CT Dose Monitoring and Optimization Using\textit{radiance}

Disclosures

- No financial disclosures
- Principal developer of RADIANCE
  (http://www.radiancedose.com) - free, open-source dose monitoring tool

Objectives

1. Describe some of the challenges in CT dose monitoring
2. Summarize the development of a dose monitoring/quality assurance program
3. Describe our facility’s experience with CT dose monitoring and protocol optimization
Known effects of exposure to high doses of imaging-related radiation, and potential effects to low doses
Increased awareness in the scientific community, lay press and federal and state legislatures
We monitor doses of other substances we administer to patients....
We'll use CT dose metrics as an example in this talk, but dose monitoring is essential in all modalities

Summary of the California Senate Bill 1237

The current status of the bill can be found here: http://www.leginfo.ca.gov/bill_status/sb1237_billstatus.html

This bill would require physicians to monitor the radiation exposure of patients undergoing CT scans and other imaging procedures. The goal is to reduce the risk of cancer and other health effects associated with exposure to high levels of radiation.

We'll use CT dose metrics as an example in this talk, but dose monitoring is essential in all modalities.
Dose related parameters stored as pixel data, not structured data
“Dose indices,” which are measured in a standardized phantom and in a standardized fashion
NOT actual patient doses, but measures of machine energy output

Actual patient dose depends on
- Scanner parameters
- Gender
- Age
- Body habitus
- Anatomy imaged
- Number of phases of imaging

We are monitoring the radiation output of our equipment, as that is what the operator has control of and must be configuring properly
Responding to the Challenges

Not all scanners currently produce RDSR (radiation dose structured reports)
- Originally the only means of transmitting data to the ACR’s Dose Index Registry
- Large numbers of CT exams with image-based dose sheets already exist around the world
- How can we monitor dose today?

Practical Limitations

Dose Monitoring Options
Choosing a Dose Monitoring Solution

- Open-source vs. commercial
- Dose sheet only vs. RDSR only vs. both
- CT only vs. multi-modality
- Dose monitoring only vs. dose/utilization monitoring

Data Input
- Image-based dose sheet (OCR) or RDSR
- DICOM header study data

Validation
- Dose parameters
- Study header data

Dose Analytics
- Routine monitoring
- Dose scorecards
- Outlier detection
- Dose registry

Database Update
- Dose parameters
- Study data
- Additional RIS data

Features of radiance
- Automated extraction pipeline
- Compatible with multiple vendors
- Small footprint – standard Windows PC, all open-source components
- Imports from image-based dose sheets or RDSRs
- Built-in reporting tools
- Can send to the ACR Dose Index Registry

Cook et al., JACR 7(11): 871-877, 2010
RADIANCE Reporting Tools

RADIANCE Dashboard

- Built on top of the RADIANCE database
- Analyze dose parameters by
  - Study type
  - Scanner model
  - Performing technologist*
  - Reporting radiologist*
- Identify outliers
- View patient profile

*If RIS integration enabled

Cook et al., RadioGraphics 31: 1833-1846, 2011

Dashboard: Scanner
RADIANCE Scorecards

- Updated monthly – all radiologists, technologists, physicists, etc.
- Tailored to the role of the recipient
- Facilitate review of dose parameters
- Allow users to leave feedback

Cook et al., RSNA 2012
User interface for customized queries of RADIANCE database
- Independent & dependent variables
- Grouping criterion
- Date range
- Generates charts → image
- Generates tabular data → spreadsheet
- Not required to know query language or deal with complicated database interface
Developing a Dose Quality Assurance Program

- Implement the dose reduction
- Monitor dose parameters at your facility
- Analyze your dose parameters
- Develop a dose reduction intervention

What Makes a Dose “High”?

- "High" dose
- Body habitus
- Patient motion
- Contrast extravasation
- Altered mental status
- Incorrect triggering
- Additional scans
- Old protocols
- "Wrong" protocols
- Test new parameters
  - Diagnostic image quality?
  - Unanticipated problems?
  - Important to-dos
    - Note the date of the protocol deployment
    - Give the new protocol a unique name

- Evaluate dose estimates pre- and post-protocol revision
  - Compliance?
  - Educational intervention?
  - Practical factors precluding use of new protocol?

“Optimizing” Protocols

- Note the date of the protocol deployment
- Give the new protocol a unique name
Penn’s CT Dose Reduction Efforts

- Thoracic CT
- CT urograms
- Coronary CTA

Dose Reduction: High-Resolution Chest CT

- Optional expiratory phase (with very low mAs)
  - Study tailored to clinical question!
- Warren Gefter, MD & Eduardo Barbosa, MD

Dose Reduction: PE Chest CTs

- kVp adjusted for patient size
  - Saves dose to smaller patients who can be imaged with 100 kVp or even 80 kVp
- Warren Gefter, MD & Eduardo Barbosa, MD

Cook et al., STR 2011
Dose Reduction: CT Urograms

- 2 imaging series instead of 3; stricter scan lengths
- Split bolus injection
- Susan Hilton, MD

Dose Reduction: Coronary CTA

radiance Ongoing/Future Work

- Automated alerts
- Patient size estimation
  - Dose normalization to patient size (SSDE)
- Protocol optimization
  - Patient size-specific protocling
  - Iterative reconstruction
- HL-7 integration
- Customizable reporting tools
- Large-scale RADIANCE validation
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# Questions?

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# The Future

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Developing a Dose Quality Assurance Program

What Makes a Dose “High”?  
- Patient factors  
  - Body habitus  
  - Ability to tolerate exam (e.g., motion, altered mental status, etc.)  
- Technical factors  
  - Contrast injection (e.g., extravasation, incorrect triggering, etc.)  
  - Additional scans though body region of interest  
- Need for protocol optimization

Reviewing Effects of Protocol Optimization  
- Evaluate changes in dose estimates pre- and post-protocol optimization  
- Verify that new protocols were actually used during the post-optimization time period  
  - Compliance?  
  - Need for educational intervention?  
  - Practical factors precluding use of new protocol?
Food for Thought

- Reporting dose estimates in dictations (CA) – it’s happening!
- Payment based on eventual study dose estimate?
- “How much radiation did I get from that CT scan?”