Utilization of a Patient Dose Tracking and Monitoring System to Modify CT Protocols and Lower Patient Doses

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Learning Objectives

1. Summarize The Joint Commission (TJC) diagnostic imaging requirements
2. Review patient dose tracking and monitoring methods and systems
3. Discuss applications and implementation of a CT patient dose tracking and monitoring system and how it can be used to lower patient dose
Presentation Outline

• Introduction and Requirements
• CT Patient Dose: Monitoring and Alerts
• CT Patient Dose: External Benchmarks
• CT Dose Case Study: Adult Head Exams
• CT Dose Case Study: Pediatric Head Exams
• Discussion and Conclusions
• Questions?
Introduction and Requirements
Introduction and Requirements

- Factors contributing to this effort
  - The Joint Commission (TJC), Diagnostic Imaging requirements updated to include CT dose
  - CT protocol review committee efforts
  - CT patient dose monitoring and alert system recently procured by our organization
  - Participation in (and feedback from) the American College of Radiology (ACR) National Radiology Data Registry (Dose Index Registry, DIR)
Introduction and Requirements

Diagnostic Imaging Requirements

Standard PI.02.01.01
The organization compiles and analyzes data.

Element of Performance for PI.02.01.01
A 6. The organization reviews and analyzes incidents where the radiation dose index (CTDvol, DLP, or size-specific dose estimate [SSDE]) from diagnostic CT examinations exceeded expected dose index ranges identified in imaging protocols. These incidents are then compared to external benchmarks.
Introduction and Requirements

- Key elements of TJC requirements
  - Determine expected dose index ranges
  - Review and analyze incidents that exceed range
  - Compare incidents to external benchmarks
- Other requirements and organizations
  - ACR CT accreditation program
  - State regulations?
  - Others (CMS, etc.)
Introduction and Requirements

CT scans by year in U.S. (millions)

- CT annual growth > 10%/yr
- U.S. population < 1%/yr

F. Mettler ICRP 2011
Introduction and Requirements

- Image Gently and Image Wisely Campaigns
  - imagegently.org and imagewisely.org
  - Adjust and review pediatric CT protocols to meet clinical need
  - Radiologist interest and participation
SAM Question?

Please use the *Poll Everywhere* app or website to answer the SAM question.
The Joint Commission requires organizations to review and analyze incidents where the radiation dose index from diagnostic CT examinations that exceeded __________ dose index ranges identified in imaging protocols. These incidents are then compared to ___________ ____________.

A. expected, ACR benchmarks  
B. ACR, external benchmarks  
C. expected, external benchmarks  
D. ACR, ACR benchmarks  

Reference: TJC Diagnostic Imaging Requirements, Performance Improvement Standard – PI.02.01.01
Diagnostic Imaging Requirements

**Standard PI.02.01.01**
The organization compiles and analyzes data.

**Element of Performance for PI.02.01.01**

**A 6.** The organization reviews and analyzes incidents where the radiation dose index (CTD\textsubscript{vol}, DLP, or size-specific dose estimate [SSDE]) from diagnostic CT examinations exceeded expected dose index ranges identified in imaging protocols. These incidents are then compared to external benchmarks.
CT Patient Dose:
Monitoring and Alerts
CT Patient Dose: Monitoring and Alerts

- Radimetrics (Bayer HealthCare LLC)
  - CT protocol dose ranges established by diagnostic medical physicist (DMP)
    - Based on reported statistics for patient DLP values
    - Alert levels set to 2x Std Dev of mean, reviewed annually
  - Patient dose alerts monitored weekly and reviewed by DMP
CT Patient Dose: External Benchmarks
CT Patient Dose: External Benchmarks

- External benchmark employed was the ACR National Radiology Data Registry (NRDR) Dose Index Registry (DIR)
- Facilities enroll in NRDR send their CT data to the DIR and receive quarterly feedback
- Diagnostic Reference Levels (DRL) and Achievable Doses (AD) for ten adult CT exams

<table>
<thead>
<tr>
<th>Exam Name</th>
<th>Median Patient Size</th>
<th>CTDvol (mGy)</th>
<th>SSDE (mGy)</th>
<th>DLP (mGy-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and brain without contrast</td>
<td>14-16</td>
<td>56</td>
<td>49</td>
<td>962</td>
</tr>
<tr>
<td>Neck with contrast</td>
<td>18-22</td>
<td>19</td>
<td>15</td>
<td>563</td>
</tr>
<tr>
<td>Cervical spine without contrast</td>
<td>18-22</td>
<td>28</td>
<td>20</td>
<td>562</td>
</tr>
<tr>
<td>Chest without contrast</td>
<td>29-33</td>
<td>12</td>
<td>9</td>
<td>443</td>
</tr>
<tr>
<td>Chest with contrast</td>
<td>29-33</td>
<td>13</td>
<td>10</td>
<td>469</td>
</tr>
<tr>
<td>Chest pulmonary arteries with contrast</td>
<td>29-33</td>
<td>14</td>
<td>11</td>
<td>445</td>
</tr>
<tr>
<td>Abdomen and pelvis without contrast</td>
<td>29-33</td>
<td>16</td>
<td>13</td>
<td>781</td>
</tr>
<tr>
<td>Abdomen and pelvis with contrast</td>
<td>29-33</td>
<td>15</td>
<td>12</td>
<td>755</td>
</tr>
<tr>
<td>Abdomen, pelvis and kidney without contrast</td>
<td>29-33</td>
<td>15</td>
<td>12</td>
<td>705</td>
</tr>
<tr>
<td>Chest, abdomen and pelvis with contrast</td>
<td>29-33</td>
<td>15</td>
<td>12</td>
<td>947</td>
</tr>
</tbody>
</table>

References:
CT Patient Dose: External Benchmarks

- Facility compared to ACR DIR values
- Top 10 adult and pediatric exams
- Identifies outliers

<table>
<thead>
<tr>
<th>Radiation Units in Computed Tomography</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Term</strong></td>
</tr>
<tr>
<td>CT Dose Index (CTDIvol)</td>
</tr>
<tr>
<td>Dose Length Product (DLP)</td>
</tr>
<tr>
<td>Size Specific Dose Estimate</td>
</tr>
</tbody>
</table>

Box-and-whiskers Plot:
- Maximum observation
- 75th percentile (upper quartile)
- Mean
- Median
- 25th percentile (lower quartile)
- Minimum observation

Red line indicates your facility’s median value for the exam.

Your Median = x
Your Exam Count = y
CT Patient Dose: External Benchmarks

- Evaluated 5 CT exam protocols
- One exam was a significant outlier
  - Head Brain w/o

Exam Key:

1 = CT HEAD BRAIN W O IVCON
2 = CT ABDOMEN PELVIS W IVCON
3 = CT ABDOMEN PELVIS WO IVCON
4 = CT CHEST WO IVCON
5 = CT CHEST W IVCON
6 = CT C SPINE WO IVCON
7 = CT CHEST ABDOMEN PELVIS W IV
8 = CT CHEST PULMONARY ARTERIES
9 = CT NECK W IVCON
10 = CT L SPINE WO IVCON
CT Dose Case Study:
Adult Head Exams
CT Dose Case Study: Adult Head Exams

- CT protocol review committee selected adult heads
- Committee: radiologist, management, DMP and RTs
- Protocol modifications reviewed, evaluated and tested
- Sites 2, 3 and 7 are hospitals with a dedicated ED CT

![CT HEAD WO IVCON – Distribution per CT scanner, total = 1,139](chart)
CT Dose Case Study: Adult Head Exams

• Adult head w/o contrast CT protocol
  • Toshiba Acquilion One CT scanners
    • Five CT scanners total, all 4-5 years old
    • Helical scan, without mA modulation
  • Image quality reviewed/monitored by radiologist
• Achieved a target DLP of <1109 mGy-cm
  • Initial data: CTDIvol = 69.5 mGy, DLP = 1271 mGy-cm
  • Iteration 1: CTDIvol = 63.7 mGy, DLP = 1167 mGy-cm
  • Iteration 2: CTDIvol = 60.8 mGy, DLP = 1115 mGy-cm
  • Iteration 3: CTDIvol = 57.9 mGy, DLP = 1064 mGy-cm
CT Dose Case Study: Adult Head Exams

Marshfield Clinic CT4 CT Adult Head Without Contrast DLP mGy-cm (Data from: 1/1 - 5/18, 966 Exams)

- Average DLP for the 1/1 - 3/11 time period: 1271 mGy-cm
- Target DLP: 1109 mGy-cm

ACR DIR identified exam (Adult Head WO) as exceeding registry mean (852 mGy-cm + 1 Std Dev, 257 mGy-cm). MC radiology practice DLP must be below target DLP value of 1109 mGy-cm to comply with QC/DR performance requirements and benchmark values.

- Reduced Dose Initial Reduction Started 3/11
- Multiple Reduced Dose Steps Initiated and Evaluated
- Reduced Dose Final Reduction Initiated 4/20

Exam Date:

Marshfield Clinic
Don’t just live. Shine.
CT Dose Case Study: Adult Head Exams

- Adult head w/o contrast CT protocol
  - Siemens Sensation 64 and 40 CT scanners
    - Four CT scanners total, all 7-15 years old
    - Helical scan, without mA modulation
  - Image quality reviewed/monitored by radiologist
- Achieved a target DLP of <1109 mGy-cm
  - Initial data: CTDIvol = 70.5 mGy, DLP = 1354 mGy-cm
  - Iteration 1: CTDIvol = 59.9 mGy, DLP = 1172 mGy-cm
  - Iteration 2: CTDIvol = 56.4 mGy, DLP = 1108 mGy-cm
  - Iteration 3: CTDIvol = 54.9 mGy, DLP = 1080 mGy-cm
CT Dose Case Study: Adult Head Exams

Marshfield Clinic LMC CT Adult Head Without Contrast DLP mGy-cm (Data from: 1/1 - 5/18, 594 Exams)

Average DLP for the 1/1 - 3/14 time period; 1354 mGy-cm

Target DLP 1109 mGy-cm

ACR DIR identified exam (Adult Head WO) as exceeding registry mean (652 mGy-cm + 1 Std Dev, 257 mGy-cm), MC radiology practice DLP must be below target DLP value of 1109 mGy-cm to comply with QCDR performance requirements and benchmark values.

Reduced Dose Initial Reduction Started 3/14

Multiple Reduced Dose Steps Initiated and Evaluated

Reduced Dose Final Reduction Initiated 5/2

Exam Date

CT Dose Case Study:
Pediatric Head Exams
CT Dose Case Study: Pediatric Head Exams

- Comparison of reduced adult head to pediatric head protocols resulted in another optimization effort
- Adult head doses approximately the same as pediatric heads
CT Dose Case Study: Pediatric Head Exams

- Pediatric optimization effort started August 2017
- Reduced CTDIvol by 10%, infant protocol not reduced
Discussion and Conclusions
Discussion and Conclusions

- Radiation dose optimization
- JACR, October 2017
- Eric Gingold, Ph.D., Radiology Dept., Thomas Jefferson University
- How can DMP guide optimization?

- Work closely with radiologists to gradually ratchet down doses of imaging protocols that are identified as potential opportunities for optimization....
- ...essential to achieve an image noise level that radiologists feel comfortable with.
Discussion and Conclusions

• Discussion (lessons learned)
  • The DMP
    • Collect, review, evaluate and analyze data
    • Team leader and guide of optimization effort
  • The radiologist(s)
    • Clinical image quality acceptability (SNR variability)
    • Compensation, medical and legal considerations
  • The CT technologist (team lead)
    • A valuable optimization implementation resource
Discussion and Conclusions

• Conclusions (the good, bad, and ugly)
  • The good
    • Limited adult and pediatric CT dose optimization
    • Reduced Adult head DLP by 11.4% for system
  • The bad
    • Did not achieve targeted values on all scanners
    • Project “black hole” effect – time, resources, etc.
  • The ugly
    • Radiologists (one really) directed return to original parameters for three Siemens CT scanners at end of effort
Questions?