Sugarbaker Procedure: What Radiologists Need to Know About the New Standard of Care for Peritoneal Carcinomatosis

**Teaching Points**
- Image based illustration of peritoneal carcinomatosis
- Principles behind the Sugarbaker procedure
- Role of imaging in guiding surgical management, including imaging based exclusion criteria
- Post operative imaging appearance
- Common complications

**Table of Contents/Outline**
- Introduction to the anatomical and pathophysiological factors that affect intraperitoneal dissemination of malignancies
- Useful tips for identification of the primary tumor
- Imaging appearance of peritoneal carcinomatosis
- The Sugarbaker procedure
- Overview of the procedure
- Role of the radiologist in directing the surgical management
- Emerging role of imaging to determine Peritoneal Carcinomatosis Index (PCI) for prognostic and preoperative assessment
- Postoperative imaging appearances with focus on potential complications of the procedure
- Challenges involved in application of tumor response assessment guidelines for follow up
- Illustration of utilization of other modalities including MRI and FDG PET/CT
- Synopsis of pertinent literature review
- Summarization by highlighting a radiologist's role in the diagnosis and management of peritoneal carcinomatosis
LEARNING OBJECTIVES

1) Provide a review of diagnostic dosimetry covering what we measure and why. 2) Examine the current dosimetry technologies available to the diagnostic medical physics practice. 3) Compare and contrast the pros and cons of conventional and new technologies used for equipment, patient and survey dosimetry.

RCC12

The Use of Business Analytics for Improving Radiology Operations, Quality, and Clinical Performance (In Association with the Society for Imaging Informatics in Medicine)

Refresher/Informatics

LEARNING OBJECTIVES

1) Understand what is meant by business analytics in the context of a radiology practice. 2) Be able to describe the basic steps involved in implementing a business analytics tool. 3) Learn how business analytics tools can be used for quality assurance in radiology, for maintenance of certification (MOC), and for practice quality improvement. 4) Be introduced to the capabilities of current and potential future business analytics technologies.

ABSTRACT

This course will provide an overview of the use of business analytics (BA) in radiology. How a practice manages information is becoming a differentiator in the competitive radiology market. Leveraging informatics tools such as business analytics can help a practice transform its service delivery to improve performance, productivity and quality. An introduction to the basic steps involved in implementing business analytics will be given, followed by example uses of BA tools for quality assurance, maintenance of certification (MOC) and practice quality improvement. The power of current business analytics technologies will be described, along with a look at potential future capabilities of business analytics tools.

Sub-Events

RCC12A  Introduction to Business Analytics Demonstrating Use of an Open-Source Tool for Application to Radiology

LEARNING OBJECTIVES

1) Gain an overview of business analytics tools and understand how they might be used in radiology. 2) Be able to describe the general steps involved in business analytics, including extract, transform, load (ETL) and key performance indicators (KPI). 3) See a demonstration implementation of an open-source business analytics tool using a radiology use case.

ABSTRACT

This session will provide a general overview of business analytics concepts and how they can be used in radiology. A walk through of the basic steps involved in implementation including identifying, collecting, transforming, and dynamically presenting key performance indicators (KPI) will be demonstrated. The extract, transform, load (ETL) steps will be shown using an example use case, and multiple database sources taken from a radiology practice.

RCC12B  Operational and Predictive Analytics in Radiology

LEARNING OBJECTIVES

1) Discuss the importance of informatics tools for ABR MOC PQI and ACGME SBP quality efforts. 2) Identify the role of informatics in capturing, extracting, analyzing, and communication quality projects. 3) Illustrate graphical dashboarding examples to support quality efforts.

RCC12C  Capabilities of Current and Future Business Analytics Technologies

LEARNING OBJECTIVES

1) Discuss the importance of informatics tools for ABR MOC PQI and ACGME SBP quality efforts. 2) Identify the role of informatics in capturing, extracting, analyzing, and communication quality projects. 3) Illustrate graphical dashboarding examples to support quality efforts.
LEARNING OBJECTIVES

1) To gain familiarity with currently available business technologies and their relevance to radiology practice. 2) To consider how existing business technologies can support quality assurance in radiology. 3) To learn about business analytics features that may be available/desirable in the future to augment and support both the practice of radiology.

RC223

Minicourse: Recording and Reporting Radiation Dose: National and International Perspectives and Activities (An Interactive Session)

Refresher/Informatics

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Mon, Dec 1 8:30 AM - 10:00 AM   Location: E353C

URL's

www.imp.uni-erlangen.de/RSNA2012

Sub-Events

RC223A

The American College of Radiology Dose Index Registry
Kalpana M. Kanal PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) Understand how registries perform. 2) How facilities are using registry to monitor dose. 3) Understand the way in which registries have altered physician behavior and improve patient care. 4) Identify the parameters involved in optimizing radiation dose in clinical practice. 5) Apply this knowledge by participating in a dose index registry and utilizing these techniques in Maintenance of Certification.

RC223B

The European Perspective
Willi A. Kalender PhD (Presenter): Consultant, Siemens AG Consultant, Bayer AG Founder, CT Imaging GmbH Scientific Advisor, CT Imaging GmbH CEO, CT Imaging GmbH

LEARNING OBJECTIVES

1) Understand that CTDI is merely a technical concept for scanner acceptance and constancy testing, but not a measure for patient dose. 2) Learn about concepts for patient- and scanner-specific patient dose estimates. 3) Learn about the concept of diagnostic reference levels and its strengths and weaknesses.

ABSTRACT

There is no major debate regarding the validity of the computed tomography dose index (CTDI) in Europe because it is considered as a tool for scanner acceptance and constancy testing. Its use for that purpose is undisputed. Measures for patient dose have been a major topic for decades. There are no common regulations valid for all of Europe, but there are a number of initiatives and concepts in place already which originated here. Among these are primarily the generation of conversion coefficients k for estimating values of the effective dose E from the dose length product (DLP) by E = k×DLP and the concept of dose reference levels (DRL). DRLs for radiological examinations in the European Union were demanded by law already in 2000. Patient dose assessment relies predominantly on pre-tabulated values generated for anthropomorphic and voxel phantoms. Efforts are underway to provide more patient-specific dose estimates (PSDE) independent of CTDI phantom measurements. The lecture will review the above concepts and will point to both strengths and weaknesses.

RC223C

Informatics Tools for Recording/Tracking Dose
Kevin O'Donnell (Presenter): Employee, Toshiba Corporation

LEARNING OBJECTIVES

1) Understand how DICOM Radiation Dose SR (RDSR) captures procedure dose information, the modalities and details covered. 2) Understand how the IHE Radiation Exposure Monitoring Profile (REM) coordinates the capture and management of RDSR objects and how it can be applied in a radiology practice. 3) Understand how ‘CT dose screens’ from legacy scanners can be ported into RDSR. 4) Understand how to apply the pre-scan dose pop-ups on the CT console specified in the MITA CT Dose Check (XR-25) standard. 5) Understand how to specify the above standards and features when purchasing and integrating radiology systems.
RCC21

Leveraging Your Data: Informatics Approaches and Solutions to Improve Imaging Care Delivery

Refresher/Informatics

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Mon, Dec 1 8:30 AM - 10:00 AM   Location: S501ABC

Participants

Moderator
Arun Krishnaraj MD, MPH : Nothing to Disclose

LEARNING OBJECTIVES

1) Identify unmet needs of current and future practices with regards to emerging and existing informatics tools. 2) Apply existing and emerging informatics applications to improve report generation. 3) Demonstrate an understanding of how best to achieve consistency of radiologists’ recommendations.

ABSTRACT

Existing and emerging informatics applications have the potential to markedly improve the quality of imaging care delivery. Much of the inefficiency and inconsistency of report generation could be potentially solved with the appropriate informatics application. In this session, the learner will gain an appreciation of the unmet needs of current and future practices and discover how novel applications developed at various institutions across the country are seeking to plug these voids and improve imaging care delivery.

Sub-Events

RCC21A

The Unmet Needs of Current and Future Practices

Michael Ethan Zalis MD (Presenter): Co-founder, QPID Health Inc Chief Medical Officer, QPID Health Inc Stockholder, QPID Health Inc

LEARNING OBJECTIVES

View learning objectives under main course title.

RCC21B

Augmenting Image Interpretation through the Use of Advanced Health Record Technology

Arun Krishnaraj MD, MPH (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) Appreciate the current state of Electronic Health Record (EHR) technology and adoption in the United States. 2) Identify areas where EHR integration into the daily workflow of Radiologists is lacking. 3) Demonstrate an understanding of the importance of incorporating data contained in the EHR to generate high quality reports. 4) Understand the consequences of under utilizing data contained in the EHR.

ABSTRACT

Advanced heath information technologies, specifically EHR systems, are undergoing rapid dissemination and widespread adoption spurred by initiatives in the American Recovery and Reinvestment Act of 2009. When properly integrated into clinical workflow, an EHR can improve both the quality and efficiency of care delivery. Radiology has long been at the forefront with respect to information technology (IT), however the integration of EHR data into radiologists’ workflow is lacking which affects the efficiency, safety, and costs of Imaging. Emerging advanced health record technologies which incorporate natural language processing and semantic search allow the radiologists to retrieve and incorporate relevant clinical data when generating reports thereby improving both efficiency and quality. In this session, the learner will explore how one such health intelligence platform, known as QPID (Queriable Patient Inference Dossier), allows for the creation of search queries tailored to the workflow of an abdominal radiologist.

RCC21C

Bone Age and Skeletal Atlas Decision Support Tools with Patient Context Integrated into Clinical Workflow

Cree Michael Gaskin MD (Presenter): Author with royalties, Oxford University Press Author with royalties, Thieme Medical Publishers, Inc

LEARNING OBJECTIVES

1) Review concepts for contemporary decision support tools for diagnostic radiologists. 2) Discuss bone age and skeletal atlas decision support tools integrated into clinical diagnostic workflow via context sharing.

ABSTRACT

There are numerous references available to radiologists to aid image interpretation or provide guidance on management of imaging findings. Given the vast amounts of information we are expected to know and the speed with which we are expected to perform our clinical work, it is helpful to quick and easy access to relevant resources at our point-of-care (e.g., during image interpretation and reporting). Such resources should be...
available in electronic format on our diagnostic workstations and, when relevant, be integrated with our clinical applications. Our Radiology Information System (RIS), PACS, and/or Electronic Health Record (EHR) can share study and patient context information with decision support tools to facilitate our diagnostic workflow. Examples to be shared include modern remakes of classic printed atlases in pediatric skeletal imaging, updated to contemporary electronic tools integrated with PACS and EHR applications to expedite workflow and reduce error.

RCC21D

Advanced Decision Support Tools for the Radiologists
Giles W. Boland MD (Presenter): Principal, Radiology Consulting Group Royalties, Reed Elsevier

LEARNING OBJECTIVES

View learning objectives under main course title.

RCC22

Monitoring Radiation Exposure: Standards, Tools and IHE REM

Refresher/Informatics

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Mon, Dec 1 10:30 AM - 12:00 PM  Location: S501ABC

Participants

Moderator
Kevin O’Donnell : Employee, Toshiba Corporation
Kevin O’Donnell (Presenter): Employee, Toshiba Corporation
Michael F. McNitt-Gray PhD (Presenter): Institutional research agreement, Siemens AG Research support, Siemens AG
Tessa S. Cook MD, PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) Learn about key radiation exposure metrics, such as CTDI, and how to interpret them. 2) Learn about radiation exposure monitoring methods and tools including 2a) Capturing dose information with the DICOM Radiation Dose SR (RDSR) standard. 2b) Managing RDSR objects with the IHE Radiation Exposure Monitoring (REM) Profile. 2c) Integrating ‘CT dose screens’ from legacy systems into RDSR. 2d) Pre-scan dose pop-ups on the CT console defined by the MITA Dose Check standard and AAPM guidance on their use. 3) Learn how to specify the above features when purchasing and integrating Radiology Systems. 9) Learn about components of a dose management program such as protocol optimization. 4) Participation in the ACR Dose Registry, and reporting requirements such as California SB-1237.

SSC06

ISP: Health Service, Policy & Research (Quality)

Scientific Papers

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Mon, Dec 1 10:30 AM - 12:00 PM  Location: S102D

Participants

Moderator
Christopher Paul Hess MD, PhD : Research Grant, General Electric Research Consultant, Imaging Endpoints Research Consultant, Cerebrotech Medical Systems

Moderator
Pari Pandharipande MD, MPH : Nothing to Disclose

Sub-Events

SSC06-01

Health Service, Policy & Research Keynote Speaker: Defining Quality in Radiology
Christopher Paul Hess MD, PhD (Presenter): Research Grant, General Electric Research Consultant, Imaging Endpoints Research Consultant, Cerebrotech Medical Systems

SSC06-02

High Fidelity Contrast Reaction Simulation Training: A Single Department’s Comparison of Performance and Comfort Level Amongst Faculty, Fellows, and Residents
Kyle Elmer Pfeifer MD (Presenter): Nothing to Disclose, Jay Kumar Pahade MD : Nothing to Disclose, Jonathan D. Kirsch MD : Nothing to Disclose, Melih Arici MD : Nothing to Disclose, Jennifer Arango : Nothing to Disclose, Lawrence H. Staib PhD : Nothing to Disclose

PURPOSE

Reactions to contrast material are uncommon in diagnostic radiology, and vary in presentation from urticaria to life threatening anaphylaxis. It is the responsibility of the radiologist to provide appropriate care. Prior work has shown a high error rate in contrast reaction management, with smaller studies using simulation showing
variable data on effectiveness. Using the largest study population to date, (>150 radiologists) we sought to assess the effectiveness of high fidelity simulation in managing contrast reactions.

**METHOD AND MATERIALS**

A 20 question multiple-choice test and Likert scale questions assessing subjective comfort levels and knowledge of management of contrast reactions was created. Three simulation scenarios (moderate reaction, severe reaction, and reaction mimic) were designed to provide simulation training. Each course was completed in one hour in groups of 8-10 with 2-3 “responders” per simulation. All participants completed a pre-test, post simulation debriefing, and post-test to assess effectiveness on test scores and subjective Likert ratings of comfort in managing reactions.

**RESULTS**

151 radiologists participated (residents=53, fellows=24, faculty=74). There was a statistically significant increase in the post-test scores after the simulation (p=0.03). Post simulation Likert scores regarding comfort in managing contrast reactions showed a significant increase across mild, moderate, and severe reactions (P<0.05). No statistical difference in test scores was noted when comparing residents to fellows to faculty.

**CONCLUSION**

High fidelity simulation is an effective learning tool, allowing practice of “high acuity” situations in a non-threatening setting. Our study revealed a statistically significant improvement in test scores, and subjective comfort in management of reactions. The study supports the use of high fidelity simulation as an effective teaching tool for contrast reaction management.

**CLINICAL RELEVANCE/APPLICATION**

Our study illustrates the successful implementation of a high fidelity contrast reaction simulation program across an entire radiology department and is the largest to date. It further supports the implementation of simulation as an effective teaching tool in contrast reaction management training with the goal of improving patient outcomes.

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**SSC06-03**

**Appropriateness of Use of Computed Tomography Pulmonary Angiography by Emergency Department by Use of Decision Rules**

Jadranka Stojanovska MD, MS (Presenter): Nothing to Disclose, Ruth C. Carlos MD, MS: Nothing to Disclose, Aamer Rasheed Chughtai MBBS: Nothing to Disclose, Aine Marie Kelly MD: Nothing to Disclose, Ella A. Kazerooni MD: Nothing to Disclose

**PURPOSE**

To apply the appropriateness of computed tomography pulmonary angiography (CTPA) utilization using existing clinical decision rules in emergency department (ED) and to assess CTPA diagnostic yield by applying decision rules.

**METHOD AND MATERIALS**

Institutional Review Board approval was obtained for this HIPPA-compliant prospective cohort study. A total of 602 consecutive adult ED patients undergoing CTPA for suspected pulmonary embolism (PE) formed the study population. Primary outcome was positive or negative for PE. PE rule-out criteria (PERC) and modified Wells (mWells) score were retrospectively calculated. Positive PERC (+PERC) was defined as having ≥1 of the criteria met. Positive mWells (+mWells) was defined if the score was > 4. PE prevalence, percentage of CTPA examinations that could have been avoided, the diagnostic yield of CTPA among patients with -PERC compared to -mWells were calculated.

**RESULTS**

Of 602 patients in total, 61 (10%) were diagnosed with PE. By applying PERC and mWells, 17.6% (106/602) and 45 (261/602) of all CTPA examinations could have been avoided. The overall diagnostic yield of PERC was higher at 10% (59/602) compared to diagnostic yield of mWells of 8% (49/602) p<0.0001. Among patients with -PERC, the diagnostic yield for PE was 1.9% (2/106) compared to a diagnostic yield of positive PE of 4% (12/273) among patients with -mWells (p=0.004).

**CONCLUSION**

PERC is safer triaging decision tool than mWells that reduces the probability of PE to below 2% and should be applied in ED setting to avoid overutilization of CTPA.

**CLINICAL RELEVANCE/APPLICATION**

The diagnostic yield of PE among negative cases by PERC (1.9%) is lower than diagnostic yield of PE among negative cases by mWells (4%). PERC is safer clinical decision rule than mWells that reduces PE posterior probability to below to 2% and it should be applied in ED setting to avoid overutilization of CTPA.

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**SSC06-04**

**Determining Social Acceptance with the Use of Patients’ Photographs Integrated with Medical Imaging Studies to Reduce Wrong Patient Errors**

Gelareh Sadigh MD (Presenter): Nothing to Disclose, Kimberly E. Applegate MD, MS: Co-editor, Springer Science+Business Media Deutschland GmbH Advisory Board, WellPoint, Inc, Timothy W. Ng MD: Nothing to Disclose, Kamilah Hendrix MD: Nothing to Disclose, Srini Tridandapani PhD, MD: Nothing to Disclose.
PURPOSE
Mislabeled imaging studies can lead to serious consequences for pediatric patients and their families due to misdiagnosis and inappropriate therapy. Integrating pediatric patients’ digital photographs with medical imaging may increase the detection of mislabeled studies. However, photographic IDs also raise concerns about patient privacy and whether this technology will be accepted by the public. The purpose of this study was to determine how the parents and guardians of pediatric patients would receive this novel technology.

METHOD AND MATERIALS
Over a two-month period in 2014, parents and guardians of patients were asked to complete a 13-question survey in the ambulatory waiting room of a Children's Hospital radiology department. The parents' anticipated perception about the use of patients' photograph with medical imaging in different clinical scenarios was investigated and its predictors were determined using logistic regression analysis.

RESULTS
498/600 parents responded to the survey (response rate 83%). 86% were female (mean age 37 years). 77% had more than high school diploma. 51% had > $50,000 annual household income. Mean age of respondents' child was 7 years. 96% and 97% of parents supported the use of a photo ID, if it improves the radiologist's imaging interpretation, or decreases the rate of mislabeled errors, respectively. A minority of respondents (38%) were worried that obtaining their child's photo would impact his/her privacy. 94% believed that they should be asked for their consent prior to obtaining their child's photo. 90%, 91% and 92% of parents supported the new technology if their child was slightly sick (outpatient), brought into the emergency department after trauma, or hospitalized in an intensive care unit, respectively. After adjusting for independent covariates, Caucasian parents were less worried about the impact of the new technology on child's privacy compared to other ethnicities (P=0.009). Parents older than 45 years of age were less supportive of the technology in outpatient setting (P=0.02).

CONCLUSION
The vast majority (96%) of parents support integrating their child's photograph with imaging studies in order to improve safety and believe that consent should be obtained.

CLINICAL RELEVANCE/APPLICATION
Integrating patients’ digital photographs with medical imaging studies is socially acceptable to patients.

Frequency of Acute Kidney Injury Following Intravenous and Intra-arterial Iodinated Contrast Material Administration in a Paired Cohort

Jennifer S. McDonald PhD (Presenter): Research Grant, General Electric Company, Robert J. McDonald MD, PhD: Nothing to Disclose, Caleb Brandon Leake BS: Nothing to Disclose, Rickey Carter PhD: Nothing to Disclose, Rajiv Gulati MD, PhD: Nothing to Disclose, Richard W. Katzberg MD: Research Grant, Siemens AG Research Grant, Bayer AG Investigator, Siemens AG Investigator, Bayer AG, Eric E. Williamson MD: Research Grant, General Electric Company, David F. Kallmes MD: Research support, Terumo Corporation Research support, Covidienn AG Research support, Sequent Medical, Inc Research support, Benvenue Medical, Inc Consultant, General Electric Company Consultant, Covidienn AG Consultant, Johnson & Johnson

PURPOSE
Purpose: Prior uncontrolled studies of contrast-induced nephropathy suggested that intra-arterial contrast administration is associated with a higher risk of acute kidney injury (AKI) compared to intravenous administration. We compared the risk of AKI following intravenous and intra-arterial contrast exposure in a cohort of patients that received both routes of contrast administration.

METHOD AND MATERIALS
Materials and Methods: This retrospective study was HIPAA compliant and approved by our IRB. All patients who received both a contrast-enhanced CT or CT angiography scan and a diagnostic or interventional cardiac catheterization between 2000-2011 were identified. Patients who lacked sufficient pre- and post-procedure serum creatinine (SCr) results, who were on pre-existing renal dialysis, who underwent additional contrast-enhanced procedures within 14 days of either procedure, or whose baseline SCr changed more than 0.3 mg/dL between procedures were excluded. The incidence of AKI, defined as SCr >= 0.5mg/dl above baseline, was compared following CT scan and cardiac catheterization using McNemar's test.

RESULTS
Results: A total of 1073 patients met all study inclusion criteria. The incidence of AKI following CT scan was similar to the incidence following catheterization when examining all patients (4.9% CT vs. 6.0% catheterization, p=.27). This similar AKI incidence was observed regardless of order of procedure (CT or catheterization) or type of cardiac catheterization performed (diagnostic or interventional).

CONCLUSION
Conclusion: In this paired cohort, the frequency of AKI following intra-arterial administration of iodinated contrast material is similar to the rate observed following intravenous contrast administration. These findings suggest that prior reports of excess incidence of AKI following intra-arterial contrast administration compared to intravenous administration may reflect differences in clinical status and baseline risk for AKI rather than differences in the nephrotoxic potential in these two routes of contrast administration.

CLINICAL RELEVANCE/APPLICATION
Clinical Relevance: The nephrotoxic risk of intra-arterial contrast administration has been overstated in prior studies lacking a suitable control group.
**SSC06-06**  
Quality Measurements in Radiology: A Systematic Review of the Literature  

**PURPOSE**
As the US healthcare delivery system transitions from volume to value, numerous public, private and non-profit entities have developed quality metrics to evaluate health care providers. Radiology quality metrics currently in use by CMS programs (e.g., Physician Quality Reporting System) do not focus on true diagnostic outcomes. We present here an exhaustive inventory of all published radiology quality metrics and classify them according the hierarchical framework of Donabedian et al., which is used widely throughout the broader healthcare quality metric literature.

**METHOD AND MATERIALS**
A systematic review was performed in which eligibility criteria included published primary research articles, commentaries, and review articles from 2000 onward. Multiple databases were searched (7/1/2013) as well as the reference lists of identified articles. Studies were double-read with discrepancies resolved by consensus. Outcome measures were organized based on standard Donabedian categories (structure, process, outcome). Results were reported according to PRISMA study guidelines for reporting systematic reviews.

**RESULTS**
Our initial search yielded 1816 unique citations (Figure 1). Our double-blind abstract screen identified 110 papers for detailed review, of which 16 were included in the final analysis. A total of 75 unique metrics were reported, which were further classified as follows: 28 (37%) structure metrics, 24 (32%) outcome metrics and 23 (31%) process metrics. The most commonly cited outcome metric was the ACR RADPEER score (50% of papers). The most commonly cited structural metric was whether or not a facility was accredited by the ACR (31% of papers). The most commonly cited process metric was whether ACR appropriateness criteria were followed (25%).

**CONCLUSION**
Numerous radiology quality metrics have been described, which are evenly divided between structure, process and outcomes metrics. Additional research is needed to determine why there has been low uptake of radiology outcome metrics into existing value-based contracting (e.g., CMS PQRS).

**CLINICAL RELEVANCE/APPLICATION**
Radiologists must work to develop quality metrics that evaluate patient centered outcomes of radiologic studies.

**SSC06-07**  
Intravenous Contrast Extravasation: Trends in Rate, Complications, and Demographics  
Martin Lee David Gunn MBChB (Presenter): Medical Advisor, TransformativeMed, Inc Spouse, Consultant, Wolters Kluwer nv Grant, Koninklijke Philips NV, Bruce E. Lehnert MD: Nothing to Disclose

**PURPOSE**
The primary purpose of this study was to examine the contrast extravasation (CE) rate and complications from power-injected intravenous low-osmolality iodinated contrast media. The secondary purpose was to determine the impact of real-time pressure monitoring and saline test injections on the CE rate.

**METHOD AND MATERIALS**
Retrospective, single-center review of adult patients (18 years and older) maintained in a dedicated CE database from 2006 to 2013 inclusive, encompassing approximately 80,000 contrast injections. Demographic information, iv line location (peripheral or central), scan protocol used, flow rate, contrast type, volume of contrast extravasation, and complications were examined. Statistical analysis included chi-squared tests for contingency tables, and t-test for continuous variables.

**RESULTS**
From 2006-2013 inclusive, there were 290 CE's from 80,045 contrast injections, yielding an overall CE rate of 0.362%. All injections were non-ionic low-osmolality contrast media (iohexol 300, iohexol 350, iodixanol 320). CE occurred in older patients than those without CE (52.04 vs 46.9 years, p<0.0001). There was a significant gender difference, with males slightly less likely to have extravasations than females (relative risk 0.74; 95%CI 0.59-0.94; p=0.014). Volume of extravasation ranged from 20 cc to 200 cc (mean 72.8cc, sd 41.14 cc). Following implementation of a power-injected saline test flush and real-time technologist pressure monitoring in 2008, there was no reduction in the extravasation rate (pre: 0.40%, post: 0.33% to (p<=0.17), or volume (69.8 cc vs 75 cc 95CI = -0.1-16.35 cc, p=0.36) CE line type were: 238 (82%) peripheral, 22 (8%) central, and 30 unknown (10%) respectively. There were two serious complications - forearm compartment syndrome requiring a fasciotomy, and central line extravasation requiring chest tube placement.

**CONCLUSION**
We report a low rate of CE following iv power injection. Age is correlated with risk. 2/259 serious complications occurred, confirming the safety of LOCM CE power-injections. The implementation of saline test power-injections
and real-time pressure monitoring was not associated with a lower rate or volume of extravasations.

**CLINICAL RELEVANCE/APPLICATION**

The risk of a complication requiring intervention due to CE is extremely low, approx 2 / 80,000 in our series. Using a saline test bolus, and real-time infusion pressure monitoring do not reduce, or volume of CE.

**Is Computerized Tomography Sufficient without Bone Scan for Routine, Asymptomatic Breast Cancer Staging?**

Jill Tichy MD (Presenter): Nothing to Disclose, Mark Raymond Waddle BS: Nothing to Disclose, Allison Deal MS: Nothing to Disclose, Lisa A. Carey: Nothing to Disclose, Hyman Muss: Nothing to Disclose, Nisha Mehta MD: Grant, Siemens AG

**PURPOSE**

Redundant use of imaging modalities for staging is not cost effective, and can result in unnecessary additional workup. This study aims to assess the added utility of routine bone scan (BS) above staging CT chest/abdomen/pelvis (CT) in detection of asymptomatic breast cancer bone metastasis (BM).

**METHOD AND MATERIALS**

Eligible patients had stage I-III asymptomatic breast cancer diagnosed between 2010-2013 and underwent staging BS and CT

**RESULTS**

Among 124 patients, the median age was 53, median tumor size 3.45 cm, and 82 had >= 1 positive lymph node. Varying receptor subsets were included. Median follow-up was 2.18 years. 102 (82.3%) were radiologically concordant for BM evaluation with 93 (75.0%) negative and 9 (7.3%) raising suspicion for metastatic disease. There were 22 (17.7%) radiologically discordant cases per initial reports, of which 9 were deemed truly discordant on review. 13 of the discordant patients underwent further workup with 1 biopsy confirmation. Of the 11 CT+/BS- patients, 9 are alive without disease, 1 died with BM, and 1 was lost to follow-up. Of the 11 BS+/CT- patients, 8 are alive without disease, 1 died with visceral-only metastases, 1 died with visceral+BM, and 1 was lost to follow up with confirmed BM. Skull-only metastases were suspected by BS in 2 cases; 1 died with visceral+BM. There was no association of any patient or tumor characteristic with measured discordance (p-values >= 0.07).

**CONCLUSION**

Of the cases demonstrating discordance between CT and BS, the vast majority had negative follow-up imaging for metastasis, and there was only 1 case out of 124 of isolated clinically significant BM identified by BS without associated abnormal CT findings. Therefore, bone scan routinely coupled with CT staging may be unnecessary in asymptomatic breast cancer.

**CLINICAL RELEVANCE/APPLICATION**

Recommendations for asymptomatic breast cancer staging may merit reconsideration; BS may only be necessary in those with findings suspicious for osseous or visceral metastatic disease on CT staging.

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**Health Service, Policy & Research Keynote Speaker: Practicing Quality in Radiology**

Annette Jean Johnson MD, MS (Presenter): Nothing to Disclose

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**ISP: Radiation Oncology & Radiobiology (Outcome and Quality of Life)**

**Scientific Papers**

AMAPRA Category 1 Credits™: 1.50
ARRT Category A+ Credits: 1.50

Mon, Dec 1 10:30 AM - 12:00 PM Location: S104A

**Participants**

Moderator
Anna Shapiro MD: Nothing to Disclose

Moderator
Beatriz E. Amendola MD: Nothing to Disclose

**Sub-Events**

**SSC13-01** Radiation Oncology & Radiobiology Keynote Speaker
Christine Megan Fisher MD (Presenter): Nothing to Disclose

**SSC13-02** ROQS: A Comprehensive Error Reporting and Quality Assurance Program for Radiation Oncology
PURPOSE
Modern radiotherapy treatment planning and delivery is a complex process involving multiple medical personnel and the transfer of critical data within organizational systems at risk for errors. In Dec 2012, the error reporting and quality assurance (QA) program at a major academic radiation oncology department was comprehensively updated to gather personnel- and systems-related data (Radiation Oncology Quality and Safety (ROQS) system). The objective of our study was to assess the utility of the ROQS system for determining logistical risk factors associated with reported errors.

METHOD AND MATERIALS
ROQS-reportable events are captured using a secure web-based form accessible to all departmental staff. A ROQS committee comprised of clinical and management personnel meet semi-monthly to classify events and guide quality improvement efforts. Problem solving initiatives are implemented as a result of events reported, as appropriate. Events are classified into 3 major categories as actual events (A class), near misses (B class), or workflow-related events (C class), and are then subclassified according to the severity of the event or potential for harm if a near miss (e.g. A1-A3 events correspond to aberrations in dose delivered with dose differences >=20%, 5% to 20%, and

RESULTS
31,309 treatments were delivered from Dec 2012 - Nov 2013. During this period, 7 class A and 23 class B events were reported (0.2235/1000 and 0.7346 /1000 treatments respectively). No A1 or A2 events or events leading to major patient harm were observed. Among linac-treated patients with complete data available for assessment (n= 1452), class A events were significantly associated with a simulation to treatment time of less than 7 days (RR 4.98, p=0.019).

CONCLUSION
The ROQS system is a comprehensive QA approach designed to capture organizational and procedural factors contributing to errors. Data obtained from the ROQS system can be used to specifically target quality improvement efforts within a complex radiation therapy delivery system.

CLINICAL RELEVANCE/APPLICATION
Targeted workflow changes designed to address logistical risk factors identified by the ROQS system are predicted to decrease error rates and improve the safety of patients undergoing radiotherapy.

Incidental Findings on Radiation Treatment Planning CT Scans
Laura E. Kollar MD (Presenter): Nothing to Disclose , Edward Y. Kim MD : Nothing to Disclose

PURPOSE
Few studies have been reported evaluating the rate of incidental findings on radiation treatment planning CT scans. We set out to review our own institutional experience with diagnostic radiology review of treatment planning CT scans and the resulting impact patient care.
Merkel Cell Carcinoma (MCC): Demographic, Clinical, and Treatment Parameters of Prognostic

SSC13-07

A Prospective Study of Toxicity Profiling in Patients with Squamous Cell Carcinoma of the Head and Neck (SCCHN) Treated with Helical Tomotherapy Intensity Modulated Radiotherapy (HT-IMRT), 5 Year Results

Samy El-Sayed MD: Nothing to Disclose, Mohammed Yahia Almaghrabi MD (Presenter): Nothing to Disclose

ABSTRACT

Purpose: Radical Radiotherapy remains the mainstay of treatment in patients with SCCHN. IMRT have become the norm in North America even before the benefits were proven. Previous studies have addressed some of the toxicities. The purpose of this prospective study is to profile the all aspects of the toxicity of IMRT treatment in patients with locally advanced SCCHN. Methods: This study was carried out from 2006-2012. Patients included had had a histologically confirmed locally advanced SCCHN to be treated to the primary site and regional lymphatics to 70 Gy in 35 Fractions, ECOG PS of =18 years of age, with no other active malignancy. Radical radiotherapy had to include initial phase of 50 Gy in 25 Fractions to involved areas and areas at risk to be followed by a boost of 20 Gy in 10 Fractions to the involved areas only using the same Fractionation as conventional radiotherapy. Treatment related toxicities were evaluated by OMAS (Oral mucositis assessment scale), RTOG and CTCAE acute and late assessment scales. Weekly mucositis assessment were collected using the OMAS and RTOG scales during the treatment and every 2 weeks after treatment until resolution. Prospective information were collected on QOL using EORTC Hand/Ne QOL module. Result: 92 patients were enrolled: 87 of them were evaluable, 48 % had undergone concomitant chemotherapy. Median age was 60 years old, 78 % were male. Most common primary tumour site was oropharynx 67 %. 80% of the patients were smokers, 35% of them continue to smoke. Acute mucositis was evaluated using the OMAS score. 5, 15, 74 and 6% have developed grade 1, 2, 3, and 4 mucositis respectively. Pattern of mucositis will be presented. Grade 1, 2, 3, skin reaction were recorded in 26, 59 and 15 % respectively. 22% of our patients reported Grade 3 dysphagia. Only 9% suffered long term salivary gland dysfunction with Xerostomia. Grade 3 mucositis had a higher incidence in the combined modality group, while Grade 3 dysphagia was more in XRT alone (56%). 19 patients (41%) in the radiotherapy group required tube feeding compared to 26(62%) combined modality patients. 4.5% of our patients suffered radiation necrosis at the high dose area despite adequate dental evaluation and use of fluoride trays. Conclusion: This study provides a benchmark for the rate and pattern of toxicity caused by IMRT Radiotherapy in a population cohort of patients with SCCHN. Compared with toxicities of conventional radiotherapy, there seems to be a significant improvement overall but with perhaps a different pattern. Part of the improvement could be due to better supportive care. Longer than 5 years follow up is required to rule out other long term toxicities such as secondary tumours and muscle dysfunction.

SSC13-08

Merkel Cell Carcinoma (MCC): Demographic, Clinical, and Treatment Parameters of Prognostic Significance

Michael Fu (Presenter): Nothing to Disclose, Evan Charles Osmundson MD, PhD: Nothing to Disclose, Daniel S. Kapp MD, PhD: Nothing to Disclose, Susan J. Knox MD, PhD: Nothing to Disclose, Rie von Eyben: Nothing to Disclose

ABSTRACT

Purpose: We explored patient, tumor, and treatment factors with regard to recurrence and overall survival in patients with primary MCC treated at a single institution over a 31-year period. Methods: A retrospective review was conducted of 47 patients diagnosed with primary MCC between 1981 and 2012. Outcomes of interest were: first recurrence (local, regional, in-transit, or distant reappearance of tumor), first locoregional recurrence (within the original tumor site or regional lymph nodes), and death. Univariate analysis (Pearson X2 test) and multivariate logistic regressions were performed to identify factors associated with each outcome. Results: Our cohort had a mean age at diagnosis of 73.3 years and was predominantly Caucasian (74.5%) and male.

METHOD AND MATERIALS

At our institution, all radiation planning CTs are reviewed by a diagnostic radiologist. Reports from all radiation treatment planning CT scans over one year from a single treatment center were reviewed. Pertinent findings were considered those that were new or previously unreported and could potentially change or delay treatment decisions. These included findings reported involving the bone, lung, liver, adrenal glands, or lymph nodes. Other non-emergent, non-cancer related findings were not included in this study.

RESULTS

347 CT scans for 326 patients were performed between January 1, 2013 and December 31, 2013. 145 were for primary breast malignancies, 19 of which were DCIS. The remainder of the scans included 35 prostate, 23 lymphoma, 16 multiple myeloma, 10 pancreatic, 10 endometrial, 7 cervical, 5 rectal, 50 metastases, and 27 other. 66 new findings were detected on a total of 56 scans (16.1%). These included 21 lung nodules, 14 bone lesions, 15 liver lesions, 8 adrenal nodules, and 11 enlarged or suspicious lymph nodes. 12 of these scans (21.4%) led to additional imaging. 4 patients experienced delay of radiotherapy due to further work up. 2 patients ultimately did not receive definitive treatment due to confirmation of metastatic disease. Of note, one patient found to have an indeterminate sclerotic bone lesion on treatment planning scan was confirmed to have bony metastatic disease 8 months later. Of the positive scans, 39 were for primary breast malignancies (69.5%).

CONCLUSION

New or previously unreported findings are not uncommon in radiation treatment planning scans, with 16.1% of scans showing unexpected, potentially cancer-related findings. 8.3% of all scans, and 21.4% of positive scans, led to additional imaging.

CLINICAL RELEVANCE/APPLICATION

New findings as reported on diagnostic radiology review of radiation planning scans can have important clinical implications and may potentially change treatment recommendations for patients undergoing radiotherapy. In our study, we found the rate of potentially cancer-related findings to be not uncommon, with such findings often leading to additional imaging to determine disease status.
AJCC stage at diagnosis was I in 40.4%, II in 8.51%, III in 25.5%, IV in 4.26%, and unknown in 10.0%. Treatments included primary tumor resection without local radiation therapy (RT) (21.3%), primary tumor resection followed by RT (63.8%), primary site treated with RT only (8.51%), no primary tumor resection or RT (6.4%), sentinel lymph node biopsy (SLNB) (38.3%), lymph node dissection (LND) (27.7%), SLNB followed by RT (27.7%), and LND followed by RT (23.4%). Mean values for RT parameters were: tumor dose 51.6 Gy (in 27.8 fractions) and regional node dose 46.2 Gy (in 24.7 fractions). In total, 53.2% of patients-recurred, with 48% failing locoregionally; 61.7% were deceased at last follow-up. Mean follow-up time was 26.0 months. On univariate analysis, lack of SLNB, low pre-RT red blood cell count, and low pre-RT hematocrit were independently associated with recurrence, while head and neck primary site, AJCC stage, nodal stage, and lack of RT treatment with locoregional recurrence. Furthermore, SLNB was independently associated with overall survival. For patients who received RT, the dose, fraction number, and duration of RT treatment and treatment breaks were not associated with outcomes. Multivariate analysis demonstrated a 4.75 adjusted relative risk (95% CI 1.85-5.43, p < 0.05) for head and neck tumors for locoregional recurrence. Year of diagnosis was not significantly associated with any of the outcomes studied. Conclusions: Our results confirm prior reports on the positive impact of RT on locoregional control but not on overall survival in MCC. SLNB was associated with improved survival. Additionally, tumor characteristics including head and neck location, AJCC stage, and nodal stage appear better prognostic for locoregional recurrence. Improvement in survival will require more effective systemic treatments.

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**SPPH21**

**AAPM/RSNA Basic Physics Lecture for the Radiologic Technologist: Radiography: Getting the Information We Need and Doing It Efficiently (An Interactive Session)**

**Special Courses**

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

Mon, Dec 1 1:30 PM - 2:45 PM  Location: S402AB

**Participants**

Moderator
A. Kyle Jones PhD : Nothing to Disclose
Behrang Amini MD, PhD (Presenter): Nothing to Disclose
A. Kyle Jones PhD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Recognize the types of information that radiologists are seeking in radiographic images. 2) Apply this knowledge to generate radiographs that provide this information, and do so using a reasonable radiation dose. 3) Integrate these skills into your clinical practice.

**SPPH22**

**Physics Symposium: Quality and Safety in Radiotherapy: Learning the New Approaches in TG-100 and Beyond**

**Special Courses**

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AMA PRA Category 1 Credits ™: 4.00
ARRT Category A+ Credits: 5.00

Mon, Dec 1 1:30 PM - 5:45 PM  Location: S102C

**LEARNING OBJECTIVES**

1) To understand radiotherapy as a work system and the requirements and necessity for a safety culture. 2) To understand how humans perform tasks and how they fail. 3) To understand the process of risk analysis. 4) To understand quality management concepts, tools and approaches. 5) To understand how to go from the results of the risk analysis to a quality program. 6) To understand the principles for establishing an incident reporting system and to learn about the national radiotherapy incident reporting systems and learning systems. 7) To understand the process of root-cause analysis for investigating events. 8) To understand the tools and techniques for quality improvement and managing change.

**ABSTRACT**

This session will give a brief summary of concepts, procedures and tools for addressing quality health care and patient safety in radiotherapy using systems engineering approaches that have proven effective in other fields of medicine and widely in industry. Establishing quality management procedures takes a risk-analysis approach, beginning with mapping a process, assessing the risks at each step, determining the propagation of failures and addressing potential failures with the most effective tools. The session also considers how to maintain and continually improve quality and safety in a radiotherapy facility through incident reporting, root-cause analysis and quality improvement techniques. Understanding these approaches requires knowledge of safety culture, work systems and how humans succeed and fail, all of which will be covered in this session.

**Sub-Events**

**SPPH22A**

Introduction: Work Systems and Safety Culture

Jennifer Lynn Johnson MSc, MBA (Presenter): Nothing to Disclose
LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22B  Errors and Actions  
Bruce Robert Thomadsen PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22C  Risk Assessment  
Frank J. Rath (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22D  Quality Management Concepts  
Barrett Caldwell (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22E  Quality Management Tools and Approaches  
Frank J. Rath (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22F  Quality Management Based on Risk Assessment  
Bruce Robert Thomadsen PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22G  Report Systems  
Peter Dunscombe PhD (Presenter): Director, TreatSafely, LLC

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22H  Root-Cause Analysis  
Barrett Caldwell (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SPPH22I  Quality Improvement  
Peter Dunscombe PhD (Presenter): Director, TreatSafely, LLC

LEARNING OBJECTIVES
View learning objectives under main course title.
Managing Change
Jennifer Lynn Johnson MSc, MBA (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

SSE05
ISP: Chest (Radiation Dose Reduction)
Scientific Papers

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AMA PRA Category 1 Credits ™: 1.00
ARRT Category A+ Credit: 1.00
Mon, Dec 1 3:00 PM - 4:00 PM Location: S404CD

Participants
Moderator
Narinder S. Paul MD: Research funded, Toshiba Corporation
Moderator
Mannudeep K. S. Kalra MD: Nothing to Disclose

Sub-Events
SSE05-01 Chest Keynote Speaker: Approaches to Radiation Dose Reduction and Image Optimization for Thoracic CT
Narinder S. Paul MD (Presenter): Research funded, Toshiba Corporation

SSE05-02 MicroSievert Chest CT: Detection of Lung Findings Using Three Different Reconstruction Algorithms (IMR, iDose, FBP) in a Prospective Clinical Study

PURPOSE
To assess the detection of lung nodules (solid and ground-glass 'GGO LN') at microSievert (µSv) chest CT examinations reconstructed with iterative reconstruction techniques (iDose and iterative model reconstruction [IMR]), and non-iterative filtered back projection (FBP) technique.

METHOD AND MATERIALS
This IRB-approved prospective study included 116 CT image series for 29 patients (51-87 years, BMI 16-32kg/m2) who underwent a routine chest CT on 256 MDCT (iCT, Philips Healthcare). Each patient underwent three µSv-CT exams at 3 dose levels: 500µSv [120kV, 12mA], 250µSv [100kV, 10mA], 100µSv [80kV, 10mA]) immediately after standard-of-care (SD) CT [3mSv, 120kV AEC enabled]. SD-FBP, µSv-FBP, µSv-IMR and µSv-iDose were reconstructed at 2.5 mm thickness. Four radiologists assessed subjective quality independently using a continuous scale. Lesions (true, pseudo and missed) were detected on µSv-images and compared to SD-FBP "reference-standard". Noise spectral density (NSD) curves to assess noise in frequency domain were obtained. Student's t-test, intraclass correlation coefficient, and Jackknife free-response receiver operating characteristic method were used for data analysis.

RESULTS
Missed lesions (mostly GGO LN ≤5mm) included 24/503 (at 250µSv FBP), 3/503 (at 250µSv IMR/iDose), 32/503 (at 100µSv FBP), and 14/503 (at 100µSv IMR/iDose). FBP images were clinically adequate for all lung findings at 250µSv (in patients with BMI ≤25kg/m2) and at 500µSv (≤30kg/m2) dose levels. Iterative images enabled adequate evaluation for solid LN at 100µSv irrespective of patient BMI (P >0.05), and GGO LN at 100µSv (≤25kg/m2; P 0.02). Irrespective of patient BMI and lesion size, both solid and GG LN were evaluated as "clinically adequate" at 250µSv and 500µSv dose levels on iterative images. Conspicuity of emphysematous and low-contrast mediastinal lesions was better with IMR images at 500µSv dose level. Compared to SD-FBP, objective noise was significantly lower in IMR images at all dose levels (P <0.001). NSD showed higher noise reduction in lower frequency for IMR compared to SD-FBP method.

CONCLUSION
Iterative reconstruction techniques enable optimal detection and evaluation of lung nodules (both solid- and ground-glass) at 250µSv radiation dose or higher.

CLINICAL RELEVANCE/APPLICATION
Clinically adequate lung evaluation in CT is achievable at 500µSv [~0.5 mSv] with filtered back projection technique and at 250µSv [~0.25 mSv] using advanced iterative reconstruction algorithms such as iDose and IMR.

**SSE05-03**

### Five Different Iterative Reconstruction Techniques across Three Vendors at the Lowest Possible Radiation Doses in Chest CT: Prospective Randomized Blinded Study


#### PURPOSE

To assess diagnostic performance of chest CT examinations reconstructed with five different iterative reconstruction techniques (IRT) from major CT vendors at lowest possible radiation doses with a comparison to standard of care CT.

#### METHOD AND MATERIALS

This multi-phase prospective randomized trial was HIPAA-compliant and IRB-approved. In 3 different phases, 3 separate patient cohorts underwent a routine chest CT on 3 different scanners from 3 different vendors (64 MDCT and above). In addition to standard-of-care CT (SD; CTDIvol 6 mGy), all patients (n=72; 26-87 years; M:F 39:33) provided written informed consent for acquisition of additional 3 ultra-low-dose “LD” series (0.9, 0.4 and 0.2mGy) immediately after SD-exam. SD-data were reconstructed with FBP (reference-standard) and LD data were reconstructed with 5 IR (IRA, IRB, IRC, IRD and IRE) at 2.5mm thickness resulting into 417 total image series. Independent blinded evaluation of lesion detection and diagnostic quality was performed. Objective image quality (HU ±SD) was measured. Student's t-test, ANOVA and Jackknife free-response receiver operating characteristic method were used for data analysis.

#### RESULTS

242 lesions (lung, 178; mediastinal, 64) were detected on standard of care chest CT. Lesion detection for both lung and mediastinal lesions was optimal across all studied 0.9 mGy IRT images (94-100% detection rate). At 0.5 mGy, detection rate for mediastinal lesions was substantially lower for IRC, IRD and IRE (33-41% missed lesions compared to SD CT). Detection for lung lesions was substantially lower for IRA, IRB and IRC (24-36% missed lesions). At 0.2 mGy, IRE missed most abnormalities (pulmonary 58% and mediastinal 60%). IRA missed the least mediastinal lesions (20%). IRC missed the least lung lesions (15%). Subjective image quality of lung parenchyma and soft-tissues (table 1) was statistically different across IR techniques (P <0.001).

#### CONCLUSION

Iterative reconstruction techniques from major CT vendors differ in lesion detection at radiation dose of 0.5 mGy and lower. Subjective image quality is also statistically different across IRT at ultra-low dose chest CT.

#### CLINICAL RELEVANCE/APPLICATION

Low dose CT protocols from one vendor iterative reconstruction technique cannot be applied to other vendors due to significant differences in image quality and lesion detection.

**SSE05-04**

### Knowledge Based Iterative Reconstruction Technique for Radiation Dose Reduction in Chest CT: Comparison with Hybrid Iterative Reconstruction and Filtered Back Projection Techniques

Qiong Li (Presenter): Nothing to Disclose, Shiyuan Liu PhD: Nothing to Disclose, Hong Yu MD, PhD: Nothing to Disclose, Yan Jiang MD: Employee, Koninklijke Philips NV

#### PURPOSE

To prospectively evaluate dose reduction and image quality features of chest CT reconstructed by using knowledge based iterative reconstruction technique(IMR,Philips Healthcare) compared with hybrid iterative reconstruction( iDose4,Philips healthcare) and filtered back projection (FBP) techniques.

#### METHOD AND MATERIALS

Institutional review board approval was obtained for this study. 42 patients (54.3±6.7 years, 28 male) underwent unenhanced chest CT with both ultra-low dose (ULD) and routine low dose (LD) protocols for once. All images were reconstructed with a 1mm slice by IMR which included 3 different settings (L1 body routine, L1 body sharpPluS and L1 body soft tissue), iDose4 (level 4)and FBP techniques, respectively. Total dose-length product (DLP) of both ULD and LD protocols were recorded. Image quality assessments for both normal lung and mediastinal structures were performed by 2 radiologists according to the features of structure demarcation, noise and artifacts using a five point scale. Standard deviation(SD) of CT attenuation in the descending aorta and mediastinal structures were performed by 2 radiologists according to the features of structure demarcation, noise and artifacts using a five point scale.

#### RESULTS

The radiation dose of ULD-CT was 0.62±0.02mSv compared with 2.54±0.63 mSv for LD-CT (P<0.001), there was a 75.6% decrease in ED. All three settings of IMR reduced image noise significantly than iDose4 and FBP (p<0.01, respectively). Both IR algorithms showed better image quality than FBP, and all IMR settings were better than iDose4 (p<0.01, respectively). IMR-sharpPlus images enabled exhibited the lung parenchyma, while IMR-routine or soft tissue images enabled showed the mediastinal images.

#### CONCLUSION

Diagnostically acceptable chest CT image acquired with radiation exposure in the range of a posterior to anterior and lateral chest X-ray can be obtained by using IMR. IMR allows more noise reduction and significant image
quality improvement in ultra-low dose chest CT compared to iDose4 techniques and FBP. Different settings of IMR can be the complement for each other which may provide more diagnosis information to reach lower dose CT without compromising image quality.

**CLINICAL RELEVANCE/APPLICATION**

Different settings of IMR can be the complement for each other which may provide more diagnosis information to reach lower dose CT without compromising image quality.

**SSE05-05**

**Iterative and Standard Filtered Back Projection Reconstruction – Comparing Image Quality of Standard and Low-dose Chest CT**

Monika Christine Dadrich MD (Presenter): Speaker, Koninklijke Philips NV , Gregor Pahn DIPLPHYS : Nothing to Disclose , Jessica Hirsch : Nothing to Disclose , Johanna Laura Mayer MD : Nothing to Disclose , Waldemar P. Hosch MD : Nothing to Disclose , Hans-Ulrich Kauczor MD : Research Grant, Boehringer Ingelheim GmbH Research Grant, Siemens AG Research Grant, Bayer AG Speakers Bureau, Boehringer Ingelheim GmbH Speakers Bureau, Siemens AG Speakers Bureau, Novartis AG , Wolfram Stiller PhD, DIPLPHYS : Nothing to Disclose

**PURPOSE**

Recently, iterative reconstruction algorithms (IR) have been introduced in CT, offering a new possibility for radiation dose (RD) reduction by reducing image noise resulting from CT examinations. The purpose of this study was to assess different levels of an IR algorithm (iDose, Philips Healthcare, Best, The Netherlands) in non-enhanced low-dose chest CT examinations in comparison with standard dose chest CT reconstructed with filtered backprojection (FBP).

**METHOD AND MATERIALS**

Non-enhanced low-dose chest CT examinations (LDCT) were acquired with a tube voltage of 100kVp and a tube current-time product of 120mAs with tube-current modulation (TCM) (Group A; 20 patients), or 60mAs without TCM (Group B; 24 patients). Images were reconstructed with FBP and different levels of iDose (levels 40 and 60 with/without MFR, i.e. homogeneous noise texturing) using lung (L) and soft-tissue kernels (B). Each patient had a prior standard-dose chest CT (SDCT; 120kVp, 120mAs with TCM, FBP). CT numbers and image noise were objectively measured in different anatomic structures (lung, aorta, liver). Three independent, blinded readers assessed diagnostic image quality by subjective ranking (best to worst) of the differently reconstructed image data sets. Radiation dose parameters (CTD1w and DLP) were recorded.

**RESULTS**

Radiation exposure could be reduced by 41% (group A), and by 72% (group B), respectively. IR did not affect CT numbers while image noise could be reduced by up to ~40 %. With regard to the assessment of subjective image quality interreader-agreement was fair to moderate ($\kappa=0.24-0.48$). Iteratively reconstructed images with iDose60 were ranked highest independent of low-dose protocol and reconstruction kernel. No difference between iDose60 with and without MFR could be observed. FBP-images of all low-dose data sets were ranked lowest.

**CONCLUSION**

Image noise can be reduced by IR in low-dose chest CT, thereby improving image quality compared to FBP. iDose60 is superior to iDose40, the use of MFR however doesn’t affect subjective image quality. Intra-individual comparisons between SDCT and LDCT suggest that IR enables radiation dose reduction of up to about 70%, while maintaining overall diagnostic acceptability.

**CLINICAL RELEVANCE/APPLICATION**

IR algorithms have great potential for reducing image noise in chest CT, allowing to lower radiation exposure of chest CT examinations while preserving overall diagnostic image quality.

**SSE05-06**

**Radiation Dose from Single-KV and Dual-KV chest CT for Routine Chest and Pulmonary Embolism Protocols**


**PURPOSE**

To compare radiation dose associated with single-KV (sK-CT) and dual-KV (dK-CT) chest CT examinations for routine chest (RC) and pulmonary embolism (PE) protocols across two CT vendors.

**METHOD AND MATERIALS**

Our IRB approved study included 824 adult patients who had contrast enhanced sK-CT using RC (n= 210 patients) dual source CT, 128-DSCT (Siemens Definition Flash):100 patients, M:F 56:44, mean age 60±15 years, mean weight 78±23 kg; 64-slice single source CT 64-SSCT,GE Discovery 750HD:110 patients, M:F 58:52, mean age 60 ± 17years, mean weight 75±19 kg) and PE protocols(n= 202 patients) (128-DSCT: 92
patients, M:F 37:55, mean age 62 ± 16 years, mean weight 80±24 kg; 64-SSCT: 110 patients, M:F 52:58, mean age 62±16 years, mean weight 81±22 kg; and dK-CT using RC (n= 210 patients) (128-DSCT: 100 patients, M:F 48:52, mean age 59 ± 16 years, mean weight 77±19 kg; 64-SSCT: 110 patients, M:F 48:62, mean age 63±14 years, mean weight 73±16 kg) and PE protocols (n= 202 patients) (128-DSCT: 110 patients, M:F 53:57, mean age 61±16 years, mean weight 80±21 kg). For each patient, we recorded CTDIvol, DLP and estimated effective dose (EED). Data were analyzed using Student’s t test and ANOVA.

RESULTS

There was no significant difference between weights of the patients undergoing sK-CT and dK-CT on the two CT scanners for RC and PE protocols (p=0.4). Following doses were noted for dK-CT: RC (64-SSCT): 7.6±0.7 mGy, 288±37 mGy.cm, 4±0.5 mSv; RC (128-DSCT): 6.6±2.8 mGy, 220±99 mGy.cm, 3.1±1.4 mSv; PE (64-SSCT): 9.3±2 mGy, 326±70 mGy.cm, 4.6±1 mSv; PE (128-DSCT): 9±3.2 mGy, 284±104 mGy.cm, 4±1.5 mSv. There was significant reduction in CTDIvol with dK-CT as compared to the sK-CT, ranging from 11-43% (p<0.0001). The dK-CT on 128-DSCT resulted in 4-16% lower CTDIvol as compared to dK-CT acquisition on 64-SSCT (p<0.01). Patient weight had significant effect on dose reduction with dK-CT as compared to the sK-CT, with mean dose reduction of 19% for patients < 90 kg (7.2 versus 8.8 mGy) versus 30% dose reduction for patients > 90 kg (11.1 versus 16.8 mGy) (p<0.001).

CONCLUSION

Routine chest CT, and pulmonary embolism CT protocols can be performed using dual kV acquisition mode at lower radiation dose levels compared to the single kV acquisition.

CLINICAL RELEVANCE/APPLICATION

Dual kV CT can be applied for acquiring routine chest CT and pulmonary embolism CT without any dose penalty compared to single energy chest CT.
1) Understand the importance of discouraging the adjustment of scanning parameters from case to case. 2) Understand why CT dose reduction efforts should be rolled into protocol settings to maintain consistency. 3) Discuss and explain why the role of the Technologist during CT protocol review is critical.

**ABSTRACT**

The lecture will focus on the role of the Radiologic Technologist during CT Protocol Review. Regular review of CT protocols is becoming a more widespread practice across the country. Some states have recommended this practice, and it is part of the ACR CT Accreditation program. The role of the technologist during CT protocol review is critical. There are many aspects of the CT exam that only a technologist can adequately describe, and these aspects are required to guide the design and modification of CT protocol parameters. Several case examples of CT technologist participation during CT protocol review will be explained, with the focus on the impact of the technologist's perspective in helping guide the review process.

**Practical, Evidence-based Methods to Reduce Radiation Dose**

Patrick C. Brennan PhD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Understand the changes that occur within biological tissue following ionizing radiation exposure. 2) Appreciate why some cells and tissues are more radiosensitive than others. 3) Discuss the differences between stochastic and deterministic changes. 4) Evaluate the risks associated with specific doses of radiation.

**ABSTRACT**

The lecture will focus on the radiobiological principles to justify radiation protection. Radiation protection is a core activity practiced by all diagnostic imaging personnel, however the principles behind why this is required is not always fully understood at doses delivered in diagnostic radiography. This talk will provide an overview of the processes that occur following biological tissues exposure to radiation and will develop the topic from the atomic to the molecular to the cell, tissue and eventually the whole organism man. The latest data from the ICRP will be presented so that a realistic understanding of the risks propose by radiation levels delivered in diagnostic departments is provided.

**Special Interest Session: Image Wisely**

**Special Courses**

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Mon, Dec 1 4:30 PM - 6:00 PM Location: S505A

**Sub-Events**

**SPSI23A**

**Image Wisely Overview**

Richard L. Morin PhD (Presenter): Nothing to Disclose, William W. Mayo-Smith MD (Presenter): Author with royalties, Reed Elsevier Author with royalties, Cambridge University Press

**SPSI23B**

**Fluoroscopy Campaign Launch, Team Performance**

James R. Duncan MD, PhD (Presenter): Consultant, Novita Therapeutics, LLC Consultant, Proteon Therapeutics, Inc

**LEARNING OBJECTIVES**

1) List team members for fluoroscopic procedures and their typical responsibilities. 2) Describe the role of shared mental models in teamwork. 3) Write in order the common stages of team development. 4) Produce examples of how teamwork improves radiation safety during fluoroscopic procedures.

**SPSI23C**

**Checklists, Task-specific and Patient Specific Factors**

Steven Y. Huang MD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Promote a checklist for fluoroscopic radiation safety designed to decrease radiation dose to the patient and radiology staff while preserving image quality. 2) Explain how task-specific and patient-specific factors can affect radiation dose and image quality during a fluoroscopic procedure. 3) Be familiar with the various techniques in which dose reduction can be successfully applied.
ABSTRACT
Radiation dose during a fluoroscopic procedure is dependent on many factors. While some factors are fixed (e.g. body habitus), others can be manipulated to minimize radiation dose to the patient and radiology staff. This presentation focuses on optimizing radiation use by adhering to basic radiation safety principles and tailoring fluoroscopic procedures to task- and patient-specific factors.

Technical Principles for Interventional Procedures
James R. Duncan MD, PhD (Presenter): Consultant, Novita Therapeutics, LLC Consultant, Proteon Therapeutics, Inc

High/Substantial Dose Patient Management
Stephen Balter PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Understand key aspects of radiobiology and technology that influence tissue reactions. 2) Understand guidelines for radiation management before, during, and after a procedure. 3) Understand the applicability of QA/QI processes to high-dose interventional procedures.

ABSTRACT
Fluoroscopically guided interventional procedures offer patients both clinical and economic benefits. Radiation-induced tissue reactions continue to be an uncommon side-effect of these procedures. Radiogenic tissue reactions should never come as a surprise to either the operator or the patient. A tissue reaction cannot always be avoided, but its magnitude can usually be minimized. Minimizing the likelihood and severity of reactions such as skin injuries requires appropriate action before, during, and after each procedure. This presentation reviews key elements of radiobiology, technology, operational guidelines, and administrative tools for interventional radiation management.

Essentials of Non-interperative Skills

Multisession Courses

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<th>MSSES31A</th>
<th>What Every Radiologist Needs to Know about Medicare</th>
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<td>Geraldine B. McGinty MD (Presenter): Nothing to Disclose</td>
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LEARNING OBJECTIVES
1) Understand the history, current administration and future directions of the Medicare program and how it impacts radiologists. 2) Understand their role in influencing Medicare policy to the benefit of our patients.

Intravenous Contrast Media
Matthew Scott Davenport MD (Presenter): Book contract, Wolters Kluwer nv

LEARNING OBJECTIVES
1) Understand the current thinking regarding risk of contrast-induced acute kidney injury from intravenously administered iodinated contrast media. 2) Learn the recent updates to the American College of Radiology’s Manual on Contrast Media. 3) Remember the correct dose of epinephrine for the treatment of anaphylaxis.

ABSTRACT
Recent changes to the ACR Manual on Contrast Media will be reviewed, with an emphasis on contrast-induced acute kidney injury. Other topics, including gadolinium-based contrast media-related complications, external warming of iodinated contrast media, and management of acute contrast reactions will be reviewed.

Quality: What It Is and How to Improve It
LEARNING OBJECTIVES

1) Understand the basic definition of quality and how it is applied in practice. 2) Understand how quality improvement principles developed in service and manufacturing are relevant to radiology. 3) Be familiar with basic improvement strategies that can be applied in a local radiology practice.

Professionalism

Milton J. Guiberteau MD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) The learner should be able to explain the elements of professionalism as they apply to the practice of radiology. 2) Attendees should be able to use available resources to comply with the requirements of professionalism. 3) Attendees will be able to choose appropriate courses of action that apply to solving issues related to lapses in professional behavior. 4) The learner will gain ability to articulate how professionalism can impact the quality of patient care. 5) The learner will be able to devise appropriate goals for professionalism within their practice.

Quality Improvement in Your Practice: Fundamentals of Lean—What, How, and Why Now?

Multisession Courses

MSQI31

Why Lean? The Fundamentals of a Lean Approach; Key Lean Management Principles

Jonathan B. Kruskal MD, PhD (Presenter): Author, UpToDate, Inc

LEARNING OBJECTIVES

1) Describe what the Lean approach is and how this can be implemented in a Radiology department. 2) Describe the fundamental principles of the Lean approach as these apply to the field of imaging. 3) Discuss why the current practice of radiology is well-suited to the Lean approach. 4) Give examples of how the Lean approach can be used in an imaging environment. (This course is part of the Quality Improvement Symposium)

Sub-Events

MSQI31A

Lean in Our Daily Practice

Ella A. Kazerooni MD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under main course title. (This course is part of the Quality Improvement Symposium)

MSQI31B

Applying Lean Process Improvement Methods for Radiology Workplace Design

Paul Martin Knechtges MD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under main course title. (This course is part of the Quality Improvement Symposium)
Sub-Events

RC323A  Issues in Interventional Fluoroscopy Procedures
Stephen Balter PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Be able to describe effects on patient’s skin, hair, eyes, and other tissues resulting from fluoroscopically-guided interventional procedures. 2) Be able to adequately communicate FGI radiation risk as part of the informed consent process. 3) Understand the use of real-time displays of radiation quantities and their relation to radiation risks.

ABSTRACT
Some fluoroscopically-guided interventional procedures (FGI) require the use of a substantial amount of radiation for their completion. Radiation can be regarded as a toxic agent in the same sense that contrast-media and drugs can be toxic if inappropriately used. The interventional radiologist should have reasonable knowledge of the toxic effects of radiation on patients at dose levels that may occur during IR procedures. These include short-term tissue reactions on the skin, hair loss, and radiogenic cataracts. Longer term effects such as cancer induction are of importance for some patients. Because radiation is potentially toxic, its risks should be appropriately discussed during the informed consent process. The display of reference air kerma and kerma area product provide risk information to the radiologist while performing a procedure. This is intended to provide ongoing inputs into a continuous evaluation of benefit-risk.

RC323B  Measurements and Dose Calculations
Beth A. Schueler PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Review methods of measuring patient radiation dose during fluoroscopically-guided interventional procedures. 2) Compare the advantages and limitations of dose measurement methods. 3) Understand parameters that are used to describe patient entrance dose. 4) Learn about new methods for skin dose calculation and recording.

ABSTRACT
The measurement of patient dose during fluoroscopically-guided interventional procedures is an important tool for assessment of individual patient radiation risk. Moreover, the display of patient dose is valuable as feedback to the operator to aid in optimization of radiation exposure. Many different methods of measuring fluoroscopy dose have been developed, including direct methods (dosimeters and film) and indirect methods (fluoroscopy time, dose-area-product meters and reference point air kerma estimation). This presentation will review the advantages and limitations of each of these methods, along with common dose metrics that fluoroscopy operators, medical physicists and technologists should be familiar with. In addition, we will discuss skin dose mapping methods that are currently being developed.

Active Handout

RC323C  Establishing an Interventional Radiology Patient Radiation Safety Program
A. Kyle Jones PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) List the radiation dose descriptors that should be recorded at the conclusion of a fluoroscopy-guided procedure. 2) Describe the actions that may be taken during the three phases of a fluoroscopy-guided procedure to enhance patient safety. 3) Discuss how to recognize cases that are outside the normal control limits of an interventional radiology practice.

ABSTRACT
An interventional radiology patient safety program is essential to better educate patients who are scheduled to undergo fluoroscopically guided interventional radiology procedures; monitor radiation doses delivered during procedures and reduce the risk of tissue effects; ensure appropriate medical management of patients experiencing significant peak skin doses; and for practice quality improvement through analysis of procedural
The program combines preprocedure evaluation and counseling, intraprocedure monitoring, and postprocedure documentation and counseling consistent with guidelines from the National Cancer Institute and the Society of Interventional Radiology. Implementation of a patient safety program is straightforward, requires little infrastructure and few resources, and can be applied in most interventional radiology practices.

**RC354**

**Health IT Incentive Programs: Experience from Radiology Practices in Hospitals and Health Systems**

*Refresher/Informatics*

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**Participants**

**Moderator**

Ramin Khorasani MD : Consultant, Medicalis Corp

Ramin Khorasani MD (Presenter): Consultant, Medicalis Corp

Curtis P. Langlotz MD, PhD (Presenter): Shareholder, Montage Healthcare Solutions, Inc Advisory Board, Reed Elsevier Advisory Board, Activate Networks, Inc Spouse, Consultant, Johnson & Johnson

Keith David Hentel MD, MS (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Understand the meaningful use program. 2) Learn how hospitals and health systems have achieved meaningful use for their radiologists. 3) Decide how your practice should respond to the program.

**RCC31**

**RadLex®: Overview of a New Lexicon for Radiology**

*Refresher/Informatics*

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**Sub-Events**

**RCC31A**

Daniel L. Rubin MD, MS (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Review the rationale for developing a new lexicon for medical imaging. 2) See how an imaging lexicon can be used for education, research, and clinical reporting. 3) Understand the key technical decision that were necessary to create a complete and organized vocabulary for medical imaging. 4) Learn about the formats in which RadLex is distributed and the tools that are available for maintaining and using terminology systems. 5) Discover how you can take advantage of RadLex in the development of radiology applications.

**ABSTRACT**

The purpose of the RadLex lexicon is to provide a uniform framework for indexing and retrieval of a variety of radiology information sources, including teaching files, research data, and radiology reports. The RadLex lexicon is unifying and supplementing radiology terms from other medical lexicons, such as the ACR Index from the American College of Radiology, the Unified Medical Language System (UMLS) from the National Library of Medicine, SNOMED-CT from the College of American Pathology, and the DICOM Content Mapping Resource. This session will explain the motivations for the creation of the RadLex imaging lexicon and describe new applications being created that leverage its rich knowledge resources, such as structured reporting, radiology information retrieval, image annotation, decision support, and computerized order entry. RadLex technical experts will describe the formats in which RadLex is distributed, and will demonstrate some of the tools available to incorporate RadLex into the development of useful software applications. An update on the recently developed RadLex "playbook" will be provided, with an overview of RadLex methods to describe radiology orderables and procedure steps.

**RCC31B**

"RadLex Inside": Information Retrieval, Radiology Reporting, and Beyond

Charles E. Kahn MD, MS (Presenter): Shareholder, Hotlight Inc Officer, Hotlight Inc

**LEARNING OBJECTIVES**

1) Learn how the RadLex lexicon enables applications in radiology research, education, and clinical practice. 2) Describe how RadLex enables information retrieval. 3) Define the role of RadLex in RSNA's structured reporting
initiative. 4) Discover new applications of RadLex in radiology education and decision support.

**ACR Usage of RadLex® Playbook for CT Dose Registry**

Richard L. Morin PhD (Presenter):  Nothing to Disclose

**LEARNING OBJECTIVES**

1) Identify the challenge related to procedure code matching across institutions. 2) Describe the RadLex Playbook. 3) Explain how the RadLex Playbook can be used to harmonize data across institutions.

**MSQI32**

**Radiologist Performance Improvement: Implementing Lean in Your Practice**

**Multisession Courses**

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**Participants**

Moderator

James Vincent Rawson MD :  Nothing to Disclose

**LEARNING OBJECTIVES**

1) Discuss implementation strategies of Lean and Change Management. 2) Discuss Alignment of Operations and Outcomes. 3) Discuss Role of Employee Engagement in Change. (This course is part of the Quality Improvement Symposium)

**ABSTRACT**

Lean techniques are being used in healthcare with increased frequency. This program will focus on how Lean can be started and implemented in a healthcare environment. The role of process redesign in strategy and operations will be discussed.

**Sub-Events**

**MSQI32A**

**Linking Vision, Strategy, Operations and Outcomes**

Karl N. Krecke MD (Presenter):  Nothing to Disclose

**LEARNING OBJECTIVES**

View learning objectives under main course title. (This course is part of the Quality Improvement Symposium)

**MSQI32B**

**Resources, Training and Teaching LEAN in Radiology**

James Vincent Rawson MD (Presenter):  Nothing to Disclose

**LEARNING OBJECTIVES**

View learning objectives under main course title. (This course is part of the Quality Improvement Symposium)

**MSQI32C**

**Lean Change Management and Engaging Employees**

Joseph R. Steele MD (Presenter):  Consultant, INTIO, Inc; Stockholder, INTIO, Inc; Stockholder, Intelliject, Inc; Stockholder, MedicaSafe, Inc; Consultant, Adient Medical Inc; Stockholder, Adient Medical Inc; Consultant, Edumedics LLC; Stockholder, Edumedics LLC

**LEARNING OBJECTIVES**

View learning objectives under main course title. (This course is part of the Quality Improvement Symposium)

**SSG04**

**Gastrointestinal (CT Dose Reduction I)**

**Scientific Papers**

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SSG04-01
Achieving Sub-millSiervet Radiation Dose: Prospective Randomized Clinical Study to Assess Ultra-low Dose Abdominal MDCT with a Three Dimensional Adaptive Iterative Reconstruction (AIDR) and Image-based Iterative Reconstruction (SafeCT)


PURPOSE
To assess ultra-low dose (ULD) abdominal MDCT using a three-dimensional adaptive iterative reconstruction (AIDR-3D) and SafeCT, an image-based vendor-neutral iterative reconstruction (IR) compared with standard-dose imaging.

METHOD AND MATERIALS
A total of 36 patients (mean age 66±12 years; M:F 19:17; mean weight 71±15 kg) gave informed consent for this prospective clinical study and underwent abdominal CT on 320 MDCT (AquillionONE, Toshiba Healthcare). Two consecutive image series were acquired in each patient: (i) standard-of-care (SD) CT [6mSv, mean CTDIvol 8 mGy] and (ii) ULD-CT (0.9 mSv, 2.5 mGy). Scan length of ULD-CT was half that of SD-CT (lung bases to mid-abdomen). SD-CT and ULD data were reconstructed with FBP, SafeCT (MedicVision Israel) and AIDR-3D resulting in 360 image series. Two radiologists independently assessed subjective quality using a task-based evaluation to assess organ-based focal lesions and normal anatomical structures (when no lesions were present). Image noise was measured at homogenous liver parenchyma. Noise-spectral density plots were obtained. Student’s t-test and ANOVA were used on SPSS v 22.0.

RESULTS
Mean dose reduction relative to SD CT was 75%. Radiologists identified 173 focal lesions with SD-FBP. Lesion detection for ULD-CT images was 79% (139/176; most lesion being missed in patients weighing ≥75kg 37% missed 50/79). ULD-FBP images were clinically inadequate for all abdominal structures. Mean subjective image quality score for ULD-IRT images was significantly higher in patients weighing <75kg (p<.01). For liver margins and parenchyma, ULD-AIDR3D and ULD-SafeCT images were significantly better than ULD-FBP images (p<0.01). Visualization of low-contrast hepatic and renal lesions was clinically adequate on both ULD-AIDR3D and ULD-SafeCT images compared to ULD-FBP (p<0.01). Mean liver image noise for ULD-AIDR3D was 17HU, significantly lower than SD-FBP (22, p=.009), ULD-FBP (60HU, p<.001) and ULD-SafeCT (26HU, p=.003). Although image quality of SD images were significantly better than ULD, lesion detection was deemed acceptable on ULD scans reconstructed with IR techniques (p<.01).

CONCLUSION
Iterative reconstruction techniques (such as 3-dimensional AIDR and SafeCT) show great potential for substantially reducing radiation dose of abdominal MDCT.

CLINICAL RELEVANCE/APPLICATION
Abdominal MDCT is achievable at 2.5 mGy (~0.9mSv) using 3D-AIDR and image-based SafeCT without significant compromise in image quality at 75% dose reduction.

SSG04-02
Comparison of Image Based, Adaptive Statistical, and Model Based Iterative Reconstruction Techniques for Substantial Dose Reduction for Abdominal CT


PURPOSE
To evaluate low dose abdominal CT images reconstructed with image based (SafeCT), adaptive statistical (ASIR), and model based (MBIR) iterative reconstruction techniques to the standard dose abdomen CT.

METHOD AND MATERIALS
In an IRB approved, prospective clinical study included 21 patients (mean age 68 ± 7 years, mean weight 82±15 kg, M:F 14:7, undergoing routine abdomen CT on a 64 channel MDCT (Discovery CT750 HD). After
standard of care abdominal CT, low dose images were acquired at 120 kV and reduced mAs (CTDvol of 2.5 mGy). Sinogram data of low dose series were reconstructed with SafeCT (AP0, AP1), ASIR (SS70, SS90 GE Healthcare) and MBIR (GE Healthcare) and standard dose abdomen CT reconstructed with ASIR (SS50) (n=6*21=210 series). Two radiologists performed independent and blinded comparison for lesion detection, lesion conspicuity, and visibility of small structures, first for all patients with low dose images and subsequently for standard dose images.

RESULTS
Mean CTDIvol were 13 ± 1.7 and 2.5 ± 0.1 mGy for standard and low dose abdominal CT, respectively. There were two missed lesions (small liver cyst and kidney cyst) on low dose images. Pancreatic ducts could be seen in only 5/10 patients at low dose regardless of iterative reconstruction techniques. The lesion conspicuity (23/25 lesions) was sufficient for clinical diagnostic performance for low dose SafeCT, ASIR and MBIR images. Low dose MBIR had limited diagnostic performance for evaluation of liver and kidney parenchyma in 18/21 patients compared to 8/21 for SafeCT and 7/21 for ASIR images. The liver margin, adrenal glands, pancreatic contour, gall bladder, peritoneum, retroperitoneum, and bowels were sufficient and equally seen on all low dose images regardless of iterative reconstruction techniques.

CONCLUSION
Low dose abdominal CT at 2.5 mGy is sufficient for most clinically significant lesions with SafeCT, ASIR, and MBIR. However, evaluation of pancreas requires higher dose than 2.5 mGy. Visibility of normal liver parenchyma is limited on low dose MBIR images.

CLINICAL RELEVANCE/APPLICATION
Iterative reconstruction techniques can allow sufficient clinical diagnostic performance for routine abdominal CT image at CTDIvol of 2.5 mGy.

CT Imaging of the Liver: Comparison of Sinogram-affirmed with Advanced Modeled Iterative Reconstructions
Fabian Morsbach (Presenter): Nothing to Disclose, Lotus May Desbiolles MD : Nothing to Disclose, Sebastian Leschka MD : Nothing to Disclose, Hatem Alkadhi MD : Nothing to Disclose

PURPOSE
To investigate image quality and conspicuity of liver lesions on abdominal computed tomography (CT) images, reconstructed with advanced modeled iterative reconstruction (ADMIRE), sinogram-affirmed IR (SAFIRE) and filtered back projection (FBP).

METHOD AND MATERIALS
Forty patients (19 female, mean age 63±14 years) with focal liver lesions (cysts, n=16; hemangiomas, n=6; metastases, n=18) undergoing standard portalvenous phase abdominal CT were included. Images were reconstructed with ADMIRE (strength levels 1-5), SAFIRE (strength levels 1-5), and FBP at a slice thicknesses of 2 mm. Two readers evaluated subjective image quality focusing on image appearance (score 1: no artifacts, 2: minor artifacts, blotchy, plastic-like appearance, 3: major artifacts, blotchy, plastic-like appearance, 4: artifacts making a diagnosis impossible), and visibility of small structures (score 1: excellent visibility, 2: above average, 3: average, 4: poor). Readers also rated the conspicuity of lesions (score 1: well-seen lesion, well delineated margin, score 2: well-seen lesion, poorly delineated margin, score 3: subtle lesions, score 4: probably an artifact mimicking a lesion). Attenuation (in HU) of the liver and subcutaneous fat and the standard deviation of attenuation indicating noise was measured. Friedman test and analysis of variance (ANOVA) were conducted.

RESULTS
Readers found a significantly improved image appearance for all strength levels of ADMIRE compared to the respective SAFIRE levels (P<0.001), as well as superior visibility of small structures (P<0.001). Lesion conspicuity was rated similarly with ADMIRE and SAFIRE (P>0.05) and superior to FBP at strength levels 3-5 (all P<0.05). HU-values of the liver and fat did not vary with reconstruction algorithms (P>0.05). Noise decreased with increasing strength levels compared to FBP (P<0.05), with no differences among corresponding strength levels (P>0.05).

CONCLUSION
As compared to SAFIRE, ADMIRE improves image quality and reduces artificial image appearance at a similar noise reduction level without impairing lesion conspicuity.

CLINICAL RELEVANCE/APPLICATION
Iterative reconstructions with a less artificial image appearance can be used for CT imaging at low radiation doses with a broader acceptance by radiologists in daily clinical routine.

Differences of Radiation Dose Estimates Compared with Direct Measurements in Morbidly Obese Patients undergoing Abdominal Computed Tomography: An Experimental Ex-Vivo and Patient-based Study
Roy Marcus MD (Presenter): Nothing to Disclose, Fabian Bamberg MD, MPH : Speakers Bureau, Bayer AG Speakers Bureau, Siemens AG Research Grant, Bayer AG Research Grant, Siemens AG, Klement Neumaier : SSG04-04
Proper CT imaging of morbidly obese patients remains an imaging challenge. The necessary increase in tube voltage and current results in dose length products (DLP) with high extrapolated effective dose estimates. However, actual equivalent dose exposition is presumably lower as an effect of the shielding of the adipose tissue layer. Thus, the aim of this study was to assess the association between conventionally estimated and measured radiation dose in morbidly obese patients.

**METHOD AND MATERIALS**

The study consisted of an ex- and an in-vivo part. In the ex-vivo experiment, an Alderson Phantom was equipped with 108 thermo-luminescent detectors (TLD) throughout the lower chest, the abdomen and pelvis and scanned on a Dual Source CT (DSCT): (I) Slim phantom with automatic potential and current modulation and (II) Obese phantom embedded in a circumferential 30 cm layer of pork fat, simulating a patient with a BMI>35, with 2x140kVp and current modulation. In the in-vivo study, 7 patients (BMI > 35) referred for abdominal imaging were scanned on a DSCT with 2x120kVp and automatic current modulation. Effective dose was derived according to IRCP-103 (TLD ex-vivo), based on DLP with standard conversion factor k (DLP-based; ex and in-vivo), and using a Monte-Carlo-Simulation (MCS; ex- and in-vivo).

**RESULTS**

TLD, MCS and DLP based dose values did not show any differences in the ex-vivo setting simulating lean body habitus (I: 3 vs. 3.2 vs. 3 mSv). In the ex-vivo setting simulating obese body habitus (II), TLD and MCS based values did not show a significant difference; however, both were significantly lower than DLP-based value (9.52 vs. 11.6 vs. 34.2 mSv, p)

**CONCLUSION**

Our results indicate that estimated and measured radiation dose in obese patients undergoing CT differs significantly with falsely documented high dose estimates in this population (up to 4-fold). Thus, a weight adapted k value of 0.0055-0.0075 for such patients may provide more accurate effective dose estimates.

**CLINICAL RELEVANCE/APPLICATION**

Currently reported dose values in obese patients undergoing CT do not provide adequate estimates of radiation dose and should be evaluated carefully.

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**SSG04-05 Risk of Cancer Associated with Radiation in Torso CT Scan: A Hospital-based Comparative Study across Different Types of Scanners**

**PURPOSE**

Radiation exposure from CT can be reduced by use of advanced CT scanners (for example, devices with advanced reconstruction algorithms (ARA), compared with conventional filtered pack projection). Radiation exposure is associated with increased lifetime attributable risk (LAR) of cancer incidence in the sensitive organs. The aim of this study was to evaluate the organ-specific risk of cancer associated with Torso CT scan in patients referred to our institution and compare these across different scanners, and protocols.

**METHOD AND MATERIALS**

Data from 7345 adult patients who underwent chest CT scan, and 8283 patients who underwent abdomen/pelvic CT scan, over a period of 4 months, were retrospectively analyzed. Radiation exposure data was obtained from a radiation-dose analytic software that calculates organ-specific effective doses for each patient. The Biological Effects of Ionizing Radiation (BEIRVII) models were used to extrapolate the LAR of cancer incidence associated with CT radiation. Data was stratified by the anatomic area imaged, machine make (General Electric, Philips, and Siemens), model, reconstruction algorithms and the technologies used in the device. The overall and organ-specific LAR of cancer associated with CT radiation was compared between different groups.

**RESULTS**

For an abdomen/pelvic CT, the LAR of cancer incidence associated with radiation was, on average, highest for kidneys (38.20±0.62, per 100,000) and gall bladder (33.10±0.55 per 100,000). About 30% of patients with abdomen/pelvic CT, and 36% of patients with chest CT, were scanned with more advanced devices (i.e. devices with ARA). For a routine chest CT, lungs (26.10±0.42, per 100,000), kidneys (18.49±0.38, per 100,000) and the liver had the maximum LAR of cancer incidence. For a routine non-contrast abdomen-pelvic CT scan, the LAR of cancer incidence in stomach, kidneys, gall bladder, pancreas and colon were significantly lower (20-30%) in more advanced devices (with ARA vs. those without). Analysis across different vendors, protocols, age groups and genders was also performed.

**CONCLUSION**

The advanced CT devices (with ARA vs. those without) are associated with 20-30% lower overall and organ-specific extrapolated risk of cancer incidence attributed to CT radiation.

**CLINICAL RELEVANCE/APPLICATION**

The overall and organ-specific extrapolated LAR of cancer associated with CT radiation can be reduced by use of more dose-efficient scanners.
Dose Estimate Considerations in SECT and DECT of the Abdomen - Perceptions and Reality

Manuel Patino MD (Presenter): Nothing to Disclose, Jorge Mario Fuentes MD: Nothing to Disclose, Yasir Andrabi MD, MPH: Nothing to Disclose, Koichi Hayano MD: Nothing to Disclose, Mukta Dilipkumar Agrawal MBBS, MD: Nothing to Disclose, Dushyant V. Sahani MD: Research Grant, General Electric Company

PURPOSE

Radiation dose remains a critical concern with the use of new CT techniques in the clinical practice. Therefore the purpose of the study is to compare Size Specific Dose Estimate (SSDE) between Single source Dual-energy (ssDECT) and Single-energy abdominal CT scans using current ACR-Dose Index Registry as reference standard.

METHOD AND MATERIALS

A total of 150 patients with cancer history (61 Males, 89 Females) underwent a follow up CE-ssDECT (GE-CT750 HD, 140/80 kV; 375-630 mA) of the abdomen-pelvis. Their recent prior CE-SECT (16-64 MDCT, 120 kV; 41-531 mA) reconstructed using FBP in 84 patients and Iterative techniques in 65, served for dose estimate comparison. Size Specific Dose Estimate (SSDE) was calculated and compared between DECT and SECT using t-test. Dose Index Registry data was used as reference.

RESULTS

The mean SSDE on ssDECT, SECT-FBP and SECT-IRT were 15.6 mGy, 14.9 mGy and 12.1 mGy respectively. There was no significant difference in SSDE between DECT and SECT-FBP (p>0.05). A difference was found in SSDE between ssDECT and SECT-IRT (p

CONCLUSION

For cancer follow-up abdomen studies, the dose estimates from ssDECT are comparable to SECT-FBP and slightly higher than SECT-IRT but remain substantially lower than ACR-DIR data.

CLINICAL RELEVANCE/APPLICATION

Dual energy CT has demonstrated added value in clinical diagnosis. However, radiation dose is still a critical concern that limits its wide implementation. This study shows comparable dose estimates between SECT and ssDECT, with minimally high SSDE in DECT, decreasing perceived radiation concerns.

Effective Dose in CT Examinations: How Much Is the Effective Dose Varying between Follow-up Examinations Performed on the Same CT Scanner?

Saravanabavaan Suntharalingam (Presenter): Nothing to Disclose, Franz Ferdinand Stecker: Nothing to Disclose, Nika Guberina MD: Nothing to Disclose, Jens Matthias Theysohn MD: Nothing to Disclose, Michael Forsting MD: Nothing to Disclose, Adrian Stefan Ringelstein MD: Nothing to Disclose, Thomas W. Schlosser MD: Nothing to Disclose, Kai Nassenstein: Nothing to Disclose

PURPOSE

To investigate, how much the effective dose (ED) varies between follow-up examinations performed on the same CT scanner.

METHOD AND MATERIALS

The effective dose (ED) was estimated retrospectively for 50 patients suffering from cancer at three different times of CT examination. At each time, a CT scan of the chest (CH), of the liver without contrast enhancing (LI) and of the entire abdomen after contrast media application (AB) was performed using the same predefined CT protocol and the same CT scanner (Siemens Definition FLASH). For automated radiation dose reduction Care Dose 4D and Care KV (Siemens) were used. Data were assessed following recommendations of ICRP 103 using Radimetrics' dose-monitoring-software eXposure™.

RESULTS

The mean ED for CH was 5.0 ± 1.9 mSv, for LI 4.9 ± 2.0 mSv, and for AB 7.6 ± 3.3 mSv. The mean differences of ED between follow-up examinations were 0.8 ± 1.1 mSv for CH, 0.6 ± 0.7 mSv for LI, and 1.2 ± 1.6 mSv for AB. The differences between ED of follow-up examinations showed a strong correlation to the differences in the tube current (CH: 12.5 ± 10.8 mAs, r = 0.85; LI: 10.4 ± 10.2 mAs, r = 0.78; AB 14.8 ± 18.2 mAs, r = 0.70). The differences between the ED of follow-up examinations showed only a weak correlation to the differences in the scan length (CH: 22.0 ± 20.4 mm, r = 0.03; LI: 14.2 ± 12.7 mm, r = 0.11; AB 21.4 ± 20.9 mm, r = 0.35). Even though in the vast majority of CT examination the tube voltages had not been changed between follow-up examinations, changes in the tube voltage in individual cases had major effect on ED.

CONCLUSION

A high variance of the effective dose exists between follow-up CT examinations, when using the same CT scanner and scan protocol. This variance is predominantly caused by differences in the tube current, which had been automatically determined by the dose reduction algorithm.

CLINICAL RELEVANCE/APPLICATION

Improvements in the automated tube current modulation algorithm are necessary to reduce radiation dose in CT.
Feasibility of Low-tube-current Gemstone Spectral Imaging (GSI) Associated with Adaptive Statistical Iterative Reconstruction (ASiR) in Upper Abdominal CT Angiography (CTA)
Qingguo Wang (Presenter): Nothing to Disclose, Zhiguo Zhou: Nothing to Disclose, Qimeng Quan MD, PhD: Nothing to Disclose, Zheng Wang MD: Nothing to Disclose, Han Wang MD, PhD: Nothing to Disclose

PURPOSE
To evaluate the impact of low-tube-current GSI associated with ASiR on radiation dose and image quality in upper abdominal CTA.

METHOD AND MATERIALS
Twenty-six patients who underwent GSI for upper abdominal CTA using a 64-row CT scanner (GE Discovery CT750 HD) were enrolled. Before confirming GSI scan, GSI assist software allowed optimal mA selected automatically based on the scout view and noise index at 12. Patients were retrospectively divided into two groups. Group A (n=14) and group B (n=12) underwent CT scan with high tube current (≥560mA) and low tube current (≤250mA).

RESULTS
The mean CTDIvol and effective radiation dose in group B (11.55 ±2.94mGy, 4.48 ±1.34mSv) were significantly lower than group A (18.13±3.64mGy, 7.56 ±2.68mSv) (p< 0.01). There were not significantly different mean CT values of AR and SMA (219.40±36.85, 194.76±40.44) between group B and group A (239.86±63.15, 217.56±59.25) (p> 0.05). The SD values of subcutaneous fat in group A (5.57±1.10) was lower than group B (7.37±2.03) (p< 0.05). There were not significantly different mean CNRs of AR and SMA between group B (61.66±14.71, 57.21±14.87) and group A (51.57±17.99, 48.17±16.66) (p> 0.05).

CONCLUSION
Compared with high tube current GSI, approximately 41% radiation dose reduction can be acquired by low-tube-current GSI associated with ASiR without degradation of image quality and noise in abdominal CTA.

CLINICAL RELEVANCE/APPLICATION
Low-tube-current GSI combined with ASIR has the ability to reduce radiation dose without image quality loss.

A Quantitative Comparison of Noise Reduction across Five Commercial (Hybrid and Model Based) Iterative Reconstruction Techniques: An Anthropomorphic Phantom Study
Manuel Patino MD (Presenter): Nothing to Disclose, Jorge Mario Fuentes MD: Nothing to Disclose, Koichi Hayano MD: Nothing to Disclose, Avinash Ranesh Kambadakone MD, FRCR: Nothing to Disclose, Jennifer W. Uyeda MD: Nothing to Disclose, Dushyant V. Sahani MD: Research Grant, General Electric Company

PURPOSE
To compare the performance of three Hybrid Iterative Reconstruction Techniques (h-IRTs) (ASIR, iDose4, SAFIRE) with their respective strengths on image noise reduction on low-dose Computed Tomography (CT) exams using Filtered Back Projection (FBP) as standard reference. Also, to compare image noise reduction between h-IRTs and Model Based IRTs (MB-IRTs) (MBIR/Veo and IMR) on low dose exams.

METHOD AND MATERIALS
An anthropomorphic abdomen phantom was scanned at 100 - 120 kVp and different mAs (25-100) on three CT systems (GE Discovery CT750-HD, ASIR, MBIR/Veo; Philips iCT, iDose4, IMR; and Siemens Somatom, SAFIRE). Images were reconstructed using FBP and various strengths of IRTs. Nine noise measurements (ROI mean size 423 mm2) on extra-colonic fat for the strengths of IRTs were recorded and compared to FBP using ANOVA. Radiation dose in CTDIvol and DLP was also compared.

RESULTS
There was no significant difference on radiation dose and image noise on FBP between the scanners (p>0.05). Gradual image noise reduction was observed with each increment of h-IRT’s strength with maximum noise suppression around 50% (48.2-53.9%). Similar noise reduction was achieved on the scanners by applying specific h-IRT strengths. Maximum noise reduction on MB-IRTs was higher (68.3-81.1%) than that on h-IRTs (p<0.01).

CONCLUSION
By using constant scan parameters, radiation dose and image noise on FBP are similar for different manufacturer CT scanners. Significant image noise reduction is achieved on low-dose CT images rendered with IRTs. The image noise on various scanners can be matched by applying specific h-IRT strengths. MB-IRTs attain substantially higher noise reduction over h-IRTs irrespective of the radiation dose.

CLINICAL RELEVANCE/APPLICATION
This study lends the opportunity to understand the impact of various IRTs and influence of their strengths on the image noise. Since implementation of these techniques in clinical practice can be complex, this experience can assist in optimizing abdomen CT protocols with standard and modified dose scan parameters.
CONCLUSION

This study presents the establishment of appropriate adult diameter-based local and national DRLs, in order to comprehensively represent the size range of the examined population.

Background

Diagnostic Reference Levels (DRLs) provide an investigative level to identify unusually high patient doses. CT adult DRLs are currently calculated as the 75th percentile of exam specific CTDIvol and DLP datasets for adult patient samples of weight range 60-80kg and typically based on small samples of 10 or more. While DRLs provide a practical metric for 'normal' adult patients, these investigative levels if used for the broad size range of all patients may prove inappropriate. Further, it is well known that body weight is poorly correlated with CT dose metrics, prompting the question as to whether DRLs in their current form are fit for representing the entire adult population. Size-specific reference doses have been suggested for paediatric patients; however, such analyses have not been performed in adults. Accordingly, the object of this work was to propose diameter-based local and national DRLs and to examine the variability of diameter-specific metrics across examinations and hospitals sites.

Evaluation

Dose metric data from 19 CT scanners across the Irish National Integrated Medical Imaging System (NIMIS), for all examinations (n=149784), was captured by Radimetrics eXposure™ software over an 18-month period, allowing for the collation of CT scanning parameters including CTDIvol, DLP, Size-Specific Dose Estimate (SSDE) and effective patient diameter. After data cleansing, diameter-specific 25th, 50th and 75th parameter percentiles were calculated to inform on establishing local and national DRLs with high volume, high dose and newly established CT exams investigated.

Discussion

For patients of increased diameter, elevated 75th percentiles were evident when compared with normal-sized patient levels, suggesting traditional DRLs to be ineffective at flagging higher dose investigative levels for all patients. The work also allowed for the comparison of examination- and size-based CT dose metrics for systems of similar model and manufacturer, in addition to across a range of manufacturers.

Effective Dose of Chest X-ray, Tomosynthesis, and Thoracic CT in a Multi-Center Clinical Trial


PURPOSE

Digital tomosynthesis (DTS) imaging is increasingly being used for numerous thoracic indications. In addition to evaluation of the diagnostic capability of this technique, it is important to understand the dose to the patient relative to conventional chest x-ray (CXR) and CT protocols.

METHOD AND MATERIALS

An international, multi-center, clinical trial was designed and conducted under IRB approval to compare the performance of DTS to conventional two-view CXR for the detection of lung nodules, using CT as the reference standard. Subjects in the study had a diagnostic CT exam as part of routine care for a variety of thoracic indications, and then received conventional 2-view CXR and DTS exams (GE Healthcare, XR656 with VolumeRAD). Effective dose for CXR and DTS was calculated using the PCXMC Monte Carlo tool (STUK, Finland). Calculation of absorbed dose was based on estimates of incident air kerma from exposure technique data and the assumption of average habitus subjects. CT effective dose was calculated using the ICRP 103 methodology from the DLP determined from reported CTDI values.

RESULTS
Technique data for dose estimation was available for all 158 subjects in the study for some modalities, and for 91 subjects for all modalities. For the 91 cases with valid data for all modalities, the mean effective dose (and standard deviation) was 0.059 (0.033), 0.088 (0.037), and 4.86 (3.2) mSv for CXR, DTS, and CT respectively. The CXR and DTS effective doses were significantly less than CT \( p < 0.01 \), and less than 0.1 mSv \( p < 0.01 \). The use of 0.2 mm Cu additional filtration (at 120 kVp) was observed to reduce the effective dose for the DTS subjects. The variation in DTS effective dose was much less than CXR as a result of increased uniformity of delivered mAs per projection in the DTS acquisition.

**CONCLUSION**

For the patients in this clinical trial, the average effective dose of a DTS acquisition was only 1.5 times greater than that of a conventional two-view chest radiograph, and significantly less than that of the diagnostic thoracic CT exams. DTS provides tomographic image information, enabling significantly increased nodule detection sensitivity, with less than 0.1 mSv effective dose.

**CLINICAL RELEVANCE/APPLICATION**

Digital tomosynthesis imaging provides volumetric image data enabling increased lung nodule detection compared to conventional chest x-ray at a similar, minimal, radiation level (less than 0.1 mSv).

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**SSG15-03**

**Multi-phase CT: Impact of Contrast Medium Propagation on Radiation Dose across a Population of Patient Models**

Pooyan Sahbaee (Presenter): Nothing to Disclose, William Paul Segars PhD : Nothing to Disclose, Ehsan Samei PhD : Research Grant, Siemens AG Research Grant, General Electric Company Research Grant, Carestream Health, Inc

**PURPOSE**

To quantify the radiation dose variation as a function of time due to the contrast medium (CM) administration in multiphase liver CT scan across a library of 5D XCAT models.

**METHOD AND MATERIALS**

The dose estimation was performed on a library of 58 adult extended cardiac-torso (XCAT) models. To generate the 5D XCAT patient models, a unique method was developed to incorporate the dynamics of CM propagation into our 4D XCAT (as demonstrated in our prior work, the fourth dimension reflects the heart and respiratory motions) anthropomorphic models. The models were created based on patient-specific iodine concentration-time results from our computational CM propagation computer model for different injection protocols, such that each organ in a patient model subjected to a specific injection protocol was assigned to its own unique CM time-concentration curve. The radiation dose to individual organs in the models was estimated from a four-phase (pre-contrast, arterial, portal venous, and delayed phases) liver CT examination modeled via a validated Monte Carlo simulation software package (PENELOPE). For each scan time point after the injection, 80 million photons were initiated and tracked through the phantoms. Finally, the dose to the liver was tallied from the deposited energy.

**RESULTS**

The liver CT scan simulation results from 5D XCAT models subjected to a commonly used injection protocol (120 mL of 350 mgI/mL CM at 4 mL/s) indicated up to 10%, 32%, and 24% increases in radiation dose delivered to the liver for arterial phase (to 9.45 mGy), portal venous phase (to 11.29 mGy), and delayed phase (to 10.65 mGy), respectively.

**CONCLUSION**

Administration of contrast medium in enhanced CT scan not only remarkably affects the CT image quality (thus the reason for its use), but also notably increases the radiation dose. Particularly, multiple acquisitions in several enhanced CT protocols accentuate the radiation dose as a critical objective in optimization of the protocols.

**CLINICAL RELEVANCE/APPLICATION**

The study aimed to provide a methodology to incorporate the contrast medium propagation in XCAT models, thus building toward an opportunity to optimize radiation dose and injection protocol in concert.

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**SSG15-04**

**Dose to Organs and Tissues from Scattered Radiation in Breast CT: Impact on Effective Dose**

Sabrina Viviane Vollmar PhD : Nothing to Disclose, Daniel Kolditz PhD (Presenter): Employee, CT Imaging GmbH, Martin Hupfer PhD : Employee, CT Imaging GmbH, Willi A. Kalender PhD : Consultant, Siemens AG Consultant, Bayer AG Founder, CT Imaging GmbH Scientific Advisor, CT Imaging GmbH CEO, CT Imaging GmbH

**PURPOSE**

To evaluate potential dose contributions by scattered radiation to organs and tissues not directly exposed and the resulting effective dose in dedicated breast CT.

**METHOD AND MATERIALS**
Calculation of dose in the directly and not directly exposed parts of the body were performed for dedicated breast CT at tube voltages of 40, 60 and 80 kV with a Monte Carlo (MC) software tool (ImpactMC, CT Imaging GmbH, Erlangen, Germany). Effective dose was calculated according to the ICRP publication 103. We used the standard female ORNL (Oak Ridge National Laboratory) phantom to mimic the patient lying prone on the examination table and added cylindrical phantoms with 10 and 14 cm diameter, and 7.5 and 10.5 cm in length, respectively to mimic the pendant breast. Only the examined breast was directly exposed. The air kerma of the scans was adapted to achieve an average glandular dose (AGD) of 1.6 and 4.6 mGy, respectively, for the two breast sizes, which corresponds to the dose limits in mammography in the European Guidelines for screening mammography.

RESULTS
Effective dose was confirmed at 0.192 mSv and 0.552 mSv for 10 and 14 cm breast sizes, respectively, for all tube voltages without scattered radiation. When taking scattered radiation into account effective dose increased to 0.200 and 0.601 mSv, respectively, for 60 kV. These values were reduced to 0.197 and 0.591 mSv when adding an absorption foil (150 µm Pb) to the examination table. Respective values were 0.196 and 0.570 mGy for 40 kV and 0.202 and 0.608 mGy for 80 kV. For the not directly exposed tissues highest organ dose values were found in the lung amounting to 0.029 and, 0.146 mGy, respectively. Adding the absorption layer to the table reduced these values to 0.026 and 0.128 mGy, respectively.

CONCLUSION
Effective dose in dedicated breast CT for a bilateral examination with typical values of 0.2 to 0.6 mSv is low; scattered radiation only contributes 2-3%, 3-7% and, 5-9% additional dose to these values for 40, 60 and 80 kV, respectively.

CLINICAL RELEVANCE/APPLICATION
Dedicated breast CT potentially offers higher sensitivity and specificity for breast cancer detection without increasing dose levels significantly.

SSG15-05 Quantifying the Effects of Patient Size, Scanner Selection and Scan Start Location on Organ Dose Estimates in Contiguous Axial Head CT Examinations
Kyle McMillan (Presenter): Institutional research agreement, Siemens AG Research support, Siemens AG, Maryam Bostani PhD: Research support, Siemens AG, Maria Zankl PhD: Nothing to Disclose, Christopher H. Cagnon PhD: Nothing to Disclose, John J. Demarco PhD: Nothing to Disclose, Michael F. McNitt-Gray PhD: Institutional research agreement, Siemens AG Research support, Siemens AG

PURPOSE
To evaluate the impact of patient size, scanner selection and scan start location on brain and lens of the eye dose for contiguous axial head CT examinations.

METHOD AND MATERIALS
Using Monte Carlo simulations of contiguous axial scanning for 64-slice multi-detector row CT scanners from four major manufacturers, brain and lens of the eye dose were estimated for eight patient models from the GSF family of voxelized phantoms. Simulations were initially performed with a scan from the top of the C1 lamina through the top of calvarium. Additional simulations were performed with start locations 1 cm, 2 cm, 3 cm and 4 cm inferior to the C1 lamina. CTDIvol-to-organ-dose conversion coefficients were calculated for each combination of patient model, scanner and start location by normalizing brain and lens of the eye dose by scanner-specific 16 cm CTDIvol values. These scanner-specific conversion coefficients were averaged across all scanners and start locations to determine scanner-independent CTDIvol-to-organ-dose conversion coefficients for each patient model. Scanner-independent conversion coefficients were then correlated with patient size, and variation between scanner-specific and scanner-independent conversion coefficients was assessed.

RESULTS
An exponential relationship between scanner-independent CTDIvol-to-organ-dose conversion coefficients and patient size was observed with correlation coefficients of 0.92 and 0.85 for the brain and lens of the eye, respectively. For the lens of the eye, scanner-specific and scanner-independent conversion coefficients for each patient model varied up to 26.1%. For the brain, variation upwards of only 8.9% was observed.

CONCLUSION
Patient size, scanner selection and scan start location all influence organ dose in contiguous axial head CT examinations. Scan start location causes surface dose variation in a manner similar to tube start angle for helical scanning. This effect can be enhanced by the scanner-specific dose efficiency of beam collimations. Dose to small, superficial organs like the lens of the eye may have pronounced variation due to these start location effects, while brain dose is relatively constant.

CLINICAL RELEVANCE/APPLICATION
For contiguous axial head CT exams of a given patient size, scanner selection and scan start location may have a noticeable impact on lens of the eye dose, while brain dose is relatively constant.

SSG15-06 Modern CT Pulmonary Angiography or Lung Perfusion Scintigraphy in Pregnant Patients Suspected for Pulmonary Embolism? Comparison of Associated Radiation Risks
Konstantinos Perisinakis PhD (Presenter): Nothing to Disclose, Ioannis Seimenis PhD: Nothing to Disclose
PURPOSE
To provide and compare maternal and fetal radiation dose burden and associated radiation cancer risk estimates from 256-slice CT pulmonary angiography (CTPA) and lung perfusion scintigraphy (LPS).

METHOD AND MATERIALS
The BodyBuilder software package was employed to generate mathematical anthropomorphic phantoms representing the average female individual at early pregnancy and at 1st, 2nd and 3rd trimester of gestation. In each phantom, 1-3 additional 1.5 cm-thick fat tissue layers were added to produce phantoms of different body size. Monte Carlo methods were used to simulate low-dose 256-slice CTPA exposures on each of the 16 generated phantoms. Normalized maternal organ and conceptus dose data were derived for exposures at 80, 100 and 120 kV. Maternal and conceptus doses from 256-slice CTPA were determined and compared to corresponding estimates for low-dose LPS. Total life attributable risks (LARs) of cancer associated with 256-slice CTPA and LPS were determined using previously published radiation cancer risk factors and compared to intrinsic risk of cancer for 20-, 30- and 40-years old female individuals.

RESULTS
For an average-size pregnant patient, the low-dose 256-slice CTPA exposure was found to result in a maternal effective dose of 1 mSv and a conceptus dose of <0.06 mGy. However, maternal effective dose was found to considerably increase with body size, while conceptus dose was increased with both body size and gestational stage. Compared to LPS, low-dose CTPA to an average-sized pregnant patient was found to result in 15% higher maternal effective dose, but 3.4-6 times lower conceptus dose. Nevertheless, LPS was found to be associated with less aggregated radiation risk for an average size pregnant patient with the difference from CTPA to be further increased for larger patients. Low-dose 256-slice CTPA at the age of 20, 30 and 40 years marginally increases the intrinsic risk of cancer by 1.0007, 1.0004 and 1.0003, respectively.

CONCLUSION
LPS remains more dose efficient even compared to low-dose CTPA performed with a modern wide-area CT scanner.

CLINICAL RELEVANCE/APPLICATION
LPS should be maintained as the preferable next step of imaging for pregnant patients suspected for pulmonary embolism who have a normal chest X-ray radiograph and require further investigation.

SSG15-07

Radiation Dose and Image Quality Performance of Organ-based Tube Current Modulation for Head and Chest CT Scans


PURPOSE
The purpose of this study was to quantify dose and noise performance of organ-dose-based tube current modulation (ODM) through experimental studies with an anthropomorphic phantom and simulations with a phantom library.

METHOD AND MATERIALS
ODM reduces tube current for anterior source positions, without increasing current for posterior positions. Axial CT scans at 120 kV were performed on head and chest phantoms (Rando Alderson Research Laboratories, Stanford, CA) on an ODM-equipped scanner (Optima CT660, GE Healthcare, Chalfont St Giles, England). Dosimeters quantified dose to breast, lung, heart, spine, eye lens and brain regions (mobile MOSFET Dosimetry System, Best Medical, Ottawa, Canada) for ODM, automA (z modulation), and smartmA (angular and z modulation) settings. Noise standard deviation was calculated in brain and chest regions of reconstructed images. To study a variety of patient sizes, Monte Carlo simulations, validated with experimental data, were performed on 28 voxelized head phantoms and 10 chest phantoms. Organ dose and reconstructed noise standard deviation were compared for all phantoms. Image quality assessment is currently underway using a task-dependent signal detectability metric.

RESULTS
ODM reduced dose at all dosimeters with respect to smartmA, with dose changes of -31.3% (breast), -20.7% (lung), -24.4% (heart), -5.9% (spine), -18.7% (eye), and -10.5% (brain). Simulations indicated average dose changes of -33.4% (breast), -20.2% (lung), -18.6% (spine), -20.0% (eye) and -7.2% (brain). ODM reduced dose to the brain and lung tissue, however these tissues would experience up to 15.2% and 13.1% dose increase respectively at noise standard deviation equal to smartmA. ODM reduced dose to the eye lens in 22 of 28 phantoms (-1.2% to -12.4%), had no change in dose for two phantoms, and increased dose for three phantoms (0.7% to 2.3%) with respect to smartmA at equal noise standard deviation. All phantoms demonstrated breast dose reduction (~2.1% to ~27.6%) at equal noise standard deviation.

CONCLUSION
Experimental and simulation studies over a range of patient sizes indicate that ODM has the potential to reduce dose to sensitive organs by 5 - 38% with a limited increase in image noise.

CLINICAL RELEVANCE/APPLICATION
Organ-based tube current modulation has the potential to reduce the dose to radiosensitive tissues with limited degradation in noise standard deviation.
Monitoring and Controlling Patient Radiation Exposure from Computed Tomography at a Community Hospital Using a Collaborative, Data-driven Approach

Jenifer Willmann Siegelman MD, MPH (Presenter): Consultant, Bayer AG, Marie Kate MacGregor MPH: Consultant, Bayer AG, Mark Patrick Supanich PhD: Research agreement, Siemens AG

PURPOSE

Evaluate the effectiveness of an organization-wide stewardship initiative based on a systematic evaluation of radiation dose using automated dose tracking software coupled with targeted interventions that included protocol modification, equipment replacement or software upgrades and operator training.

METHOD AND MATERIALS

Design: Retrospective, observational study of consecutive CT exams with a 3-month control, 12-month intervention and 3-month follow-up period in a community health system. Intervention: Periodic analysis of dose by protocol, equipment and operator using automated radiation dose capture software with built-in analytic tools provided the data for the intervention and confirmation of dose optimization. The optimization strategy engaged physicians, physicists, technologists, and hospital administrators and included equipment software upgrades, new equipment, changes in protocol parameters and training/retraining of technologists. Analysis: Pre- and post-intervention radiation dose (surrogate parameters CTDIvol, Dose Length Product (DLP) and Size Specific Dose Estimate (SSDE)) by protocol group was assessed and significance tested using an Analysis of Covariance on log transformed values.

RESULTS

Compared with control period, mean CTDIvol by protocol in the follow up period was reduced by 13% for all head exams and by 22% for all body exams. The difference in mean CTDIvol between the control and follow up period within all protocols was significant. Model R-squared values for analysis of covariance (ANCOVA) ranged from 0.03 to 0.68 and demonstrated equipment and gender as significant covariates. Low model R-squared values for the majority of tests indicated changes in protocol parameters and technique were likely contributors to dose reduction. Analysis of the difference in means pre- and post-intervention by equipment found dose reduction was significant for equipment that was not upgraded during the intervention and for equipment that was upgraded.

CONCLUSION

Systematic review of radiation dose by protocol and by patient demographics combined with an iterative process of image review, education, protocol modification and equipment upgrades resulted in a decrease in radiation exposure to a patient population.

CLINICAL RELEVANCE/APPLICATION

Tracking radiation dose by protocol and patient demographics provides information for ongoing, targeted quality improvement and quality control.

Calculation of Individualized Organ Dose for CT Patients in National Lung Screening Trial

Choonsik Lee PhD (Presenter): Nothing to Disclose, Randell L. Kruger PhD: Nothing to Disclose, Philip F. Judy PhD: Nothing to Disclose, Wesley E. Bolch PhD: Nothing to Disclose, Dianna D. Cody PhD: In-kind support, General Electric Company, Michael James Flynn PhD: Nothing to Disclose

PURPOSE

We calculated doses to major organs associated with CT screening examinations for 23,773 CT scans, a subset of the total cohort of the National Lung Screening Trial (NLST), using a library of computational human phantoms coupled with Monte Carlo radiation transport technique.

METHOD AND MATERIALS

First, we collected scan parameters (patient ID, age, gender, height, weight, scanner manufacturer, model, scan length, kVp, and mAs) from 23,773 CT scans. Second, organ dose conversion coefficients (organ dose normalized to CTDIvol of a reference CT scanner) was calculated using Monte Carlo code, MCNPX2.7, where experimentally-validated CT scanner simulation was coupled with 193 adult hybrid computational phantoms representing the height and weight of the current U.S. population. Finally, dose to selected organs (lung, heart, and thyroid) were calculated by using the organ dose library and the abstracted technical parameters. The other set of organ doses was also calculated for comparison using organ dose conversion coefficients based on a single adult male phantom with reference body size.

RESULTS

We established a comprehensive organ dose library for 193 adult phantoms: six dimensional dose matrix, D (31 organs, 190 slices max, 7 height bins, 19 weight bins, 2 genders, and 6 x-ray spectra). Patient size-specific organ doses were calculated for 23,773 CT scans using the dose library coupled with abstracted technical parameters. Mean doses to lung, heart, and thyroid were 4.5 (SD=1.6), 4.5 (SD=1.6), and 3.7 (SD=2.0) mGy, respectively, while mean CTDIvol was 3.6 mGy (SD=1.2). Organ doses based on the reference size phantom under- or over-estimated the values of thin and obese patients, respectively, up to 60%.

CONCLUSION

We calculated individualized doses to major organs for 23,773 CT scans involved in the NLST by using...
We calculated individualized doses to major organs for 23,773 CT scans involved in the NLST by using size-dependent computational phantoms coupled with Monte Carlo calculations. The organ dose conversion coefficients and batch calculation technique developed in this study can also be used for other studies including patient dose monitoring, epidemiological studies of cancer risk, and the analysis of CT dose trend.

**CLINICAL RELEVANCE/APPLICATION**

The results from the study provide the individualized organ dose estimations for NLST patient cohort. The dosimetry method used in this study will be useful for calculation patient size-specific organ dose in other studies without performing intensive Monte Carlo simulation.

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**RCC33**


*Refresher/Informatics*

**LEARNING OBJECTIVES**

1) Understand the meaning and purpose of structured reporting and standard terminology. 2) Review the progress on RSNA's library of best-practices radiology report templates. 3) Discuss directions for further development of the report template library. 4) Learn how radiologists can use these reporting templates to improve their practice.

**ABSTRACT**

This session will review the RSNA-sponsored initiative to improve radiology reporting practices. The RSNA has created a library of over 200 exemplary report templates that contain reusable structured data based on RadLex® and other standard terminologies. These report templates represent best-practices that can be adopted by radiologists and adapted based on local practice patterns. The template library, available on the RSNA web site, serves as a resource for radiologists who wish to improve their practice by standardizing the format, content, and structure of their reports. Over the last 2 years, the RSNA has collaborated with IHE and DICOM to develop standards for radiology report templates that will provide new reporting capabilities. This session will provide an overview of structured reporting, review the progress of the RSNA-sponsored initiative, and describe how radiologists can take advantage of this effort to improve their clinical practice.

**URL's**


**Sub-Events**

**RCC33A**

**The RSNA Reporting Initiative: Background and Status**

Curtis P. Langlotz MD, PhD (Presenter): Shareholder, Montage Healthcare Solutions, Inc Advisory Board, Reed Elsevier Advisory Board, Activate Networks, Inc Spouse, Consultant, Johnson & Johnson

**LEARNING OBJECTIVES**

View learning objectives under main course title.

**RCC33B**

**RSNA's Reporting Initiative: Accomplishments and New Directions**

Charles E. Kahn MD, MS (Presenter): Shareholder, Hotlight Inc Officer, Hotlight Inc

**LEARNING OBJECTIVES**

1) Describe the RSNA Report Template Library and how radiologists can access its reporting templates. 2) Understand current efforts to integrate the RSNA's reporting templates into clinical practice. 3) Define a vision for reporting that will advance the specialty of radiology as a leader in data-driven healthcare delivery.

**URL's**

http://www.radreport.org/tour/

**RCC33C**

**Using Templates from radreport.org: Benefits, Critiques and Solutions**

Marta Elise Heilbrun MD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

View learning objectives under main course title.
Staff and Patient Safety: The Lean Toolbox in Practice

Multisession Courses

**Sub-Events**

**MSQI33A**

The Egregious 8-Getting Rid of Waste (and Non-value Added Activities) in Radiology  
Paul G. Nagy PhD (Presenter): Nothing to Disclose  
LEARNING OBJECTIVES  
1) Discussion around the definition of waste (muda) in quality management. 2) Characterizations of types of waste. 3) Examples of radiology quality improvements projects for each type of waste. (This course is part of the Quality Improvement Symposium)  
ABSTRACT  
Quality improvement is not just preventing unnecessary harm to patients. Quality Improvement is creating an environment where optimal patient care is consistently delivered. Waste a defined in lean quality management is defined as any activity that consumes resources without creating value to the end customer. The types of waste can help someone think about opportunities for improvement for a quality improvement project.

**MSQI33B**

Mistake Proofing Imaging Processes  
Lucy W. Glenn MD (Presenter): Nothing to Disclose  
LEARNING OBJECTIVES  
1) Understand the culture of safety. 2) Understand the different levels of mistake proofing. 3) Understand the different components used to mistake proof a process. (This course is part of the Quality Improvement Symposium)

**MSQI33C**

Improving Flow and Patient Throughput: Value Stream Mapping  
David M. Paushter MD (Presenter): Advisory Panel, AIM Specialty Health  
LEARNING OBJECTIVES  
1) Understand the meaning of ‘waste’ when applied to health care in lean terminology. 2) Learn the basic methods of value stream mapping to gain improvements in efficiency of flow and patient throughput. 3) Understand the organizational imperatives required to successfully implement value stream mapping. 4) Learn the critical role of direct, collaborative observation of processes in understanding waste and improving function. (This course is part of the Quality Improvement Symposium)  
ABSTRACT  
Value Stream Mapping is an important Lean tool that has been applied successfully to improve flow and patient throughput in healthcare environments. Applications of this technique require mapping by direct observation the complex pathways of patient care that occur from the perspectives of all participants, including physicians, nurses, technologists, receptionists, supply chain, space design, environmental services and most importantly, patients. This requires defining the terms ‘waste’, ‘product’ and ‘customer’, and describing all facets of patient, care team, materials and product flows involved in care situations. Ultimately significant improvements in communication, wait times, efficiency of movement, utilization of resources and quality of service can be achieved. The goal of this session is to provide an introduction to Value Stream Mapping, its role in Lean transformation and its application to common clinical situations.

**URL’s**

Active Handout  
Normalization of Deviance: What Is Happening in Your Department (Sponsored by the Associated Sciences Consortium) (An Interactive Session)

**Participants**

**Moderator**
Susan Crowley RT, MEd: Nothing to Disclose
Kathleen Kath: Nothing to Disclose
Andrew P. Woodward MA, RT (Presenter): Educator, Siemens AG
Melissa Jackowski Ed.D, RT(R)(M) (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Define Normalization of Deviance. 2) Discuss the History of Normalization of Deviance as it relates to NASA and health care in general. 3) Reflect on current practice and describe normalization of deviance as it is applied in imaging. 4) List negative consequence of normalization of deviance in imaging. 5) Explain ways that management can combat normalization of deviance in imaging.

**ABSTRACT**

As an imaging professional we are taught to be a patient advocate, to be technically competent and to have a patient safety mindset. Why is it then that often times we see “seasoned” imaging professionals taking shortcuts and exhibiting behaviors that don't necessarily embody those characteristics? This lecture will explore “Normalization of Deviance” as a possible cause of this phenomenon. "Normalization of Deviance breaks the safety culture, substituting a slippery slope of tolerating more and more errors and accepting more and more risk, always in the interest of efficiency and on-time schedules.” (Prielipp, Mago, Morell and Brull, 2010) Simply, we take short cuts and veer from standards in the interest of patient flow and these short cuts become the norm because we don’t “see” any extreme negative outcome. Overtime, these new norms push the boundaries more and more. Normalization of Deviance theory has been applied to the Challenger space shuttle accident. Before the space shuttle blew up, O-ring erosion problems were documented numerous times. Over many occurrences and time, the engineers and managers started believing that these flaws were acceptable. This deviance became the new norm UNTIL the space shuttle accident. This lecture will discuss some of the new norms that may be becoming acceptable in imaging and possible negative outcomes. The role of management in combatting Normalization of Deviance will be explored. Reference: Prielipp, R. C. (2010-05). The Normalization of Deviance Do We (Un)Knowingly Accept Doing the Wrong Thing?. Anesthesia and analgesia, 110(5), 1499-1502.doi:10.1213/ANE.0b013e3181d5adc5

Minicourse: Recording and Reporting Radiation Dose: CT

**LEARNING OBJECTIVES**

1) The audience will be able to identify and discuss the standard parameters used for reporting dose in computed tomography, including the volume CTDI, DLP, and effective dose using the k-coefficients. 2) The audience will be able to identify and discuss parameters which influence the radiation dose to the patient, including patient size, dose modulation protocols, and scan length. 3) Participants will be able to identify the limitations of using effective dose in describing radiation dose levels to individual patients.

**ABSTRACT**

Computed tomography has experienced rapid growth in utilization over the past 10 years, due in part to the dramatic increase in image quality and decrease in scan time that helical and multi-slice CT scanners have allowed. This increased utilization has raised legitimate concerns about the radiation dose levels in CT. Traditional dose metrics such as the volume computed tomography index (CTDIvol) and the dose length product (DLP) will be discussed. The limitations of these metrics in the context of individual patient dosimetry will also be explained. In recent years, a number of new CT dose concepts have been introduced in the peer-reviewed literature, in task group reports, and in other documents. A number of these new dose metrics will be discussed, including the rise-to-equilibrium-dose, H(L), and the site-specific dose estimate (SSDE). CT dosimetry has historically been performed used integrating ion chambers. In light of the dynamic scanning capabilities of modern CT scanners, the utility of a real-time radiation meter will be discussed. Real-time dose
meters can substantially reduce the time required by the physicist in the CT scanner suite, while increasing the quantity and quality of the dose information that is measured. Niche applications include the rapid assessment of beam quality (half value layer) and the characterization of the beam shaping filters used in CT. In summary, this presentation will discuss existing CT dose parameters, and will then review a number of proposed new CT dose parameters which will likely be useful for CT dose assessment in the future. The recent growth of CT technology has outgrown the simple dose metrics of the past, and there is a need for the CT community to embrace new and more accurate CT dose metrics.

### Estimating Patient Dose

**Dianna D. Cody PhD (Presenter):** In-kind support, General Electric Company

**LEARNING OBJECTIVES**

1) Recognize the limitations of current approaches to estimate CT patient dose. 2) Understand several methods available for estimating CT patient dose. 3) Understand potential future options for patient CT dose estimations.

### Initial Experience with California Law on Reporting Dose from CT

**J. Anthony Seibert PhD (Presenter):** Nothing to Disclose

**LEARNING OBJECTIVES**

1) Describe the provisions of the California State law on dose reporting for computed tomography (CT) scanners. 2) Demonstrate ways in which the required elements volume Computed Tomography Dose Index (CTD$\text{vol}$) and Dose Length Product (DLP) can be placed into the radiology report. 3) Discuss discrepancies regarding the relationship between CTD$\text{vol}$ and patient dose, and issues in accumulating dose indices for CT scans in a multi-series exam and for individual exams over time. 4) Report on the status of compliance with the statutes of the law.

**ABSTRACT**

Radiation over-exposure for computed tomography (CT) perfusion studies occurring in the 2008-2009 timeframe resulted in California Senate Bill 1237, legislation that was authored by Senator Padilla in response to these incidents. The legislation was signed by the Governor in September 2010. The law contains three parts: (1) Recording CT dose indices for each patient, placing these values in the radiology report, and verifying accuracy of the volume Computed Tomography Dose Index (CTD$\text{vol}$); (2) Requiring accreditation for all CT scanners performing diagnostic exams that are under the authority of the California Department of Public Health; (3) Reporting of radiation exposures that exceed specified limits to organs, cause unanticipated erythema or hair loss, or inappropriate irradiation to body parts not ordered by a physician. Part 1 of the law commenced on July 1, 2012, and the other two parts are to commence on July 1, 2013. This presentation describes the steps taken to comply specifically with Part 1 of the law. To ensure compliance, an automated extraction and delivery of the CTD$\text{vol}$ and DLP indices to the radiology report were implemented. However, the legislation does not provide guidance on how to: (1) adjust CTD$\text{vol}$ for patient size; (2) deal with CT exams having multiple different series, each with individual dose indices; (3) sum CTD$\text{vol}$ and DLP for the same or different body areas scanned (if appropriate). The consequence is variable reporting at the initial implementation of the law, which requires standardized reporting metrics. Recommendations by the University of California Dose Optimization and Standardization Endeavor (UC DOSE) is discussed in this context, with relevant solutions described and specific examples demonstrated. To conclude, an update from the users perspective of compliance, as well as reporting of the status from the State of California Department of Public Health office is provided.

### Measuring Quality in Radiology

**RC432**

**Measuring Quality in Radiology**

**Refresher/Informatics**

| Students | LM | Category 1 Credits: | 1.50 | ARRT Category A+ Credits: | 1.50 |

**AMA PRA Category 1 Credits™:** 1.50

**Location:** N226

**Sub-Events**

### Business Intelligence and Analytics in Radiology: Scorecards, Dashboards, Big Data, and Beyond

**Paul J. Chang MD (Presenter):** Co-founder, Stentor/Koninklijke Philips Electronics NV Technical Advisory Board, Amisys, Inc Research Contracts, Koninklijke Philips NV Medical Advisory Board, lifeIMAGE Inc Medical Advisory Board, Merge Healthcare Incorporated

**LEARNING OBJECTIVES**

1) The technical steps required to develop and implement dashboards and scorecards (including data/state aggregation, semantic normalization, modeling, data mining, and presentation) will be discussed. 2) Specific strategies and technologies that can be used to create dashboards and scorecards (including HL7, DICOM, ETL, web services, and SOA) will be illustrated. 3) Strategies to create a sustainable and agile architecture to support advanced business intelligence and analytics (BIA) tools will be explored. (This course is part of the
ABSTRACT

Current and near future requirements and constraints will require radiology practices to continuously improve and demonstrate the value they add to the enterprise. Merely “managing the practice” will not be sufficient; groups will be required to compete in an environment where the goal will be measurable improvements in efficiency, productivity, quality, and safety. Although the phrase “one cannot improve a process unless one can measure it” is a familiar platitude, it is an increasingly important and relevant concept. The proper leveraging of formal Business Intelligence and Analytics (BIA) is a critical, absolutely essential strategy for any radiology group. Although currently underutilized, concepts such as Key Performance Indicators (KPIs), tactical dashboards, and strategic scorecards, should be familiar tools for radiology groups attempting to “navigate disruption.”

Population Health: A Mandate for Leadership and Quality

Paul E. Berger MD (Presenter): Chairman, Partners in the Imaging Enterprise, LLC
Shareholder, Partners in the Imaging Enterprise, LLC

LEARNING OBJECTIVES

1) Define population health and articulate the essential role of quality in this new health care paradigm. 2) Consider the key role of patient experience in the concept of radiology quality. 3) Explore the concepts of quality and value in radiology. (This course is part of the Leadership Track)

ABSTRACT

Quality has become an essential component of radiology practices. But what is quality and how is it measured? The course will attempt to answer these questions from three perspectives. First, the perspective of quantitative radiology quality metrics and ways of measuring them will be explored, and methods of data analytics will be considered. Second, the concept of quality as it applies to a new health care delivery paradigm of population health will be analyzed. Population health is a framework in which health care entities and providers are tasked with keeping an entire defined population healthy, rather than the current healthcare delivery system that focuses largely on individual sick patients. The third speaker will address the essential role of patient satisfaction and positive patient experience in the concept of quality in radiology. These areas are increasingly prevalent in on line rating sites, a domain that is not typically assessed with current standardized quality metrics.

Quality: Going Beyond the Metrics

Jonathan W. Berlin MD (Presenter): Stockholder, Nuance Communications, Inc
Radiology Advisory Board, Nuance Communications, Inc

LEARNING OBJECTIVES

1) Define population health and articulate the essential role of quality in this new health care paradigm. 2) Consider the key role of patient experience in the concept of radiology quality. 3) Explore the concepts of quality and value in radiology. (This course is part of the Leadership Track)

ABSTRACT

Quality has become an essential component of radiology practices. But what is quality and how is it measured? The course will attempt to answer these questions from three perspectives. First, the perspective of quantitative radiology quality metrics and ways of measuring them will be explored, and methods of data analytics will be considered. Second, the concept of quality as it applies to a new health care delivery paradigm of population health will be analyzed. Population health is a framework in which health care entities and providers are tasked with keeping an entire defined population healthy, rather than the current healthcare delivery system that focuses largely on individual sick patients. The third speaker will address the essential role of patient satisfaction and positive patient experience in the concept of quality in radiology. These areas are increasingly prevalent in on line rating sites, a domain that is not typically assessed with current standardized quality metrics.

Minicourse: Recording and Reporting Radiation Dose: Nuclear Medicine

Refresher/Informatics

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

Wed, Dec 3 8:30 AM - 10:00 AM  Location: S502AB
LEARNING OBJECTIVES

1) Identify the more common radiopharmaceuticals used in functional imaging of normal and diseased tissues.
2) Demonstrate understanding of the parameters needed to estimate tissue dose during nuclear medicine imaging and therapy. 3) Identify fundamental data sources for organ and effective dose per unit administered activity. 4) Demonstrate understanding of the physiological and anatomic sources of individual variability in organ and effective dose per unit administered activity. 5) Identify key features of new generation anatomical models that can reduce dose uncertainties through improved matching of patient body morphometry.

ABSTRACT

A main clinical application of nuclear medicine is that of functional imaging of normal and diseased tissue, and the localization of malignant tissue and its potential metastatic spread. In these applications, the amount of administered activity is such that the absorbed dose to both imaged and non-imaged tissues are typically very low and thus stochastic risks of cancer induction are greatly outweighed by the diagnostic benefit of the imaging procedure. Nevertheless, these tissues doses and their stochastic risks should be quantified for each patient, and placed in context of both their cumulative values received over multiple imaging sessions, and of doses and risks received by other diagnostic imaging procedures they may have (fluoroscopy and computed tomography, for example). The role of internal dosimetry in diagnostic nuclear medicine is thus to provide the basis for stochastic risk quantification. Once this risk is quantified, it may be used to optimize the amount of administered activity in order to maximize image quality while minimizing patient risk. This optimization process is of particular importance for pediatric patients owing to their enhanced organ radiosensitivities and years over which any stochastic effects may become manifest. This optimization should consider, as much as possible, patient age, gender, and body morphometry, and pharmacokinetics, along with all available image acquisition and processing techniques. Unlike other forms of diagnostic imaging, for which dose indices are readily measured, only the administered radioactivity is typically available for "dose tracking". In this course, we will review data sources for organ and effective dose per unit administered activity for the more common molecular imaging radiopharmaceuticals. Particular attention will be given to sources of individual variability in both organ and effective dose attributed to both physiological and anatomical variations among patients. Advances in computat

LEARNING OBJECTIVES

1) List three considerations in estimating the radiation dose from pediatric nuclear medicine. 2) Discuss three factors that affect the radiation dose from the CT component of hybrid imaging. 3) Describe three factors that can affect the appropriate choice of administered activity for a nuclear medicine study. 4) List 2 advances that may lead to further reduction in the administered activity in pediatric nuclear medicine.

LEARNING OBJECTIVES

1) Broadly describe the role of IT in helping improve quality and safety for radiology. 2) Discuss some of the key next generation IT requirements to improve quality and safety. 3) Use case examples to demonstrate the use of IT to improve access, appropriateness, report value and results communication and care coordination.

LEARNING OBJECTIVES

View learning objectives under main course title.
**RCC41B**

**Improving Value of Radiology Reports**

V. Anik Sahni MD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

View learning objectives under main course title.

**RCC41C**

**Critical Test Result Communication and Care Coordination**

Ramin Khorasani MD (Presenter): Consultant, Medicalis Corp

**LEARNING OBJECTIVES**

1) Define clinical attributes of critical test results and their relevance to national patient safety goals. 2) Describe functional requirements and current gaps for optimal communication of critical test results. 3) Using a case example, describe how IT tool can be embedded in workflow of radiologists and referring providers to optimize communication of critical test results and help ensure appropriate and timely execution of follow up recommendations made by radiologists.

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**SSK12**

**ISP: Informatics (Quality and Safety)**

*Scientific Papers*

AMA PRA Category 1 Credits™: 1.50

ARRT Category A+ Credits: 1.50

**RCC41B**

**SSK12-01**

**Informatics Keynote Speaker: Quality Metrics—It’s Time to Do It Right**

Woojin Kim MD (Presenter): Co-founder, Montage Healthcare Solutions, Inc Shareholder, Montage Healthcare Solutions, Inc Board of Directors, Montage Healthcare Solutions, Inc Advisory Board, Zebra Diagnostics Ltd

**RCC41C**

**SSK12-02**

**The Truth Behind the Fiction: Erroneous Clinical Information in Electronic Radiology Requests**

Maria Twomey MBChB, FFR(RCSI) (Presenter): Nothing to Disclose, Fiachra Gerard Moloney MBCh, MRCP: Nothing to Disclose, Jennifer Sammon MBCh: Nothing to Disclose, Jennifer Murphy MBCh, MRCP: Nothing to Disclose, Kevin Noel O Regan MD: Nothing to Disclose, Michael M. Maher MD, FRCR: Nothing to Disclose

**PURPOSE**

Accurate clinical information is paramount for the radiologist to accurately prioritise, protocol and report an imaging study. The purpose of this study was to investigate the rate of erroneous biochemical and haematological parameters as detailed on electronic requests for CTPA, CT Thorax and abdominopelvic CT.

**METHOD AND MATERIALS**

A total of 250 electronic requests submitted on a radiology information system over a 6 month period (July-Dec 2013) performed in a single institution were randomly selected comprising 100 CTPA, 70 CT TAP and 80 abdominopelvic CT. The creatinine level, haemoglobin level, CRP and WCC levels supplied for each patient by the referring clinician were compared to the reported levels on our institutions biochemical and haematology electronic reporting system. In the CTPA subgroup d-dimer levels and pO2 levels were also compared. The level of experience of the referring clinician and the referring department were also recorded.

**RESULTS**

Overall 45% of the total 250 requests contained erroneous biochemical and/or haematological information. CTPA requests had a significant number of erroneous D-dimer and pO2 levels; 15% reported an abnormal D-dimer result when the actual reported result was normal. A further 25% had reported hypoxia when the reported pO2 was normal. 10% of all requests contained an incorrect normal creatinine level. 30% of abdominopelvic CT requests detailed a low haemoglobin with iron deficiency anaemia, however the formal reported results were normal or revealed a normochromic normocytic anaemia in 75%. Elevated CRP and/or WCC were reported in 70% of acute abdominopelvic CT requests; 20% of the formal results in this subgroup were normal.
significantly higher incidence of erroneous parameters were supplied by medical physician referrals as opposed to surgeons.

**CONCLUSION**

This study reveals a high level of erroneous clinical information on electronic requesting which may result in inappropriate prioritisation, protocolling and administration of iv contrast and may affect the accuracy of the consequent radiology report.

**CLINICAL RELEVANCE/APPLICATION**

Accurate clinical information is essential to enable informed judgment on patient exposure to radiation. The level of erroneous information in this study raises concern; clinicians must be made aware that providing incorrect information is potentially deleterious to patient management and does not foster productive professional colleague interaction.

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**SSK12-03**

**Contextual CT Radiation Exposure Sentinel Event Detection**

Sam J. Weisenthal  BA :  Nothing to Disclose ,  Ari   Seff :  Nothing to Disclose ,  Xiao   Zhang  PhD :  Nothing to Disclose ,  Ronald M.  Summers MD, PhD (Presenter):  Royalties, iCAD, Inc Research funded, iCAD, Inc Stockholder, Johnson & Johnson Grant, Viatronix, Inc ,  Les Roger   Folio DO, MPH :  Nothing to Disclose ,  Jianhua   Yao  PhD :  Royalties, iCAD, Inc

**PURPOSE**

To detect anomalous radiation events by taking into account exam-specific clinical characteristics, we implement a statistical method for context-dependent CT radiation sentinel event detection directly from DICOM header data that is size and exam-specific rather than a general threshold for all exams/ patient sizes.

**METHOD AND MATERIALS**

Patient and scanner parameters (study description, scan length, dose length product (DLP), patient age, scanner model) were obtained with an automatic Radiation Exposure Extraction Engine (RE3) for all CT chest abdomen and pelvis exams in January and February 2014 (n=892). BMI data was acquired from RIS. A multivariable regression was applied with scanner model, age, BMI, BMI*scan length, height and weight as predictors for DLP. Using leave-one-out cross validation, we predict a DLP for each exam. All exams with observed DLPs greater than two standard deviations (95th percentile) from the mean residual were flagged. All studies were also analyzed with a simple thresholding model to identify exams with DLPs over two standard deviations above the mean of all exams. Exams flagged by the context-dependent and independent methods were checked for factors in patient weight and multi-phase exams.

**RESULTS**

Our multivariable regression model detected 18 anomalous exams with a mean DLP of 2678 mGy*cm (1350 to 4101). The context-independent thresholding detected 43 with a mean DLP of 2765 mGy*cm (2206 to 4101). 11 exams were detected by both methods. The average BMI for exams detected by only our context-dependent model (n=7) was 25.6 ±6.5 kg/m2, and that of those only by the thresholding model (n=32) was 36.9±5.2 kg/m2 (mostly obese patients). The average number of acquisitions for exams detected only by our context-dependent model was 1.6 ± 0.8 passes and that of the thresholding model was 2.7±0.58 passes (mostly multi-phase exams).

**CONCLUSION**

We present a context-dependent CT radiation anomaly detection method using exam-specific variables. Our model takes into account clinical context and therefore detects patient-specific outliers missed by simple thresholding, but does not falsely flag exams that would be detected by simple thresholding due to high exposure from patient weight and multiple phases.

**CLINICAL RELEVANCE/APPLICATION**

Contextual sentinel event detection allows for earlier detection of individual or systemic excessive radiation exposures.

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**SSK12-04**

**Adherence to Standard Nomenclature in CT Protocols: Assessing Consistency of Existing Naming Conventions Used in Clinical Operations**

Jenifer Willmann Siegelman MD, MPH (Presenter):  Consultant, Bayer AG ,  Matthew M.  Raffol  MA :  Nothing to Disclose ,  Mohammad Hadi   Bagheri  MD :  Nothing to Disclose ,  Ramin   Khorasani  MD :  Consultant, Medicalis Corp ,  Aaron D.  Sodickson  MD, PhD :  Research Grant, Siemens AG

**PURPOSE**

Systematic review of CT protocols for patient safety and quality improvement requires consistent, accurate, and intelligible protocol naming. Our goal was to assess naming consistency of our CT protocols via adherence to RadLex body region convention.

**METHOD AND MATERIALS**

CT protocol names used in our multi-institution hospital system over a 27-month period (2012-2014) were
assessed for conformance to the RadLex Playbook naming conventions. 193,000 consecutive CT exams at three institutions on 12 scanners from two vendors with 1622 unique protocol names were examined. Scanner protocol names for the head, neck, abdomen, chest, and spine were manually mapped to RadLex. Single body region clinical protocol names (n=848) were assessed for inclusion of the relevant RadLex body region designation.

RESULTS

54% of protocol names contained the RadLex-prescribed term for body region. Chi-squared tests for independence detected statistically significant variation in conformance rates across body regions (p < .001) or scanners (p < .005). No significant difference was detected among institutions (p > .8). Body region conformance rates were: neck 100%, spine 98%, head 53%, chest 81%, and abdomen 31%. Variation within a single protocol type (unique RadLex ID) was also observed, with as many as 19 unique names across the 3 institutions. Many protocols also deviated from the RadLex conventions by including reference to patient weight categories, contrast timing, clinical indication (PE, stent hypervascular) and number of scanner passes.

CONCLUSION

Variable naming of CT scanner protocols is prevalent within our healthcare system. In the context of accreditation standards, quality improvement and patient safety, healthcare-system wide review of CT protocols to assess the appropriateness of scan parameters and radiation exposure is necessary but is hampered by the current lack of protocol naming standardization due to suboptimal adherence to conventions. Additional modifiers beyond the RadLex terminology may be required to adequately reflect the complexity and diversity of protocol specifications needed for clinical operations. Character limits on scanners may also inhibit full and standardized parameter specification in all protocol names.

CLINICAL RELEVANCE/APPLICATION

Increased standardization of protocol nomenclature (using Radlex) may enable quality improvement initiatives by facilitating health-system wide protocol review and optimization.

SSK12-05

HITECH Act: The Critical Missing Encryption Tools to Comply

Anne Clara Krok (Presenter): Nothing to Disclose, Nogah Haramati MD: Investor, Kryon Systems Ltd Investor, OrthoSpace Ltd Investor, BiProtek Ltd Board Member, Kryon Systems Ltd Board Member, OrthoSpace Ltd Board Member, BioProtect Ltd Consultant, AFC Industries, Inc Advisory Board, General Electric Company, Karen Ellen Sperling MD: Nothing to Disclose, Shlomit Goldberg-Stein MD: Research Consultant, Intrinsic Therapeutics Inc, Malka B. Finkelstein MD: Nothing to Disclose, Shari Friedman MD: Nothing to Disclose, Mony Weschler MSC, BSC: Nothing to Disclose

PURPOSE

To assess whether the existing electronic encryption and multiplatform tools are sufficient for full compliance with the 2009 HITECH Act by non-tech savvy users operating in USA-based healthcare organizations

METHOD AND MATERIALS

We reviewed all existing encryption tools that are available as stand-alone products as well as tools that are packaged by vendors within more robust healthcare information systems. We reviewed each tool and package for the following characteristics 1. Ability to be used without requiring administrator privileges or authorization to install software on a computer/PC. 2. Ability for the user to decrypt the files on-the-fly without requiring installation of the encrypting program on the destination computer/PC. 3. Ability to encrypt/decrypt files in a multiplatform environment. Platforms utilized were Microsoft Windows (XP/Vista/7/8), MAC OSX (Versions 7 and higher), Android (Versions 4.0 ICS and higher), and iOS (6 and higher).

RESULTS

No tools were identified that fulfilled all three of the major characteristics.

Several packages were identified that can encrypt and decrypt on-the-fly, but these were all limited by platform.

No USB-stick based tools exist that encrypt and decrypt on the fly without Computer/PC administrator privileges in a mixed Windows PC/Mac OSX environment.

CONCLUSION

Better tools are needed for compliance with the HITECH Act by non-tech savvy physicians USB-stick based tools that could encrypt and decrypt on the fly without Computer/PC administrator privileges might be the most crucial

CLINICAL RELEVANCE/APPLICATION

Physicians collaborate, consult and lecture at institutions that are not their home institutions. Powerpoints and other information should be transported in an encrypted format to be fully HITECH Act compliant. Often, the Computer/PC available at the host institution does not allow software to be installed, and often, cloud services are blocked.
CONCLUSION

The on-call radiologist operates in a highly disruptive work environment as evidenced by the frequency of interruption by incoming and outgoing telephone calls. Further research is needed to specifically ascertain the effects of frequent interruptions on the performance of on-call radiologists at academic institutions.

Background

Workflow interruptions in the healthcare delivery environment are a major contributor to medical error and have been extensively studied within numerous hospital settings including the nursing environment, the operating room, and on physician workflow. Less understood, though, is the role of interruptions in other highly specialized clinical domains and subspecialty services such as diagnostic radiology. The workflow of the on-call radiologist, in particular, is especially susceptible to disruption by telephone calls and other modes of physician-to-physician communication. Herein, we describe our initial efforts to quantify the degree of interruption experienced by the on-call radiologist and examine its potential implications in patient safety and overall clinical care.

Evaluation

An annotated list of all completed telephone encounters including call time stamps, duration, and call origin were analyzed. The records cover a period of 13 weeks from midnight July 14, 2012 through 11:59 PM on October 12, 2012 (90 days). Data were analyzed using the R statistical package.

Discussion

A total of 10,378 calls were completed during on-call hours, 5759 (55%) of which were incoming calls. Median call duration was 57 seconds. During a typical 12-hour overnight on-call shift (8PM to 8AM), there were an average of 72 telephone calls with an average total time of 108 minutes spent on the phone. There were an average of 19.3 CT studies during an overnight shift. Average telephone call volume per hour varied from 2.82 to 10.81. Hourly average CT and telephone call volume were highly correlated, with Spearman’s rho = 0.75 (rho < 0 with p < 0.001).

SSK12-07

Adult CT Dose Monitoring Using Web Based Radiation Dose Tracking Software

Kevin Murphy MBBCch, MRCS : Nothing to Disclose, Maria Twomey MBChB, FFR(RCSI) (Presenter): Nothing to Disclose, James Ryan : Nothing to Disclose, Kate Carey : Nothing to Disclose, Patrick Nicholson MBBCch : Nothing to Disclose, Niamh Moore : Nothing to Disclose, Mary-Jane Murphy : Nothing to Disclose, Michael Sheehy : Nothing to Disclose, Owen J. O’Connor MBBCch : Nothing to Disclose, Michael M. Maher MD, FRCR : Nothing to Disclose

CONCLUSION

Radiation dose tracking software results in excellent streamlining of information collection and manipulation. In our study it quickly identified our mean doses for common examinations and pinpointed outliers and helped identify reasons for high radiation doses.

Background

Dose monitoring, audit and CT optimization are key factors in achieving widespread CT dose reduction. We assess the ease and feasibility of using web based radiation dose tracking software (DoseWatch, GEHC) in assessing radiation dose (dose length product, DLP and size-specific dose estimate) at adult CT and comparing these values to published diagnostic reference levels (DRLs)

Evaluation

Following IRB approval, 576 consecutive CT studies were retrospectively assessed (223 thorax, 353 abdomen-pelvis). Information regarding DLP, SSDE, demographics, effective diameter and time of acquisition were automatically obtained from the analysis software. In addition, information on the radiographer experience and inpatient status was also obtained from the radiology information system analysed. Results showed a mean thoracic CT DLP of 282±151 mGycm (range 5-1753) and SSDE of 9.22±1.82 (range 5-21 mGy). Mean radiation dose from CT abdomen-pelvis was 621±231 mGycm (range 244-1582); SSDE 13.7 mGy (range 3-21 mGy). Both studies had mean levels below the published DRLs [thorax: 460 mGycm; abdomen-pelvis 640 mGycm]. 12% had anomalously high doses. These higher doses were significantly associated with inexperienced technologists (p=0.009), out of hours scanning (p=0.04) and multiphase studies (p

Discussion

Our mean thoracic CT dose levels are significantly superior to published DRLs abdominopelvic dose levels are satisfactory when compared with diagnostic reference level. We have identified reasons for aberrantly high doses for certain patients with the use of radiation dose tracking software. This information will be of vital importance in future planning

SSK12-08

Radiation Feedback to Improve Awareness and Decrease Dose

Michael Bazylewicz MD (Presenter): Nothing to Disclose, Ross Warren Filice MD : Nothing to Disclose

PURPOSE

To measure changes in reporting compliance after implementation of a standardized radiation reporting template for interventional radiology reports.

To raise awareness of radiation use by presenting regular feedback at section meetings in an easily consumable format.
METHOD AND MATERIALS

HL7 report data was collected from 2012 to 2014. An algorithm screened free-text interventional radiology reports in real-time to detect use of a standardized dose template and parsed fluoroscopy time for each report into a database. Accuracy of the algorithm was tested by manually comparing recorded data to the reports with iterative refinements to improve performance. Reporting template compliance was calculated monthly. Compliance before and after an educational program and mandatory directive to use the template were compared. Average fluoroscopy time and standard deviations were calculated for a list of top ten procedures. Visualizations were produced to display reporting compliance and average fluoroscopy time for individual physicians with comparisons to departmental means and standard deviations. These reports were presented at regular interventional radiology section meetings.

RESULTS

Accuracy of the algorithm for detecting fluoroscopy time was 98%. The rate of fluoroscopy time recorded in reports before and after mandatory use of a standard template was 66% and 96% respectively. Graphically displaying the radiation data highlighted studies where fluoroscopy time exceeded departmental norms, identified dictation and procedure tracking errors, and helped refine algorithm accuracy. This data will continue to be presented regularly at section meetings to provide feedback on fluoroscopy use and facilitate future analysis of radiation dose.

CONCLUSION

Use of a standardized template for reporting fluoroscopy time improves radiation dose recording rates and allows data to be consumed and presented. Providing easily consumable feedback on fluoroscopy use raises awareness, identifies outliers, and detects report and tracking errors. We predict that continual feedback at section meetings will decrease radiation use and improve reporting compliance.

CLINICAL RELEVANCE/APPLICATION

The results of this study can be used by radiology departments to improve radiation documentation and raise awareness of radiation use within an interventional radiology department.

SSK12-09

Story of Stickr - Design and Usage of an Automated Biopsy Follow Up Tool

Marc D. Kohli MD (Presenter): Research Grant, Koninklijke Philips NV Research Grant, Siemens AG, Aaron P. Kamer MD: Nothing to Disclose

PURPOSE

Mammographers are legally required to evaluate pathology from each biopsy in order to determine concordance. Many other sub-specialist radiologists find large-scale followup challenging due to task complexity. We set out to design and implement a web-based biopsy follow up worklist application. Important quality metrics such as adequacy rates and diagnostic rates would also be calculated from data collected.

METHOD AND MATERIALS

Prior to implementation of the worklist, radiology faculty who regularly perform biopsies were surveyed about their biopsy practices. Our application was built to receive biopsy reports and pathology reports in real-time from HL7 feeds. Each radiology report is processed to assign a radiologist and a resident (if applicable). Upon logging in, the faculty or resident is presented with a list of biopsies performed. The biopsies that have associated pathology reports are highlighted. With just two clicks, a biopsy can be marked as adequate/concordant. If biopsies are flagged as inadequate/discordant, an option to visit the hospital paging webpage is presented.

RESULTS

Of the 21 faculty survey respondents (with 8 mammographers), only 43% follow up the pathology results every time. 3 faculty (14%) follow up on their biopsies up to 20% of the time. Over 1300 image-guided biopsy reports have entered the successfully deployed application, with 82% of these reports having been linked with respective pathology, a rate much higher than before discarding a body part matching requirement between reports. The participating physicians have noted concordance/discordance in 23% of biopsies that have pathology.

CONCLUSION

Radiologists, particularly mammographers, have a high rate of biopsy follow up. Many other faculty do not as reliably follow up on their pathology results, instead depending on the referring clinician to determine repeat biopsy necessity. Use of NLP for body part matching in biopsy/pathology reports results in a low number of report matching, but reports matched using only time and patient ID number criteria results in a high number of reports delivered. A biopsy-pathology follow up worklist can be well-integrated into current radiology practice systems.

CLINICAL RELEVANCE/APPLICATION

By automatically populating a web-based worklist with radiology and pathology reports, an otherwise time consuming and tedious task can be educational and add value to patient care.
**Sub-Events**

**SSK21-01**

Investigation of Iterative Model Reconstruction to Determine Maximum Obtainable CT Radiation Dose Reduction with Preserved Diagnostic Quality in a Cadaver Study

David Knipp MD : Nothing to Disclose, Barton Frederick Lane MD : Nothing to Disclose, Seth Jay Kligerman MD : Author, Reed Elsevier, Amar Dhanantwari : Employee, Koninklijke Philips NV, Barry David Daly MD (Presenter) : Research Grant, Koninklijke Philips NV

**PURPOSE**

To assess quantitative and qualitative measures of image quality from cadaver data with progressively reduced-dose abdominopelvic CT scans using a knowledge-based iterative reconstruction algorithm compared to standard dose filtered back projection (FBP).

**METHOD AND MATERIALS**

Two human cadavers were scanned at 120kVp on a 256-slice CT scanner (Philips Medical, Cleveland) at standard dose (300 mAs) and reconstructed with FBP. Subsequent reduced dose scans were performed at 60%, 70%, 80%, 90%, and 95% dose reduction (DR), (as low as 15mAs) and reconstructed with iterative model reconstruction (IMR) technology, (Philips Medical) at both 3mm and 1mm slice thickness. Sample images with focal pathology in the liver, mid abdomen and pelvis were selected for review. Three experienced radiologists graded scans for image quality (IQ), perceived noise, and presence of artifacts using a 1-5 Likert scale. All scans were compared directly to the standard dose FBP scan for reference. ROIs were placed in the liver, mid abdomen and pelvic tissues wall to calculate noise, attenuation, and contrast to noise ratio (CNR).

**RESULTS**

At full dose FBP, average noise (21.2) and CNR (2.3) was not significantly different than noise at 90% and CNR at 95% DR respectively (p>0.05 for all). There was no significant difference in noise or CNR between 3mm and 1mm slice thickness for IMR. At 60%, 70%, and 80% DR had equal aggregate IQ compared to standard dose FBP (p>0.05 for all). Perceived noise was improved with IMR compared to FBP for all levels of DR up to 80% (p<0.01 for all) and equal to FBP for 90-95% DR. Artifacts were not different between FBP and IMR at up to 70% DR. For IMR, there was no significant difference in scoring of IQ, perceived noise or artifact presence between 3mm and 1mm slice thickness.

**CONCLUSION**

In this cadaveric study, quantitative data and subjective reader evaluations suggest that IMR can allow 80% dose reduction compared to standard dose FBP in abdominopelvic CT without loss of image quality. No noise penalty was seen with thinner image slice reconstruction.

**CLINICAL RELEVANCE/APPLICATION**

The introduction of IMR into clinical use should allow major reductions in radiation dose for abdominopelvic CT while maintaining diagnostic image quality.

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**SSK21-02**

Fully Automated Geometric Calibration of a Tiled Directly-converting Single X-ray Photon Counting Detector Array for CT

Christian Steiding MSc : Employee, CT Imaging GmbH, Daniel Kolditz PhD (Presenter) : Employee, CT Imaging GmbH, Felix Althoff : Nothing to Disclose, Willi A. Kalender PhD : Consultant, Siemens AG Consultant, Bayer AG Founder, CT Imaging GmbH Scientific Advisor, CT Imaging GmbH CEO, CT Imaging GmbH

**PURPOSE**

Single x-ray photon counting detector (PCD) concepts may offer superior imaging performance. However, to date the manufacturing of large-area homogeneous high-Z PCDs for CT still remains a challenge. Tiled PCD arrays usually suffer from complex geometric detector alignment errors and artifacts may occur in the CT volumes if not corrected. The aim of this work was to introduce and validate a novel approach for the fully automated geometric calibration of CT systems equipped with a tiled PCD array.

**METHOD AND MATERIALS**
To estimate the actual imaging geometry, we developed a two-step calibration approach utilizing genetic algorithms: (1) identification of errors for each single PCD tile; (2) calculation of the rotational source-detector geometry. The proposed calibration approach was verified in simulation studies; realistic alignment errors of position and orientation for both the x-ray source and the PCD tiles were used. The ideal case mimicking the specified system geometry was set as a reference. The experimental validation was carried out on a breast CT prototype equipped with a tiled cadmium telluride detector array with 100 µm pixel size. The 10% modulation transfer function (MTF) value, the slice sensitivity profile’s full width at tenth maximum (FWTM), and the maximum contrast were assessed in the reconstructed volumes for centrally and peripherally positioned small wires and thin disks, respectively. Results were compared for non-calibrated, calibrated, and ideal geometry data.

RESULTS

Measurements on the prototype revealed the following: With the use of the non-calibrated geometry data, maximum contrast dropped by 65-80%, MTF was no longer evaluable, and FWTM fell by about 50%. The maximum error in misalignment estimation was 0.02 mm for the proposed calibration approach; i.e., accuracy was equal to a fifth of the detector pixel. 3D resolution and contrast was above 95% of the values obtained for the assumed ideal geometry for all phantom positions.

CONCLUSION

The proposed calibration approach provided accurate and fully automated geometry estimation for a tiled PCD array and is applicable for arbitrary CT systems and scan trajectories.

CLINICAL RELEVANCE/APPLICATION

The proposed approach ensures undisturbed image quality and thereby allows for applying tiled PCD concepts in clinical CT.

Deformable 3D-2D Registration-based Running Prior for Low Dose Tomographic X-Ray Fluoroscopy

Barbara Flach: Nothing to Disclose, Marcus Brehm: Nothing to Disclose, Jan Kuntz: Nothing to Disclose, Rolf Kueres: Nothing to Disclose, Soenke Heinrich Bartling MD: Research support, Siemens AG, Marc Kachelriess PhD (Presenter): Nothing to Disclose

PURPOSE

To provide a continuously adaptive prior at high temporal resolution for motion correction in low dose tomographic fluoroscopy.

METHOD AND MATERIALS

To guide minimally-invasive interventions a continuous data acquisition is necessary. In low dose tomographic fluoroscopy (3D+time) volumes are reconstructed from only 15 cone-beam projections per 180°. This keeps the patient dose level as low as in today's C-arm-based projective fluoroscopy (2D+time). The combination of this highly sparse information with a high quality prior allows to continuously provide high quality update volumes for intervention guidance. To account for patient motion a continuous adaptation of the prior during the intervention is required. We developed a deformable volume-to-rawdata (3D-2D) registration that uses not more than the latest 15 projections. Thus, the running prior is continuously updated with a high temporal resolution. The registration calculates the forces for adaptation on the basis of the sum of squared differences in rawdata domain and regularizes the vector field by convolution with Gaussian kernels. Our approach was implemented in an experimental prototype flat detector CT scanner. To validate the new technique we used the head scan of a pig in vivo. During the intervention the position of the pig's head was moved manually to mimic patient motion. Reconstruction was done with 3D-3D and with the new 3D-2D prior using only 15 projections for registration. The results were assessed by visual inspection. For quantitative evaluation the sum of squared differences (SSD) was calculated in image and rawdata domain.

RESULTS

The resulting running prior images obtained by 3D-2D registration show a higher matching to the ground truth compared to the 3D-3D prior. The SSD of 3D-2D prior in image domain is 88% of the 3D-3D prior. In rawdata domain the matching was improved by 35% compared to the 3D-3D prior. The time frames show less inconsistency which can be attributed to the higher temporal resolution of the 3D-2D prior.

CONCLUSION

Low dose tomographic fluoroscopy should use the 3D-2D running prior to ensure maximal image quality.

CLINICAL RELEVANCE/APPLICATION

Improved visualization of the correct position of interventional material with respect to the surrounding patient tissue. No additional dose needed in case of patient motion during the intervention.
PURPOSE

Metal artifacts often contaminate CT images and hinder medical diagnosis around the metal implant and surrounding soft tissue. The purpose of this study was to assess a novel compressed sensing based method developed to remove metal artifacts from clinical CT images.

METHOD AND MATERIALS

The compressed sensing metal artifact reduction (CS-MAR) algorithm was implemented and retrospectively applied to DICOM image data sets from 40 human subjects. Metal artifact levels were qualitatively evaluated based on the perceived metal artifact level and quantitatively evaluated by measuring the standard deviation of CT numbers in soft tissue surrounding the metal implants. The qualitative and quantitative results were compared between both the original clinical images and processed images.

RESULTS

Qualitative observation demonstrated that, for all 40 subjects in this study, the metal implants appeared properly reconstructed after the CS-MAR algorithm was applied. The shading and streaking artifacts surrounding the metal implants were significantly reduced to enable clear visualization of the surrounding soft tissue. Quantitatively, the standard deviation of the CT numbers in the surrounding soft tissue regions were significantly reduced due to the mitigation of both metal streaks and shading artifacts. Quantitative measurements for two subjects are presented as examples. In the first example, the standard deviation of the CT numbers for three regions of interest (ROIs) proximal to the metallic implant were reduced from 61, 56, and 63 HU to 36, 27, and 31 HU respectively. The standard deviation of the CT numbers for the three ROIs farther away from metallic implants were reduced from 56, 53, and 64 HU to 37, 32, and 39 HU respectively. For the second example case, the standard deviation of CT numbers was reduced from 124, 111, and 137 HU to 47, 27, and 49 HU respectively for the three ROIs proximal to the metal implants, while the standard deviations of CT numbers were reduced from 102, 57, and 86 HU to 31, 30, and 28 HU respectively for the three ROIs further away from the metal implants.

CONCLUSION

The CS-MAR algorithm can be applied to any clinical CT dataset to reduce metal artifacts, enabling clear visualization of both metal implants and surrounding soft tissues.

CLINICAL RELEVANCE/APPLICATION

The CS-MAR algorithm can be applied to any clinical CT cases with metal artifacts directly from DICOM images to improve diagnostic performance.

SSK21-05

A Subjective and Objective Comparison of Cardiac Computed Tomography Angiography (CCTA) Model-based Iterative Reconstruction (MBIR) with Standard of Care Images


PURPOSE

Subjective image quality (IQ) comparison using CCTA scans was performed on EKG-gated MBIR and ASiR images. The clinical study was supported by quantitative measurement of resolution using a cardiac phantom.

METHOD AND MATERIALS

Clinical CCTA exams (n=20; age: 67 ± 6 yrs; BMI: 25 ± 4) showing pathology such as stents, plaque and acquired using high-resolution step and shoot acquisition mode on Discovery CT750 HD scanner (GE Healthcare, Waukesha, WI) were used in this study. Each CCTA scan was reconstructed with 40% ASiR (HD Stnd. kernel) and MBIR at 0.625 mm slice thickness. The clinical images were reviewed by two radiologists on a 5 point Likert scale (1 = Non-diagnostic, 2 = Sub-optimal, 3 = Acceptable, 4 = Good, 5 = Excellent). Noise and signal-to-noise (SNR) were calculated in the proximal arteries to support the IQ comparison. In addition, a phantom consisting of contrast enhanced vessels with stent, calcified plaque (Hydroxyapatite), and stair-step, non-calcified plaque (ABS resin) was also scanned using a similar protocol. Images at 0.625mm thickness were generated using FBP (HD Stnd. kernel) and MBIR. Contrast dependent resolution was compared between FBP and MBIR using the phantom data. Full-width half maximum (FWHM) of the line spread function (LSF) was used as metric.

RESULTS

MBIR images had superior overall image quality and vessel visualization compared to standard of care ASiR images (5 vs 4, P <0.001). The mean attenuation in the proximal vessels for MBIR images was not different from ASiR (435.6 ± 74.2 HU vs 433.5 ± 71.1 HU; p=0.39). The MBIR images showed significantly higher SNR (23.23±4.24 vs 11.22±2.28; p<0.001) and significantly lower noise (19.0 ± 3.2 HU vs 39.3 ± 4.6 HU; p<0.001). The FWHM of LSF across calcified plaque, stents and contrast enhanced vessels were 0.46 mm, 0.74mm and 0.64mm for MBIR compared to 0.93 mm, 1.17 mm and 0.91 mm for FBP.

CONCLUSION
MBIR CCTA images were significantly better than ASiR images in overall IQ and vessel visualization. MBIR images also demonstrated superior SNR and lower noise. Improvement in subjective IQ is also supported by significantly lower FWHM of LSF in MBIR compared to FBP images.

**CLINICAL RELEVANCE/APPLICATION**

MBIR has been demonstrated to lower the radiation dose compared to standard of care images. In addition, the superior SNR and resolution characteristics of MBIR images can lead to improved diagnostic quality of CCTA images.

Cardiac Motion Correction Based on Partial Angle Reconstruction in X-ray CT

**SSK21-06**

Seungeon Kim (Presenter): Nothing to Disclose, Yongjin Chang: Nothing to Disclose, Jong Beom Ra: Research Grant, Samsung Electronics Co Ltd Research Consultant, Samsung Electronics Co Ltd

**PURPOSE**

Coronary artery imaging is important for early detection of cardiac disease. Since coronary arteries are small and move fast, high spatial and temporal resolution is required to get a diagnostic image quality. Due to the limited gantry rotation speed of X-ray CT, however, the reconstructed image usually contains motion artifact or blur. To improve the image quality via the motion correction in the reconstruction process, we use a novel motion estimation scheme based on partial angle reconstruction (PAR) images.

**METHOD AND MATERIALS**

The algorithm aims to reconstruct a motion-artifact-reduced 3D cardiac CT image using projections obtained in a slightly larger angular range than the one needed for a short scan. In the algorithm, two conjugate PAR images are reconstructed from the projections on the small angular range, respectively. Using a pair of conjugate PAR images, we estimate a motion model. The motion correction is then performed by incorporating the estimated motion model into the image reconstruction process. The XCAT phantom and physical dynamic cardiac phantom are used for the feasibility test of the algorithm. The XCAT phantom dataset is generated with a heart rate of 70 bpm and a gantry rotation speed of 300 ms. Two physical dynamic cardiac phantom datasets are also generated by using a slowly rotating X-ray CT system so that the effective heart rate can become 70 and 85 bpm, respectively, if the system rotation speed is assumed to be 300 ms.

**RESULTS**

The PAR-based motion estimation and correction algorithm is applied to the phantom datasets. The reconstructed images at 20% (rapid motion) and 40% (quiescent motion) of R-R peak of the XCAT phantom show that motion artifact or blur can be significantly reduced by applying the motion correction algorithm; thereby coronary arteries are more clearly visible. Physical dynamic cardiac phantom images reconstructed at 10 phases with two different heart rates, 70 and 85 bpm, also provide the improved temporal resolution.

**CONCLUSION**

The PAR-based cardiac motion correction algorithm is proposed for 3D cardiac imaging of high temporal resolution. Its performance is verified by using a digital XCAT phantom dataset and two physical cardiac phantom datasets.

**CLINICAL RELEVANCE/APPLICATION**

This work improves the accuracy of the cardiac disease diagnosis, by improving the temporal resolution, or reducing the motion blur, in cardiac X-ray CT imaging.

1024 Matrix Model-based Iterative Reconstruction Improves Clinical Image Quality in Lung Imaging

**SSK21-07**

Patrik Rogalla MD (Presenter): Nothing to Disclose, Bernice E. Hoppel PhD: Employee, Toshiba Corporation, Mini Vithal Pakkal MBBS: Nothing to Disclose, Christin Farrell: Employee, Toshiba Corporation, Sonja Kandel MD: Nothing to Disclose

**PURPOSE**

To evaluate model-based iterative reconstruction (IR) using 512 and 1024 image matrix against hybrid iterative reconstruction (AIDR).

**METHOD AND MATERIALS**

Raw-data from 20 randomly selected chest CTs (Toshiba Aquilion1) were reconstructed by using AIDR with 6 different kernels and filters that were optimised for lung imaging. 3 radiologists (18, 6 and 3 years of clinical experience, blinded to the reconstruction method) ranked the images separately according to their overall personal preference (forced ranking, no quality criteria given). The reconstruction technique with the highest median ranking was defined as the optimized reference standard for this study. All datasets were then reconstructed using model-based IR at 4 different regularization parameters with a 512 image matrix and 4 corresponding parameters with a 1024 matrix. All nine images (IR and the radiologist's AIDR reference standard) were displayed on one screen and the same 3 radiologists (blinded to the reconstruction method) were asked to rank all images according to their preference for lung imaging. Image noise was measured on all
reconstructions within air.

RESULTS

The preferred reference hybrid reconstruction techniques (AIDR) was based on FC 81 (high frequency kernel); the median/mode and mean SD of image noise in sequential order for IR at 512 matrix with b=300,400,500,700, for AIDR, and for IR at 1024 matrix with b=1600,2400,3200,4000 were 7/7 and 17.7, 5/6 and 15.7, 4/4 and 13.4, 6/5 and 11.3, 9/9 and 14.5, 2/2 and 17.4, 1/1 and 15.6, 3/3 and 13.5, 8/8 and 11.1, respectively. The difference between median rank 1 and 5, and 5 and 9 were statistically significant (both p<0.0001). With the exception of one case for one reader, AIDR always ranked the worst, and with the exception of b=4000, 1024 matrix was always preferred over 512. SD was the highest on 512 IR b=300 and lowest on 1024 IR b=4000 (p<0.0001).

CONCLUSION

1024 matrix model-based IR improved image quality compared to both 512 model based IR and AIDR. After further optimization of reconstruction parameters tailored to the specifics of lung imaging, model-based IR with 1024 image matrix may become the reconstruction method of choice.

CLINICAL RELEVANCE/APPLICATION

Image quality in lung imaging can be improved by 1024 matrix model-based iterative reconstruction without modification of CT scanning parameters.

SSK21-08

Saving CT Radiation Dose with Iterative Reconstruction Algorithms: The Influence of Scan and Reconstruction Parameters on Image Quality, Resolution, and CTDIvol

Verena Obmann MD (Presenter): Nothing to Disclose, Alexander Stork: Nothing to Disclose, Johannes T. Heverhagen MD, PhD: Speaker, Bracco Group, Philipp Georg Christian Begemann MD: Nothing to Disclose, Thorsten Klink MD: Nothing to Disclose

PURPOSE

To evaluate image quality, resolution, and radiation dose of iterative reconstruction (IR) in comparison to filtered back projection (FBP) in a combined phantom and patient study.

METHOD AND MATERIALS

The phantom (Catphan®) was helically and axially imaged with a multi-slice CT scanner (Philips Brilliance iCT) using a collimation of 2x128x0.625mm. Varying tube voltages (140, 120, 100, 80 kV) and currents (200, 150, 100, 30 mAs) were combined. 198 phantom data sets were generated applying FBP and IR with increasing iterations (Level 1-7), and reconstructed using a soft and a sharp kernel. Further, 25 chest (120 kV) and abdomen (120 kV) CT scans with small overlap at the basal thorax, were reconstructed with IR (Level 5) and FBP. Two independent observers evaluated image quality, resolution, and radiation doses of both phantom and patient scans. Statistical analysis included Kappa-statistics Wilcoxon-Matched-Pairs test to test for significance.

RESULTS

In phantom scans, image noise was significantly improved using IR by 52.2% (p<0.05) in comparison to FBP, independent from material, scan mode, tube voltage, tube current, and kernel. IR did not negatively affect high-contrast and low-contrast resolution. In low-dose acquisitions (CTDlvol, 5mGy), IR resulted in significant higher low-contrast resolution (detectable object size, 4.5mm vs. 8.4mm; κ=0.85; p<0.01), but low-contrast object detectability decreased. At identical image quality levels of IR and FBP, CTDIvol could be reduced by 26-50% using IR. In patients mean tube current was 124.7 ±57.7 mAs for IR/100kV acquisitions and at 262.1 ±106.7 for FBP/120kV acquisitions (p=0.0004) while image quality was good to excellent applying IR as well as FBP.

CONCLUSION

IR improves image quality of lower-dose acquisitions to comparable levels of higher-dose acquisitions reconstructed with FBP. IR does not negatively affect high- and low-contrast resolution, potentially improves low-contrast resolution in low-dose scans. Thus, IR rendered significant reduction of CTDIvol (>50%) in the patient study.

CLINICAL RELEVANCE/APPLICATION

Iterative reconstruction algorithms have been shown valuable for saving CT radiation dose. Implementation in clinical routine protocols shows possible reduction of radiation risks of patients.
METHOD AND MATERIALS

The algorithm converts first each attenuation value to a number \( N_a \) of detected photons based on calibration measurements taking tube current modulation, bowtie filtration, and beam hardening into account. Next, \( N_a \) is reduced to \( N_b = \alpha + \text{Poisson}(\beta + N_a) \). Based on the rules for conditional expectation and variance the factors \( \alpha \) and \( \beta \) are derived from a model describing quantum noise, electronic noise, and noise due to the polychromatic x-ray spectrum. Finally, the simulated attenuation values are passed back to the scanner to reconstruct low dose images. Reading and writing of sinogram data was performed with vendor-supplied software. For the validation, an anthropomorphic thorax and abdomen phantom were scanned on a dual source scanner (Definition Flash, Siemens) at various exposure values (30-240 mAs). Dose reduction potential of the IR technique (SAFIRE) was assessed with patient scans of various body parts, including thorax and abdomen. Contrast dependent sharpness and lesion detectability were evaluated as a function of simulated dose reduction and IR technique strength setting.

RESULTS

No significant difference was found for the standard deviation of the image noise between measured and simulated low dose phantom scans (\( p<0.01 \)). The shape of the noise power spectrum was not affected by the algorithm. In patients, the IR at maximum strength was able to compensate for the image noise increase due to a simulated dose reduction of a factor 3-4, depending on the reconstruction kernel used. This was accompanied by a change in image impression due to a change of the noise power spectrum. Subtraction images revealed slightly improved high contrast sharpness in simulated low dose scans with IR compared to measured normal dose scans with filtered backprojection.

CONCLUSION

In phantoms, simulations were in good agreement with measurements at reduced dose. In patients, influence of dose reduction and IR on image impression, noise texture and low contrast detectability could be assessed.

CLINICAL RELEVANCE/APPLICATION

Scanning patients both at normal and low dose is unethical and unpractical. Phantoms, however, lack realistic tissues. Low dose simulations offer an alternative to evaluate iterative reconstructions.
compared with the measured CTDIvol values.

RESULTS

The calculated \( D_w \) and \( D_{\text{eff}} \) values of the PMMA phantoms (32, 24, 16 and 8cm diameter) were \((D_{\text{eff}}, D_w) = (32.0, 33.7), (24.0, 25.2), (16.0, 16.7) \) and \((8.0, 8.0) \) (cm). The resulting SSDE from \( D_{\text{eff}} \) were both 39.1 mGy at middle and upper lung level. SSDE from \( D_w \) were 40.7 and 37.7 mGy at middle and upper lung level. Measured CTDIvol were 40.5 and 38.3 mGy at middle and upper lung level. Comparison of the calculated SSDE with the dose measurements yielded errors in SSDE from \( D_{\text{eff}} \) were -3.5% and +2.0%, and errors in SSDE from \( D_w \) were 0.4% and -1.6% at middle and upper lung level respectively.

CONCLUSION

SSDE calculated from Water - Equivalent Diameter may be more accurate than the effective diameter method. In addition, this Water - Equivalent Diameter method calculated from an axial image or scout image has a potential possibility to be automatically determined on a CT scanner.

CLINICAL RELEVANCE/APPLICATION

This Water - Equivalent Diameter method enables a CT scanner to calculate the more accurate SSDE automatically.

Impact of Table Positioning on Dose Reduction Systems and Organ Doses within Cadaveric Subjects

Rebecca Huke, Lamoureux MS, BS (Presenter): Nothing to Disclose, Anna Mench: Nothing to Disclose, Izabella Lipnarski: Nothing to Disclose, Brian Cormack: Nothing to Disclose, Sharatchandra S. Bidari MD: Nothing to Disclose, Lynn Neitzey Rill PhD: Nothing to Disclose, Manuel M. Arreola PhD: Nothing to Disclose

PURPOSE

To measure the effects of table positioning on dose reducing systems and organ dose in computed tomography (CT), and determine the clinical occurrence of miscentering.

METHOD AND MATERIALS

The post-mortem dose measurement methodology established in house was utilized to perform organ dose measurements on varying body habitus subjects for a clinically standardized chest/abdomen/pelvis protocol on a 320-slice scanner. The table was moved in increments of 1cm for a total range of 8cm anteriorly and posteriorly and 4cm laterally. The organ dose measurements taken at each position were then compared with dose measurements from a central position for each subject. Clinical miscentering occurrence assessment includes measuring the AP and lateral miscentering of 80 CAP exams through a retrospective chart study.

RESULTS

Strong correlations were established between the degree of AP miscentering and the percentage difference in dose from the central position for eight out of ten organs of interest including lung, liver, stomach, small intestines, colon, ovary, uterus, and skin (R2 range: 0.7284 - 0.9888), with the percentage difference from the central position dose among all organs ranging from -22.4% to 21.8%. Reasonable correlations were established for the degree of lateral miscentering and one side of an organ, including left lung, right lung, left breast, right breast, descending colon and ascending colon (R2 range: 0.5746 - 0.9433), with the percentage difference from the central position dose among all organs ranging from -14.7% to 14.7%. Measurements for multiple post-mortem subjects present a correlation between varying body habitus and effects of table positioning on dose. Results for the occurrence of AP and lateral miscentering clinically show a range of 2.55cm posterior to 3.9cm anterior, 1.55cm left to 1.56cm right, and an average of 1.24cm posterior and 1.74cm anterior, and 0.71cm left and 1.21cm right

CONCLUSION

Table positioning has a strong correlation to optimizing system output to varying degrees for different body habitus and therefore minimizing dose to organs and miscentering occurs frequently in clinic.

CLINICAL RELEVANCE/APPLICATION

Correct patient centering is rarely achieved in a clinical setting the effects of which, as seen in this study, are reduction in system optimization which negatively impacts patient outcome.

Body Volume and Adiposity as Metrics for Patient and Region-specific Dose Estimation: A Comparison with BMI

Sam J. Weisenthal BA: Nothing to Disclose, Vana M. Derderian BS: Nothing to Disclose, Les Roger Folio DO, MPH (Presenter): Nothing to Disclose, Ronald M. Summers MD, PhD: Royalties, iCAD, Inc Research funded, ICAD, Inc Stockholder, Johnson & Johnson Grant, Viatronix, Inc, Jianhua Yao PhD: Royalties, iCAD, Inc

PURPOSE
BMI is commonly used as a surrogate for patient size to estimate radiation dose from DLP. We investigate the association between adiposity, scanned body volume, BMI, and DLP to seek a more accurate and accessible patient size metric to correlate with radiation dose. Because our method extracts directly from DICOM headers, is applied to each slice and is computationally inexpensive, it can serve as a shorthand organ and region-specific dose estimator.

**METHOD AND MATERIALS**

Chest, abdomen and pelvis CT exams (n=73) were retrospectively analyzed by an automated fat and body volume measurement tool that used segmentation to calculate total body volume (TBV), total subcutaneous fat (TSF), and total visceral fat (TVF) for every slice and exam. Slice-specific scan and dose metrics were obtained from DICOM headers by an in-house Radiation Exposure Extraction Engine (RE3). A multivariable regression was used to associate TBV, TSF and TVF with scanner-modulated exposure at the slice level and with DLP at the exam level. A single variable regression was used to relate DLP to BMI data acquired from the RIS. The BMI and TBV, TSF, TVF regressions were compared with a paired t-test on their residuals.

**RESULTS**

DLP ranged from 352 to 1,961 mGy*cm; TBV from 46,578 to 155,747 cm³; and BMI from 17 to 46 kg/m². At the exam level, the multivariable regression incorporating TBV, TSF, and TVF (R²=0.92) had higher correlation to DLP than did BMI (R²=0.74). The BMI residuals had a mean of 126.0±113.8 and the TVB, TSF, TVF had a mean of 75.8±58.1; a paired t-test indicated significant (p<0.001) difference between the two. At the slice level, the correlation between TBV, TSF, TVF and radiation exposure held (R² = 0.69).

**CONCLUSION**

We demonstrate TBV, TSF, and TVF as an accurate region-specific dose estimator that can be obtained from scan data alone (DICOM header and image data) does not rely on external data such as BMI.

**CLINICAL RELEVANCE/APPLICATION**

Accurate and accessible region and size-specific dose estimations will help radiology departments produce meaningful patient-tailored dose data, optimizing internal and national quality benchmarks for dose tracking and reduction.

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**SSK22-04 A Radiation Dose Reporting System for Mammography and Digital Breast Tomosynthesis**

Bruno Barufaldi BSC, MSc (Presenter): Nothing to Disclose, Tessa S. Cook MD, PhD: Nothing to Disclose, Marie Synnestvedt: Nothing to Disclose, Emily F. Conant MD: Scientific Advisory Board, Hologic, Inc, Mitchell Dennis Schnall MD, PhD: Nothing to Disclose, Andrew D.A. Maidment PhD: Research support, Hologic, Inc Research support, Barco nv Spouse, Employee, Real-Time Radiography, Inc Spouse, Stockholder, Real-Time Radiography, Inc

**PURPOSE**

To monitor radiation dose in a mixed breast screening and diagnostic imaging environment using an automated dose tracking system.

**METHOD AND MATERIALS**

The tracking software consists of three components. A custom DICOM SCP accepts x-ray breast images, maps DICOM metadata into a relational database using an object relational mapper including a thumbnail of the image, and creates a disk backup. Intermediate software cleans the metadata. A client-side application (Sharepoint PowerView, Microsoft, Redmond WA) enables realtime data exploration. Various data views support different user roles (e.g., technical supervisor or medical physicist). The addition of breast glandularity is ongoing.

**RESULTS**

Radiation dose in breast imaging is a function of various factors, including: (i) compressed breast size and glandularity; (ii) image system; and (iii) phototimer programming. Dose can be extracted directly from the DICOM metadata or more accurately calculated from machine calibration data, image technique factors, breast size and glandularity. We track radiation dose by room, technologist, procedure and view. Phantom measurements fail to capture the effect of breast size and glandularity; clinical image data provide a more accurate estimate of dose. At our institution, the average breast size is 60 mm, and the average mammography and tomosynthesis doses are 1.76 and 3.78 mGy (per view).

**CONCLUSION**

A fully automated patient dose tracking system for breast imaging has been implemented and tested in a large multicenter institution. The system is robust and portable, allowing for widespread utilization.

**CLINICAL RELEVANCE/APPLICATION**

There is an increased awareness of radiation utilization. Breast cancer screening requires particular scrutiny,
because it involves repeated irradiation of women who are largely free of disease.

SSK22-05

A New and Accurate Tool for Live Skin Dose Monitoring in Interventional Radiology: Measuring Dose without Compromise

Jonathan Boivin (Presenter): Nothing to Disclose, Sam Beddar PhD: Nothing to Disclose, Maxime Guillemette: Nothing to Disclose, Luc Beaulieu PhD: License agreement, Standard Imaging, Inc

CONCLUSION

The proposed real-time dosimeter is sensitive enough to measure in and out of field exposure in a clinical environment. It does not induce artefacts and cannot be taken for a catheter. This instrument has the potential to replace the fluoroscope estimate with accurate dose values, providing a much needed real-time dosimetry tool.

Background

Long-lasting or repetitive fluoroscopically-guided interventional (FGI) procedures may build up radiation dose to harmful levels, leading to tissue injuries. Fluoroscopy systems provide a dose rate estimate at a single point in space. However, this value does not consider fundamental parameters, such as patient size and location. NCRP report 168 recommends that peak tissue dose shall be used to evaluate the potential for deterministic effects in specific tissue. A new plastic scintillation detector (PSD) is proposed, allowing real-time skin dose measurements during FGI procedures.

Evaluation

The PSD is composed of a 10 mm long plastic scintillation fiber having a 1 mm diameter. It is enclosed in a sealed plastic sheath and coupled to a 10 m long clear optic fiber. A photomultiplier tube is connected to its end and collects the light emitted by the scintillator when exposed to radiation. Calibration is performed at the fluoroscope estimation point by setting the PSD on the table along with an ion chamber, while increasing the dose rate. A Rando humanoid phantom is then set over the detectors. Field size, table height and gantry two axis are explored to assess the PSD performance. Every measure is performed in fluoroscopy and fluorography operation mode and compared to the fluoroscope dose rate estimate.

Discussion

The PSD's coefficient of variation remains under 1% when dose rate is more than 12 mGy/min, and does not exceed 5% at the lowest dose rate achievable of 1.4 mGy/min. Phantom measurements show a dose rate difference between the ion chamber and the PSD of less than 2% when moving the table's height, while the fluoroscope can underestimate the dose rate up to 120% at lowest table position. Angular motions can bring the PSD out of the imaging field, but scattering dose is still measured accurately. In addition, the PSD is nearly invisible on the images.

SSK22-06

Computing Organ Doses from Fluoroscopically Guided Interventions Equipped with Radiation Dose Structured Reporting (RDSR)

David Borrego MS (Presenter): Nothing to Disclose, Daniel A. Siragusa MD: Nothing to Disclose, Wesley E. Bolch PhD: Nothing to Disclose

PURPOSE

Knowledge of a patient's organ doses from a fluoroscopically guided interventional (FGI) procedure is prudent for longitudinal dose tracking and assessing procedural risks. The authors of this work have focused on quantifying patient organ doses to compliment previous efforts of a rapid in-clinic peak skin dose algorithm. These methods allow for the computation of patient-specific organ doses per procedure without the limitations of dose conversion coefficients (DCCs).

METHOD AND MATERIALS

Upon completion of a FGI procedure the RDSR is used to generate inputs for a Monte Carlo transport code. The software accounts for patient anthropometric variations with a library of hybrid computational phantoms. A one-time entry of geometry models, measured half-value layers, and KAP calibration factors is required. By clinician design, only five parameters are needed: patient sex, age, height, weight, and patient position on the table. The absorbed dose to organs is determined with energy deposition and volume-averaged fluence tallies. By default, these methods allow for dosimetry to 17 organ sites including breast, gonad, and the two radiosensitive skeletal tissues - active and shallow marrow. The list of organs amenable to dosimetry is extensive and dependent on physician input.

RESULTS

On average, the wall time for an entire RDSR is 38-min. In/out-of-field organ doses converged to within 1%. Neither the cumulative reference air kerma nor KAP correlated well with the excess lifetime risk of cancer incidence due to a FGI procedure (Pearson coefficients of r=0.07 and r=0.14 respectively). While not all irradiation events contribute equally to the aggregate organ dose, they do all contribute equally to computational time. In the interest of reducing computational time, limiting the model to only those irradiation events with a cumulative reference air kerma in the 50th percentile and above can provide reasonable estimates of the organ doses - within 10%.

CONCLUSION
One can achieve absolute organ dosimetry without the use of DCCs on a patient-dependent phantom. The results demonstrate clinical feasibility and require only minimal input parameters from clinicians.

**CLINICAL RELEVANCE/APPLICATION**

This software may serve as a powerful training tool for physicians and clinical staff by providing high-specificity dosimetric reports for radiation safety protocols.

### SSK22-07

**Assessment of the Impact of Additional Tin Filtration for Spectral Shaping on Image Quality and Dose**

Bernhard Krauss PhD: Employee, Siemens AG, Bernhard Schmidt PhD: Employee, Siemens AG, Thomas G. Flohr PhD (Presenter): Employee, Siemens AG

**PURPOSE**

To evaluate the dose efficiency of various spectra and dedicated beam filtrations for phantoms of different attenuation and size in case of non-contrast CT scans.

**METHOD AND MATERIALS**

We used a third generation dual source CT (SOMATOM Force, Siemens AG) which was equipped with a movable pre-patient beam filter to enable data acquisition with standard spectra (70 to 150kV in steps of 10kV), and shaped spectra with 0.6mm additional tin beam filtration (Sn). The standard deviation of the image pixel noise (SD) at constant radiation dose (in terms of CTDIvol) was evaluated for circular water phantoms with diameters of 10-40cm, representing different patient attenuations. For each phantom diameter, the relative image noise normalized to the standard 120kV spectrum was determined. Subjective image quality was assessed with an anthropomorphic phantom.

**RESULTS**

The relative image noise at constant radiation dose depends strongly on the phantom size and on the beam spectrum. For all phantom diameters, relative image noise was lowest for 100kV plus Sn. At a phantom diameter of 30 cm (equivalent to the mean attenuation of a thorax), image noise at constant radiation dose noise was reduced by 30% for 100kV plus Sn, compared with the standard 120 kV spectrum. For larger diameters, the 150kV plus Sn had the lowest relative image noise. In addition, the use of Sn substantially reduced beam hardening at all kV levels. In particular, subjective image quality at equal radiation dose was significantly better at 100kV plus Sn than at 80kV, which would traditionally be used for low dose CT scanning.

**CONCLUSION**

Additional tin filtration of the beam allows for a substantial reduction of image noise and therefore increase in radiation dose efficiency for non-contrast CT examinations. Image noise reduction of up to 30% and better subjective image quality at constant dose are feasible.

**CLINICAL RELEVANCE/APPLICATION**

In non-contrast CT scans, the use of addition filtration allows for a substantial reduction of patient dose without compromising image noise and subjective image quality. Further on, the additional beam filtration strongly reduces the tube output, thus providing the technical prerequisite for very low dose scans beyond previous limits.

### SSK22-08

**Measurements, Analysis & Comparison with Calculations of Peak Skin Doses during Common Interventional Radiology Fluoroscopy Procedures**

Amy Brito Delgado BSC (Presenter): Nothing to Disclose, Rajeev Suri MD: Nothing to Disclose, Michael Aaron Charlton PhD: Nothing to Disclose, Gregory Ramsey MD: Nothing to Disclose

**PURPOSE**

The purpose of this study is to measure the peak skin doses for four routinely high dose hepatic interventional procedures by using optically stimulated luminiscence dosimeters (OSL). This study compares actual measurements of the peak skin dose utilizing locally calibrated OSL dosimeters (NanoDot Landauer) with the traditional medical physics calculations of Peak Skin Dose. By doing so we aimed to assess the validity and accuracy of these calculations. Subsequently, the calculated and the actual doses were compared with the Reference Dose Levels (RDLs) set by the NCRP.

**METHOD AND MATERIALS**

Four OSLs per patient were affixed to the patient's back overlying the expected location of the liver, ensuring that they were included in the fluoroscopic field of view. These OSLs were read with a Microstar II reader, and the highest dose was recorded as the OSL peak skin dose (OSL PSD), against which other calculated measurements were compared. PSDs were calculated using the displayed Cumulative air KERMA (per the Philips Allura XPer FD 20 DICOM display). Patient thickness (a critical component of the dose calculation) was assessed by three separate methods: (1) using calipers; (2) estimated by kV and SID (from DICOM); (3) estimated by height and weight.
RESULTS
For 5 TIPS patients, mean OSL PSDs were 23.3% lower than RDLs. The OSL PSDs were higher than the calculated PSDs by 24.8% (1), 26.3% (2), and 21.7% (3). For 12 TACE patients mean OSL PSDs exceeded the reference dose levels by 75.4%. The OSL PSDs were higher than the calculated PSDs by 22.7% (1), 30.9% (2), and 27.7% (3). For 4 MAA patients mean OSL PSDs exceeded the reference dose levels by 36.7%. The OSL PSDs were higher than the calculated PSDs by 40.38% (1), 42.52% (2), and 38.91% (3).

CONCLUSION
OSL PSDs were higher than the calculated PSD using all three methods. OSL PSDs most closely correlated with the calculations using height and weight for estimating patient thickness. Discordance between the two may be at least partially explained by patient positioning closer to the X-Ray tube than what was previously assumed. The fluoroscopic output variability has to be taken into account.

CLINICAL RELEVANCE/APPLICATION
Knowledge of accurate Peak Skin Doses are relevant to deterministic effects, and can be verified using OSL dosimeters as they relate to the traditional medical physics method.

Radiation Dose Assessment of a 4D DSA Acquisition Protocol on an Interventional X-Ray Angiography C-Arm System
Mark Patrick Supanich PhD (Presenter): Research agreement, Siemens AG, Kevin Royalty MS, MBA: Employee, Siemens AG, Sebastian Schafer: Consultant, Siemens AG, Heike Zimmermann: Employee, Siemens AG, David A. Stidd MD, MS: Nothing to Disclose, Demetrius Lopes: Consultant, Stryker Corporation

PURPOSE
We evaluate the radiation dose measured in a phantom for a novel neuroendovascular angiography acquisition protocol, 4D digital subtraction angiography (DSA), along with the dose from conventional angiography protocols. The 4D DSA incorporates time dependent enhancement to a standard 3D DSA acquisition and reconstruction.

METHOD AND MATERIALS
All measurements were performed on a Siemens Artis Zee Biplane system with default protocol settings in a modified anthropomorphic head phantom using both a 0.6 cc ion chamber and optically stimulated luminescence (OSL) dosimeters. Dose measurements were made with the ion chamber at 4 peripheral locations and 1 central location in the phantom for the following acquisitions: 12 and 6 second 4D DSAs (consisting of both mask and contrast-enhanced acquisitions), 10 and 5 second 3D acquisitions and a biplane 2D DSA acquisition. OSLs were placed at the location of the eyes for a subset of the acquisitions. An average, weighted dose in phantom metric was used to compare the dose in the phantom from the acquisitions. The average weighted dose (D_w) was calculated by summing two-thirds of the average of the 4 peripheral chamber readings and one-third of the central reading.

RESULTS
The 12 and 6 second 4D DSA acquisitions resulted in D_w values of 24.5 and 13.9 mGy, respectively. D_w values of 19.8 and 10.6 mGy were measured for the 10s and 5s 3D acquisitions. The biplane acquisition gave a D_w of 0.45 mGy per acquired frame (from both planes). Average eye lens dose as measured by the OSLs were 33.8, 23.7 and 0.25/f mGy for the 12s 4D, 10s 3D, and 2D DSA acquisitions, respectively.

CONCLUSION
A typical clinical workflow at our institution for an AVM embolization is to acquire a 10s 3D acquisition and at least two 2D DSA biplane runs of about 10s each. The cumulative D_w metric for these acquisitions is 38.7 mGy. The 4D DSA acquisition may provide similar clinical information with the added ability to rotate the image to visualize the filling of the vasculature from any angle at a dose that is 2/3 that of our standard acquisition protocol.

CLINICAL RELEVANCE/APPLICATION
This single 4D acquisition may provide equivalent diagnostic information to a standard 3D acquisition and multiple 2D DSA runs. Given the unique temporal and spatial characteristics of this acquisition and reconstruction and its potential dose savings, we believe that it offers an attractive alternative to the standard clinical workflow.
Participants

Timothy J. Blackburn PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) Describe quality measures in radiological imaging. 2) List regulatory, advisory and accrediting bodies monitoring quality performance. 3) Identify the increasing role of the radiologic technologist in quality initiatives.

ABSTRACT

Improvement of image quality is an ongoing process within any radiology department. A quality assurance triangle is often used to describe the contributions from the technologist, radiologist and medical physicist. Alone each member of the quality improvement team is not as effective as the collective whole. The radiologic technologist plays a key role in this synergistic process. Preventative maintenance and equipment evaluations may be performed annually but the technologist utilizes the equipment on a daily basis. The technologist is typically the first person to visualize a change in equipment performance. It is imperative that any such changes are reported to ensure quality imaging. Regulatory and accrediting agencies are placing an increased significance on quality improvement initiatives. Improved outcomes will require more active participation of the radiologic technologist.

PS40

Wednesday Plenary Session

Plenary Sessions

1.25

Participants

Presiding

N. Reed Dunnick MD Nothing to Disclose President, Radiological Society of North America

Sub-Events

PS40B

Annual Oration in Radiation Oncology: “Error Bars” in Medical Imaging: Stealth and Treacherous

Lawrence B. Marks MD (Presenter): Institutional research support, Elekta AB Institutional research support, Siemens AB Institutional research support, Accuray Incorporated, Nina A. Mayr MD Nothing to Disclose

Imaging has markedly improved radiation therapy (RT). 3D data from CT, MRI, PET, etc enables better targeting of gross lesions, and better understanding of their position relative to surrounding tissues. Linked with sophisticated software, we can design complex RT beams, oriented from arbitrary positions, that conform to the target and reduce normal tissue exposure. The relationship between dose/volume parameters and outcome can be quantitatively assessed for tumors and normal tissues. Imaging is sustaining and enhancing RT. However, there are inherent limitations in medical images and in their application to RT. While known, these limitations are often not acknowledged or appreciated. Clinician’s failure to consider these limitations may have unintended consequences that might undermine patient care. Further, additional errors maybe introduced by the manner that we report the findings of medical images. Sensitivity: Cancer infiltrates, and (almost by definition) often ambiguous. Clinician’s requisitions and Radiologist’s reports both often lack clarity. Standardization, facilitated by HER, can improve this. Widespread use of quantitative scales (e.g. BI-RADS) to score images would be helpful. Comprehension of reports can be enhanced by attention to details such as font, color, formatting and case selection. Black font on a white background with upper and lower case lettering and standard formatting is typically optimal. We need to acknowledge and minimize the error bars associated with the application of medical images to RT.
Feasibility of Abdominal CT Scan at Sub Milli-Sievert Doses with Two Iterative Reconstruction Techniques: A Prospective Study


PURPOSE

To assess feasibility of abdominal CT scan acquired at CTDIvol of 1.4mGy (less than 1mSv) and reconstructed with filtered back projection (FBP) and two iterative reconstruction (IR) techniques.

METHOD AND MATERIALS

In an IRB approved prospective study, 25 patients (58.8 ±12.5 years, M:F 15:10) undergoing standard of care (SOC) abdominal CT on 128-MDC (Definition FLASH, Siemens) gave written informed consent for acquisition of an extra series low dose CT scan (LD, lower reference mAs). The LD images were reconstructed with SafeCT (A1,A2,A3 settings; MedicVision) and SAFIRE (S3, S4, S5). Two radiologists evaluated LD images for lesion detection and contour delineation including liver (parenchyma, margins), adrenal (nodule detection), pancreas (duct), kidney (parenchyma and stones), bowel (wall, abnormalities) and lymph nodes. All structures were evaluated on a 5-point scale in comparison to SOC-FBP (1=supra-clinical diagnostic performance, 5=unacceptable clinical diagnostic performance). Objective noise was measured in liver and spleen. Modal scores and inter-observer agreement (kappa) were calculated for subjective quality.

RESULTS

Average CTDIvol for SOC-FBP and LD were 9±5mGy (6±4mSv) and 1.4±0.2mGy (0.9±0.05mSv), respectively. Inter-observer agreement was good (κ= 0.65). LD-FBP were suboptima (14/25) or unacceptable (11/25). SafeCT showed improvement in diagnostic performance as acceptable (7/25), limited (11/25) and suboptimal (7/25) with A2 setting. Evaluation of the SAFIRE also showed improvement in diagnostic performance, as acceptable (9/25), limited (9/25) and suboptimal (7/25) with S5. Patients with limited and suboptimal diagnostic performance had significantly higher BMI (S5: 34.0 ±7.5 kg/m2 and A2: 32 ± 9.2 kg/m2) as compared to acceptable performance (S5: 22.2 ± 6 kg/m2 and A2: 23.4 ± 5.4 kg/m2) (p =0.000). In patients with BMI < 23, liver parenchyma and liver margin on LD images were not significantly different from SOC-FBP (p = 0.17-0.3). A2 (28 ± 14) and S5 (23 ± 11) settings showed similar objective noise as for the SOC-FBP abdominal CT (23 ± 7).

CONCLUSION

Both of the iterative reconstruction techniques (SafeCT and SAFIRE) improve diagnostic performance of low dose abdominal CT as opposed to FBP. However, it is crucial to select the optimal settings of the IR techniques to achieve a desirable image quality.

CLINICAL RELEVANCE/APPLICATION

It is feasible to lower the radiation dose of abdominal CT in small patients (BMI<23 kg/m2) by use of iterative reconstruction techniques.
METHOD AND MATERIALS

This IRB-approved prospective study included 41 patients (62 ± 12 years; BMI 28 ± 5 kg/m²) who underwent ultra-low dose (ULD) CT immediately after their standard-of-care (SD) CT on 256 MDCT (iCT, Philips Healthcare). Size-specific dose estimates for SD and SubmSv CT were 10 ± 3 mGy (~6 mSv) and 1.5 ± 0.4 mGy (~0.9 mSv), respectively. SD CT were reconstructed using filtered back projection (FBP), whereas ULD CT were with FBP, IMR and iDose. Four radiologists assessed subjective image quality independently, using 5-point scale (1 = supraclinical; 5 = unacceptable). Lesions (true, pseudo or missed) were detected on ULD-FBP and compared to SD-FBP ‘reference-standard’. Objective noise and CT numbers of soft tissue structures were measured. Friedman’s test, ANOVA and intraclass correlation coefficient were used for data analysis.

RESULTS

All true lesions (n=52) on SD-FBP were detected on ULD images. There were no missed or pseudo-lesions on ULD images. Mean intraclass correlation was 0.7. ULD-FBP was deemed unacceptable for subjective quality. Subjective ratings showed higher image quality for IMR for liver margins, soft-tissue structures, and retroperitoneal lymphadenopathy, compared to iDose in patients with a BMI ≤25kg/m². For patients with BMI >26kg/m², ULD IMR outperformed FBP and iDose for subjective ratings. Irrespective of patient BMI, subjective ratings for hepatic lesions, renal cysts, and colonic diverticula were significantly better with ULD IMR images. Objective noise for ULD FBP and iDose was 57-66% and 10-23% higher compared to SD-FBP, but 8-56% lower with ULD-IMR. NSD showed significantly lower noise in the frequency domain with IMR technique in all patients irrespective of BMI.

CONCLUSION

Lesion detection is similar in standard-dose and ultra-low dose abdominal MDCT (~1.5 mGy). IMR considerably improved image quality compared to iDose and FBP with mean 85% dose reduction.

CLINICAL RELEVANCE/APPLICATION

Knowledge-based Iterative Model Reconstruction technique enables substantial dose reduction in abdominal MDCT with uncompromised lesion detection compared to standard-of-care abdominal CT.

Application of kV Assist Associated with Adaptive Statistical Iterative Reconstruction (ASiR) in Upper Abdominal CT Angiography

Qingguo Wang (Presenter): Nothing to Disclose, Qimeng Quan MD, PhD: Nothing to Disclose, Zheng Wang MD: Nothing to Disclose, Han Wang MD, PhD: Nothing to Disclose

PURPOSE

To evaluate the impact of kV assist associated with adaptive statistical iterative reconstruction based on body mass index (BMI) on dose and image quality of CT angiography (CTA) for upper abdomen.

METHOD AND MATERIALS

This study included 46 patients who underwent CT angiography for upper abdomen using a 64-row CT scanner (GE Discovery CT750 HD). Patients were divided into two groups using and not using kV assist technique. Group A (n=23, BMI: 20.72±2.37) and group B (n=23, BMI: 22.31±1.82) underwent CT scan with standard tube kVp (120kVp) and low tube kVp (≤100kVp) recommended by kV assist. Data of Group B were reprocessed with a fixed blending level (50% and 0% respectively) of adaptive statistical iterative reconstruction (ASiR) for each image set. The baseline was 120 kVp, noise index (NI) =12.0±(5mm). The CT value of abdominal fat layer, aorta (AR), superior mesenteric artery (SMA) were measured. The contrast noise ratio (CNR) and signal noise ratio(SNR) of AR and SMA were calculated respectively. The CT dose index volume (CTDVol) of each patient were recorded. The dose length produce (DLP) was recorded and effective radiation dose was calculated.

RESULTS

The mean CTDVol and effective radiation dose in group B (6.06 ±2.80mGy, 2.31 ±1.06mSv) were significantly lower than group A (9.26±4.69mGy, 3.81 ±2.31mSv) (p

CONCLUSION

KV assist can recommend optimal scan protocol and approximate 39% radiation dose reduction can be reached without degradation of image quality.

CLINICAL RELEVANCE/APPLICATION

KV assist helps to improve patient care through personalized protocols and simplify scan technique optimization. There is a potential to use significantly less radiation dose without image quality loss.

Effect of Patient Centering Technique on In-Vitro Human Organ Doses for Abdominal CT


PURPOSE

SSM10-04

SSM10-03
SSM10-05
Dose Optimization of a Dual-source, Dual-energy Abdominal CT Protocol in Comparison to a Single-source CT Protocol: Assessment of Radiation Dose, Quantitative and Qualitative Image Analysis
Matthias Benz MD (Presenter): Nothing to Disclose, Caroline Zahringer: Nothing to Disclose, Achim Kircher: Nothing to Disclose, Luigia D’Errico: Nothing to Disclose, Fides Schwartz: Nothing to Disclose, Maka N. Kekelidze MD, PhD: Nothing to Disclose, Andre Euler MD: Nothing to Disclose, Georg M. Bongartz MD: Research Grant, Bayer AG Research Grant, Siemens AG, Sebastian Tobias Schindera MD: Research Grant, Siemens AG Research Grant, Ulrich GmbH & Co KG
PURPOSE
To compare the radiation dose and image quality of two dual-energy abdominal CT protocols compared with a single-energy protocol.

METHOD AND MATERIALS
75 routine abdomino-pelvic CT examinations were performed on a dual-source CT scanner (Somatom Definition Flash, Siemens). 25 CT scans were performed using the dual-energy protocol recommended by the vendor (A) 120kV-200mAs fixed-mA (CTDIvol 14mGy) (B) 120kV-125mAs (7mGy) with automatic exposure control (AEC, CareDose 4D) at three different positions (a) gantry isocenter, (b) upward off-centering, (c) downward off-centering. Scanning was repeated three times at each position. Six thinners (in liver, stomach, kidney, pancreas, colon, urinary bladder) and four MOSFET (on cornea, thyroid, testicle, breast) dosimeters were placed. Automatic dose measurements were also retrieved from dose-tracking software (Xposure, Bayer) for comparison. Statistical analysis was performed using SPSS v22.

RESULTS
There was a significant difference between the trends of organ point doses with AEC and fixed-mA at all three positions (p<0.001). Degree of fluctuation of point dose between fixed-mA and AEC protocols was statistically significant across all organs at all table positions (p<0.001). With fixed-mA protocol, there was up to 5% decreased point dose with upward off-centering and up to 6% increased point dose with downward off-centering relative to gantry isocenter. With AEC protocol, there was up to 6% decreased and increased dose with upward and downward off-centering, respectively. With both protocols, there were statistical significant differences in point dose measurements at all positions derived from dosimeters and dose tracking software (mean difference for internal organs, 5-36% for fixed-mA and 7-48% for AEC protocols; p<0.001; mean difference for surface organs, >92% for both protocols; p<0.0001). For both protocols, the highest mean difference in point doses was found for stomach and lowest for colon.

CONCLUSION
Measured absorbed organ doses in abdomino-pelvic CT vary significantly with patient centering in the gantry isocenter. Automatic dose tracking software did not capture the change in absorbed organ doses with patient off-centering.

CLINICAL RELEVANCE/APPLICATION
Patient off-centering directly affects in-vitro point dose measurements for body surface and internal organs. Urinary bladder, colon and liver point doses vary most significantly with off-centering.
By optimizing the default abdominal dual-source protocol, dual-energy CT can be acquired at no extra radiation dose compared with single-energy CT, yielding potential clinical benefits from the dual-energy data set.

### SSM10-06

**Spectral CT Imaging in Abdominal Patients: Evaluation of Whether the Virtual Nonenhanced Images from Contrast-enhanced Spectral CT Could Replace Plain Scan for Radiation Dose Reduction**

Duan Haifeng MMed (Presenter): Nothing to Disclose, Ma Guangming MMed: Nothing to Disclose, Zhang Xirong MMed: Nothing to Disclose, Yang Chuangbo MMed: Nothing to Disclose, Guo Youmin MD: Nothing to Disclose, Tian Qian MMed: Nothing to Disclose, Jia Yongjun MMed: Nothing to Disclose

**PURPOSE**

To evaluate if the virtual nonenhanced (VNE) images generated from the contrast-enhanced spectral CT images could replace the true nonenhanced (TNE) for radiation dose reduction.

**METHOD AND MATERIALS**

40 adults (28 males and 12 females, ages: 23-76 years) underwent 3-phase abdominal CT were retrospectively analyzed. Plain CT was performed with conventional 120kVp. The contrast-enhanced scans in the arterial phase (AP) and portal venous phase (VP) were performed with spectral CT imaging mode. VNE images were generated from the AP and VP spectral CT images. 2 board-certified radiologists reviewed both TNE and VNE images for image quality and lesion detection. Mean CT value, signal-noise-ratio (SNR) and contrast-noise-ratio (CNR) for liver, spleen, kidney, pancreas and muscle were measured. Lesion detection rate, subjective image rating and radiation dose were also assessed and compared.

**RESULTS**

Both the TNE and VNE images satisfied clinical needs for lesion detection and image quality. The image quality scores were 4.73±0.55, 4.25±0.90 and 4.55±0.64 for TNE, VNE at AP and VNE at PP, respectively, and there was no difference in terms of number of lesions detected (108, 100 and 104, respectively) (p>0.05). The mean and standard deviation values (in HU) of the CT number in liver, spleen, kidney, pancreas and muscle were, respectively, (53.16±6.11, 48.40±6.06, 36.84±9.41, 32.00±3.34 and 46.00±5.62) on TNE, (54.12±6.39, 50.79±5.06, 41.99±7.65, 34.34±4.62 and 48.22±5.90) on VNE at AP and (57.09±5.91, 53.80±3.98, 43.30±6.87, 34.08±3.68, and 49.16±6.19) on VNE at VP. There was slight bias for CT numbers on VNE. However, the absolute difference in CT number between VNE and TNE was less than 10HU, with the largest at VP for the pancreas. VNE at AP had better CT number fidelity with the smallest difference for the liver. CNR values in 3 groups were similar. VNE images provided statistically higher SNR. The potential dose reduction for replacing TNE with VNE was 21.4%.

**CONCLUSION**

VNE image generated from the contrast-enhanced abdominal spectral CT provides adequate image quality for lesion depiction, high CT number fidelity and 20% dose reduction compares with TNE.

**CLINICAL RELEVANCE/APPLICATION**

VNE images generated from the contrast-enhanced abdominal spectral CT may be used to replace TNE images to provide adequate image quality for lesion depiction and 20% dose reduction.

### SSM15

**Musculoskeletal Imaging (Utilization, Dose Reduction and Technical Considerations)**

**Scientific Papers**

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**SSM15-01**

**Utility of Pre and Post MR Arthrogram Imaging of the Shoulder: Effect on Patient Care**

Thomas Henry Magee MD (Presenter): Nothing to Disclose

**PURPOSE**

MR arthrogram imaging of the shoulder is considered to be more accurate in assessing shoulder pathology than
conventional MR imaging. Arthrography is a minimally invasive procedure. However, most patients prefer to have conventional MR imaging rather than MR arthrogram imaging. We report the benefit of assessing pre-arthrogram conventional MR imaging to determine whether an MR arthrogram is needed for further evaluation.

**METHOD AND MATERIALS**

One hundred consecutive conventional shoulder MR and MR arthrography exams performed on the same patients were reviewed retrospectively by consensus reading of two musculoskeletal radiologists. Both conventional MR and MR arthrogram exams were performed on each patient on the same day. Conventional MR and MR arthrogram exams were assessed for labral tears and supraspinatus tendon tears. All patients went on to arthroscopy.

**RESULTS**

Of these one hundred patients, forty-three had SLAP (superior labral anterior to posterior) tears, twenty-eight had posterior labral tears, twenty-three had anterior labral tears, and forty-seven had full thickness supraspinatus tendon tears on conventional MR exam. On MR arthrogram exam, fifty-one patients had SLAP tears, thirty-three had posterior labral tears, twenty-nine had anterior labral tears, and twenty supraspinatus tendon tears not detected on conventional MR exam. All MR arthrogram findings were seen at arthroscopy. Eighteen of the twenty-one patients with additional finding on MR arthrogram exam had normal appearing conventional MR exams.

**CONCLUSION**

Use of pre and post MR arthrogram imaging may benefit patient care. When positive findings are demonstrated on MR exam, few additional findings are demonstrated on MR arthrogram exam. These patients may not need to proceed to MR arthrogram. If the conventional MR exam is negative then additional information may be obtained by proceeding to MR arthrogram.

**CLINICAL RELEVANCE/APPLICATION**

Clinical relevance: Use of pre arthrogram imaging may allow for cancellation of a substantial number of MR arthrogram exams in patients with positive findings on conventional MR exam. If conventional MR imaging is negative proceeding to MR arthrogram may demonstrate additional findings.
**SSM15-03**

Quality-controlled Dose-reduction of Full-leg Radiography in Patients with Knee Malalignment

Jost Kloth: Nothing to Disclose, Volker Ewerbeck: Nothing to Disclose, Wolfram Stiller PhD, DIPLPHYS: Nothing to Disclose, Iris Burkholder: Nothing to Disclose, Hans-Ulrich Kauczor MD: Research Grant, Boehringer Ingelheim GmbH Research Grant, Siemens AG Research Grant, Bayer AG Speakers Bureau, Boehringer Ingelheim GmbH Speakers Bureau, Siemens AG Speakers Bureau, Novartis AG, Marc-Andre Weber MD (Presenter): Research Grant, Bayer AG Research Grant, Guerbet SA Research Grant, Bracco Group Research Grant, Siemens AG Speakers Bureau, Merck & Co, Inc

**PURPOSE**

Since digital plain radiographs of the full leg are frequently performed in children and young adults, the objective was to reduce the radiation exposure dependent on specific indications and to determine objective quality control criteria to ensure accurate assessment.

**METHOD AND MATERIALS**

Institutional review board approval and informed consent of all participants were obtained. In this prospective, randomized controlled, blinded, two-armed single-center study, 288 patients underwent plain-radiography of the full leg with standard (exposure class of SC 400) and reduced (SC 800) dose. The evaluation of the plain radiographs was conducted using the following criteria: mechanical axis, leg length, and maturation of the epiphyseal plate. Two blinded radiologists evaluated these criteria using scores ranging from 1 (definitely assessable) to 4 (not assessable). If a single criterion had been evaluated with a score of 3 or more points or more than 2 criteria with 2 points, the radiograph was scored as "not assessable". The study was designed as non-inferiority-trial with pre-specified non-inferiority margin of delta = 0.1, defining the maximum difference of clinically tolerated non-assessable radiographs with reduced dose for claiming non-inferiority. Both dose groups were randomized using a block randomization with the relation 1:1.

**RESULTS**

279 of 288 plain radiographs were rated similarly by both observers regarding the primary outcome measure (inter-observer agreement of 96.9%). Eleven (3.8%) plain radiographs were scored as not assessable. The rate of non-assessable radiographs with 33% reduced dose was not inferior to the rate of non-assessable radiographs with standard dose (p<0.0001). Also, the individual evaluation of the defined criteria was independent.

**CONCLUSION**

Full-leg plain radiography in patients with knee malalignment can be performed at 33% reduced dose without loss of relevant diagnostic information. Since all relevant parameters of orthopedic measurements could be assessed with SC 800 instead of 400, we recommend this setting as new reference parameter for standing full-leg radiography in patients with knee malalignment.

**CLINICAL RELEVANCE/APPLICATION**

Radiation dose reduction of up to 33% in full-leg radiography is possible without loss of diagnostic information. Thus, an exposure class of SC 800 is recommended in patients with knee malalignment.

**SSM15-04**

Reducing Artifacts from Metallic Implants Spectral CT Imaging after Pedicle Screw Internal Fixation

Jia Yongjun MMed (Presenter): Nothing to Disclose, Yu Yong MMed : Nothing to Disclose, Yang Chuangbo MMed : Nothing to Disclose, Chen Xiaoxia MMed : Nothing to Disclose, Zhang Xirong MMed : Nothing to Disclose

**PURPOSE**

To assess the value of spectral CT in reducing artifacts caused by metallic implants of lumbar pedicle.

**METHOD AND MATERIALS**

20 patients with metallic implants of lumbar pedicle were scanned using dual energy spectral CT protocol. 11 sets of monochromatic images from 40-140keV with the energy interval of 10keV and a set of polychromatic 140kVp image were generated. Two regions of interest (ROI) based on the most or the less pronounced artifact in the inferior vena cava were chosen and marked as ROIa and ROIb to measure CT numbers and calculate their difference CTa-CTb. The length of metallic artifacts along the pedicle screw was measured, and the subjective image quality assessed for the 12 image sets. The CT numbers of different ROIs for the 12 sets were compared with paired-samples t Test, and the CTa-CTb value, artifact length and image quality score (5 being the best) among the 12 sets were compared using LSD-t test.

**RESULTS**

The CT numbers between ROIa and ROIb of the 120 keV monochromatic images(figure 1)had no difference (42.50±3.64HU and 42.34±3.49HU), while those of other image(figure 2)sets were statistically different. Image at 120keV had the smallest CTa-CTb value (0.16±1.65HU) and was significantly different from those of other 11 groups (all P

**CONCLUSION**

Reducing Artifacts from Metallic Implants Spectral CT Imaging after Pedicle Screw Internal Fixation...
Dual energy spectral CT imaging significantly reduced the artifacts caused by metallic implants of lumbar pedicle. The optimal monochromatic image was determined at 120keV.

**CLINICAL RELEVANCE/APPLICATION**

Spectral CT provides monochromatic images at high energy to reduce metal artifacts and is useful in assessing patients with metallic implants of lumbar pedicle.

**SSM15-05**

Which One is Better for Metal Artifact Reduction in Postoperative Spine Evaluation: Dual Energy CT Images with Metal Artifact Reduction Software or Not?

Nam Bo da (Presenter): Nothing to Disclose, Hyun-Joo Kim MD: Nothing to Disclose, Jang Gyu Cha MD: Nothing to Disclose, Seong Sook Hong MD: Nothing to Disclose, Jung Hwa Hwang MD: Nothing to Disclose

**PURPOSE**

To evaluate the effectiveness of gemstone spectral imaging (GSI) dual-energy CT (DECT) with or without application of metal artifact reduction software (MARS) and compare visualization in different keV values.

**METHOD AND MATERIALS**

This clinical study was performed in 25 patients who received spine surgery with metallic devices, between October 2013 and February 2014. All patients underwent GSI-DECT for postoperative evaluation. The CTs were performed using fast kV-switching between 80 and 140 keV. The CT data were reconstructed with monochromatic energy in the range 70-140 keV with or without MARS. All images were retrospectively reviewed according to the visibility of periprosthetic regions including bone and soft tissue by a six-point scale (0-5) and the severity of beam-hardening artifacts by using a four-point scale (0-3). Also the size differences of metal devices were measured with or without MARS in the range of 110keV.

**RESULTS**

There were twelve men and thirteen women. The mean age of patients was 58.2. The range of mean visibility scale of soft tissues is 1.36-3.16 in different keV values with or without MARS and that of bones is 1.44-3.8. Also the range of mean artifacts scale is 0-1.08 in same condition (p-values:<0.0001-1.000). Using 110 kev is the least affected by artifact (mean value of artifact scale : 1.08). The bone is most effectively visualized on 110 keV and the soft tissue on 120 keV without MARS. The sizes of devices were measured 1.5mm smaller with MARS and 1.7mm larger without MARS than real sizes.

**CONCLUSION**

Monochromatic energy images with 110-120 keV without MARS most effectively reduce artifacts and improve the delineation of the prosthesis and periprosthetic regions.

**CLINICAL RELEVANCE/APPLICATION**

Monochromatic energy images with 110-120 keV without MARS using DECT enables the radiologist to evaluate the periprosthetic lesions for the patient with previous spine surgery using metallic device.

**SSM15-06**

Evaluation of a New Prototype Correction Algorithm to Reduce Metal Artifacts in Flat-detector Computed Tomography – An Ex-vivo Study

Lukas Filli MD (Presenter): Nothing to Disclose, Magda Marcon MD: Nothing to Disclose, Bernhard Georg Scholz PhD: Employee, Siemens AG, Maurizio Calcagni: Nothing to Disclose, Thomas Pfammatter MD: Nothing to Disclose, Gustav Andreisek MD: Grant, Holcim Ltd Grant, Siemens AG Speaker, Mepla Pharma AG Speaker, Guerbet SA Travel support, Guerbet SA Consultant, Otsuka Holdings Co, Ltd Travel support, Otsuka Holdings Co, Ltd Institutional Research Grant, Bayer AG Institutional Research Grant, Guerbet AG Institutional research collaboration, Siemens AG Institutional research collaboration, Koninklijke Philips NV Speaker, General Electric Company Speaker, Koninklijke Philips NV Speaker, Siemens AG, Roman Gugenberger: Nothing to Disclose

**PURPOSE**

In the past two years, flat-detector computed tomography (CT) has gained great interest for imaging small anatomic structures of the appendicular skeleton. However, flat-detector CT imaging can be significantly impaired by metal artifacts induced by orthopedic hardware. The aim of this study was to evaluate a new prototype metal artifact correction algorithm for flat-detector CT systems.

**METHOD AND MATERIALS**

IRB approval was waived. An experienced hand surgeon inserted commercially available scaphoid fixation screws into six cadaveric human specimens to fix artificially induced scaphoid fractures. Flat-detector CT was performed using an angiographic unit (Artis Zeego multiaxis system, Siemens Medical Solutions, Forchheim, Germany). From the raw data, images were reconstructed not using and using the prototype metal artifact correction algorithm. Two independent radiologists analyzed quantitatively the amount of artifacts and qualitatively the visibility of (anatomic) structures. For comparison, Wilcoxon signed-rank test were used. A p-value of < 0.05 was considered to indicate statistically significant differences. Intra-class-correlation was calculated for inter-observer agreement.

**RESULTS**
The overall intra-class-correlation was 0.85. The artifact-related noise around the scaphoid fixation screws was significantly lower on the images corrected with the prototype metal artifact reduction algorithm (p < 0.001). Qualitative analyses showed significantly fewer artifacts (p < 0.001), better visible screw contour (p < 0.001), and more clearly defined fracture lines (p < 0.01) on the corrected images.

CONCLUSION
The new algorithm for FDCT systems significantly reduces metal artifacts and improves visibility of relevant (anatomic) structures.

CLINICAL RELEVANCE/APPLICATION
The prototype metal artifact correction algorithm may facilitate intra- and postoperative follow-up imaging.
Although the pathogenesis of hypergalactosemia is variable, a major cause is portosystemic shunt. In neonates with hypergalactosemia, US should be acquired to rule out portal venous system anomalies requiring surgical intervention.

SSM20-02

Diagnostic Performance and Safety of Contrast-enhanced Voiding Urosonography with a Second-generation Ultrasound Contrast Agent for the Diagnosis of Vesicoureteral Reflux: The Experience of a Single Center in 1350 Children

Frederica Papadopoulou MD (Presenter): Nothing to Disclose, Aikaterini Ntoulia MD, PhD: Nothing to Disclose, J. Christopher Edgar PhD: Nothing to Disclose, Kassa Darge MD, PhD: Nothing to Disclose

PURPOSE

To evaluate the diagnostic performance and safety of intravesical administration of a second-generation ultrasound contrast-agent (UCA) for the diagnosis of vesicoureteral reflux (VUR) in children.

METHOD AND MATERIALS

1350 children (587 boys/763 girls, mean-age 2.6y, range 15d-17y) with 2720 pelvi-ureter-units, underwent contrast-enhanced voiding urosonography (ceVUS) to rule out VUR and/or urethral pathology. A second-generation UCA (SonoVue®, Bracco, Milan) was administered intravesically through 5-8F feeding-tube at a dose of 0.5 ml/bladder filling. Possible adverse-events were monitored during the examination and followed-up 7 days after the ceVUS by phone-calls. Urine analysis and culture were performed 3-5d before ceVUS in all children and 24-48h in any patient reported with adverse-events.

RESULTS

VUR was detected in 450/1350 (33%) patients (162 boys/288 girls). This was in 653 (24%) pelvi-ureter-units. The distribution of grade of reflux was: grade I=1, grade II=276, grade III=266, grade IV=100, grade V=10). The urethra was imaged in 1300 (96%) children and it was of normal morphology in all but one case of an infant with posterior urethral valves. Mean duration of examination was 14±7 min, including urethral imaging. Minor adverse-events were reported in 45 (3.3%) children. These included dysuria (n=40), abdominal pain (n=1), increased frequency of micturition (n=1), vomiting (n=1), perineal irritation (n=1), and urinary-tract-infection after ceVUS (n=1). The onset of adverse-events was sub-acute in 92% and delayed in 8% of cases and the symptoms were self-limited non-requiring hospitalization.

CONCLUSION

Ce-VUS with intravesical administration of a second-generation UCA was capable to detect and grade VUR and urethral morphology. There were no serious adverse-events with intravesical use of SonoVue®. Only a few minor adverse-events were reported during ceVUS most likely due to catheterization process.

CLINICAL RELEVANCE/APPLICATION

Ce-VUS with intravesical administration of a second-generation UCA is a safe and highly sensitive imaging modality for vesicoureteral reflux detection and urethral imaging in children.

SSM20-03

Clinical Significance of Incidentally Discovered Renal Cysts in Pediatric Patients

Teerasak Phewplung MD (Presenter): Nothing to Disclose, Avram Zohar Traum: Nothing to Disclose, Ruth Lim MD: Consultant, Alexion Pharmaceuticals, Inc Officer, New England PET Imaging System, Michael Stanley Gee MD, PhD: Nothing to Disclose

PURPOSE

To determine the clinical significance of incidentally discovered renal cysts in pediatric patients and identify imaging predictors of polycystic kidney disease (PKD).

METHOD AND MATERIALS

An IRB-approved, HIPAA-compliant retrospective search of radiology reports from 1989-2013 was performed to identify patients < 18 years old with an imaging exam identifying at least one renal cyst as well as a follow up renal imaging exam for cyst evaluation and/or subsequent clinical evidence of PKD. Electronic medical records and imaging were reviewed. Cysts with clear solid mass components were excluded.

RESULTS

84 pediatric patients with renal cysts were identified (46 females and 38 males; mean age, 9.48 years), including 76 patients with incidentally discovered cysts and 8 patients with cysts identified from screening for family history of PKD. US (81%) was the most common imaging modality for initial cyst identification. Among the incidentally discovered cyst group, 7.9% (6/76) were found to have PKD compared with 100% (8/8) patients with cysts plus a positive family history of PKD. Multiple cysts or bilateral cysts were imaging features associated with a significantly higher (P < 0.01, Fisher's Exact Test) incidence of PKD, both for the entire study population (12/14 and 11/14, respectively) and the incidentally discovered cyst group (5/5 and 5/5, respectively). Renal cyst size or complexity was not significantly associated with PKD. 74 patients had a followup renal imaging exam (mean time 36.8 months from initial exam), and an increase in cyst size on the followup study was associated with a higher incidence of PKD (3/5 vs 1/69; P < 0.05). No malignancies were identified in the study population, although one case was found to be a multicellular cystic nephroma on follow up imaging and surgery.

CONCLUSION
Incidentally discovered renal cysts in pediatric patients are associated with a small but nonzero risk of PKD. Among cyst characteristics, bilaterality, multiplicity, and increased size on followup imaging were associated with significant elevation in PKD risk.

**CLINICAL RELEVANCE/APPLICATION**

 Pediatric patients with bilateral, multiple, or enlarging renal cysts should be carefully screened for clinical/family evidence of PKD.

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**SSM20-04**

**Open-label, Multicenter, Pharmacokinetic and Safety Study in Children Below 2 Years of Age undergoing a Contrast-enhanced MRI with an Intravenous Injection of a Single Standard Dose of Gadobutrol**


**PURPOSE**

To evaluate the pharmacokinetics (PK) of gadobutrol at the standard dose of 0.1 mmol/kg body weight in plasma of pediatric subjects aged <2 years as a primary objective. Safety, tolerability and efficacy are secondary endpoints.

**METHOD AND MATERIALS**

Subjects <2 years of age (term newborn infants to 23 months of age) with normal renal function, undergoing routine MRI of any body region following administration of 0.1 mmol/kg gadobutrol. Plasma PK was analyzed using a population-based PK approach. Qualitative imaging efficacy variables were assessed by investigators.

**RESULTS**

47 subjects 0.2-23 months of age were enrolled, 44 subjects were evaluated for safety and efficacy, 43 subjects were eligible for PK evaluation including 9 term newborns to <2 months of age. The gadobutrol PK profile in pediatric subjects <2 years, including term newborns, was similar to the PK profile in older children and adults. The most common non-serious AEs unrelated to gadobutrol were cough, nasopharyngitis, rhinitis, pyrexia and vomiting. In one subject, vomiting was reported as a mild AE related to gadobutrol. Serious AEs were unrelated to gadobutrol and were reported in 3/44 subjects (6.8%). The evaluation of gadobutrol-enhanced images provided improved diagnosis, increased confidence in diagnosis, and contributed to subject clinical management.

**CONCLUSION**

The PK of gadobutrol is similar to that observed in adults and children >2 years of age and supports the effectiveness of gadobutrol in this pediatric population <2 years. Body weight dosing of gadobutrol at a standard dose (0.1 mmol/kg) is therefore adequate for the pediatric population <2 years (including term newborns). Gadobutrol has shown a good safety profile and was well tolerated in children below 2 years of age.

**CLINICAL RELEVANCE/APPLICATION**

First clinical study to evaluate PK, safety and tolerability of gadobutrol in pediatric population <2 years of age, including term newborns.

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**SSM20-05**

**Safety Profiles of Gadolinium-based Contrast Agents in Pre-Weaning Juvenile Rats Differ according to the Risk of Gadolinium Release**


**PURPOSE**

The need for contrast-enhanced MRI is widely recognized in neonates and infants with immature renal function. The aim of this study was to compare the tolerance of two marketed gadolinium-based contrast agents (GBCAs) of different thermodynamic stabilities in rats with immature renal function.

**METHOD AND MATERIALS**

Firstly, changes in renal function (plasma creatinine and cystatin C levels) and kidney histopathology were identified in juvenile rats (from post-natal day [PND] 4 to PND 30). Subsequently, juvenile rats received 5 intravenous injections (between PND 4 and 18) of gadoteric acid (macrocylic and ionic GBCA, Dotarem®), gadodiamide (linear and non-ionic GBCA, Omniscan®) or saline. Daily clinical examinations were performed. At sacrifice (PND 25), the Gd concentration was measured in the tissues (plasma, skin, liver, bone, heart). Histopathologic and relaxometry studies were also performed. The study was blinded.

**RESULTS**

Biological and statistical data were obtained from each group from PND 25. The histological evidence of...
Biochemical characterization showed maturation of renal function from PND 21. The histopathology evidenced maturation of the renal structure from PND 11. In the comparative study, gadodiamide induced mortality (4 out of 14 rats from PND 10), heterogeneous hair growth (from PND 8), alopecia (from PND 18) and hyperpigmentation of the dorsal skin. Two gadodiamide-treated rats had severe epidermal and dermal lesions (from PND 21). No abnormal sign was detected following the administration of gadoteric acid or saline. Higher tissue Gd concentrations were found in gadodiamide-treated rats compared to those found in gadoteric acid-treated rats. Relaxometry studies showed dissociation of gadodiamide in the skin and liver, with the presence of dissociated and soluble Gd3+. The dissociated Gd3+ concentration in plasma was < limit of detection for gadoteric acid and 0.12 ± 0.06 µmol/L in the gadodiamide group, corresponding to 61 ± 32% of the total Gd concentration.

CONCLUSION

Repeated administration of gadoteric acid was well tolerated in juvenile rats with immature renal function. Conversely, gadodiamide induced significant morbi-mortality, skin abnormalities, and more Gd retention (at least in part, in the dissociated and soluble form) in the skin and liver of juvenile rats.

CLINICAL RELEVANCE/APPLICATION

Neonates and infants with immature renal function could be at greater risk from the higher systemic toxicity induced by the linear GBCA gadodiamide vs. the macrocyclic GBCA gadoteric acid.

SSM20-06 Teleradiology through iPad May Positively Affects the Quality of Health Care in a Paediatric Children Hospital

Floriana Zennaro : Nothing to Disclose, Sergio Demarini : Nothing to Disclose, Gabriele Cont MD : Nothing to Disclose, Pierpaolo Guastalla MD : Nothing to Disclose, Francesca Vittoria : Nothing to Disclose, Manuel Belgrano (Presenter): Nothing to Disclose, Luca Odoni MD : Nothing to Disclose, Valentina dicarlo : Nothing to Disclose, Daniela Dibello : Nothing to Disclose, Giuliano Barbo : Nothing to Disclose, Antonella Steinbock : Nothing to Disclose, Daniele Grosso PhD : Nothing to Disclose, Marzia Lazerini PhD : Nothing to Disclose

PURPOSE

This was a prospective controlled study with the objective of evaluating the impact of teleradiology using iPad in two different emergency contexts in a tertiary care children hospital: an orthopaedic on-call service, and a newborn intensive care department with complex pathologies and young doctors supported by more senior staff.

METHOD AND MATERIALS

Radiologic examinations were sent anonymously to an iPad using an encrypted system, Aycan OsiriX Pro, to allow remote consultation from specialists on call. Orthopaedics and senior neonatologists received two sets of information subsequently - the written report from the radiologist (Phase I) and the X-ray image through the iPad (Phase II). Their decisions on case management during Phase 1 and Phase 2 were recorded blindly in a database and compared. The primary outcome of the study was any relevant change in decisions on case management. Other outcomes included: time needed for decision-making; technical difficulties; quality of the images and diagnostic confidence using iPad compared to a dedicated PACS (on a Likert scale from 1 to 10).

RESULTS

During the period September 2013 to December 2013, 111 radiological exams were sent with teleradiology using an iPad. In 21 (36%) of neonatology cases and in 16 (38%) of orthopaedic cases the approach on patient treatment was changed by the availability of the X-ray image via the iPad (p=0.01; p< 0.01). Technical difficulties occurred in 15/111 (13.5%) of cases, and were mainly due to a slow down in the internet line. Average time for decision making including time for image transmission was 11.3 minutes (range 3 to 42). There was not a statistically significant difference in quality of images neither in diagnostic confidence using iPad compared to the dedicated PACS.

CONCLUSION

Teleradiology through Aycan OsirIX PRO and iPad should be considered as a mean for providing the X-ray image for remote consultation to orthopaedics and neonatologists on call, for its potential of optimising case-management. Future studies could further explore the impact of teleradiology on cost of health care.

CLINICAL RELEVANCE/APPLICATION

This study supports the use of teleradiology through Aycan OsirIX PRO and iPad for allowing remote consultation to orthopaedics and neonatologist on call, for its potential of optimising case-management.
Monte Carlo Based Organ Dose and Effective Dose Coefficients for Common Computed Tomography Torso Examinations on the ICRP 89 Reference Phantoms that Account for Tube Current Modulation

Elliott James Stepusin BS (Presenter): Nothing to Disclose, Daniel J. Long PhD: Nothing to Disclose, Wesley E. Bolch PhD: Nothing to Disclose

PURPOSE

In recent years, states and health care organizations have required the reporting of computed tomography (CT) exposure reports for all patients. These requirements coupled with national attention on radiation exposure have created a need for accurate and accessible computed tomography dosimetry. This work shows a computational method for creating exam-specific organ dose and effective dose coefficients that can account for tube current modulation (TCM).

METHOD AND MATERIALS

Organ dose estimates (mGy per average-effective-mAs) were calculated for the ICRP 89 reference computational phantoms for common CT torso exams using a Monte Carlo transport code modeling a Toshiba 64-slice scanner. Local attenuation values within each phantom were the basis for accounting for TCM during the organ dose calculations. Effective dose coefficients (µSv•mGy-1•cm-1) were calculated using CTDIvol and exam length data with each phantom's weighted organ doses. These values were compared to effective dose estimates derived from physical measurements (using OSL dosimeters) inside anthropomorphic phantoms representing the ICRP 89 reference 10-year-old hermaphrodite, 15-year-old female, and adult male phantoms.

RESULTS

Effective dose was estimated using an adult reference effective dose coefficient and the scanner reported DLP, using an adult reference effective dose coefficient and the SSD weighted scanner reported DLP, using the phantom-specific effective dose coefficient and the scanner reported DLP, and using the phantom-specific organ dose values and the image-based average effective mAs. The average magnitude in percent error when comparing measured and calculated effective dose across all phantoms and energies for the four methods were 23.0 ± 15.8%, 14.6 ± 7.1%, 12.5 ± 4.4%, and 6.4 ± 3.7%, respectively.

CONCLUSION

This work shows the potential for predicting patient organ dose and effective dose values that account for TCM. Image based average effective mAs shows increased accuracy over scanner reported DLP as a means for patient-specific organ dosimetry.

CLINICAL RELEVANCE/APPLICATION

This work can be expanded to provide patient-specific organ dose and effective dose estimates that can account for tube current modulation across a variety of scanner makes and models.

Dose Optimization in CT of the Paranasal Sinus

Johannes M. Voigt (Presenter): Nothing to Disclose, Christian Guldner: Nothing to Disclose, Stefan Schaefer: Nothing to Disclose, Martin Fiebich: Nothing to Disclose

CONCLUSION

This study shows that consequent optimization following the ALARA principle is able to lower patient dose dramatically (vendor standard settings CTDIvol = 9.0 mGy vs. optimized settings CTDIvol = 0.93 mGy) but are also time consuming and deliver individual results. But we could also show that there is saturation in reachable image quality (CTDIvol ~ 3.5 mGy). Facing this fact a dose reduction of about factor 3 compared to the standard settings is possible without causing difficulties in diagnostics.

Background

Dose optimization in CT following ALARA-principle is an iterative and time-consuming procedure. This study points out the patient dose reduction caused by optimizing image acquisition and reconstruction parameters.

Evaluation

Paranasal sinus CT scans (Siemens Definition Dual Source) of three cadaveric heads had been performed under variation of kVp (80kVp, 100kVp and 120kVp), mAs (starting from 7mAs up to a value where a CTDIvol less or equal 9.0mGy, which is the vendors standard setting, was reached) and reconstruction kernel (H47, H50, H60 and H70). All series were anonymized, randomized and evaluated by three different observers. Diagnostic
Quality of selected anatomic structures was graded from 1: excellent; 2: adequate; 3: difficult; 4: not visible). For each reconstruction kernel the mean value of all scores was displayed as function of indicated CTDIvol. The minimum CTDIvol at which diagnostic image quality is reached was defined to be grater less or equal 2.0.

**Discussion**

The subjective image quality differs significantly between the convolution kernels. For an acceptable image quality the lowest CTDIvol = 0.93 mGy was delivered by H47 kernel, 100 kVp and 10 mAs. The next lowest CTDIvol = 1.52 mGy was achieved with the H50 kernel, 120 kVp and 10 mAs. H60 and H70 kernels could be excluded because of too bad image quality (minimum CTDIvol = 4.0 mGy). The application of the H47 and H50 kernels showed saturation in image quality (mean score ~ 1.4). Hence, the best image quality (1.0) could not be reached. The saturation for the H47 and H50 kernels lies at a CTDIvol of about 3.5 mGy for all skulls and all observers.

**Demonstration of Dose or Noise Reduction, as well as Radiographic Spatial Resolution, on a Commercial CT Scanner**

Shuai Leng PhD (Presenter): Nothing to Disclose, Katrina Nesta Glazebrook MBChB: Nothing to Disclose, John Ignatius Lane MD: Nothing to Disclose, Kristin D. Zhao MA: Nothing to Disclose, Ryan Breighner: Nothing to Disclose, Thomas J. Vrieze RT: Nothing to Disclose, Cynthia H. McCollough PhD: Research Grant, Siemens AG

**PURPOSE**

To assess noise, dose and spatial resolution of an ultra-high resolution (UHR) scan mode on a CT scanner equipped with an x-ray tube capable of small focal spot sizes at high mA, and to compare resolution to computed radiography (CR).

**METHOD AND MATERIALS**

A human skull, a cadaver wrist, and a spatial resolution target were scanned on a 192-slice scanner (scanner A, Siemens Force) equipped with dynamic focal spot control, IR, and z-axis deconvolution, which allow a 0.4 mm image to be reconstructed from 0.6 mm detectors. All objects were scanned with 120 kV and 64x0.6mm collimation. The skull was scanned with 380 effective mAs (CTDIvol=45 mGy), the wrist with 200 effective mAs (CTDIvol=12 mGy), and the resolution target with 400 effective mAs (CTDIvol=24 mGy). For comparison, objects were scanned on a 128-slice scanner (scanner B, Siemens Flash) with 16x0.6 mm collimation and matched CTDIvol values. Images were reconstructed at the minimal thickness available (0.4 mm on scanner A and 0.5 mm on scanner B) with IR and high resolution kernels. For the skull and wrist images, sharpness was qualitatively evaluated by sub-specialty radiologists and image noise measured over uniform anatomic regions. CR images were acquired of the wrist and bar pattern, the limiting spatial resolution determined from the bar pattern, and all results compared between the two scanners and CR.

**RESULTS**

Images from scanner A were considerably sharper than those from scanner B. Two skull intralabyrinthine bone fragments were detected on scanner A that were not visible on scanner B. Trabecular bones of the wrist were better delineated on scanner A relative to scanner B, and were similar in appearance to CR. Image noise values on scanners A and B were 159 and 255 HU, respectively, for the head phantom, representing a 38% reduction in noise, and 71 and 73 HU for the wrist, respectively, representing a 8% reduction in noise. Limiting spatial resolution was 22 lp/cm for scanner A, 18 lp/cm for scanner B, and 22-25 lp/cm for CR.

**CONCLUSION**

Scanner A provided better spatial resolution and lower image noise compared to scanner B, and similar spatial resolution as CR. For the same CT image noise level, dose could be reduced on scanner A.

**CLINICAL RELEVANCE/APPLICATION**

Spatial resolution comparable to CR can be achieved on CT systems, at noise or dose levels lower than previously available CT systems.

**Radiation Dose Reduction to the Eye Lens in Head CT by Use of a New Organ-based Dose Modulation: A Phantom Study for Evaluation of the Dose Distribution and the off-center Effect**

Shohei Kudomi (Presenter): Nothing to Disclose, Yasuyuki Ueda PhD : Nothing to Disclose, Katsuhiko Ueda BS : Nothing to Disclose, Katsuhiro Ichikawa PhD : Nothing to Disclose

**PURPOSE**

The purpose of this study was to evaluate the performance of the radiation dose reduction to the eye lens and the resulting image quality produced using a new organ-based dose modulation (ODM).

**METHOD AND MATERIALS**

The study was performed on a 64-slice CT scanner (optima660, GE Healthcare). First, we scanned a 16 cm CT
dose index phantom to investigate the dose distribution for a completely symmetric phantom by using a 10-cm ion chamber (Unfors Xi, RaySafe) for obtaining dose angular profile which indicate the fundamental performance of the new ODM. Second, we scanned an anthropomorphic head phantom (Kyoto Kagaku) to evaluate the radiation dose to the eye lens and the intracranial area by using radio-photoluminescence dose dosimeters (Dose Ace FDG 1000, Chiyoda Technol) with and without ODM in the head scanning protocols. The phantom was placed at the center of the gantry and at off-center positions in the y-direction at 50, 25, -50, and -75 mm. The quantitative image quality evaluation was performed by measuring the standard deviations (SD) in regions of interest placed on the eyes and the center of a selected intracranial area.

RESULTS

The dose profile indicated that the ODM reduced 16-19% of the dose to the midline of the anterior surface. Also, the dose angular profile showed no increased-dose region. Dose measurement results for the anthropomorphic head phantom placed at the center of the gantry showed 18% dose reduction to the eye lens and it corresponded to the dose profile. Dose to the intracranial area was reduced 5.5%. SD increases when using ODM of the eye and the intracranial area were 0.12 and 0.24, respectively. The increase of SD could be negligible in clinical settings. Furthermore, no artifacts were introduced by using the new ODM. The effects of ODM showed little position dependence and reduced the eye dose by 17.7% on average.

CONCLUSION

Our results show that the new ODM is a robust dose reduction technique in cases where patients are placed at off-center positions without significantly degrading image quality.

CLINICAL RELEVANCE/APPLICATION

Our results showed the performance of a new ODM. Because there is no increased-current region, the new ODM is safe for use when patients are placed at off-center position.

SSM21-05

A Comparison of Methods for Reporting Water Equivalent Diameter (WED) to Predict Organ Dose from Tube Current Modulated (TCM) Thoracic and Abdominal CT Examinations

Maryam Bostani PhD (Presenter): Research support, Siemens AG, Kyle McMillan: Institutional research agreement, Siemens AG Research support, Siemens AG, Christopher H. Cagnon PhD : Nothing to Disclose, John J. Demarco PhD : Nothing to Disclose, Michael F. McNitt-Gray PhD : Institutional research agreement, Siemens AG Research support, Siemens AG

PURPOSE

The purpose of this study was to compare several methods of reporting water equivalent diameter (WED) in terms of the ability to correlate with radiation doses to organs from thoracic and abdominal CT exams performed with TCM.

METHOD AND MATERIALS

101 thoracic and 82 abdomen/pelvis scans from clinically indicated CT exams were collected from a 64 slice MDCT (Sensation 64, Siemens Healthcare) with Institutional Review Board approval. All scans were performed with TCM (CareDose4D) and image data were used to create voxelized patient models. Relevant organs for each scan type were segmented and used as tally regions in Monte Carlo simulations for calculating organ doses. Raw projection data were also collected to obtain tube current information for simulating TCM. WED was calculated per image for each patient and reported as: (a) an average WED over the entire length of the exam (WEDglobal), (b) an average WED over the region containing the organ of interest (WEDregional) (e.g. chest excluding shoulder for lung dose) and (c) a single value calculated from only the image in the middle of the scan length (WEDmiddle). Organ doses were normalized by CTDIvol-Regional, CTDIvol weighted by the average effective mAs over the anatomical region of interest, to reflect regional variation of tube current in TCM scans. To compare the different WED metrics, each was correlated with normalized organ doses using linear regression analysis.

RESULTS

For lung dose, WEDregional and WEDmiddle had stronger correlations with normalized organ dose than WEDglobal : 0.70, 0.70 and 0.51, respectively. For abdominal organs, all three methods had similar correlations (0.85 and above) with normalized organ dose.

CONCLUSION

Due to homogeneity in the abdominal region, all three methods of reporting WED resulted in similar and reasonable correlations with normalized organ dose. On the contrary, due to thoracic heterogeneous characteristics, WEDglobal performed poorly (R2=0.51) compared to the other two methods. While both WEDregional and WEDmiddle performed similarly in chest, it is worth noting that WEDmiddle can be less reliable due to scan length variations among thoracic CT examinations.

CLINICAL RELEVANCE/APPLICATION

WEDregional and WEDmiddle were shown to be robust metrics of patient size and can be used, with a regional measure of scanner output, to estimate organ doses from thoracic and abd/pel CT exams.

SSM21-06

Clinical Experience with Dosimetric Measurement of CT Beam Width

David M. Gauntt PhD (Presenter): Co-owner, X-Ray Imaging Innovations, LLC Stockholder, General Electric Company, Rani Al-Senan PhD : Nothing to Disclose

CONCLUSION
It is practical to use dosimetric techniques to routinely measure CT beam widths. However, care must be taken to ensure that the beam width is measured not only for each collimation width, but for each collimation/focal spot combination.

**Background**

The ACR now requires annual measurement of the CT beam width for all clinically used collimations in accredited scanners. We have developed a technique for purely dosimetric measurement of CT beam width. We are presenting the results of one year of clinical experience with this technique.

**Evaluation**

We determine the dose-length product (DLP) per millimeter of beam width on a given scanner by measuring the DLP in air for a wide beam, both with and without a 10mm tungsten mask on the pencil chamber. The difference between these measurements is the DLP that would be measured for a beam exactly 10mm wide. The beam width for all collimations on this scanner can be determined by measuring the DLP in air, and dividing by the DLP per millimeter. Over the past year this measurement technique has been used on three GE CT scanners and seven Philips scanners at our facility. We have compared the results to film width measurements on some scanners, and compared the results of each scanner to other scanners of the same model, and to the ACR recommendations and vendor specifications.

**Discussion**

The excess beam width varies significantly from one scanner model to another, but remains fairly consistent between scanners of the same model. For example, the Philips Brilliance 40 scanners consistently fail to meet the recommendations of the ACR for beam width, while the Philips Brilliance 64 scanners consistently meet the recommendations. The CT beam width of General Electric scanners varies between low tube currents and high tube currents. This appears to be due to the use of two different focal spot sizes; at high currents the large focal spot is used, and so the collimation width is increased to keep the beam penumbra from overlapping the detector. In all cases, the beam width was within specifications set by the manufacturers, which are consistently looser than the ACR recommendations.

**SSM24**

**Vascular/Interventional (IR: Radiation Safety)**

**Scientific Papers**

AMA PRA Category 1 Credits™: 1.00
ARRT Category A+ Credit: 1.00
Wed, Dec 3 3:00 PM - 4:00 PM Location: E352

**Participants**

Moderator
Sarah Beth White MD : Consultant, Guerbet SA Consultant, Vascular Solutions, Inc Research support, Seimens AG
Moderator
Robert G. Dixon MD : Nothing to Disclose

**Sub-Events**

**SSM24-01 Should the Informed Consent Process for Interventional Radiology Procedures include the Risk of Radiation Exposure: The Interventional Radiology Patient Perspective**

Rebecca Zener MD (Presenter): Nothing to Disclose, Daniele Patrice Wiseman MD, FRCPC: Nothing to Disclose, Amol Mujoomdar MD : Speaker, Cook Group Incorporated Speaker, Coviden AG

**PURPOSE**

Radiation exposure is inherent in interventional radiology procedures. A potential exposure of 1 mSv has been suggested as a cutoff for provision of risk information, as it corresponds to a 1 in 10000 cancer risk. Informed consent requires disclosure of rare yet potentially significant risks, yet patient knowledge of these risks is lacking. The purpose of this study is to explore patient perception of cancer-related risk exposure and whether inclusion of radiation risks in the informed consent is warranted.

**METHOD AND MATERIALS**

A multiple-choice survey was prospectively administered to 26 adult interventional radiology patients at a tertiary care centre (patient mean age = 61.4 years; 64% female, 36% male). 58% of patients had previously undergone an IR procedure. Statistical analysis with Fisher Exact test (p<0.05) was performed.

**RESULTS**

Most patients want to be informed if there is a radiation-related 3% increased cancer risk over 5 years (89%), or if the associated risk is 1 in 1000 (79%) or 1 in 10000 (63%). While half of the cohort considers 3% small, 35% want to further discuss the risks and alternate options, and 15% would only proceed if it were a life-saving procedure. Only 62% of patients were aware they were going to be exposed to radiation, irrespective of previous IR history. Most patients believe radiation consent should be routine for IR procedures (85%) and include radiation-related cancer risks (88%). A majority (62%) believes that the referring physician and the interventional radiologist are responsible for informing patients, and verbal radiation consent is sufficient. No significant difference was present between groups based on previous IR history (p>0.05).

**CONCLUSION**
Patient awareness of radiation exposure is suboptimal. Based on this survey, a majority of patients want to discuss cancer-related radiation risks in order to make informed decisions. Interventional radiologists should consider including radiation consent in the informed consent for procedures with anticipated doses above 1 mSv.

**CLINICAL RELEVANCE/APPLICATION**

Interventional radiology patients want to discuss cancer-related radiation risks in order to make informed decisions, and interventional radiologists should consider including radiation consent in the informed consent for procedures with anticipated doses above 1 mSv.

**SSM24-02  Substantial X-ray Dose Reduction in Intra-arterial Therapy for Liver Cancer: A New Angiographic Imaging Technology**

Ruediger Egbert Schernthaner MD (Presenter): Nothing to Disclose, MingDe Lin PhD : Employee, Koninklijke Philips NV, Julius Shapiro MD : Nothing to Disclose, Rafael Duran MD : Nothing to Disclose, Boris Gorodetski : Nothing to Disclose, Jean-Francois H. Geschwind MD : Consultant, BTG International Ltd Consultant, Bayer AG Consultant, Guerbet SA Consultant, Nordion, Inc Grant, BTG International Ltd Grant, F. Hoffmann-La Roche Ltd Grant, Bayer AG Grant, Koninklijke Philips NV Grant, Nordion, Inc Grant, ContextVision AB Grant, CeloNova BioSciences, Inc Founder, PreScience Labs, LLC CEO, PreScience Labs, LLC

**PURPOSE**

To investigate potential x-ray dose reduction, without compromising image quality, of fluoroscopy and digital subtraction angiography (DSA) of a new angiographic imaging system in patients undergoing intra-arterial therapy (IAT) for liver cancer.

**METHOD AND MATERIALS**

In this ongoing prospective trial, 25 consecutive patients underwent hepatic IAT on a new imaging platform (AlluraClarity, Philips Healthcare, Best, The Netherlands). For detailed dose-logging, a radiation dose structured reporting (RDSR) system was setup that included air kerma (AK) and dose area product (DAP) for each run (fluoroscopy, digital subtraction angiography (DSA), single shot exposure and Cone Beam CT). The dose from this imaging platform was compared to 25 other consecutive patients who underwent similar procedures on the predecessor imaging platform (Allura, Philips Healthcare). DSA image quality for both imaging platforms was assessed on a five-rank-scale in a randomized and blinded fashion. Paired t-test was performed for BMI and fluoroscopy time, Mann-Whitney U test was used to compare image quality and dose of each type of run between the two imaging platforms.

**RESULTS**

Both patient cohorts showed no difference with regard to BMI (p=0.87) and fluoroscopy time (p=0.98). The new system resulted in a significant dose reduction in total AK and DAP of 58% and 60% compared to the old platform (median of 0.47 Gy and 143.41 Gy*cm² vs. 1.12 Gy and 359.59 Gy*cm², respectively (p<0.01)). Specifically, DAP for fluoroscopy and DSA decreased significantly by 60% and 77%, respectively (p<0.01). During the procedures, no relevant problems due to image quality were reported. Likewise, the blinded evaluation of image quality revealed no differences between the new and the old imaging platforms (mean score 1.16 vs 1.24; p=0.48).

**CONCLUSION**

The new imaging platform allowed for significant x-ray radiation dose reduction in patients undergoing IAT for liver cancer without compromising image quality.

**CLINICAL RELEVANCE/APPLICATION**

During the last decade, the use of hepatic IAT has steadily increased. Thus, the reduction of x-ray dose for both patients and clinicians is essential for radiation protection.

**SSM24-03  Occupational Radiation Exposure during Endovascular Aortic Repair**

Anna Margaretha Sailer MD, MBA (Presenter): Nothing to Disclose, Geert Willem H. Schurink MD, PhD : Nothing to Disclose, Martine Bol : Nothing to Disclose, Michiel W. De Haan MD, PhD : Nothing to Disclose, Wim Van Zwam MD : Nothing to Disclose, Joachim Ernst Wildberger MD, PhD : Nothing to Disclose, Cecile R. L. Jeukens PhD : Nothing to Disclose

**PURPOSE**

Aim of this study was to evaluate the radiation exposure to operating room personnel and its determinants during endovascular aortic repair procedures.

**METHOD AND MATERIALS**

Occupational radiation exposure was prospectively evaluated during forty-four endovascular aortic repair procedures. Procedures were performed between 07/2013 and 01/2014 on our hybrid operating room (Allura Xper with ClarityIQ, Philips Medical Systems, Best, The Netherlands). Twenty-two infrarenal aortic procedures (EVAR), eleven thoracic aortic procedures (TEVAR) and eleven fenestrated or branched aortic procedures (FEVAR) were included. Real-time over-lead dosimeters attached to the left breast pocket (DoseAware, Philips)
were used to measure personal doses for operators (first (FS) and second (SS) surgeon), radiology technicians (RT), scrub nurses (SN), and anesthesiologists (AN). Besides protective apron and thyroid collar, no radiation shielding was used. Procedural dose area product (DAP), iodinated contrast volume, fluoroscopy time, patients' weight and angulation of the C-arm were documented. Results were analyzed using regression coefficient and Kruskal-Wallis test.

RESULTS

Average procedural over-lead dose and standard deviation was 0.17 ±0.21 mSv for the FS, 0.042 ±0.045 mSv for the SS, 0.019 ±0.042 mSv for the RT, 0.017 ±0.031 mSv for the SN and 0.006 ±0.007 mSv for the AN. FS doses were significantly higher during FEVAR compared to EVAR and TEVAR (mean FS dose during FEVAR: 0.34 ±0.28 mSv, EVAR: 0.11 ±0.21 mSv, TEVAR: 0.06 ±0.05 mSv; p= 0.003). There was a significant correlation between the dose of the FS and procedural DAP (R= 0.686, p< 0.001) and iodinated contrast volume (R= 0.672, p< 0.001) and a weak correlation with fluoroscopy time (R= 0.396, p= 0.049). Usage of left anterior C-arm projections >60 degrees was associated with significantly higher FS doses (p= 0.02). For EVAR procedures, a significant correlation between FS dose and patient's weight was found (R= 0.561, p= 0.024). SS dose and AN dose were significantly correlated with the FS dose (R= 0.668, p= 0.003 and R= 0.838, p< 0.001).

CONCLUSION

Strong predictors for high personal doses are procedural DAP, iodinated contrast volume, patient weight and left lateral C-arm angulation >60 degrees.

CLINICAL RELEVANCE/APPLICATION

The first surgeon received an average procedural dose of 0.17 mSv, which was on average a factor four higher than the second surgeon who received the second highest average dose.

SSM24-04 Patient Radiation Dose Reduction during Transarterial Chemoembolization Using a Novel X-ray Fluoroscopy Imaging Acquisition and Processing Platform


PURPOSE

To compare the patient radiation doses during transarterial chemoembolization (TACE) for hepatocellular carcinoma (HCC) performed with Philips Allura Xper versus Philips Allura Clarity imaging platforms.

METHOD AND MATERIALS

Total fluoroscopy time, cumulative air kerma, and cumulative dose area product data were retrospectively collected for 129 TACE procedures performed to treat HCC. The first 85 procedures were performed in an interventional radiology suite equipped with the Philips Allura Xper imaging platform. The subsequent 44 procedures were performed in the same suite following installation of the Philips Allura Clarity imaging platform. To confirm similarities in patient size, the anteroposterior diameter of the upper abdomen at the level of the portal vein bifurcation was assessed on CT or MRI for all patients in both groups. Mean values were compared using two-tailed t-tests.

RESULTS

Following installation of the Philips Allura Clarity platform, a 43.7% reduction in mean cumulative dose area product (3033.2 versus 1707.2 mGy-cm2, p < 0.0001) and a 29.5% reduction in mean cumulative air kerma (1445.4 versus 1019.3 mGy, p < 0.001) were found in comparison to procedures performed with the Philips Allura Xper platform. Total fluoroscopy time was 20% greater (1679.3 versus 2015.7 seconds, p < .05) for procedures performed with Allura Clarity compared with Allura Xper. Patient size was similar between the two groups (Anteroposterior thickness of 268.4 versus 265.9 mm, p = .70).

CONCLUSION

The Philips Allura Clarity imaging acquisition and processing platform significantly reduces patient radiation dose when compared to Philips Allura Xper in patients of comparable size undergoing TACE for HCC treatment. Dose reduction was achieved despite an increase in average fluoroscopy time. Further studies are necessary to determine whether the increase in fluoroscopy time is related to image quality or bias in patient selection to treat more difficult cases in the new low-dose room.

CLINICAL RELEVANCE/APPLICATION

TACE procedures can be successfully performed at patient radiation doses significantly below current norms.

SSM24-05 Radiation Dose Reduction in Two Common Interventional Procedures Following Allura ClarityIQ Upgrade

Jaydev Kardam Dave PhD, MS (Presenter): Nothing to Disclose, David J. Eschelman MD : Consultant, Guerbet SA, Carin F. Gonsalves MD : Nothing to Disclose, Eric Laurence Gingold PhD : Nothing to Disclose
PURPOSE
To investigate radiation dose reduction post installation of an image processing upgrade for an interventional x-ray system.

METHOD AND MATERIALS
Philips Allura ClarityIQ upgrade provides automatic motion artifact reduction, temporal and spatial noise reduction, and contrast enhancement, allowing a reduction in radiation dose. Air kerma rate (AKR) measurements were made with acrylic simulating 9-27cm patient thickness for 19"-6" magnification modes and 2 dose modes, before and after ClarityIQ upgrade. Dose indicators (cumulative air kerma (CAK) and dose area product (DAP)) for two types of interventional procedures (chemo/immuno-embolization and routine catheter check/change) were analyzed for patients who were treated, before and after ClarityIQ upgrade, as part of their standard of care. Two experienced interventional radiologists (blinded to dose values) selected cases matching in complexity, number of digital acquisitions and fluoroscopy time, and provided a subjective evaluation of image quality.

RESULTS
For acrylic measurements, AKR was reduced by 25-77% after ClarityIQ upgrade. Thirteen chemo/immuno-embolization patients and 20 patients with routine catheter procedures were identified. There were no statistical differences in fluoroscopy time or digital acquisitions between the procedures for each patient. The mean reduction for the embolization procedures in CAK was 347 mGy (95% CI: 251-442 mGy; P<0.001) and in DAP was 159137 mGy.cm² (95% CI: 126282-191992 mGy.cm²; P<0.001) when ClarityIQ was used; resulting in a 37-79% reduction in CAK and 51-84% in DAP on a per patient basis. For routine catheter procedures, the mean reduction in CAK was 33 mGy (95% CI: 17-48 mGy; P<0.001) and in DAP was 10795 mGy.cm² (95% CI: 6653-14937 mGy.cm²; P<0.001) when ClarityIQ was used, resulting in a reduction of 27-81% in CAK and 14-89% in DAP on a per patient basis. Subjective evaluation of patient images revealed no loss in image quality when ClarityIQ was used.

CONCLUSION
ClarityIQ upgrade resulted in a 14-84% reduction in radiation dose indicators to patients for the procedures considered in this study, consistent with expectations based on phantom measurements, without loss in perceived image quality.

CLINICAL RELEVANCE/APPLICATION
An image processing upgrade for an interventional radiology system allows reduced radiation dose in both fluoroscopy and digital acquisition modes, reducing potential risks to both patients and staff.

PURPOSE
We aimed to investigate the feasibility of reducing the radiation exposure dose in diagnostic cerebral DSA examinations while preserving the overall image quality for diagnostic purposes.

METHOD AND MATERIALS
Following IRB approval, a prospective study was performed on patients undergoing diagnostic cerebral DSA using biplane flat detector angiography unit. DSA images were acquired using a predefined manufacturer standard program by selecting detector dose of 3.6 μGy/frame (mean typical tube voltage (TTV): 80.6 kVP, mean tube current (TC): 230.6 mA, using focal spot size (FS) of 0.6 and inherent filtration) and reduced detector dose of 1.2 μGy/frame (mean TTV: 73.6 kVP, mean TC: 153.5 mA, using FS of 0.3 with additional 0.1/0.2 copper filter) dose protocols for each patient. Using identical contrast agent, contrast injection rate, and fluoroscopy time, randomly selected internal carotid or vertebral arteries and their contralateral equivalent arteries were injected to obtain standard radiation dose and low radiation dose AP and lateral DSA images, respectively. Image quality assessment was performed independently by two neurointerventionalists. A 5 point scale was used for qualitative evaluation of arterial, capillary, and venous phases of DSA images respectively. The total score was defined as the overall diagnostic value. Paired sample t-test and Wilcoxon’s signed rank test compared the kerma-area product (KAP) and scores assigned to image quality parameters, respectively. P value <0.05 was considered statistically significant.

RESULTS
Twenty-three DSA image series were obtained from nine patients (8M/1F, mean age: 65.9) undergoing diagnostic DSA. Mean KAP was significantly reduced by 60% or 2.5 fold (1408.90 ± 419.18 μGy/m² versus 557.08 ± 214.56 μGy/m², P<0.0001). No significant difference was observed between image quality scores assigned by the observers while assessing arterial (observer 1(O1)): P=1.0; observer 2 (O2): P=0.24), capillary (O1: P=0.54; O2: P=0.3), venous (O1: P=0.14; O2: P=0.7) phases, and overall diagnostic value (O1: P=0.34; O2: P=0.8).

CONCLUSION
Radiation exposure dose can be reduced significantly without compromising image quality for diagnostic

SSM24-06
Significant Acquisition Dose Reduction Maintains Diagnostic Quality of Biplane Cerebral Digital Subtraction Angiography
Amir Reza Honarmand MD (Presenter): Nothing to Disclose, Ali Shaibani MD : Nothing to Disclose, Michael Charles Hurley MBCh : Nothing to Disclose, Christina Louise Sammet PhD : Nothing to Disclose, Sameer A. Ansari MD, PhD : Shareholder, RaPID Medical Technologies, LLC

PURPOSE
We aimed to investigate the feasibility of reducing the radiation exposure dose in diagnostic cerebral DSA examinations while preserving the overall image quality for diagnostic purposes.

METHOD AND MATERIALS
Following IRB approval, a prospective study was performed on patients undergoing diagnostic cerebral DSA using biplane flat detector angiography unit. DSA images were acquired using a predefined manufacturer standard program by selecting detector dose of 3.6 μGy/frame (mean typical tube voltage (TTV): 80.6 kVP, mean tube current (TC): 230.6 mA, using focal spot size (FS) of 0.6 and inherent filtration) and reduced detector dose of 1.2 μGy/frame (mean TTV: 73.6 kVP, mean TC: 153.5 mA, using FS of 0.3 with additional 0.1/0.2 copper filter) dose protocols for each patient. Using identical contrast agent, contrast injection rate, and fluoroscopy time, randomly selected internal carotid or vertebral arteries and their contralateral equivalent arteries were injected to obtain standard radiation dose and low radiation dose AP and lateral DSA images, respectively. Image quality assessment was performed independently by two neurointerventionalists. A 5 point scale was used for qualitative evaluation of arterial, capillary, and venous phases of DSA images respectively. The total score was defined as the overall diagnostic value. Paired sample t-test and Wilcoxon’s signed rank test compared the kerma-area product (KAP) and scores assigned to image quality parameters, respectively. P value <0.05 was considered statistically significant.

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CONCLUSION
Radiation exposure dose can be reduced significantly without compromising image quality for diagnostic
purposes in cerebral DSA studies.

**CLINICAL RELEVANCE/APPLICATION**

Significant reduction of radiation exposure dose is feasible while maintaining image quality for diagnostic and therapeutic purposes in intracranial endovascular procedures.

**MSRT51**

**ASRT@RSNA 2014: Contrast Media - Adverse Reactions and Management**

*Multisession Courses*

SQ SQ

AMA PRA Category 1 Credits™: 1.00
ARRT Category A+ Credit: 1.00
**Thu, Dec 4 8:00 AM - 9:00 AM  Location: N230AB**

**Participants**

Gauravi Kaur Sabharwal MD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

1) Know incidence of reactions to contrast media. 2) Understand risk factors that may increase incidence of an adverse reaction to contrast media. 3) Understand pathogenesis of the reactions to contrast media. 4) Know classification of the different contrast reactions. 5) Review management of the different types of contrast reactions. 6) Known about premedications for prevention of contrast reactions.

**ABSTRACT**

Contrast media is the most commonly used pharmacological agent in Radiology. It is associated with multiple adverse reactions. While these reactions are relatively uncommon, some of them can be severe and even fatal. This makes it important to be able to recognize these reactions and appropriately manage them. Patients with known prior reactions to contrast media and with other risk factors should be premedicated prior to the administration of this agent.

**RC629**

**HCC Diagnosis Using LI-RADS (An Interactive Session)**

*Refresher/Informatics*

SQ MR GL

AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credits: 1.50
**Thu, Dec 4 8:30 AM - 10:00 AM  Location: E450B**

**Sub-Events**

**RC629A**

**MRI Features**

Benjamin M. Yeh MD (Presenter): Research Grant, General Electric Company Consultant, General Electric Company

**LEARNING OBJECTIVES**

1) Review underlying clinical scenarios that predispose patients to develop hepatocellular carcinoma. 2) Understand typical imaging appearances at MR imaging such that when characteristic imaging features are seen in the correct clinical setting, we can be certain that the diagnosis is hepatocellular carcinoma. 3) Describe variant features and secondary signs that are either suggestive of, or argue against, the diagnosis of hepatocellular carcinoma.

**RC629B**

**LI-RADS Principles**

Cynthia Sawhney Santillan MD (Presenter): Consultant, Robarts Clinical Trials Research Group

**LEARNING OBJECTIVES**

1) To familiarize radiologists with the current version of the Liver Imaging Reporting and Data System (LI-RADS) and its associated lexicon, atlas, and reporting recommendations. 2) To review the categories for liver observations in LI-RADS. 3) To demonstrate how to access and use the algorithm for determining the category of a liver observation.

**URL's**

http://www.acr.org/Quality-Safety/Resources/LIRADS
LI-RADS Cases
Reena Chhetna Jha MD (Presenter): Consultant, CeloNova BioSciences, Inc

LEARNING OBJECTIVES
1) We will review LI-RADS categories, and criteria for classification by means of clinical cases. 2) Classic and atypical cases will be presented with audience participation to reinforce the LI-RADS algorithm.

Reporting LI-RADS Results
Mustafa Rifaat Bashir MD (Presenter): Research support, Siemens AG Research support, Bayer AG

LEARNING OBJECTIVES
1) To discuss standards for liver lesion reporting, using the Liver Imaging Reporting and Data System (LI-RADS).

ABSTRACT
The Liver Imaging Reporting and Data System (LI-RADS) includes a reporting template for contrast-enhanced CT and MRI, and minimum reporting standards. This talk will discuss those reporting standards and provide tips for clear and concise reporting.

Current and Next Generation Health IT Tools to Enable Radiation Exposure Reduction - A Practical Guide

Refresher/Informatics

RC653

ABSTRACT
The acceptance of the risks associated with radiation is conditional on the benefits to be gained from the use of radiation. The risks must be restricted and protected against by the application of radiation safety standards. A significant part of the challenge of patient dose management in CT arises from the fact that over-exposure in CT is frequently not detected. In contrast to film based radiography where overexposure results in a dark image, increasing dose in CT and in other digital imaging techniques results in images with: (1) less noise (improved visual appearance) and (2) fewer streak artifacts, (3) although not necessarily with greater diagnostic information. Image quality in CT often exceeds the clinical requirements for diagnosis. It is critical to have a thorough understanding of the basics of radiation dose in CT before we explore the multiple issues around opportunities to reduce these dose parameters. Furthermore, it is also critical to comprehend the role of newer technologies, innovations and developments that are rapidly taking place to address radiation dose reduction in CT - both on the vendor as well as on the private and academic communities. A through and comprehensive understanding of the quality and patient safety issues around this is also critical to making sound decisions around imaging on multiple levels. Different organs have different sensitivities to radiation. Tissue Weighted Factor, WT takes into account the risk to the person exposed to radiation that is not uniform over the entire body. As an example, if 1 mSv is received only by the lungs, this results in an effective dose to that person of 0.12 mSv. This means that 1 mSv received by the lungs poses approximately the same risk as 0.12 mSv to the entire body. Fundamentals such as these will be presented in easily digestible chunks in the refresher course. Also covered will be Protocol Optimization, Scanner Interfacing, Data Connectivity and Interoperability.

Participants
Moderator

LEARNING OBJECTIVES
1) Number of CT scans is increasing annually. 2) Wider adoption/ availability of CT scanners. 3) Indications for CT use are increasing (without possible consideration for risks). 4) Rapid increase in number of protocols: Varying equipment leading to protocol variance. A thorough outline of patient-centric approach to dose optimization will be covered, as well as data mining dose data for improved quality, safety and outcomes.

Sub-Events
Before the Scan: Optimizing Dose before the Patient Is On the Table

LEARNING OBJECTIVES
1) Number of CT scans is increasing annually, 2) Wider adoption/ availability of CT scanners. 3) Indications for
CT use are increasing (without possible consideration for risks). 4) Rapid increase in number of protocols: Varying equipment leading to protocol variance. A thorough outline of patient-centric approach to dose optimization will be covered, as well as data mining dose data for improved quality, safety and outcomes.

ABSTRACT
The acceptance of the risks associated with radiation is conditional on the benefits to be gained from the use of radiation. The risks must be restricted and protected against by the application of radiation safety standards. A significant part of the challenge of patient dose management in CT arises from the fact that over-exposure in CT is frequently not detected. In contrast to film based radiography where overexposure results in a dark image, increasing dose in CT and in other digital imaging techniques results in images with: (1) less noise (improved visual appearance) and (2) fewer streak artifacts, (3) although not necessarily with greater diagnostic information. Image quality in CT often exceeds the clinical requirements for diagnosis. It is critical to have a thorough understanding of the basics of radiation dose in CT before we explore the multiple issues around opportunities to reduce these dose parameters. Furthermore, it is also critical to comprehend the role of newer technologies, innovations and developments that are rapidly taking place to address radiation dose reduction in CT - both on the vendor as well as on the private and academic communities. A thorough and comprehensive understanding of the quality and patient safety issues around this is also critical to making sound decisions around imaging on multiple levels. Different organs have different sensitivities to radiation. Tissue Weighted Factor, WT takes into account the risk to the person exposed to radiation that is not uniform over the entire body. As an example, if 1 mSv is received only by the lungs, this results in an effective dose to that person of 0.12 mSv. This means that 1 mSv received by the lungs poses approximately the same risk as 0.12 mSv to the entire body. Fundamentals such as these will be presented in easily digestible chunks in the refresher course. Also covered will be Protocol Optimization, Scanner Interfacing, Data Connectivity and Interoperability.

RC653B
During the Scan: Patient-Centric Imaging
Tessa S. Cook MD, PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
View learning objectives under main course title.

RC653C
After the Scan: Data-Mining Dose Data for Improved Quality, Safety, and Outcomes
Jenifer Willmann Siegelman MD, MPH (Presenter): Consultant, Bayer AG

LEARNING OBJECTIVES
View learning objectives under main course title.

VSPD51
Pediatric Series: Minimizing Sedation in Pediatric MRI

Series Courses
SQ PD MR SQ PD MR

AMA PRA Category 1 Credits ™: 3.25
ARRT Category A+ Credits: 3.50
Thu, Dec 4 8:30 AM - 12:00 PM Location: S102D

Participants
Moderator
Donald P. Frush MD: Nothing to Disclose
Moderator
Aliya Qayyum MBBS: Spouse, Employee, Imorigon Medical
Moderator
Rajesh Krishnamurthy MD: Research support, Koninklijke Philips NV Travel support, Koninklijke Philips NV

LEARNING OBJECTIVES
1) Highlight techniques for minimizing the need for sedation and intubation in pediatric MRI. 2) Provide abbreviated protocols for common indications in pediatric chest, abdominal, and neuroimaging that can be performed without sedation, or with brief conscious sedation. 3) Provide an overview of state of the art MR techniques for free-breathing acquisition in the pediatric chest, abdomen and pelvis. 4) Share experience with imaging aids that are available to enable unsedated imaging in children.

Sub-Events
VSPD51-01
Minimizing Sedation in Pediatric Neuroimaging
A. James Barkovich MD (Presenter): Research Consultant, General Electric Company

LEARNING OBJECTIVES
View learning objectives under main course title.
ABSTRACT

There are several keys to minimizing sedation in Pediatric Neuroimaging. Most important are targeting the study to obtaining the specific answer requested by the referring clinician, and obtaining the data as efficiently as possible by using sequences that will answer the question in the shortest time. The second is that the strategy changes depending upon the age of the patient: neonates most often can be scanned without sedation; a relatively short scan can be performed on infants by the ‘feed and swaddle’ method, and older children (6 years and above) can very frequently be studied if training and/or movies (to give them focus) are used. For neonates requiring a relatively short scan (is injury present or not), a useful technique is to feed the baby immediately before the procedure and then wrap them in a vacuum bean bag or wrap (swaddle) them in a blanket. Reducing noise by use of ear muffs, insulating the inner bore of the magnet, parallel imaging or ultra-short TE sequences can help, as can retrospective motion correction. Infants can also be scanned using feed and swaddle; it helps to do the scan during their nap time, if possible, and to take them to a quiet room with a parent so that they are asleep when placed in the MRI scanner. Use quiet sequences early in the study, saving the noiser ones for the end. Again, use of parallel imaging or ultra-short TE sequences helps to reduce noise. It is very difficult to image children between ages of 1 and 6 years without sedation. The goal is to scan efficiently. For older children, a training session before the scan to reduce anxiety is useful. Use of a system that allows the child to watch a movie of their own choice is very helpful as well.

Optimized Neuroimaging in Infants Using a Prototype Dedicated16-Channel Neonatal Head Coil

Maura E. Ryan MD : Nothing to Disclose, Jie Deng PhD (Presenter): Nothing to Disclose, Jingyi Xie PhD : Employee, Siemens AG, Shrivram Giri PhD : Employee, Siemens AG, Abraham Padua : Employee, Siemens AG

PURPOSE

Magnetic resonance imaging (MRI) is highly sensitive for evaluating intracranial pathology in newborns and infants, and can detect abnormalities not evident by ultrasound or computed tomography. However, MRI in this population can be technically difficult due to small size, motion and limited parenchymal contrast. Many infants are currently imaged with larger than necessary commercially available head coils or smaller coils designed for other uses. A dedicated phased array head coil with a smaller field of view (FOV) would allow for improved image quality through greater signal to noise, increased field uniformity, and shorter imaging times.

METHOD AND MATERIALS

A prototype 16 channel phased-array head coil (Siemens AG, Healthcare sector, Erlangen, Germany) was designed for neonatal and infant neuroimaging. Three of the posterior arrays overlapped with the standard spine array and could be used for cervical spine imaging as well. Imaging was performed on either a 1.5T or 3T (MAGNETOM Aera/Skyra, Siemens AG, Healthcare Sector, Erlangen, Germany) MRI scanner following the clinical practice. All pathology evident on comparable sequences on the commercial head coil was also detectable on the research coil. Some findings and anatomic evaluation were qualitatively better appreciated on research coil images (figure). The smaller FOV and higher SNR enabled higher resolution imaging without increasing imaging time.

CONCLUSION

In comparison to commercially available standard head or small part coils, the use of a dedicated neonatal head coil enables small FOV imaging with better SNR to improve diagnostic quality and decrease imaging time in infant patients.

CLINICAL RELEVANCE/APPLICATION

Neuroimaging in infants is technically difficult and the use of a dedicated neonatal head coil can improve diagnostic confidence.

Efficacy of Ultrasound Elastography in Detecting Active Myositis in Children. Can It Replace MRI?

Netanel Berko MD (Presenter): Nothing to Disclose, Arielle Hay MD : Nothing to Disclose, Yonit Sterba MD : Nothing to Disclose, Dawn Wahezi MD, MS : Nothing to Disclose, Hillel Cohen PhD, MPH : Nothing to Disclose, Terry L. Levin MD : Nothing to Disclose

PURPOSE

To compare strain ultrasound elastography with magnetic resonance imaging (MRI) of the quadriceps muscles for the detection of active myositis in children with inflammatory myositis.

METHOD AND MATERIALS

Multisequence noncontrast MRI of the quadriceps muscles was compared to grey scale and cine ultrasound elastography in eighteen children with inflammatory myositis (15 juvenile dermatomyositis, 2 systemic lupus erythematosus, 1 polymyositis; 15 girls, 3 boys; mean age 10.5 +/- 4.7 years; range 3-19 years). Active myositis was defined on MRI as increased muscle signal on T2-weighted images. Elastography images were evaluated based on a previously published numerical scale of muscle elastography in normal children by two radiologists in consensus, blinded to the patients’ MRI findings. Disease duration, serum muscle enzyme levels,
and clinical assessment of active versus inactive disease were correlated with imaging findings. Statistical analyses were performed with Fisher’s exact test, Spearman’s correlation and Mann-Whitney U test as appropriate. P-value < 0.05 indicated statistical significance.

RESULTS

Quadriceps muscle signal was normal on T1-weighted images in all subjects. T2 hyperintensity was present in 9 subjects; of these, elastography was abnormal in two (decreased elasticity) and normal in seven. Twelve patients had normal MRI; elastography was normal in 7 and abnormal in 5 (decreased elasticity). MRI signal hyperintensity and increased muscle echogenicity correlated strongly with clinically active disease (p = 0.035 and p = 0.015, respectively). However, there was no significant correlation between elastography and clinically active disease (p = 0.144), or elastography and MRI (p = 0.64). A nonsignificant trend toward decreased muscle elasticity in children with longer disease duration was present (p = 0.265).

CONCLUSION

Ultrasound elastography does not accurately detect active myositis in children with inflammatory myositis.

CLINICAL RELEVANCE/APPLICATION

Ultrasound elastography does not replace MRI as the gold standard for detecting active myositis in children.

VSPD51-04

Minimizing Sedation and Radiation in Pediatric Cardiovascular Imaging

Rajesh Krishnamurthy MD (Presenter): Research support, Koninklijke Philips NV Travel support, Koninklijke Philips NV

LEARNING OBJECTIVES

View learning objectives under main course title.

VSPD51-05

Clinical Validation of Using Free Breathing Navigator Echo and Triggered Cardiac Gated Delayed Myocardial Enhancement MR Imaging in Sedated Infants

Ryutaro Matsuura MSc (Presenter): Nothing to Disclose, Yuichi Omura: Nothing to Disclose, Noriaki Akagi BS: Toshihide Itoh is employee of Siemens Healthcare, Sachiko Goto PhD: Nothing to Disclose, Yoshiharu Azuma PhD: Nothing to Disclose, Shuhei Sato MD, PhD: Nothing to Disclose, Seiji Tahara: Nothing to Disclose

PURPOSE

The delayed myocardial enhancement on MRI is preferred sequence in order to evaluate state of myocardium. However it is not yet performed to a sedated infant with congenital heart disease who has high heart rate and small myocardium since it requires suspended respiration. In this study, we validate a navigator echo triggered sequence that drives the magnetization before cardiac gated inversion recovery-T1 turbo field echo (IR-T1TFE) acquisition in the sedated free breathing pediatric population.

METHOD AND MATERIALS

Cardiac MRI was performed with clinical trial on 24 sedated infants with single ventricle (female: 11, male: 13) ranged in age from 0 to 5 years (mean age: 2.3 years). The Gadoteridol (0.4ml/kg) was injected into them as the contrast media. Imaging (Figure 1) was performed on a 1.5T MR scanner (Phillips Achieva 1.5T). To compare image quality, we calculated the signal to noise ratio (SNR) and contrast to noise ratio (CNR) of two image groups which were obtained by using respiratory triggering with navigator echo and without navigator echo. Wilcoxon signed rank test was performed to compare the significant difference among two image groups at each result. Furthermore, all the images were visually assessed by 2 radiologists who are specialist of cardiac MRI.

RESULTS

The SNR with navigator echo was higher than without navigator echo. The CNR shows no significant difference. The visual assessment scores with navigator echo were consistently better than without navigator echo. The high spatial resolution and low noise for a clinical image is required in order to diagnose, especially in the case of an infant cardiac MRI. In this study, free breathing navigator echo has the advantage which decreases the motion artifact caused by respiration. It brings the improvement of the noise and spatial resolution for a clinical image.

CONCLUSION

Cardiac gated IR-T1FFE sequence for free breathing and using navigator echo triggered respiration allows clinically diagnostic images in sedated infants with improvement of the noise and spatial resolution for a clinical image.

CLINICAL RELEVANCE/APPLICATION
PURPOSE

Feasibility of performing pediatric computed tomography angiography (CTA) at 70 kVp. Low kVp scanning has the potential to allow for reduced patient dose and improved diagnostic quality by virtue of increased contrast enhancement in the vessel. This phantom study aims to systematically evaluate the potential for dose reduction/improved image quality at 70 kVp in pediatric CTA exams for various patient sizes, contrast concentrations and reconstruction algorithms.

METHOD AND MATERIALS

Four anthropomorphic pediatric thoracic phantoms were used (nominal ages: newborn, 1, 5, 10 years). Phantoms contained holes (1 cm diam) in the center and periphery. Rods with iodine concentrations of 0, 3, 6, 8, 10, 15 mg/cc (HU = 0, 85, 170, 230, 290, 450) were manufactured. Contrast rods were inserted into the phantom center between the lung regions. Each phantom size and concentration was scanned with the clinical CTA protocol (80 kVp) as well as 70, 100, 120 and 140 kVp (Siemens Biograph mCT). The mA was fixed and adjusted at each kVP to match the CTDI obtained with the 80 kVp clinical protocol. Images were reconstructed using FBP and Iterative Reconstruction (SAFIRE). For each image set, the Contrast to Noise Ratio (CNR) was averaged over five images. Using the method of calculating the Relative Dose Factor (RDF) to optimize CNR with noise constraint (Yu, 2009), the RDF was calculated for each image set.

RESULTS

At conservative levels of noise contrast (< 1.25), there were conditions that resulted in an increased Relative Dose Factor at 70 kVp. The RDF showed dependence on the noise constraint parameter and iodine concentration. The RDF was lower at 70 kVp in all phantom sizes for noise contraints > 1.5.

CONCLUSION

These results challenge conventional wisdom that 'if 80 kVp is good, 70 kVp is better'. It is important to understand the factors that potentially allow for reduced dose at 70 kVp. It is accepted that the noise constraint should be lower for children, as children have smaller organs and less adipose tissue. Under such conditions, 70 kVp scanning provides benefits in a very limited set of clinical situations that depend on patient size and contrast concentration.

CLINICAL RELEVANCE/APPLICATION

We present the specific conditions where 70 kVp is appropriate and warn against scenarios where scanning at 70 kVp is inappropriate. This information is valuable to end-users designing pediatric CTA protocols on scanners with 70 kVp capability.

Pediatric Thoracic CT Angiography at 70 kVp: A Phantom Study to Investigate Effects on Diagnostic Quality and Patient Radiation Dose

Robert MacDougall MSc (Presenter): Nothing to Disclose, Edward Yungjae Lee MD, MPH: Nothing to Disclose, Patricia Louise Kleinman: Nothing to Disclose

A Prospective Clinical Trial for the Determination of Minimum Radiation Dose in Pediatric Cardiovascular CTA

Aya Kino MD (Presenter): Nothing to Disclose, Jia Wang PhD: Nothing to Disclose, Beverley Mansfield Newman MD, MBBCh: Nothing to Disclose, Frandics Pak Chan MD, PhD: Nothing to Disclose

PURPOSE

We conduct a prospective clinical trial to evaluate the minimum radiation dose, in terms of equivalent dose (ED) and organ doses (OD), that can produce diagnostic studies in children who underwent cardiac gated (CG) and high-pitch (HP) CTA. We also examine dose savings from image based iterative reconstruction (SAFIRE).

METHOD AND MATERIALS

With IRB approval, pediatric patients referred for thoracic CTA were recruited for a split dose protocol in which a high-dose and a low-dose scans were performed in tandem under a single contrast bolus and breath-hold on a Siemens Flash scanner. The tube current in each scan was adjusted such that the combined CTDI was the same as a routine scan. The percentage of dose split was randomized. Other scan controls, such as CG versus HP mode, tube-voltage, contrast protocol, and scan range were chosen according to the clinical needs. Images were reconstructed at 0.6 mm thickness without SAFIRE and with SAFIRE at all levels (1-5). Two cardiac radiologists categorized these images as diagnostic without SAFIRE, diagnostic with SAFIRE, and non-diagnostic at any SAFIRE level. ED was estimated from patient size and DLP. OD was calculated with an image-based Monte Carlo simulation.

RESULTS

31 patients (age 8 weeks to 7 years old, weight 4 to 74kg) were recruited, producing 62 scans. 48 scans are HP and 14 scans are CG. 44 scans are first-pass contrast bolus studies while 18 scans are delay-phase blood pool studies. For first-pass HP, the average ED is 0.78 mSv, and the OD for lung, bone, liver, and breast are 1.33, 3.13, 1.25, and 1.19 mGy. Dose values for delay-phase HP are similar. For CG, the average ED is 2.41 mSv, and the OD are 7.93, 16.65, 8.53, and 10.2 mGy, respectively. Among diagnostic studies without SAFIRE, the average ED are 0.8-0.9 mSv for first-pass HP, 1.8-2.0 mSv for delay-phase HP and 3.1-4.0 mSv for CG. Nondiagnostic first-pass HP at ED as low as 0.12 mSv are convertable to diagnostic studies with SAFIRE. The highest ED values for unrecoverable studies are 0.55 mSv for delay-phase HP and 0.93 mSv for CG.
CONCLUSION
With currently technology, we can expect a minimum dose of 0.1 to 0.5 mSv for non-gated CTA and 1 mSv for retrospectively gated CTA. In routine practice, actual dose will be higher, depending on patient size and protocol.

CLINICAL RELEVANCE/APPLICATION
Pediatric cardiovascular CTA of the chest should aim for less than 1 mSv for non-gated studies and 3 mSv for gated studies.

VSPD51-08 Minimizing Sedation in Pediatric Abdominal and Musculoskeletal MRI
Shreyas Shreenivas Vasanawala MD, PhD (Presenter): Research collaboration, General Electric Company Stockholder, Morpheus Imaging, Inc

LEARNING OBJECTIVES
View learning objectives under main course title.

ABSTRACT
Sedation for pediatric MRI has multiple disadvantages. It confers risk of adverse events for what is an otherwise non-invasive procedure. Additionally, sedation contributes to cost, makes exam scheduling complex, and leads to inefficient imaging utilization. This presentation will present some approaches to reduce the incidence, duration, and depth of sedation for pediatric abdominal and musculoskeletal indications. An overview of child developmental approaches that reduce the incidence of sedation will be given. Then an approach for compact protocols to minimize duration of sedation will be presented. This will be followed by discussion of methods of managing respiratory motion artifacts without periods of suspended respiration, thus reducing depth of anesthesia.

Rapid MRI in Pediatric Appendicitis without Contrast or Sedation
Ryne Didier MD (Presenter): Nothing to Disclose, Bryan Robert Foster MD: Nothing to Disclose, Fergus V. Coakley MD: Nothing to Disclose, Sanjay Krishnaswami MD: Nothing to Disclose, David Spiro MD: Nothing to Disclose, Katharine Lee Hopkins MD: Nothing to Disclose

PURPOSE
Historically, limited availability, high cost and motion artifact prevented the use of MRI in the evaluation of acute pediatric appendicitis. However, recent developments have allowed utilization even in non-sedated pediatric patients. Concerns regarding ionizing radiation employed by CT have encouraged use of alternative imaging modalities. The purpose of this study was to evaluate the performance characteristics of MRI without contrast or sedation in the diagnosis of pediatric appendicitis.

METHOD AND MATERIALS
Patients <18 years of age with suspected acute appendicitis who underwent clinically indicated US were eligible. No contrast or sedation was administered. After a scout sequence was performed, five sequences were obtained including diffusion weighted imaging (DWI). The duration from the scout sequence to the presence of images in PACS (overestimate of total scan time) was recorded. Previously established diagnostic criteria for acute appendicitis were used to interpret the MR by two blinded reviewers. In the case of discrepancy, the official report issued by a non-bindered radiologist was used as a ‘tie-breaker.’ Results were compared with US results, clinical outcome, operative reports, and surgical pathology results, if available.

RESULTS
To date, 36 examinations have been performed, 21 females (58%) and 15 males (42%). Mean age was 11.05 years (3.16-17.9). The examination was tolerated by all participants. The two reviewers demonstrated good agreement (kappa = 0.667). 5 discrepancies were identified; two were resolved by the ‘tie-breaker.’ The average time from scout to PACS was 27.44 minutes. The protocol yielded 92.9% sensitivity and 90.9% specificity for acute appendicitis with a diagnostic accuracy of 89.7%. Two false positives and one false negative were reported which were concordant with the ultrasound results. Additionally, these three studies produced discrepant results among the two reviewers. All three patients ultimately underwent appendectomy based on clinical data.

CONCLUSION
Preliminary implementation of a rapid MRI protocol without contrast or sedation in the evaluation of pediatric appendicitis yielded promising performance characteristics. Although further investigation is warranted, this imaging protocol may provide clinicians with an alternative to CT.

CLINICAL RELEVANCE/APPLICATION
Rapid MRI without contrast or sedation is a promising alternative to CT in the evaluation of pediatric appendicitis.
VSPD51-10
Utility of a Motion Correction with Radial Blades (BLADE) MRI Sequence over Standard Single Shot Turbo Spin Echo (HASTE) T2 Weighted Imaging in Pediatric Abdominal MRI

Unni K. Udayasankar MD, FRCR (Presenter): Nothing to Disclose, Chakradhar Reddy Thupili MD: Nothing to Disclose, Jennifer Bullen MSc: Nothing to Disclose, Neel Vachhani MD: Nothing to Disclose, Ellen Park MD, MS: Nothing to Disclose

PURPOSE
BLADE MRI sequence has been used to mitigate the motion artifact seen with T2-weighted imaging of the abdomen, and thus could improve the accuracy of abdominal MRI in children. The objective of the study is to evaluate the effectiveness of the BLADE MRI in comparison to the standard HASTE sequence in pediatric abdominal MRI.

METHOD AND MATERIALS
Fifty eight consecutive pediatric subjects (M:F 25:33) who underwent MRI study of the abdomen were included in this IRB approved study. Axial T2 BLADE and HASTE T2 FSE sequences were acquired on a 1.5T scanner as part of the protocol. Two radiologists retrospectively evaluated the images for image quality, presence of artifacts (respiratory, bowel motion, and other), sharpness of liver margins, conspicuity and sharpness of the portal triad, and lesion conspicuity. For quantitative comparison, ROIs were placed in similar areas of fat and air to measure signal intensity and noise levels. Wilcoxon signed rank test (qualitative) and paired t test (quantitative) were used for statistical evaluation.

RESULTS
The BLADE images were significantly superior for sharpness of the liver edge, definition of portal triad, and for respiratory motion artifacts on subjective evaluation (p < 0.001 for both readers). 30/58 studies demonstrated intra-abdominal lesions, and BLADE images also demonstrated significantly improved lesion conspicuity (p < 0.001 for both readers). No significant difference was noted for the bowel motion or other artifacts. Quantitative analysis revealed the image intensity and image noise were better with BLADE sequence.

CONCLUSION
In pediatric abdominal MRI, BLADE T2 weighted images demonstrate significantly improved image quality with better definition of the portal triad, liver edge and with reduced respiratory motion artifact when compared with the standard HASTE T2 sequence.

CLINICAL RELEVANCE/APPLICATION
BLADE T2 weighted sequence improves overall image quality of abdominal MRI in children and could function as an alternative to standard single shot fast spin echo sequence.

VSPD51-11
Predictable Index of Vesicoureteral Reflux (VUR) in Children with Urinary Tract Infection (UTI): Usefulness of Intravoxel Incoherent Motion (IVIM) Diffusion Weighted Magnetic Resonance Imaging (DW-MRI)

Jeong Woo Kim MD (Presenter): Nothing to Disclose, Chang Hee Lee MD: Nothing to Disclose, Yang Shin Park MD: Nothing to Disclose, Jong Mee Lee: Nothing to Disclose, Jae Woong Choi MD: Nothing to Disclose, Kyeong Ah Kim MD: Nothing to Disclose, Cheol Min Park MD: Nothing to Disclose

PURPOSE
To compare the index values made by combination of diffusion parameters between the "reflux" kidney and the "non-reflux" kidney and to evaluate the feasibility of IVIM DWI for predicting vesicoureteral reflux in children with urinary tract infection.

METHOD AND MATERIALS
This retrospective study was approved by our institutional review board and the requirement for informed consent was waived. 83 kidneys from 57 pediatric patients with UTI were included. Kidneys were classified into two groups, "reflux" kidney and "non-reflux" kidney according to the results of voiding cystourethrography (VCUG). DWI using IVIM was performed with eight b factors. ADC, true diffusion coefficient(D), pseudo-diffusion coefficient(D*), and perfusion fraction(f) in the renal pelvises of both "reflux" and "non-reflux" kidneys were measured five times by a radiologist and compared between the two groups. We used the median value of the measurements as the representative value of the measured parameter. Additionally, four indices(D*/ADC, D*/D, f/ADC and f/D) were developed by combining diffusion parameters and four indices were also calculated. ROC curve analyses were performed for each index to evaluate their diagnostic performance and to identify optimal cut-off value to predict the VUR.

RESULTS
VURs were detected in 21 kidneys on VCUG. Among ADC- and IVIM-derived parameters, ADC and D were significantly lower in the renal pelvis of the "reflux" kidney than that of the "non-reflux" kidney while D* and f were significantly higher. (p = 0.037, 0.020, 0.010, and <0.001, respectively) Four indices(D*/ADC, D*/D, f/ADC, and f/D) were all significantly higher in the renal pelvis of the "reflux" kidney than that of the "non-reflux" kidney. (p = 0.022, 0.008, <0.001, and <0.001, respectively) In ROC curve analysis, f/D showed the highest AUC (Az = 0.813) with optimal cut-off value of 7.33 and corresponding sensitivity and specificity of 85.7 and 64.5%, respectively.

CONCLUSION
Perfusion fraction(f) was significantly higher in the renal pelvis of the "reflux" kidney than that of the "non-reflux" kidney. Our new index, f/D could detect VUR with relatively high sensitivity. In the future, IVIM DWI which is both radiation and contrast media-free, can be used for detecting VUR in children with UTI and further replace VCUG.

CLINICAL RELEVANCE/APPLICATION
Index of VUR in IVIM DW-MRI which is both radiation and contrast media-free can be easily calculated and may be used prior to VCUG study.

**VSPD51-12  Reliability of Contrast-enhanced Voiding Urosonography with a Second Generation Ultrasound Contrast-agent in the Diagnosis and Grading of Vesicoureteral Reflux**

Frederica Papadopoulou MD (Presenter): Nothing to Disclose, Aikaterini Ntoulia MD, PhD: Nothing to Disclose, J. Christopher Edgar PhD: Nothing to Disclose, Kassa Darge MD, PhD: Nothing to Disclose

**PURPOSE**

The diagnostic accuracy of contrast-enhanced voiding urosonography (ce-VUS) in the diagnosis and grading of vesicoureteral reflux (VUR) is high compared to voiding cystourethrogram. However, its reliability has not been yet adequately evaluated. The purpose of this study is to assess the reliability of ce-VUS in VUR detection and grading by estimating the inter- and intra-observer agreement of two pediatric radiologists.

**METHOD AND MATERIALS**

Two hundred ten children (86 boys/124 girls, mean-age 2.7y) with 421 pelvi-ureteral-units underwent ce-VUS examination with a second-generation contrast-agent to assess possible (180) or follow-up known (30) VUR. The video-clips of all ce-VUS examinations were twice independently assessed by two pediatric radiologists 4-6 weeks apart. The inter- and intra-observer agreement was estimated by kappa statistic.

**RESULTS**

The inter- and intra-observer agreement of both radiologists regarding the presence or grading of VUR was excellent (κ>0.94). There were only two disagreements regarding the presence of VUR (grade I and II false-negative and false-positive respectively). There were 5 cases of disagreement in VUR grading: three cases of VUR grade II-III and two cases grade III-IV. VUR was detected in 123(29%) pelvi-ureteral-units of 87 (41.4%) children and it was more common in completely duplicated ureters (6/7) than in single ones (p=0.03). The rate of VUR was independent of sex, age and presence or side of hydronephrosis (p>0.05).

**CONCLUSION**

The reliability of ce-VUS with a second generation ultrasound contrast-agent in VUR detection and grading is high. Ce-VUS could be used as a radiation-free alternative.

**CLINICAL RELEVANCE/APPLICATION**

To demonstrate the reliability of ceVUS for vesicoureteral reflux detection in children

**VSPD51-13  Comparative Assessment of New Generation CT Scanners for Pediatric Applications**

Whal Lee MD, PhD (Presenter): Nothing to Disclose

**LEARNING OBJECTIVES**

View learning objectives under main course title.

**VSPD51-14  Impact of Iterative Reconstruction and Low Dose on Low Contrast Detectability in Pediatric Patients in CT**

Usman Mahmood MS (Presenter): Nothing to Disclose, Yusuf Emre Erdi DSc: Nothing to Disclose

**PURPOSE**

To determine low contrast detectability (LCD) in the pediatric patient while maintaining the noise magnitude and texture.

**METHOD AND MATERIALS**

A CIRS liver phantom with three rows of 7 spherical targets, ranging from 10 mm to 2.5 mm, that are 5, 10, and 20 HU below the liver equivalent background was used to assess low contrast detectability. A Gammex 464 CT accreditation phantom was used to calculate CNR. The minimum observable spherical target was detected under appropriate viewing conditions. CNR was calculated according to the method described in the ACR CT phantom scanning instructions. The phantoms were scanned with the current pediatric CT protocol (80 mA, 10% iterative reconstruction). In order to maintain an equivalent level of noise in the reduced dose protocol (45 mA, 40% iterative reconstruction), a decrease in mA was accompanied by an increase in iterative reconstruction. Multiple levels of mA and iterative reconstruction between the current protocol and the reduced protocol have also been investigated.

**RESULTS**

A minimum spherical target diameter of 6.3 mm was detectable on reconstructed images acquired with the current CT protocol. With the reduced dose protocols, a minimum spherical target diameter of 9.5 mm was detectable on the reconstructed images. CNR was 0.593 ± 0.006 for all protocols. For an equivalent noise magnitude and texture as the current CT protocol, CTDI was found to decrease by up to 43%.

**CONCLUSION**
Optimization of CT protocols, while maintaining an equivalent noise magnitude and texture of CT images, leads to a loss of LCD. Furthermore, trying to optimize protocols based on the CT accreditation phantom alone may not be enough for optimum LCD.

**CLINICAL RELEVANCE/APPLICATION**

Dose reduction achieved with a decreased mA and increased application of iterative reconstruction may result in a loss of LCD.

### VSPD51-15 Radiation Dose Reduction in Pediatric Body CT Using a Novel Image-based Denoising Technique

**Lifeng Yu** PhD (Presenter): Nothing to Disclose, **Joel Garland Fletcher** MD: Grant, Siemens AG, **Maria Shiung**: Nothing to Disclose, **Kristen Barry Thomas** MD: Nothing to Disclose, **Jane Sexton Matsumoto** MD: Nothing to Disclose, **Shannon Nicole Zingula** MD: Nothing to Disclose, **Cynthia H. McCollough** PhD: Research Grant, Siemens AG

**PURPOSE**

To evaluate the radiation dose reduction potential of a novel image-based denoising technique in pediatric body CT exams and compare it with an iterative reconstruction (IR) method.

**METHOD AND MATERIALS**

Fifty pediatric CT exams (25 chest, 25 abdominopelvic (AP)) acquired using a weight-based low-kV protocol were included in this retrospective study. For each case, we used a validated noise-insertion tool developed in our lab to simulate half-dose images. A novel denoising technique, adaptive non-local means (aNLM) filter, which was developed in our institution, was applied to the half-dose images. An IR method (SAFIRE, Siemens) was also used to reconstruct the half-dose images. Three pediatric radiologists evaluated 4 sets of images for each of the 50 cases: (1) full dose + filtered-backprojection (FBP), (2) half dose + FBP, (3) half dose + IR, and (4) half dose + aNLM, in a randomized and blinded fashion. The overall image quality and the diagnostic confidence for each organ (chest: lung and mediastinum; AP: liver, kidney, and small bowel) were rated using a five point scale. For each case, each reader ranked dose/reconstruction method preference using a side by side comparison. Image sharpness for AP exams was rated.

**RESULTS**

The original CTDIvol was 5.3±2.1 mGy for AP exams and 2.4±1.1 mGy for chest exams. At half dose, both IR and aNLM improve the overall image quality over the FBP for both chest and AP exams (p<0.01). In AP, there was no significant difference between aNLM denoised images at half dose and the original full dose images (3.61±1.01 vs. 3.55±0.86, p=0.54), and aNLM performed better than IR (3.61±1.01 vs. 3.33±0.89, p<0.01). In chest, there was no significant difference between IR at half dose and the original full dose images (4.12±0.61 vs. 4.16±0.58, p=0.66), but IR performed better than aNLM (4.12±0.61 vs. 3.68±0.69, p<0.01). The organ-specific diagnostic confidence and preference order were consistent with the overall image quality evaluation.

**CONCLUSION**

The use of a novel image-based denoising technique resulted in a 50% radiation dose reduction in pediatric AP CT while maintaining the same diagnostic quality as in the full dose FBP images. IR image quality was worse than aNLM in the abdomen, but better in the chest.

**CLINICAL RELEVANCE/APPLICATION**

A novel denoising technique, which can be implemented across all scanner platform, can preserve diagnostic image quality despite a 50% radiation dose reduction in pediatric AP CT.
**Virtual Single-source CT Using Dual-source Acquisition: A New Technique for the Dose-neutral Intra-individual Comparison of Different Scan Protocols**


**PURPOSE**

To compare the image quality of a standard single source computed tomography (SSS-CT) with a virtual single source CT (VSS-CT) dataset reconstructed from two raw datasets obtained by dual source CT (DSCT) acquisition in abdominal computed tomography (CT) in order to establish a radiation dose-neutral approach for intra-individual comparison of three acquisition protocols at different radiation dose levels.

**METHOD AND MATERIALS**

An abdominal phantom representing an 80kg male was imaged using DSCT (Somatom Definition, Siemens Healthcare) at three radiation dose levels (RDL) with 120kVp and different tube currents (low, standard, high mAs). For each RDL, raw data was obtained once in single source mode using x-ray tube A only and in dual source mode using 5 different ratios for tube current of x-ray tube A and B (same total radiation dose; A/B: 90/10%, 80/20%, 70/30%, 60/40%, 50/50%). For each RDL, one standard (SSS-CT) and five virtual single source image datasets (VSS-CT50 - 90) were reconstructed. To compare SSS-CT and VSS-CT datasets, image quality was assessed in terms of high and low contrast performance by calculating the modulation transfer function (MTF), image noise, noise power spectrum (NPS) and for low contrast lesion detectability the modified multiscale structural similarity index (MS-SSIM*). A maximum decrease of Δ=5% of image quality compared to SSS-CT was defined as acceptable and a non-inferiority analysis with Δ was performed.

**RESULTS**

For MTF, non-inferiority was observed for all VSS-CT datasets and RDL (P<0.05). Image noise demonstrated an acceptable increase (<3.2%, P<0.05) for each RDL and NPS showed only minor differences in the mid frequency range. The MS-SSIM* index demonstrated for the high RDL protocol a minor decrease for VSS-CT datasets (<2%, P>0.05). For the standard and low RDL the relative differences of MS-SSIM* index increased and were only in one case above Δ (standard RDL, mean VSS-CT60 5.1%, P>0.05).

**CONCLUSION**

Image quality obtained by VSS-CT and SSS-CT using equivalent total radiation exposure to the patient showed only negligible differences in image quality. Therefore, this technique might allow an intra-individual comparison of full and reduced radiation dose protocols within one image acquisition step by splitting the radiation dose between two x-ray tubes of a DSCT.

**CLINICAL RELEVANCE/APPLICATION**

Radiation dose-splitting with DSCT may enable an iterative, task dependent radiation dose reduction in CT.

**The Master CT Protocol Concept in Practice: How a Small Set of Optimized Protocols Can Be Used to Create Acquisition Parameters for a Wide Range of Clinical Indications**

Timothy Peter Szczykutowicz PhD (Presenter): Equipment support, General Electric Company Research Grant, Siemens AG, Myron Andrew Pozniak MD: Stockholder, Collectar Biosciences, Inc, Frank N. Ranallo PhD: Grant, General Electric Company

**CONCLUSION**

The framework presented in this paper makes complying with ACR and AAPM recommendations easier; as well as creating new protocols. IT solutions to capturing tube output information and radiologist quality assurance information was vital to using this method.

**Background**

Maintaining a set of CT protocols specific to indication, patient size, body region, and scanner can be a daunting task; ideally hundreds of protocols are required to cover this range. This work proposes two concepts to aid this process: (1) basing all protocols within a given body region from a single basis protocol and (2) using graphical/spreadsheet tools to manage and develop protocols.

**Discussion**

Use of the master protocol concept enabled our institution to reduce the number of unique scan protocols by 37.5% for the body section. A case of an image quality issue for one protocol that triggered preventive action to be taken for all protocols using the same master protocol was implemented. Use of optimized master protocols allowed for easy creation of a new HCC liver and an organ donor protocol at our institution.

**Evaluation**

Acquisition parameters from the body section (114 protocols in total) at our institution were put into a spreadsheet program. After combining similar scan parameters, only 35 master protocols were needed to span all 114 clinical protocols. All 34 master protocols were based off a single basis protocols using mathematical
relationships between acquisition parameters. These relationships were used to model protocol changes in order to optimize parameters like rotation time, pitch, tube current limits, etc. All of the changes were based off having a validated basis protocol in which the mAs ranges required by individual scanners were recorded as a function of patient size. Graphical depictions of acquisition parameters were created from the master protocols and used to visually identify and confirm trends in protocol optimization (e.g. increase in kV with patient size).

**SSQ18-04**

Radiation Dose Reduction by Applying New Computed Tomography Protocols for Imaging Kidney Disease

Tobias De Zordo MD (Presenter): Nothing to Disclose, Thomas Auer MD: Nothing to Disclose, Daniel Junker: Nothing to Disclose, Gudrun Feuchtner MD: Nothing to Disclose, Werner R. Jaschke MD, PhD: Nothing to Disclose, Friedrich Hermann Aigner MD: Nothing to Disclose, Marco Hollaus: Nothing to Disclose

**PURPOSE**

Comparison of radiation dose and image quality of traditional 4 phases computed tomography (CT) imaging of the kidney to split-bolus CT on a 64-slice and 128-slice scanner.

**METHOD AND MATERIALS**

Retrospectively, 80 patients undergoing kidney CT with 4 different scanners or protocols were analyzed: protocol 1: 4 phases (native, corticomedullar, nephrographic, excretory) CT on 64-slice CT; protocol 2: 4 phases CT on a 128-slice CT; protocol 3: split-bolus CT on 64-slice CT; protocol 4: split-bolus dual-energy CT on 128-slice CT. Split-bolus CT was performed using a split contrast bolus that yields synchronous nephrographic and excretory phase enhancement besides native and corticomedullary phases. Overall, 20 sex, age and body-mass-index matched patients for each group were assessed regarding radiation dose, subjective (2 observers) and objective (HU measurements at cortex, pyramids and pelvis) image quality. Virtual unenhanced images were calculated from dual energy CT scans and subjective image quality was evaluated.

**RESULTS**

A significant dose reduction was obtained when using new split-bolus CT protocols: protocol 1: median 19.1 mSv (range:13.8-28.8) (CTDIvol: 23.4 mGy (12.6-40.7)), protocol 2: 24.3 mSv (16.0-50.2) (CTDIvol: 44.0 mGy (30.5-79.3)), protocol 3: 14.4 mSv (5.9-26.9) (CTDIvol: 23.4 mGy (12.6-40.7)), protocol 4: 13.4 mSv (8.8-29.3) (CTDIvol: 26.5 mGy (15.4-50.9). When comparing median CTDIvol of the nephrographic and excretory phases only, radiation could be reduced more than 50% using split-bolus CT: protocol 1: 17.2 mGy (12.8-22.7), protocol 2: 22.3 mGy (16.3-38.7), protocol 3: 8.1 mGy (4.8-14.0), protocol 4: 9.1 mGy (6.1-20.1). Comparable subjective (p=0.58) and objective (p=0.46) image quality could be observed for all protocols. Good interobserver variability was found (92%). Virtual unenhanced images of dual-energy CT resulted in sufficient image quality for diagnosis in all patients.

**CONCLUSION**

Split-bolus CT technique combining the nephrographic and excretory phase in one CT scan allows for a significant dose reduction when assessing kidney pathologies while maintaining image quality. Using the
dual-energy modus would allow for further dose reduction by omitting also the native scan and calculating a virtual native image.

**CLINICAL RELEVANCE/APPLICATION**

Patients undergoing CT imaging of the kidneys can be scanned with significantly lower radiation dose when using split-bolus CT techniques.

**SSQ18-05**

**Comparisons of Lung Nodule Detection Capability on Ultra-low and Low-dose CTs among Newly Developed Full Iterative Reconstruction, Clinically Available Adaptive Iterative Dose Reduction 3D and Filter Back Projection Techniques in Chest Phantom Study**

Hisanobu Koyama, MD, PhD (Presenter): Nothing to Disclose, Yoshiharu Ohno, MD, PhD: Research Grant, Toshiba Corporation Research Grant, Koninklijke Philips NV Research Grant, Bayer AG Research Grant, DAIICHI, SANKYO Group Research Grant, Eisai Co, Ltd Research Grant, Terumo Corporation Research Grant, Fuji Yakuhiin Co, Ltd Research Grant, FUJIFILM Holdings Corporation Research Grant, Guerbet SA: Nothing to Disclose, Shinichiro Seki: Nothing to Disclose, Mizuho Nishio, MD, PhD: Research Grant, Toshiba Corporation, Hiroyasu Inokawa: Employee, Toshiba Corporation, Naoki Sugihara, MENG: Employee, Toshiba Corporation, Noriyuki Negi: Nothing to Disclose, Tohru Murakami: Nothing to Disclose, Takeshi Yoshikawa, MD: Research Grant, Toshiba Corporation, Sumiaki Matsumoto, MD, PhD: Research Grant, Toshiba Corporation, Kazuro Sugimura, MD, PhD: Research Grant, Toshiba Corporation Research Grant, Koninklijke Philips NV Research Grant, Bayer AG Research Grant, Eisai Co, Ltd Research Grant, DAIICHI SANKYO Group

**PURPOSE**

To compare lung nodule detection capability of ultra-low-dose and low-dose CTs among newly developed full iterative reconstruction techniques (FIR), clinically available iterative reconstruction (i.e. adaptive iterative dose reduction using three dimensional processing <AIDR 3D>) and filter back projection (FBP) techniques in chest phantom study.

**METHOD AND MATERIALS**

A chest CT phantom including simulated GGOs (-800HU) and part solid nodules (-630HU), was scanned on an area-detector CT at standard-dose CT (SDCT: 270mA), low-dose CT (LDCT: 50mA) and ultra-low-dose CT (ULDCT: 10mA) protocols. Then, all CT data sets were reconstructed with FIR, AIDR 3D and/or FBP. For quantitative image quality assessment, image noise at each protocol was assessed by ROI measurements. To determine the capability of nodule identification on each protocol, two chest radiologists independently evaluated lesion conspicuity at each nodule by means of 5-point scoring system, and final scores were made by consensus of two readers. Image noise was compared each other by Tukey’s HSD test at each tube current. Then, ROC analyses were performed to compare identification capability among all techniques at each tube current, between SDCT and each LDCT, and between SDCT and each ULDCT.

**RESULTS**

Image noises of FBP were significantly higher than that of others at each tube current (p<0.05). In addition, image noise of FIR was the lowest at both tube currents. When compared identification capability, area under the curves (Az) of LDCT and ULDCT reconstructed with FIR (LDCT: Az=0.94, ULDCT: A=0.90) and those with AIDR 3D (LDCT: Az=0.94, ULDCT: Az=0.90) were significantly higher than those with FBP (LDCT: Az=0.91, p<0.05; ULDCT: Az=0.70, p<0.05). When compared with SDCT (Az=0.95), identification capability of ULDCT with each method was significantly lower than that of SDCT (p<0.05) in this setting.

**CONCLUSION**

Newly developed FIR algorithm as well as AIDR 3D is useful for LDCT and ULDCT, and can improve image quality and nodule identification as compared with FBP at each tube current level.

**CLINICAL RELEVANCE/APPLICATION**

On low- and ultra-low-dose CT, newly developed full iterative reconstruction algorithm as well as commercially available iterative reconstruction technique is useful than filter back projection for improving image quality and nodule identification.

**SSQ18-06**

**Radiation Exposure Reduction on Multiphase Dual Energy CT Exams: How Virtual Non-Contrast Combined with Iterative Reconstruction Cut Doses in Half**

Les Roger Folio, DO, MPH (Presenter): Nothing to Disclose, Peter L. Choyke, MD: Researcher, Koninklijke Philips NV Researcher, General Electric Company Researcher, Siemens AG Researcher, iCAD, Inc Researcher, Aspyrian Therapeutics, Inc Researcher, ImaginAb, Inc Researcher, Aura

**PURPOSE**

To minimize radiation dose on multiphase CT exams while maintaining diagnostic quality by 1) eliminating the pre-contrast pass and 2) reducing mAs and 3. applying iterative reconstruction. We also share a streamlined workflow, processing Virtual Non Contrast (VNC) across vendors.

**METHOD AND MATERIALS**

We compared radiation exposures of 22 consecutive multiphase chest, abdomen and pelvis CTs in patients with Von Hippel Lindau (VHL), to determine amount of total DLP reduction relative to prior exams. Tube current reduction (from 240mAs to 150 mAs) effects were compensated for noise using iterative reconstruction (SAFIRE, Siemens Medical, Malvern, PA) with an iterative strength of 2 (of 5 strengths available). The reduced exposure exams were performed on Siemens Flash in Dual Energy mode while the VNC was...
processed on Siemens PACS (Syngo.via) then pushed to our PACS (Carestream Health, Rochester, NY).
Radiologists and referring clinicians compared the quality of mAs reduced exams and VNC series to prior actual non-contrast series and overall scan quality.

RESULTS
Eliminating the non-contrast scan and applying iterative reconstruction resulted in an average exposure reduction of more than 50% (avg 59.9%) while maintaining diagnostic quality. VNC was limited in larger patients (FOV of 80 kVp tube is only 33 cm), causing incomplete analysis of a small portion of one kidney in one patient. Workflow was streamlined by co-locating a PACS node next to the CT console.

CONCLUSION
Significant dose savings on multiphase CT exams were achieved by replacing the non-contrast phase with a VNC exam, reducing tube current and compensating for noise with iterative reconstruction. This resulted in greater than 50% exposure reduction when compared to previous exams in the same patients, while maintaining image quality.

CLINICAL RELEVANCE/APPLICATION
Multiphase exams are of clinical importance, however, expose patients to higher doses of radiation. Replacing the non-contrast images with a VNC, while using tube current reductions/iterative reconstruction can provide substantial dose savings; especially in patients that receive frequent surveillance exams.

SSQ18-07
256-slice Coronary Computed Tomography Angiography Using Low Voltage 100kV
Bhoj Raj Sharma MBBS, MD (Presenter): Nothing to Disclose , Madhu Gupta MBBS : Nothing to Disclose , Yuan Qing Hai MD, PhD : Nothing to Disclose
CONCLUSION
The protocol of low tube voltage CCTA using 100 kV/1000mAs retrospectively ECG-gated shows significant reduction of the radiation dose without disturbing the subjective image quality of CCTA.

Background
To evaluate the image quality and radiation dose of 100kv with 1000mAs retrospectively electrocardiography (ECG)-gated CTCA protocol, compared to the standard protocol of 120-kV with 800 mAs retrospective ECG-gated CCTA.

Discussion
Although the objective image quality of the 100-kV with 1000 mAs was significantly better than the 120-kV with 800 mAs (mean SNR, 36.65 ± 2.95 vs. 33.47 ± 3.86, P < 0.0001; mean CNR, 34.27 ±2.92 vs. 30.62 ±3.90, P < 0.0001). There was no significant variation in the subjective image quality between two groups of patients with normal body mass index (mean image score, 4.54 ± 0.37 vs. 4.56 ± 0.25 for radiologist 1, P = 0.781; 4.52 ± 0.25 vs. 4.56 ± 0.25 for radiologist 2, P = 0.486). The radiation dose was found to be reduced by 28 % with the 100-kV/1000mAs protocol than with the standard protocol of 120-kV/800mAs retrospective ECG-gated CCTA (7.87 ± 0.59 vs. 10.95 ± 1.67 mSv, P <0.0001).

Evaluation
We evaluated the CCTA images of 70 patients with normal body mass index (18.5 kg/m2 and 25 kg/m2). We divided 70 patients into two, a reduced dose group with 35 patients (18 M, 17 F; Mean age 56.94 ± 11.51 years) were examined by 100-kV with 1000 mAs retrospective ECG-gated CCTA, and another as a standard group with 35 patients (21 , 14 F; Mean age 54.03 ± 9.81 years) were examined by 120-kV with 800 mAs retrospective ECG-gated CCTA. The two blinded radiologists analyzed the image quality of the coronary arteries independently. They performed a subjective and an objective image quality. The subjective image quality was assessed according to 5-point scoring scale. The objective image quality was measured in terms of a signal-to-noise ratio [SNR] and contrast-to-noise ratio [CNR].The radiation dose was also measured as effective radiation dose [ED] and was calculated using CT dose volume index [CTDIvol.], dose-length product [DLP] and conversion coefficient for chest (conversion factor k=0.014 mSv mGy-1cm-1).

SSQ18-08
A Comparison of Three Methods for Measuring Patient Positioning from Localizer Imaging in CT: Which Correlates Best with Optimal Image Quality?
Timothy Peter Szczykutowicz PhD (Presenter): Equipment support, General Electric Company Research Grant, Siemens AG , Myron Andrew Pozniak MD : Stockholder, Collectar Biosciences, Inc , Frank N. Ranallo PhD : Grant, General Electric Company
PURPOSE
Patient positioning in CT is critical for obtaining the lowest possible imaging dose and minimizing artifact level. Traditionally, CT technologists are instructed to align the geometric center of patients with the scanner’s isocenter. We propose an alternative positioning and evaluate three metrics for position determination.

METHOD AND MATERIALS
Localizer images were taken from 184 clinical abdominal patients and one anthropomorphic phantom at our institution and three centering determination metrics were applied to each. The optimality of the metrics was
RESULTS

On average, the geometric center metric provided the most "anterior" offcentering measurement, followed by the "center of mass" (0.2 cm lower relative to the geometric center) and then the COM of the highest 3% of the attenuation profile (1.7 cm lower relative to the geometric center). The third approach may be the most clinically relevant approach because it is directly correlated with how well the most attenuating part of the patient is positioned relative to iso-center. Having the most attenuating part of the patient aligned with isocenter in most cases ensures the lowest level of image noise non-uniformity and beam hardening.

CONCLUSION

Due to patient tissue inhomogeneity, patient positioning determination metrics based on the geometric center of the patient will not accurately provide information on optimal patient positioning. Tissue inhomogeneity within patients must be taken into account in order for position metrics to act as surrogates for optimal patient positioning.

CLINICAL RELEVANCE/APPLICATION

Dose monitoring companies are offering tools to aide in determining proper patient positioning, however, these tools may not be surrogates for optimal positioning due to patient tissue inhomogeneity.

Efficient Mapping of Protocol Selection Targets across Different CT Scanners Using Channelized Hotelling Observer Based Image Quality Metric


PURPOSE

CT Protocol recommendation tools used to determine tube potential and tube current based on the specific clinical indication and patient size were developed independently for two scanner types using a time-consuming, manual process. The purpose of this work was to determine the utility of a comprehensive quantitative image quality metric based on Channelized Hotelling Model Observer (CHO) to more efficiently predict patient size-dose curves for a new CT scanner platform based on existing curves for a different scanner.

METHOD AND MATERIALS

Previously validated CT scanner-specific protocol recommendation tools are used in daily clinical practice to determine optimal tube potential and tube current based on patient size for the evaluation of thoracic aortic disease with CT. Patient size (water equivalent diameter [Dw]) and dose (CTDIvol) were determined for patients from each of two scanners (256-slice Philips Brilliance iCT [Scanner 1] and 64-slice Philips Brilliance 64 [Scanner 2]). Both scanners were evaluated for image quality using a phantom containing three sections (Dw = 12, 25 and 32 cm), at five dose levels. Each section contains a region with three 5 mm and 2 mm low contrast rods, a uniform region, and a region to measure rod contrasts in the image (Plexar Imaging phantom). This characterization incorporates a CHO based image quality metric and generates an Image Index curve for the scanners across a wide range of body sizes and dose levels. Using the size-dose curve determined from patient scanning on Scanner 1 and the Image Index curve determined from phantom scanning on both scanners, the required size-dose curve for Scanner 2 was predicted.

RESULTS

93 patients (Dw range: 20-37 cm) were included in the study. The predicted size-dose curve for Scanner 2 closely fit the actual curve across the patient size range (Figure).

CONCLUSION

Scanner characterization using the ConvergeCT phantom and the Image Index metric enables the automated development of scanner and indication-specific protocol recommendation tools for new scanner platforms based on established practices.

CLINICAL RELEVANCE/APPLICATION

Scanner characterization using a dedicated phantom and quality metric provides an objective, automated process for adjusting proven protocols for new CT scanner platforms.

Case-based Review of Breast (An Interactive Session)
Sub-Events

MSCB52A  Percutaneous Breast Biopsies
Wendy Burton Demartini MD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Understand the advantages and limitations of percutaneous breast biopsy. 2) Compare the different potential methods of core needle biopsy. 3) Apply techniques for the biopsy of routine and challenging cases using mammography, ultrasound and MRI guidance.

MSCB52B  Post biopsy Radiologic-Pathologic Correlation
Sughra Raza MD (Presenter): Consultant, Seno Medical Instruments, Inc

LEARNING OBJECTIVES
1) The importance of following up on and communicating pathologic results of image-guided breast biopsies. 2) How to determine if a pathologic result is concordant or discordant with imaging. 3) When to recommend repeat core biopsy or surgical excision based on the biopsy result.

MSCB52C  Performance Measures
Janie M. Lee MD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Identify the data to be collected and calculate performance measures for the basic clinically relevant breast imaging audit. 2) Compare audit results with appropriate performance benchmarks. 3) Understand additional data and calculations needed to perform a comprehensive breast imaging audit.

RC707

Quality and Safety 2014: Best Practices, Radiation and Contrast Media

Refresher/Informatics

LEARNING OBJECTIVES
1) Understand the background and current status of best practice clinical and workflow management and its imperative for improving patient outcomes. 2) To review indications for premedication prior to contrast material administration. To summarize the current understanding of iodinated contrast media nephrotoxicity. To describe common errors made in treating contrast reactions. 3) To understand the requirement to match radiation dose according to the individual patient, clinical question and modality used. To outline meaningful radiation metrics including organ dosages and the overall radiation absorbed to estimate patient risk.

ABSTRACT
BEST PRACTICES: Increasingly medicine is being defined and evaluated based on patient outcomes rather than procedural events. While best practices are evolving and sometimes incomplete, many do exist, yet there is marked departmental variation from one organization to another. This session will outline why and how best practice implementation, particularly as it relates to IV contrast use and radiation dose, is essential to achieve better patient outcomes. This will require evaluation of current practices and comparison to nationally driven guidelines, with subsequent compliance to guidelines where they exist. CONTRAST SAFETY: Some patients have contrast reactions despite premedication. Patients who have repeated reactions in this setting tend to have reactions of similar severity. Studies performed with control groups suggest that there is minimal to no increased risk of contrast-induced renal failure in patients who receive iodinated contrast material; however, the control groups likely included patients at increased risk of acute kidney injury. Some errors treating contrast reactions relate to failure to administer epinephrine or using the wrong dose / wrong route. The act of administering this drug can also be problematic. RADIATION DOSE: In all radiological examinations that utilize x-rays, there are always three important issues that must be taken into consideration. The first relates to the appropriate amount of radiation to be used, which must always explicitly take into account the imaging task at hand as well as the physical characteristics of the patient undergoing the CT examination. The second issue is how to transform the radiation incident on the patient into the organ doses received which are essential to understanding
(any) patient risks. The final consideration is to understand the radiological significance of the radiation absorbed by the patient, and to estimate (any) radiological risks, as well as the corresponding uncertainties.

RC723

Minicourse: Current Topics in Medical Physics—Radiation Dose Reduction in Medical Imaging

Refresher/Informatics

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Thu, Dec 4 4:30 PM - 6:00 PM  Location: E351

Participants

Moderator
Mahadevappa Mahesh MS, PhD: Nothing to Disclose

ABSTRACT

This mini-course will include discussions on how to optimize radiation dose and clinical management in the areas of CT, Fluoroscopy and Radiography (CR and DR). Discussion will include dose optimization strategies applicable due to technological advances, and also include practical steps on how to manage patient and staff safety clinically.

Sub-Events

RC723A  CT Dose Reduction and Clinical Management

Mahadevappa Mahesh MS, PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) To identify various radiation optimization strategies in CT. 2) To update impact of technological advances on reducing CT dose. 3) To describe ways to optimize CT protocols.

ABSTRACT

The number of CT examinations performed in the United States has been growing steadily leading to peak of more than 85 million procedures in 2011, but has shown a downward trend (76 million in 2013) in the past two years. Similar trends are observed world wide. The rapid increase in the number of CT procedures, new protocols and the associated radiation dose and risks has drawn considerable attention. It appears that the so-called 'slice wars' with regard to the number of slices provided per CT gantry rotation may be reaching a plateau and increasing concerns about radiation dose due to CT examinations are fueling the efforts to reduce radiation dose and has lead to 'dose wars'. Tube current modulation, iterative reconstruction algorithms, tube voltage reduction and many other strategies will be discussed in this presentation. These and many numbers of radiation dose reduction strategies are enabling users to acquire CT images at a much lower radiation dose. At the same time, efforts to optimize CT protocols are leading further improvement in image quality and image quantifications.

RC723B  Fluoroscopy Dose Reduction and Clinical Management

Pei-Jan Paul Lin PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

1) To identify that there are two basic schools of fluoroscopy operation logic design (FOLD). Discussion of FOLD enables us to understand how the modern fluoroscopy systems are able to (1) lower radiation dose to the patient, (2) maintain the image quality required and (3) provide a wider dynamic range of patient thickness. While equipment based reduction of patient dose is effective, there is a need to monitor the overall radiation dose as the patient receives various types of radiological examinations. A hospital wide radiation monitoring (HWRM) is ever increasing as public-at-large becomes aware of potential radiation injuries from some of the radiological examinations. A sample monitoring system that is designed to monitor various patient dose data generated from CT and RF equipment will be discussed.

URL's


RC723C  CR and DR Dose Reduction and Clinical Management

Charles E. Willis PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES
1) Appreciate why dose reduction efforts are necessary in projection radiography using CR and DR. 2) Identify the meaning of vendor-specific receptor exposure indicators and the new standardized receptor exposure indicators, and their indirect relationship to patient dose. 3) Assess the role of output indicators, DAP, KAP, and EAP, in estimating patient dose. 4) List simple operational methods for managing radiation doses in clinical radiography.

ABSTRACT

Computed Radiography (CR) and Digital Radiography (DR) are key technologies that enable the electronic practice of radiology. Both CR and DR are capable of producing acceptable diagnostic quality images over a wide range of exposures. A combination of traditional and new methods is necessary to manage the concomitant radiation dose to patients undergoing projection radiography examinations.

RC751

CT Dose Reduction: Diagnostic Information, Image Quality and CT Radiation Dose (How-to Workshop) (An Interactive Session)

Refresher/Informatics

AMA PRA Category 1 Credits ™: 1.50
ARRT Category A+ Credits: 1.50
Thu, Dec 4 4:30 PM - 6:00 PM   Location: E450B

LEARNING OBJECTIVES

1) Visual impression of general image quality parameters such as image noise, texture, sharpness and artifacts in CT. 2) Image guided tour on effects of radiation dose on general image quality parameters. 3) Image based display of effects of different scan parameters on general image quality metrics. 4) Image guided display of effects of radiation dose and different scan parameters on appearance of different lesion subtypes in adult and pediatric body CT examinations.

Sub-Events

RC751A  General Image Quality Session: Interactive Discussion on Image Quality Parameters Such As Noise, Contrast, Sharpness, and Artifacts at Different Dose Levels

Mannudeep K. S. Kalra  MD (Presenter):  Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under main course title.

ABSTRACT

Using CT images acquired at different dose levels, radiologists will learn about general image quality metrics, such as image noise, sharpness, contrast, texture and artifacts. In addition, they will learn from images, how dose and different scan parameters affect these image quality metrics. In order to accomplish this, radiologists will scroll through clinical cases at different dose points in different body regions. Next, the radiologists will learn about the specific effects of dose on lesion detection and appearance. In this section, radiologists will go through multiple series of CT images at different dose levels to assess the effect of changing dose on specific lesion and image appearance for specific lesion types. They will be asked to perform a directed search for structures and lesions, some of which will exist and others will not exist in the provided datasets. At the end of each case, they will get to see the specific example template protocol for at least two scanner vendors. This course will help radiologists understand the need for specific clinical indication and size driven protocols.

RC751B  Lesion Detection: Multi-Dose CT Images with Clinical/Pathology Correlation

Mannudeep K. S. Kalra  MD (Presenter):  Nothing to Disclose , Donald P. Frush  MD (Presenter):  Nothing to Disclose , Sarabjeet Singh  MD (Presenter):  Research Grant, Siemens AG Research Grant, Toshiba Corporation Research Grant, General Electric Company Research Grant, Koninklijke Philips NV , Subba Rao Digumarthy  MD (Presenter):  Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under main course title.

RC829

Should I Scan That Patient? A Very Interactive Session on MR Safety and Regulations (An Interactive Session)
LEARNING OBJECTIVES

1) Analyze the cause and avoidance of a spectrum of common MR safety issues, including burns. 2) Assess the most current information about the development of NSF (nephrogenic systemic fibrosis) and the possibility of other chronic conditions following GBCA administration. 3) Compare indications and contraindications for MRI on patients with pacemakers, neurostimulators, and other devices with wires or leads. 4) List the factors (including regulation and guidelines) which should be evaluated in order to determine the safety of MRI in patients with implants, devices, or foreign objects.

ABSTRACT

The major potential safety considerations in magnetic resonance imaging relate to those stemming from the static magnetic field, the time varying radiofrequency oscillating magnetic fields, the time varying switched gradient magnetic fields, the contrast agents often utilized in the MR imaging process, sedation/anesthesia and monitoring-related issues unique to the MR imaging environment, and cryogen related potential safety concerns. These can present confounding situations for MR practitioners faced with questions relating to the safety of exposing particular patients and devices, implants, or foreign bodies to MR imaging examinations. This session will introduce and briefly explain the above safety considerations, and highlight specific issues likely to confront MR practitioners in their daily practice by utilizing real-life examples. The methodology and reasoning process used to approach these clinical examples in determining risk-benefit ratios for accepting or rejecting such patients from MR exposure will be stressed. The emphasis will be on not so much the particular examples used, but rather having the attendee feeling more comfortable with the approach to such clinical and research situations in order to better enable them to appropriately address such questions in their own daily practice routines. Audience polling and interaction will be actively utilized throughout this session. This will help enable the attendee to not only hear the opinions of the presenters on the cases being discussed, but also to assess their own responses to the questions being posed relative to that of the other attendees of this session.

RC854

Health IT Tools to Improve Quality and Safety in Radiology (An Interactive Session)

LEARNING OBJECTIVES

1) Describe a practical framework for measuring quality and value in radiology to help drive performance improvement initiatives. 2) Using case example, describe how measuring quality and value can improve performance and sustain change inside the radiology department. 3) Using case example, describe how measuring quality and value can improve performance and sustain change across the healthcare enterprise. 4) Panelists will discuss how radiology practices can practically begin to introduce measurements of quality and value and use such measurements to drive and sustain needed change.

Sub-Events

RC854A

Measuring Quality in Radiology, A Practical Framework

Jenifer Willmann Siegelman MD, MPH (Presenter): Consultant, Bayer AG

LEARNING OBJECTIVES

View learning objectives under main course title.

RC854B

Using Quality Metrics to Drive Change and Improve Quality in Diagnostic Radiology: Case Example

Paul G. Nagy PhD (Presenter): Nothing to Disclose

LEARNING OBJECTIVES

View learning objectives under main course title.

RC854C

Using Quality Metrics to Drive Change and Improve Quality Across the Enterprise
LEARNING OBJECTIVES

View learning objectives under main course title.

SST13

Physics (Radiation Doses IV: Methodology, Organ Doses for CT)

Scientific Papers

SST13-01 Organ Doses from Longitudinally Modulated Chest CT Scans in Commercial Software and Monte Carlo Simulations

Xochitl Lopez-Rendon MSc (Presenter): Nothing to Disclose, Guozhi Zhang: Nothing to Disclose, Raymond H. Oyen MD, PhD: Nothing to Disclose, Hilde Bosmans PhD: Co-founder, Qaelum NV Research Grant, Siemens AG, Federica Zanca PhD: Nothing to Disclose

METHOD AND MATERIALS

Data from 9 patients (4 female, 5 male) with normal BMI (20.3-24.4), who underwent a chest scan on a Siemens Definition Flash scanner were collected. Examinations were performed with longitudinal TCM, 120 kV and 110 reference mAs. Patients organ doses (lungs for both gender and breasts only for female) were calculated using the new CT-Expo v. 2.2, which includes a dose correction for exams performed with tube current modulation. Specifically it uses two unique mAs profiles, one for male and one for female, which are modified based on the specific scan range by a set of correction factors for each z-position every cm. Dose to the same organs were also calculated with MC simulation (EGSnrc) for the ICRP phantoms, but this time using the patient specific tube current modulation profiles. The longitudinal TCM information from each patient was extracted from the images using an in-house tool. Percentage error between the dose calculated with the full MC simulation and the commercial software was assessed with respect to the MC simulations.

RESULTS

For all the patients, doses estimated with the full MC simulation were higher than with CT-Expo. For female patients, the percentage error for breasts ranged from 3.9 to 12.4%, while for the lungs from 10.8 to 21.2%. The percentage error for dose to the lungs for male patients ranged from 10.9 to 13.3%.

CONCLUSION

All included patients were similar in BMI to the stylized CT-Expo phantoms and to the ICRP anthropomorphic phantoms used for MC simulations. Observed organ dose differences are due to the stylized phantoms and the two single TCM profiles used in CT-Expo. TCM profile can vary considerably even across normal size patients due to different body habitus.

CLINICAL RELEVANCE/APPLICATION

To have accurate patient specific organs doses, even for normal patient sizes, MC simulations have to be preferred.

SST13-02 CTDIvol per Slice: How It Should Be Interpreted and How It Can Be Used as an Aid in Computing Organ Dose in the Presence of Current Modulation

Donovan M. Bakalyar PhD (Presenter): Nothing to Disclose, Sarah Eva McKenney PhD: Nothing to Disclose

CONCLUSION
CTD \( _{vol} \) as a function of position is neither the patient dose nor even the phantom dose. Nonetheless, when properly interpreted, it can be a valuable tool in the computation of organ dose using tools such as ImPACT, even in the presence of tube current modulation.

**Background**

CTD \( _{vol} \) can be stored as an optional attribute with tag (0018,9345) in the DICOM metadata on an image by image basis. This attribute is described in the DICOM literature as the average dose associated with that image. Although this description is not correct, this parameter can still be very useful for dose computations, even in the presence of current modulation.

**Discussion**

ImPACT is designed for the computation of dose with fixed scanning parameters and the start and end positions of the scan. However, CTD \( _{vol} \), by itself, accounts for tube current, rotation time, pitch and collimation. (In general, variations in tube potential and scanner model only weakly affect the dose distribution.) Linearity along with the scan region dependency of ImPACT allows for the computation of dose in the presence of current modulation. Tabulation of CTD \( _{vol} \) as a function of position makes it unnecessary to know the collimation, tube current, rotation time and pitch in the computation of organ dose.

**Evaluation**

CTD \( _{vol} \) is obtained from the approximate spatial average of a 100 mm central portion of the single scan dose profile in the central plane of standard cylindrical phantoms. It is a function of collimation, pitch, tube potential, tube current, rotation time, and specific machine model. The reasoning in AAPM Task Group Report 111 along with published data shows that CTD \( _{vol} \) is directly proportional to the energy absorbed per rotation. Using ImPACT as a model and taking advantage of linearity, CTD \( _{vol} \) as a function of position can be used for the calculation of dose even in the presence of current modulation. Though ImPACT is limited to a standard, stylized patient, the principle should apply to any dose computation program where CTD \( _{vol} \) is computed.
METHOD AND MATERIALS

Detailed Monte Carlo simulations of chest CT examinations were performed for one 64-slice multi-detector row CT scanner (Sensation 64, Siemens Healthcare) using a single voxelized patient model (GSF model “Irene”). Simulations were performed with a nominal collimation of 32 x 0.6 cm and a pitch of 1. As per the recommendations of the AAPM Routine Chest CT Protocol, an “ideal scan range” was set from the top through the bottom of the lungs. In order to model both z-axis over-ranging and scan over-prescription, scan start (beam on) and stop (beam off) locations were independently increased in 1 cm increments until full coverage of the thyroid and liver occurred. For each scan range, dose to the thyroid, liver and red bone marrow (RBM) was tallied, and relationships between organ dose and z-axis over-ranging and scan over-prescription were derived.

RESULTS

For all organs, dose as a function of over-ranging and over-prescription follows a cubic function. Correlation coefficients for these relationships were 0.99. The difference between dose from an “ideal scan range” and a scan range that included 2 cm of over-ranging only was 62.4%, 34.1% and 15.6% for the thyroid, liver and RBM, respectively. The difference between dose from an “ideal scan range” and a scan range that included over-ranging and maximum over-prescription (i.e. full coverage of the thyroid and liver) was 89.3%, 164.4% and 52.8% for the thyroid, liver and RBM, respectively.

CONCLUSION

Z-axis over-ranging and scan over-prescription can have a significant impact on dose to partially irradiated organs. Strong correlations between partially irradiated organ dose and over-ranging and over-prescription can be used to predict dose to organs outside the image range.

CLINICAL RELEVANCE/APPLICATION

Results presented can be used to estimate the impact of over-ranging and over-prescription for dose to partially irradiated organs and help facilitate clinical decisions of scan range prescription.

SST13-05

Individualized Organ Dose Calculations for Body CT Patients from Automatically Segmented Anatomy Coupled with Fast Monte Carlo Transport

Choonsik Lee PhD (Presenter): Nothing to Disclose, Jiamin Liu PhD : Nothing to Disclose, Jianhua Yao PhD : Royalties, iCAD, Inc, Les Roger Folio DO, MPH : Nothing to Disclose, Ronald M. Summers MD, PhD : Royalties, iCAD, Inc Research funded, iCAD, Inc Stockholder, Johnson & Johnson Grant, Viatronix, Inc

PURPOSE

To establish the feasibility of individualized organ dose calculations in body computed tomography (CT) patients by using semi-automatic segmentation of major organs, scan parameters abstracted from DICOM header, CT scanner simulation model, and Monte Carlo transport in high-speed parallel computing system.

METHOD AND MATERIALS

We used the abdominal CT images (four male and five female) of patients, ranging in age from 19 to 46 years, sampled from our clinical PACS. First, we contoured 6 organs and tissues using threshold (body contour and skeleton) and Multi-Atlas Label Fusion (left and right kidneys, pancreas, spleen, and liver) techniques. Second, scan parameters (scanner model, average mAs, and tube potential) were automatically abstracted from DICOM headers by using an in-house script. Parameters and patient contours were coupled with a CT scanner simulation model within a Monte Carlo transport code, MCNPX2.7. Organ doses for kidneys, pancreas, spleen, and liver were estimated using a hi-speed 32-processor computing server.

RESULTS

The automatic segmentation, data abstraction, and Monte Carlo calculation took about an hour for each patient. All organs were completely included within the scan coverage. The coefficient of variations in organ volumes across the 9 patients were 20, 13, 34, and 26 % for liver, kidneys, spleen, and pancreas, respectively. When organ dose was normalized to mAs, the maximum dose (mGy/mAs) to each organ was from 1.2- (liver) up to 2.5-fold (spleen) greater than the minimum dose among the 9 patients. The dose discrepancy may be attributed to different locations/shapes of organs and body size. When patient-specific mAs was multiplied, the maximum dose to spleen was up to 3.5-fold greater than the minimum dose.

CONCLUSION

Our pilot study presented the feasibility to calculate patient-specific organ dose from segmented patient anatomy coupled with fast Monte Carlo calculation. The comparison of organ dose (normalized to mAs) revealed significant variation (over 2.5-fold) in all patients even though they were all adults and the organs were completely included into the scan coverage.

CLINICAL RELEVANCE/APPLICATION

We presented an important step towards estimating true patient dose. We are currently working to apply our method to help validate computational phantom-based organ dose in patient dose monitoring.

SST13-06

The AAPM-ICRU CT Dose Phantom: A Robust and Versatile Tool for Dose Measurements Across CT Platforms

Donovan M. Bakalyar PhD (Presenter): Nothing to Disclose, Erin Angel PhD : Employee, Toshiba Corporation, John M. Boone PhD : Research Grant, Siemens AG Research Grant, Hologic, Inc Consultant, Varian Medical Systems, Inc, , Heath Chen-Mayer PhD : Nothing to Disclose, Dianna D. Cody PhD : In-kind support, General Electric Company, Wenzheng Feng BMBS : Nothing to Disclose, Iacovos Kyprionou PhD : Nothing to Disclose, Shuai Leng PhD : Nothing to Disclose, Sarah Eva Mckenney PhD : Nothing to Disclose, Michael F. McNitt-Gray PhD : Institutional research agreement, Siemens AG Research Group

METHOD TO HELP VALIDATE COMPUTATIONAL PHANTOM-BASED ORGAN DOSE IN PATIENT DOSE MONITORING.
Designed to incorporate the approaches described in TG111, the AAPM-ICRU phantom provides the means to standardize and unify dose measurements on a wide variety of CT scanners including diagnostic scanners with extended beams, cone beam and flat panel geometries.

Background
The phantom and measurement techniques used to obtain CTDIvol and DLP have limitations that can impose challenges in obtaining equivalent measurements on the growing number of cone beam and very wide fan beam CT machines. In accordance with the recommendations of AAPM Task Group 111 (TG111), TG200 has designed a phantom and tested procedures which are suitable over a broader range of machines than the current methodology. The phantom design and measurement methods lend themselves to a more unifying set of dose descriptors, especially when the concept of irradiated length is employed.

Evaluation
The phantom is 30 cm in diameter and is constructed of polyethylene; it is of sufficient length (60 cm) so that scatter reaching the central plane from the ends of the phantom is negligible. For scanners with a moving table, a small detector is placed within the central plane and a helical scan through the entire phantom is performed. The dose recorded by the chamber approaches \( D_{eq} \), the value that would be reached for an infinite scan. By recording the dose rate simultaneously, \( dD/dL \) can be determined, where \( D(L) \) is the dose as a function of the irradiated length \( L \). Integrating this gives us the approach to equilibrium function \( H(L) = D(L)/D_{eq} \). By employing the principle of irradiated length, these concepts can be extended to axial scans on stationary tables. These phantoms have been tested at a variety of locations either with the assistance of a member of TG200 or “cold” using written instructions only.

Discussion
\( H(L) \) is a robust function with only a weak dependence on tube potential, z-axis collimation and even scanner model. The phantom design is easily adaptable to the size specific dose estimates described by the report of AAPM Task Group 204 resulting in an index that remains simple but accounts for both girth and scan length. Correlations to air and small phantom measurements can be used for verification in the field.
Dose from localizer radiographs may contribute significantly to total effective dose. Software tools allow fast and accurate patient dose calculations taking localizer radiograph dose into account.

**SST13-08**

**Estimating Organ Dose from Tube Current Modulated CT Exams Using Size Data Available in the DICOM Header of CT Localizer Radiographs and Regional Scanner Output**

Kyle McMillan (Presenter): Institutional research agreement, Siemens AG Research support, Siemens AG, Maryam Bostani PhD: Research support, Siemens AG, Cynthia H. McCollough PhD: Research Grant, Siemens AG, Michael F. McNitt-Gray PhD: Institutional research agreement, Siemens AG Research support, Siemens AG

**PURPOSE**

To demonstrate the feasibility of estimating organ doses for patients undergoing tube current modulated (TCM) CT exams using a combination of: (a) a patient size metric derived from existing data in the CT localizer radiographs and (b) a scanner output metric based on the anatomical region of interest (CTDIvol-regional).

**METHOD AND MATERIALS**

For 20 patients who underwent clinically indicated TCM exams of the chest (n=10) or abdomen/pelvis (n=10), the CT localizer radiograph, image data and TCM data were obtained. The CT localizer radiograph (topogram) generated from most Siemens CT scanners contains a private DICOM field that stores an array of numbers describing AP and LAT attenuation-based measures of patient dimension. The square root of the product of the AP and LAT size data was used to calculate an estimate of water-equivalent diameter (WED-topo). For comparison, the image data was also used to calculate water-equivalent diameter (WED-image). Using a previously published approach, the average effective mAs over the anatomical region of interest was used to generate a regional descriptor of scanner output (CTDIvol-regional). Using previously described correlations between WED and organ doses normalized by CTDIvol-regional, estimates of organ dose (OD) were obtained using WED-topo and WED-image over the anatomical region of interest for the lung (chest scans) and liver (abd/pel scans). These estimated organ doses were then compared to estimates obtained with detailed Monte Carlo (MC) simulations that modeled individual patient anatomy and CT data.

**RESULTS**

For abdomen/pelvis scans, the average difference between MC liver dose and OD(WED-image) and OD(WED-topo) was 6.06% and 7.43%, respectively. For chest scans, the average difference between MC lung dose and OD(WED-image) and OD(WED-topo) was 11.10% and 12.93%, respectively.

**CONCLUSION**

For both abdomen/pelvis and chest TCM CT examinations, organ dose estimated using WED derived from data in the DICOM header of the topogram was comparable to organ dose estimated using WED derived from image data. The topogram-based method has the advantage that WED data are readily available without additional post-processing of the image data.

**CLINICAL RELEVANCE/APPLICATION**

Accurate estimates of dose to patients undergoing TCM CT examinations can be obtained based on size data already available in some CT scan radiographs and a regional measure of scanner output.

**SST13-09**

**Estimating the Role of Iodinated IV Contrast Media in Organ Radiation Dose: Effects of Vascular Phase and Tube Voltage in Multiphase Body CT**

Huong Tran MS: Nothing to Disclose, Choonsik Lee PhD:Nothing to Disclose, Vana M. Derderian BS (Presenter): Nothing to Disclose, Les Roger Folio DO, MPH: Nothing to Disclose, Elizabeth C. Jones MD: Nothing to Disclose

**PURPOSE**

To develop and apply a CT radiation dose estimation method accounting for IV iodinated contrast in computational phantom-based Monte Carlo simulations for more accurate scan and organ-specific radiation dose. We assessed the impact of time-dependent contrast phase and tube voltage (kVp) on organ radiation dose in multiphase body CT.

**METHOD AND MATERIALS**

An adult male computational phantom and CT scanner modeling within Monte Carlo n-particle extended (MCNPX2.6) code simulated x-ray photon interactions for a standard clinical Contrast-Enhanced body CT (CECT). Elemental composition of chest, abdominal and pelvic organs was adjusted to reflect the addition of iodinated contrast media (Isovue-300™) using predicted pharmacokinetic data of body contrast distribution. We modeled contrast phases (non-contrast, arterial, venous) at 120, 100 and 80 kVp; organ dose estimates were obtained with 2.6 million simulations on a supercomputer cluster.

**RESULTS**

Estimated organ dose showed greatest increase at the 120 kVp venous phase (absolute change: 1.9-10.3 mGy) in kidneys (361%), adrenals (379%), spleen (266%) and colon (229%) compared to non-contrast. Overall dose reduction was shown at lower kVp (100kVp: 37%, 80kVp: 73%) in all phases with largest magnitude of dose reduction in the same abdominal organs. Average dose increase was 15% from non-contrast to arterial and 84% continuing to venous. Lowering kVp reduced doses to near (100kVp) or below (80kVp) the non-contrast dose. Pelvic and thoracic organs received predicted radiation scatter.
CONCLUSION

Iodinated contrast increases organ radiation dose proportional to iodine accumulation and elapsed time, with the highest doses received by kidneys, adrenals, spleen and colon in the venous phase. Reducing organ doses by lowering kVp is effective in the presence of iodinated contrast media in all phases. Inclusion of iodinated contrast in radiation dose assessment is warranted.

CLINICAL RELEVANCE/APPLICATION

Though clinical significance is currently unknown, increased x-ray absorption and energy deposition linked to tissue concentrations of iodinated contrast media increases non-uniform radiation dose distribution to organs during CT scanning. This can be accounted for by computational phantoms, allowing scan and patient-specific modeling which more closely approximates routine clinical CT scanning.