NEMA (MITA) XR-25
CT Dose-check Standard

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Outline

• Introduction to CT Dose-check
  – Need for Monitoring
  – Standard Dose Metrics
  – Goals and Definitions
  – Sample

• Clinical Implementation
  – Sources of Information
  – Developing a Workflow

• Conclusions
  – Summary
  – Future Applications
  – Conclusion


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### Radiation in CT

#### Annual Dose

**NCRP Report 93 (1987)**

- **Radon and Thoron**: 11%
- **Cosmic**: 8%
- **Internal**: 11%
- **Terrestrial**: 8%
- **Medical X-rays**: 55%
- **Nuclear Medicine**: 4%
- **Consumer**: 1%
- **Occupational**: 0.1%
- **Industrial**: 0.1%

**NCRP Report 160 (2009)**

- **Radon and Thoron**: 2%
- **Cosmic**: 5%
- **Internal**: 3%
- **Terrestrial**: 5%
- **Medical X-rays**: 37%
- **Nuclear Medicine**: 24%
- **Consumer**: 3%
- **Occupational**: 5%
- **Industrial**: 5%

#### Table: Annual Effective Dose

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radon and Thoron</td>
<td>55%</td>
<td>2.00</td>
<td>37%</td>
<td>2.30</td>
</tr>
<tr>
<td>Cosmic</td>
<td>8%</td>
<td>0.27</td>
<td>5%</td>
<td>0.34</td>
</tr>
<tr>
<td>Internal</td>
<td>11%</td>
<td>0.40</td>
<td>5%</td>
<td>0.28</td>
</tr>
<tr>
<td>Terrestrial</td>
<td>8%</td>
<td>0.28</td>
<td>3%</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>BKG</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed Tomography</td>
<td>11%</td>
<td>0.39</td>
<td>24%</td>
<td>1.50</td>
</tr>
<tr>
<td>Interventional Fluoroscopy</td>
<td>4%</td>
<td>0.14</td>
<td>12%</td>
<td>0.80</td>
</tr>
<tr>
<td>Conventional Rad/Fluoro</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>3%</td>
<td>0.07</td>
<td>2%</td>
<td>0.12</td>
</tr>
<tr>
<td>Consumer</td>
<td>0.1%</td>
<td>&lt; 0.01</td>
<td>&lt; 0.1%</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Occupational</td>
<td>0.1%</td>
<td>&lt; 0.01</td>
<td>&lt; 0.1%</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.1%</td>
<td>&lt; 0.01</td>
<td>&lt; 0.1%</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

**3.0 mSv vs. 3.1 mSv**

**0.5 mSv vs. 3.0 mSv** (6X More)

**3.6 mSv vs. 6.2 mSv Annual Effective Dose**

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WHAT WE KNOW:
• There exists a potential for radiation injury from medical imaging\(^1,2\)
• Prominent news coverage\(^3\) has led to a higher level of patient awareness that has driven the demand for greater oversight
• Dose-check, a new method of CT dose monitoring has become available

WHAT WE WANT TO DO:
• Minimize the potential for CT overdose
• Evaluate and implement vendor mandated alert value (AV) and notification value (NV) for usage in neuro radiology:
  1. Understand the new Dose-check nomenclature and definitions
  2. Introduce reasonable AV/NV into the clinical scanner (neuro)
  3. Establish a clinical workflow incorporating usage of Dose-check

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• **What is NEMA (MITA) XR-25 CT Dose-Check?**
  – Standard defined and created collaboratively between NEMA (MITA) and manufacturers

• **GOAL:**
  – Increase *active* awareness of standard CT dose metrics (CTDI\textsubscript{vol} and/or DLP)
  – Introduce tighter controls to mitigate singular over-exposure events

• **Primary Terminology**
  – ALERT VALUE (AV)
    • *Global* threshold
    • Compares: Accumulated dose index value (spatially) and the assigned AV
    • Passing AV: requires ‘AV Exceeder’ login credentials
  
  – NOTIFICATION VALUE (NV)
    • *Localized or incremental* threshold
    • Compares: Line-item (by group) estimated CTDI and the line-item NV
    • Passing NV: warning message
† Notice delineation between scan location (i.e. focal spot location) and image location (reconstructed images) – helical overscan included.
DOSE ALERT
A dose alert value will be exceeded!

<table>
<thead>
<tr>
<th>CTDIvol (mGy)</th>
<th>AV</th>
<th>Projected/Accum</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>1150</td>
<td>S2.5</td>
<td>S22.5</td>
<td></td>
</tr>
</tbody>
</table>

Logon Name: 
Password: 
Diagnostic Reason: 

ONLY CERTAIN INDIVIDUALS HAVE PRIVILEGE...

FDA recommended ALERT VALUE
<table>
<thead>
<tr>
<th>Images</th>
<th>CTDI\textsubscript{vol} mGy (NV)</th>
<th>DLP mGy\cdot cm</th>
<th>Dose Eff. %</th>
<th>Phantom cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-28</td>
<td>43.96 (50)</td>
<td>615.42</td>
<td>92.70</td>
<td>Head 16</td>
</tr>
</tbody>
</table>

Est. max Z location CTDI\textsubscript{vol}: 43.96 mGy
Projected series DLP: 615.42 mGy\cdot cm
Accumulated exam DLP: 0.00 mGy\cdot cm
CLINICAL IMPLEMENTATION
• CONSIDER THE PERSONALITY OF YOUR HOSPITAL
  – The decisions you make should match the hospital setting
    • General Hospital
    • Cancer Center
    • Trauma Hospital
    • Neighborhood Clinic

• THIS PROCESS SHOULD INVOLVE MULTIPLE CLINICAL GROUPS
  – Implementation should maximize benefits with minimal unnecessary clinical interruption
    • Physics
    • Clinical Personnel (Radiologist / Technologist)
    • Protocol Committee
    • Managerial Staff
• SUGGESTION:
  – Determine the largest ‘expected reasonable’ single cumulative dose
• Default value of AV = 1000 mGy seems reasonable at this time
• Future technology/techniques may allow decrease in AV

Image:

1. **DOSE ALERT ENCOUNTERED**
2. Contact AV Exceeder*
   - CT Managers, Physics, Attending
   * Limited, but available, access
3. Where appropriate, proceed with caution or re-assess
4. Audit Tool to follow up
Implementation

EASY

• Fixed mA
• Consistent anatomy
• Minimal number of series
• Minimal nested groups

DIFFICULT

• Modulated mA
• Largely varying anatomy
• Multi-stage acquisitions
• Multiple groups within series

Patient Variance

Clinical Workflow

Dose Awareness

VS.
Implementation

Projected CTDI Values
- Readily available (protocol dump)
- Separated by group
- Based on what? !

## ADULT HEAD 1.1 HEAD Axial NON CONTRAST

<table>
<thead>
<tr>
<th>Exam Dose Settings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ExamCtdi</td>
<td>NA</td>
</tr>
<tr>
<td>ExamDLP</td>
<td>NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series 1</th>
<th>Scout</th>
<th>HeadFirst</th>
<th>Supine</th>
<th>AutoStore Gating</th>
<th>SeriesLevel</th>
<th>Injector</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**AutoTransferPACS By Exam**

<table>
<thead>
<tr>
<th>Scan</th>
<th>kV</th>
<th>mA</th>
<th>Start</th>
<th>End</th>
<th>Plane</th>
<th>Message</th>
<th>Light</th>
<th>Timer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120</td>
<td></td>
<td>10</td>
<td>S150</td>
<td>I100</td>
<td>90</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td></td>
<td>10</td>
<td>S150</td>
<td>I100</td>
<td>0</td>
<td>0</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series 2</th>
<th>Axial</th>
<th>HeadFirst</th>
<th>Supine</th>
<th>AutoStore Gating</th>
<th>SeriesLevel</th>
<th>Biopsy</th>
<th>SmartPrep</th>
<th>Biopsy</th>
<th>Injector</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**AutoTransferPACS By Exam**

<table>
<thead>
<tr>
<th>Message</th>
<th>Light</th>
<th>Timer</th>
<th>CTDI NV</th>
<th>CTDI</th>
<th>DLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>NA</td>
<td>140</td>
<td>NA</td>
</tr>
<tr>
<td>0</td>
<td>No</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

--------------------

**Series 2 Group:**

<table>
<thead>
<tr>
<th>Group</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Series 2 Group:**

<table>
<thead>
<tr>
<th>Group</th>
<th>DFOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Message</th>
<th>Light</th>
<th>Timer</th>
<th>CTDI NV</th>
<th>CTDI</th>
<th>DLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>NA</td>
<td>43.9586</td>
<td>NA</td>
</tr>
</tbody>
</table>
Implementation

Projected CTDI Values
- Readily available (protocol dump)
- Separated by group
- Based on what? ▲

Internal Dose Metrics
- Site specific
- Cumulative DLP
- Assumed scan extent

Implementation

**Projected CTDI Values**
- Readily available (protocol dump)
- Separated by group
- Based on what? 😱

**ACR Dose Index Registry**
- Separated by protocol type
- Provides ‘max’ and ‘cumulative’

**Internal Dose Metrics**
- Site specific
- Cumulative DLP
- Assumed scan extent

---

Sample ACR DIR Report

### CT ABD

**CTDivol Per Exam**

<table>
<thead>
<tr>
<th>Summary Stats for Facility Medial Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># of Facilities</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Median</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Mean</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Min</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Max</td>
<td>87</td>
<td>87</td>
</tr>
</tbody>
</table>

### CTDivol Per Scan

<table>
<thead>
<tr>
<th>Summary Stats for Facility Medial Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># of Facilities</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Median</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Mean</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Min</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Max</td>
<td>23</td>
<td>23</td>
</tr>
</tbody>
</table>

---

![Graphs showing CT Divol statistics for exam and scan]

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20
Implementation

Projected CTDI Values
- Readily available (protocol dump)
- Separated by group
- Based on what?⚠️

ACR Dose Index Registry
- Separated by protocol type
- Provides ‘max’ and ‘cumulative’

Internal Dose Metrics
- Site specific
- Cumulative DLP
- Assumed scan extent

AAPM Recommendations†
- Simple and direct
- Simple and direct

Table 1: Notification Values recommended by the AAPM Working Group on Standardization of CT Nomenclature and Protocols

<table>
<thead>
<tr>
<th>CT Scan Region (of each individual scan in an examination)</th>
<th>CTDI\textsubscript{vol} Notification Value (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>80</td>
</tr>
<tr>
<td>Adult Torso</td>
<td>50</td>
</tr>
<tr>
<td>Pediatric Head</td>
<td></td>
</tr>
<tr>
<td>&lt;2 years old</td>
<td>50</td>
</tr>
<tr>
<td>2 – 5 years old</td>
<td>60</td>
</tr>
<tr>
<td>Pediatric Torso</td>
<td></td>
</tr>
<tr>
<td>&lt;10 years old (16-cm phantom)\textsuperscript{a}</td>
<td>25</td>
</tr>
<tr>
<td>&lt;10 years old (32-cm phantom)\textsuperscript{b}</td>
<td>10</td>
</tr>
<tr>
<td>Brain Perfusion (examination that repeatedly scans the same anatomic level to measure the flow of contrast media through the anatomy)</td>
<td>600</td>
</tr>
<tr>
<td>Cardiac</td>
<td></td>
</tr>
<tr>
<td>Retrospectively gated (spiral)</td>
<td>150</td>
</tr>
<tr>
<td>Prospectively gated (sequential)</td>
<td>50</td>
</tr>
</tbody>
</table>

\textsuperscript{a} As of January 2011, GE, Hitachi and Toshiba scanners use the 16-cm-diameter CTDI phantom as the basis for evaluating dose indices (CTDI\textsubscript{vol} and DLP) displayed and reported for pediatric body examinations.

\textsuperscript{b} As of January 2011, Siemens and Philips scanners use the 32-cm-diameter CTDI phantom as the basis for evaluating dose indices (CTDI\textsubscript{vol} and DLP) displayed and reported for pediatric body examinations.

Implementation

EASY

Projected CTDI Values
- Readily available (protocol dump)
- Separated by group
- Based on what? 🚫

ACR Dose Index Registry
- Separated by protocol type
- Provides ‘max’ and ‘cumulative’

Manual Sample
- Accurate and specific
- Time Consuming

DIFFICULT

Internal Dose Metrics
- Site specific
- Cumulative DLP
- Assumed scan extent

AAPM Recommendations†
- Simple and direct
- Simple and direct


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• RECALL: A dose notification is *not* a hard stop, the technologist *could* simply click through the window

• We have requested that the technologist get radiologist approval

• The Audit Tool tracks the conditions during dose notification

```
DOSE NOTIFICATION ENCOUNTERED

Contact active radiologist to confirm parameters and rationale

Proceed with scan after approval, document the diagnostic reason

Audit Tool to follow up
```
## Implementation

### Audit Tool

- **The Audit Tool:**
  - Allows for a protocol dump
  - Instances surpassing AV/NV
    - Protocol Number
    - Series Number
    - Notification Value
    - Projected CTDI$_{vol}$

---

### After 3 Months on One Scanner

<table>
<thead>
<tr>
<th>Instance</th>
<th>Protocol</th>
<th>NV (CTDI$_{vol}$) [mGy]</th>
<th>Projected CTDI$_{vol}$ [mGy]</th>
<th>% Diff from NV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L-spine Non-contrast</td>
<td>30</td>
<td>32.12</td>
<td>7.1%</td>
</tr>
<tr>
<td>2</td>
<td>L-spine Non-contrast</td>
<td>30</td>
<td>32.92</td>
<td>9.7%</td>
</tr>
<tr>
<td>3</td>
<td>T-spine Non-contrast</td>
<td>30</td>
<td>32.31</td>
<td>7.1%</td>
</tr>
<tr>
<td>4</td>
<td>T-spine Non-contrast</td>
<td>30</td>
<td>32.63</td>
<td>9.8%</td>
</tr>
<tr>
<td>5</td>
<td>Neck Soft Tissue w/ IV</td>
<td>50</td>
<td>59.27</td>
<td>18.5%</td>
</tr>
<tr>
<td>6</td>
<td>Neck Soft Tissue w/ IV</td>
<td>50</td>
<td>59.27</td>
<td>18.5%</td>
</tr>
</tbody>
</table>

**Average (Spine):** 8.4%

**Average (Neck):** 18.5%
CONCLUSIONS
Conclusions

Protocol Listing

Collect Current Protocol CTDI$_{vol}$
  - Protocol Level
    - Series Level
      - Group Level $\rightarrow$ CTDI$_{vol, estimated}$

Determine appropriate Threshold for Notification Value (NV)
  - Again, at group level

Re-convene with clinic, then implement staged thresholds

CLINICAL FEEDBACK
Conclusions

• Active monitoring using AV and NV is a useful, non-invasive tool in minimizing the likelihood of gross overdose (AV) and of ‘abnormal’ incremental overdose (NV).
  1. Understand the new Dose-check nomenclature and definitions
  2. Introduce reasonable AV/NV into the clinical scanner (neuro)
  3. Establish a clinical workflow incorporating usage of Dose-check

• There are a variety of resources that are available to us in setting the AV/NV; however, there is inherent difficulty in reducing this data down to the group level of the protocol

• Future Work
  – Introduce NV into more complicated protocols (abdominal, ATCM)
  – Consider modification of clinical workflow based on feedback
  – Incorporation of Size Specific Dose Estimates (SSDE)?
ACKNOWLEDGEMENTS

• Clinical & Administrative Support
  – Kalpana Kanal, Ph.D., DABR
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  – William Shuman, MD
  – Mario Ramos, RTR, CT
  – Radiologist Faculty
  – CT Technologist Staff

• GE Healthcare
  – Randy Grover
  – Robert Flye

THANK YOU FOR YOUR ATTENTION

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