an independent party. The information can be used for meta-analysis for aggregating bias and variability of a measureland. 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 the potential direction of meta-analysis when we use the common terminology of QI biomarkers and measurements from radiomics.

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 a fair and 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 to describe the uncertainty of measurement and to derive a clinically meaningful metric in quantitative imaging.

RC825B 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 repeatability and reproducibility through test-retest studies. 2) Understand how to assess bias and linearity through phantom studies (or studies with an established reference standard). 3) Understand how technical performance can affect the utility of a quantitative imaging biomarker or radiomic signature.

ABSTRACT

Developments in extracting biological information from medical images have given rise to a number of proposed quantitative imaging (QI) biomarkers and the field of radiomics. Critical to these research areas are the establishment of accurate and reproducible QI tools 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 the technical performance of QI tools. We will also present examples of applying the concepts discussed in this course to actual QI biomarkers.

RC825C Statistical Methods and Principles for Algorithm Comparison Assessment

Participants
Gene Pennello, PhD, Silver Spring, MD (*Presenter*) Nothing to Disclose

For information about this presentation, contact:

gene.pennello@fda.hhs.gov

LEARNING OBJECTIVES

1) Understand objectives of algorithm comparison studies and study design principles. 2) Identify methods for testing hypotheses, estimating performance, and producing descriptive summaries for algorithm comparison. 3) Apply the statistical methods to real data 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.

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SST10

Physics (CT: Image Quality and Techniques)

Friday, Dec. 1 10:30AM - 12:00PM Room: E264

CT PH SQ

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

Participants
Xiaochuan Pan, PhD, Chicago, IL (*Moderator*) Research Grant, Koninklijke Philips NV ; Research Grant, Toshiba Medical Systems Corporation; Research Grant, Varian Medical Systems, Inc
Timothy P. Szczykutowicz, PhD, Madison, WI (*Moderator*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC

Sub-Events

SST10-01 Effect of Model-Based Iterative Reconstruction on Computer-Aided Detection for Quantitative Analysis of Airway Tree in Routine Dose Chest CT: Comparison with Adaptive Statistical Iterative Reconstruction

Friday, Dec. 1 10:30AM - 10:40AM Room: E264

Participants
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Nan Yu, MD, Xian Yang, China (*Presenter*) Nothing to Disclose
Jianying Li, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company
Chuangbo Yang, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Taiping He, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Xiaoxia Chen, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Yong Yu, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Xirong Zhang, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Haifeng Duan, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The pulmonary airway display can reflect the image quality of the chest CT.this retrospective study comparative evaluation of model-based iterative reconstruction (MBIR),adaptive statistical iterative reconstruction (ASIR) with lung kernel on the performance of computer-aided detection (CAD) for quantitative analysis of airway in routine dose chest CT.

METHOD AND MATERIALS

30 patients were included who were scanned for pulmonary disease using a clinical routine dose MDCT system (Discovery CT750 HD,GE Healthcare).Data were reconstructed with MBIR,ASIR(40% ASIR and 60% FBP mix).Airway dimensions were measured from the two reconstructions using an automated, quantitative software that was designed to segment and quantify the bronchial tree, and a skeletonization algorithm to extract the center-line of airway trees automatically (Figure 1).For each patients and reconstruction algorithm chose the right middle lobe bronchus with the least tortuous and bifurcation as a representative to measure the bronchial length of the matched airways. Two radiologists used a semi-quantitative 5-point scale (from -2 for inferior to +2, for superior; -1 for slightly inferior to +1 slightly superior ; and 0, equal with ASIR) to rate subjective image quality of airway trees on the MBIR images.Using paired t and Wilcoxon signed-rank tests for comparison.

RESULTS

Algorithm impacted the measurement variability of the length of bronchus in routine dose chest CT,and MBIR was better,which produced longer bronchus than ASIR($P<0.05$) (Table 1, Figure 2). ($P<0.05$) (Table1,Figure 2).MBIR reconstructions also had higher subjective scores for the airway trees than ASIR($P<0.05$) (Table 2, Figure 3).

CONCLUSION

The quantification accuracy of airway is strongly influenced by reconstruction algorithm.The MBIR algorithm potentially allows the desired airway quantification accuracy to be achieved. which may enable a wider clinical use of low-dose Chest MDCT.

CLINICAL RELEVANCE/APPLICATION

Compare ASIR,MBIR algorithm potentially allows the desired airway quantification accuracy to be achieved on the performance of CAD in routine dose chest CT.which may be used to reduce radiation dose.

SST10-02 Optimization of Multi-Energy Non-Local-Means Denoising for Ultra High Resolution Photon Counting Detector CT Images

Friday, Dec. 1 10:40AM - 10:50AM Room: E264

Participants
Andrea Ferrero, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Wei Zhou, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Shengzhen Tao, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose

Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG

For information about this presentation, contact:

ferrero.andrea@mayo.edu

PURPOSE

Ultra-high-resolution (UHR) photon-counting-detector (PCD) CT has been shown to produce clinical images of unsurpassed spatial resolution, with slices as thin as 0.25 mm. However, the substantially increased noise of UHR images at these thin slices could potentially degrade diagnostic value. In this work, we investigated how to optimize noise reduction with an image based multi-energy, non-local-means (MENLM) method without loss of anatomical details.

METHOD AND MATERIALS

After IRB approval, UHR-PCD CT images of patients were obtained for different diagnostic tasks, including high resolution chest and musculoskeletal exams. MENLM was applied to the 0.25-mm thick filtered-back-projection (FBP) images for each case with variable filter strengths. Each denoised image was then combined with the original FBP image with variable blending ratios. 2D noise power spectra (NPS) were generated from a clinically relevant anatomic region within the patient anatomy. The optimal combination of FBP weighting and MENLM filtration was determined as the one producing the largest amount of image noise reduction without significantly shifting the NPS towards lower spatial frequencies. A board-certified radiologist reviewed all combinations of denoised images and ranked them for image noise, sharpness, presence of artifacts and overall diagnostic quality.

RESULTS

Approximately equal weighting between FBP and aggressively filtered MENLM-denoised images was shown to be the best compromise for the evaluated clinical tasks. For both exams, the radiologist assessment of image quality confirmed the selection based on NPS profiles. The images that were ranked with the highest overall diagnostic quality showed 40% noise reduction for the knee exam and upwards of 50% noise reduction for the chest exam, compared to the original FBP images. In both cases, denoised images received much higher scores in every aspect of image quality that was assessed.

CONCLUSION

NPS profiles computed directly from a relevant anatomic region provide a useful reference to guide a clinical task-specific optimization of denoising algorithms for UHR PCD CT images, allowing noise to be reduced by 40-50% without alteration of fine details or noise texture.

CLINICAL RELEVANCE/APPLICATION

Noise reduction algorithms can be limited by degradation of fine structures. Blending aggressively denoised images with the FBP data resulted in improved performance with preserved anatomical details.

SST10-03 Achieving Higher Image Quality at 75% Lower Dose with Model-Based Iterative Reconstruction in Abdominal CT

Friday, Dec. 1 10:50AM - 11:00AM Room: E264

Participants
Chuangbo Yang, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Jianying Li, Beijing, China (*Abstract Co-Author*) Employee, General Electric Company
Nan Yu, MD, Xian Yang, China (*Presenter*) Nothing to Disclose
Haifeng Duan, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Guangming Ma, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose
Yongjun Jia, MMed, Xianyang City, China (*Abstract Co-Author*) Nothing to Disclose
Chenglong Ren, Shanxi, China (*Abstract Co-Author*) Nothing to Disclose
Lihua Fan, Xian Yang, China (*Abstract Co-Author*) Nothing to Disclose
He Taiping, MMed, Xian Yang City, China (*Abstract Co-Author*) Nothing to Disclose
Yuhuan Chen, MD, Xianyang, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

937874041@qq.com

PURPOSE

To assess image quality of a model-based iterative reconstruction (MBIR) in lower-dose abdominal CT, in comparison with the filtered back projection (FBP) reconstruction with standard dose.

METHOD AND MATERIALS

This study was approved by ethics committee and written consent was provided by all patients. Twenty patients underwent (75%) lower dose contrast-enhanced abdominal CT and reconstructed with MBIR after routine-dose contrast-enhanced CT which was reconstructed with conventional FBP algorithm. Two radiologists assessed the images blindly per the sharpness, image noise, diagnostic acceptability and artifacts with 5-point scoring (1-5 points, Grade 1: cannot be used for diagnosis; Grade 2: poor; Grade 3: acceptable; Grade 4: good; Grade 5: very good). Image noise and signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of abdominal organs relative to abdominal fat were assessed. The volume CT dose index (CTDIvol), dose length product (DLP) and dose reduction rate were also obtained.

RESULTS

CTDIvol and DLP were 3.04±1.48mGy and 95.56±47.17mGy*cm for the lower-dose CT, 12.16±5.18mGy and 376.39±160.40mGy*cm for the routine-dose CT, respectively with 75% reduction (Table 1). Lower-dose MBIR images had significantly lower objective image noise (6.12±1.03HU), higher SNR (11.56±3.30) and CNR (26.96±5.88) than both the lower-dose (39.61±4.55HU, 2.03±0.41 and 4.75±0.98, respectively) and routine-dose (21.45±3.92HU, 3.79±0.68 and 9.01±1.90, respectively) FBP images (all $P<0.001$) (Table 2). In addition, MBIR had better subjective scores (4.20±0.77) than FBP (2.70±0.66 in routine-dose and 1.55±0.51 in lower-

dose) in noise, sharpness and artifacts (Fig. A-D).

CONCLUSION

The MBIR significantly improves the objective and subjective image quality in (75%) lower-dose abdominal CT scans, compared with the routine-dose FBP reconstructions.

CLINICAL RELEVANCE/APPLICATION

The MBIR significantly improves the objective and subjective image quality in (75%) lower-dose abdominal CT scans, compared with the routine-dose FBP reconstructions.

SST10-04 Combination of Dual Phase Acquisition and Snapshot Freeze Technique to Improve the Image Quality in Patients with Intermediate Heart-Rate

Friday, Dec. 1 11:00AM - 11:10AM Room: E264

Participants
Fang Wang, Yinchuan, China (*Presenter*) Nothing to Disclose
Lili Yang, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose
Yongpei Cao, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose
Jie Ding, Yin Chuan, China (*Abstract Co-Author*) Nothing to Disclose
Ruoshui Ha, BA, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose
Yongbin Gao, Yinchuan, China (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

xiaoxiao_8236@sina.com

PURPOSE

To investigate the value of dual phase (45% and 75% of R-R interval) acquisition and snapshot freeze technique on the image quality of coronary computed tomographic angiography (CCTA) on patients with intermediate heart rate (70 to 80bpm), in comparison with single phase.

METHOD AND MATERIALS

Forty-six patients [28 men and 18 women; age (M±SD), 55.3 ± 8.0 years; body mass index (BMI) (M±SD), 25.20±2.8kg/m2] with intermediate heart rate (70 to 80bpm) were scanned on a 256-row detector CT scanner (Revolution CT, GE healthcare). The volume and flow rate of the contrast medium were adapted to the patient's body weight. The scanning range was 140mm or 160mm from the level of the tracheal bifurcation to the diaphragm. Dual phase (45% and 75% of R-R interval) acquisition was performed for all the patients. For both phases, snapshot freeze (SSF) and standard (STD) reconstructions were applied for each patient. Two experienced radiologists, who were blinded to reconstruction information, independently graded the CT images in terms of visibility and artifacts with likert 4-point score(1 = insufficient, 4 = excellent) on a per-patient- and a per-artery-base analysis.Image interpretability of 45%+75% of R-R interval was compared with single 45% and 75% of R-R interval with paired Chi-square test. Image score of 45%+75% of R-R interval was compared with 45% and 75% of R-R interval with signed rank sum test.

RESULTS

For STD reconstruction, dual phase showed higher interpretability than single 45% and 75% of R-R interval on per-artery level [84.8%(117/138) vs 62%(85/138) vs 67%(93/138),P<0.001], and on per-patient level [63%(29/46) vs 39%(18/46) vs 37%(17/46),P=0.021]. When combined with SSF reconstruction, image interpretability on per-artery level and per-patient level was further improved from [84.8%(117/138) and 63%(29/46)] to [96.4%(133/138) and 89.1%(41/46)]. The image quality score for dual phase was higher than single 45% and 75% of R-R interval on both per-artery level and per-patient level (both P<0.001).

CONCLUSION

Combination of dual phase (45% and 75% of R-R interval) acquisition and snapshot freeze technique could improve the image quality and interpretability of CCTA of patients with intermediate heart rate.

CLINICAL RELEVANCE/APPLICATION

Adequate selection of the cardiac phase with this SSF can provide acceptable diagnostic image in patients with an average 70<=HR<=80.

SST10-05 An Image Quality Assessment of the Noise Problem in Edge Preserving Regularization of Low-dose Statistical Iterative CT Image Reconstruction

Friday, Dec. 1 11:10AM - 11:20AM Room: E264

Participants
Zhicong Yu, Mayfield Village, OH (*Abstract Co-Author*) Employee of UIH America Inc
Chunfeng Qian, MD, Shanghai, China (*Abstract Co-Author*) Employee of United Imaging Healthcare
Wenjing Cao, Shanghai, China (*Abstract Co-Author*) Employee of United Imaging Healthcare
Rengcai Yang, Shanghai, China (*Abstract Co-Author*) Nothing to Disclose
Patrick Kling, Mayfield Village, OH (*Abstract Co-Author*) Employee , UIH America, Inc
Stanislav Zabic, PhD, Mayfield Village, OH (*Presenter*) Employee, UIH America, Inc

PURPOSE

This report assesses a new regularization within the framework of statistical iterative image reconstruction in CT, which results in a more uniform noise distribution than other edge preserving regularizations.

METHOD AND MATERIALS

Iterative image reconstruction with edge preserving penalties in CT is known for noise reduction while recovering high spatial resolution and low contrast details. However, a preserved edge is also known to keep the surface around anatomic features noisier

than the surrounding flat areas, which may degrade diagnostic performance of an observer. The new coherent L1 norm reduces the dimensionality of the noise reduction close to the surface between the two tissues and performs noise reduction more uniformly across the entire volume, while keeping the advantage of high spatial resolution.

RESULTS

A medical doctor was asked to review 24 low dose CT abdomen cases, with each containing 4 images reconstructed using the new coherent L1 norm, total variation, Huber penalty and quadratic penalty regularizations. Special attention was paid to critical anatomy with known diseases, including stomach cancer, hemangioma, small cyst, cirrhosis, liver abscess, carcinoma, liver and pancreatic cancer. Total variation and Huber penalties produced images with rough edges, quadratic penalty produced images with low spatial resolution and coherent L1 norm images had both high spatial resolution and uniform noise performance, receiving the highest rating from the observer in all cases. A noise study was conducted on an analytic phantom with inserts of various contrast and image pixel noise variance was calculated for every voxel in the image. We compared the noise variation on the edge voxels and noise variation on the flat regions; the coherent L1 norm showed the least amount of difference on those regions of interest.

CONCLUSION

Coherent L1 norm substantially improves the edge appearance in the reconstructed image with preserved low-contrast details and high-contrast spatial resolution.

CLINICAL RELEVANCE/APPLICATION

Low-dose CT may result in images that have rough edges and leave a doubt with the physician about the condition of the patient. The main cause is the edge preserving regularization in CT reconstruction reduces the noise, but makes organ edges appear rough. Coherent L1 norm with its edge preserving and uniform noise reduction across the image volume has a potential to increase physicians diagnostic confidence.

SST10-06 The Application of Deep Learning Algorithm Pixel Shine in Arterial Phase Pelvic CT for Image Quality Improvement

Friday, Dec. 1 11:20AM - 11:30AM Room: E264

Participants
Shifeng Tian, Dalian, China (*Abstract Co-Author*) Nothing to Disclose
Ailian Liu, MD, Dalian, China (*Abstract Co-Author*) Nothing to Disclose
Jinghong Liu, MD, PhD, Dalian, China (*Abstract Co-Author*) Nothing to Disclose
Yijun Liu, Dalian, China (*Abstract Co-Author*) Nothing to Disclose
Judong Pan, MD, San Jose, CA (*Abstract Co-Author*) Medical Advisor, AlgoMedica Inc
Miao Niu, Dalian, China (*Presenter*) Nothing to Disclose

PURPOSE

To assess the effect of a deep learning denoising algorithm, Pixel Shine (AlgoMedica, Inc, Sunnyvale, CA) on the quality of pelvic arterial phase CT images.

METHOD AND MATERIALS

A retrospective analysis was performed on arterial phase pelvic CT images from 33 patients (BMI<=20) obtained with a GE Revolution CT (70 kVp tube voltage, and ASIR-V-FBP 50% blending) and designated group A. Group B images were then obtained by applying Pixel Shine algorithm to group A image datasets. Subjective image quality was evaluated using a 5-point scoring system by two radiologists, and the scores of the groups were compared. Image signal was assessed using CT values of the urinary bladder. The CT and standard deviation (SD) values of the gluteus maximus were measured, and the SD values of the gluteus maximus were used to represent image noise. The signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of the bladder were then calculated. The image noise, SNR and CNR of two groups were compared using paired t-test.

RESULTS

The subjective visual image quality score of groups A and B, respectively, were 3.03±0.17 vs. 3.85±0.57, the image noise was 15.79±2.05 HU vs. 11.06±2.22 HU, the SNRs of bladder were 0.50±0.23 vs. 0.79±0.39, the CNRs of bladder were 3.72±0.85 vs. 5.14±1.27. Group B showed better subjective image quality, lower image noise, and improved SNR and CNR compared to group A; these differences were statistically significant ($p<0.05$).

CONCLUSION

Processing of arterial phase pelvic CT images reconstructed using ASIR-V technique by deep learning algorithm Pixel Shine significantly improved subjective image quality, reduced image noise, and increased SNR and CNR.

CLINICAL RELEVANCE/APPLICATION

Superior image quality and reduced image noise may be achieved by processing of low-dose ASIR-V reconstructed pelvic CT images using deep learning algorithm such as Pixel Shine.

SST10-07 Human Observer Performance for Localization of Liver Lesions: Correlation between Anatomical and Uniform Background

Friday, Dec. 1 11:30AM - 11:40AM Room: E264

Participants
Samantha Dilger, PhD, Rochester, MN (*Presenter*) Nothing to Disclose
Baiyu Chen, PhD, New York, NY (*Abstract Co-Author*) Nothing to Disclose
Lifeng Yu, PhD, Chicago, IL (*Abstract Co-Author*) Nothing to Disclose
Shuai Leng, DPHIL, Rochester, MN (*Abstract Co-Author*) License agreement, Bayer AG
Christopher P. Favazza, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Rickey Carter, PhD, Rochester, MN (*Abstract Co-Author*) Nothing to Disclose
Joel G. Fletcher, MD, Rochester, MN (*Abstract Co-Author*) Grant, Siemens AG; ;
Cynthia H. McCollough, PhD, Rochester, MN (*Abstract Co-Author*) Research Grant, Siemens AG

For information about this presentation, contact:

Yu.Lifeng@mayo.edu

PURPOSE

To determine the correlation of human performance for localization of small low contrast lesions within uniform water background and within anatomical liver background under the conditions of varying dose, lesion size, and reconstruction algorithm.

METHOD AND MATERIALS

Liver lesions of 5, 7, and 9mm diameter (contrast -21HU) were digitally inserted into projection data of disease-free liver CT scans in regions free of major vessels. Noise was inserted into the full-dose projection data to create three image sets: full dose, simulated half dose, and simulated quarter dose. The images were reconstructed with a standard filtered back projection (FBP) and an iterative reconstruction (IR) algorithm. Lesion and noise insertion procedures were repeated for water phantom data at the same three dose levels. For each background, 2D regions of interest were selected, randomized, and independently reviewed by three medical physicists. Each region of interest had either one lesion present or no lesions present (66 lesion-present, 34 lesion-absent). The readers identified the most likely location of the lesion and provided a confidence score. The locations and confidence scores were assessed using the area under the localization receiver operating curve (AzLROC). We examined the correlation of human performance for the cases of uniform and liver backgrounds as dose level, lesion size, and reconstruction type varied.

RESULTS

As lesion size or dose increased, the readers' ability to locate the lesion improved. At full dose, the AzLROC for the 5, 7, and 9mm lesions in the liver background IR images were 0.53, 0.91, and 0.97, respectively. Similarly, the AzLROC in the uniform background IR images were 0.51, 0.96, and 0.99 for the 5, 7, and 9mm lesions. Similar trends were seen for the other dose levels. The performances between liver and uniform water backgrounds were highly correlated for both FBP and IR. For liver vs. uniform background, the average difference in AzLROC was 0.03±0.03 and had a Spearman correlation of ρ=0.97.

CONCLUSION

For the task of localizing low contrast liver lesions, human observer performance was highly correlated between anatomical and uniform backgrounds.

CLINICAL RELEVANCE/APPLICATION

Liver lesion localization studies may use uniform or anatomic backgrounds, as similar and highly correlated human performances were seen between uniform and liver backgrounds.

SST10-08 Quantifying Quality: Correlating Phantom and Clinical Scan CT Noise Levels to Construct a Quality Reference Level

Friday, Dec. 1 11:40AM - 11:50AM Room: E264

Participants
Joseph T. Davis, MD, Durham, NC (*Presenter*) Nothing to Disclose
Francesco Ria, DMP, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Ehsan Samei, PhD, Durham, NC (*Abstract Co-Author*) Research Grant, General Electric Company; ; Research Grant, Siemens AG; ; Advisory Board, medInt Holdings, LLC
Justin B. Solomon, PhD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose
Donald P. Frush, MD, Durham, NC (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

joseph.davis@duke.edu

CONCLUSION

This study represents a proof of concept method to develop and refine a Noise Reference Level for a given protocol and scanner. This represents a first step in establishing an automated Performance Reference Level for a given scan protocol that incorporates both radiation dose and image quality.

Background

The use of ionizing radiation in computerized tomography mandates risk-benefit understanding. However, this consideration may weight the presumed risk of the ionizing radiation at the expense of the benefits of the examination, with protocol optimization often focusing on dose reduction to the potential detriment of image quality, hence diagnostic value. In fact, the standardized Diagnostic Reference Levels (DRL) are based solely on dose metrics. The purpose of this study is to begin to systematically evaluate an efficient tool for image quality, an automated noise metric in CT to eventually develop a performance metric consisting of both radiation dose and image quality.

Evaluation

Using an IRB-exempt protocol, automated noise values were determined for 1904 contrast enhanced abdominopelvic (AP) and unenhanced chest CT scans on two different scanner models. These data were used to calculate a Noise Reference Level (NRL) by calculating a noise median across a 25-35 cm patient size range, defining the NRL as this median ±20%. A variable diameter phantom was also scanned utilizing both protocols on both scanners, and the resultant noise-size curves for the phantom were compared to those utilizing clinical scan data.

Discussion

Utilizing our novel noise evaluation tool, noise-patient size curves demonstrate agreement between clinical scan and phantom data. Noise measurements were varied based on the region scanned, with the NRL interval between 25 and 37 HU for AP CT, and between 10 and 15 HU for chest CT. This demonstrates the utility of noise monitoring across large numbers of scans to generate a target noise range based on region scanned and scanner equipment, and to identify and evaluate image quality outliers. This automated tool can thus be used to compare performance in a single scanner and between scanners for similar sized patients independent of interpreting radiologist subjective biases.

SST10-09 Quantification of Ellipticity Ratios for Head, Shoulders, Chest, and Abdomen and Their Impact on AEC in CT

Friday, Dec. 1 11:50AM - 12:00PM Room: E264

Participants
Timothy P. Szczykutowicz, PhD, Madison, WI (*Presenter*) Equipment support, General Electric Company; License agreement, General Electric Company; Founder, Protocolshare.org LLC
Ashley Hermanns, Madison, WI (*Abstract Co-Author*) Nothing to Disclose
Christiane S. Burton, PhD, Madison, WI (*Abstract Co-Author*) Nothing to Disclose

For information about this presentation, contact:

tszczykutowicz@uwhealth.org

PURPOSE

It has been reported that CT scanner automatic exposure control (AEC) systems consider patient ellipticity ratio when setting the dose level. In other words, two patients of identical water equivalent diameter (WED) would receive different doses if their ellipticity ratio differed. Because of this effect, understanding large aggregate dose datasets where one plots WED against dose requires incorporation of patient ellipticity ratio to fully predict and model a scanner AEC response.

METHOD AND MATERIALS

We analyzed 884 patient CT scans under IRB approval. The average effective mAs, WED, and ellipticity ratio were calculated for each patient's scan. Data from routine head, chest, ad abdomen/pelvis scans was included for both adults and pediatrics. These datasets were further broken into specific body regions corresponding to: head, chest, shoulders, thorax, abdomen, and abdomen/pelvis. We measured the ellipticity ratio by taking the ratio of the lateral to anterior-posterior patient dimension for each body region. We developed a theoretical model for the CT scanner's AEC function that includes parameters for angular tube current modulation, WED based dose compensation, and ellipticity based dose compensation. We applied the model to fit a dataset containing 294 adult abdomen/pelvis exams under IRB approval.

RESULTS

As expected, the ellipticity ratio of the shoulder region was the highest at 2.28+/- 0.22. The abdomen/pelvis, chest, thorax, and abdomen regions all had ellipticity values near 1.5. The adult head had an ellipticity value of 0.85 +/- 0.08. Our AEC model predicted changes in effective mAs for a given WED as a function of ellipticity as desired. We noted that issues due to patient truncation and the presence of metal implants caused our model to fail. The former is understandable as a truncated image produces a WED smaller than what the AEC systems assumed. Interestingly, the presence of metal orthopedics caused an increase in WED but not a corresponding increase in effective mAs.

CONCLUSION

We measured and showed why patient ellipticity is important in understanding the function of a CT scanner's AEC system.

CLINICAL RELEVANCE/APPLICATION

AEC systems are complex and take into consideration more than just the patient size in terms of WED. We report on and model how ellipticity of a patient influences the output of a CT scanner.