Pediatric Radiation Dose Reduction during Direct Radiography Exams

Background

**Question:** What is our Xray dose to the patient?  
**Problem:** Standardized radiographic techniques within the department were not available.  
**Answer:** Unknown. Radiation dose patient received was strongly dependent on which technologist performed the exam.
Improvement Goals

1. Develop a standardized set of radiographic techniques for all technologists to use.
2. Use all technological features available in state-of-the-art equipment to manage radiation dose.
3. Radiographic techniques must result in diagnostic images for radiologists without resulting in unnecessary radiation dose.
4. Simplify the technologist’s communication with the imaging equipment.

Initial Investigation

Radiology Clinical Imaging Physicist reviewed historical:
  • Patient data
  • Radiographic techniques used by RTs
  • Image quality

Findings:
  • Significant variation in radiographic technique
  • Under utilization of control features built into x-ray equipment
  • Some images significantly elevated patient dose.
Variation in Imaging Techniques

Actual radiography exposures vs. target exposures: Single 16-year-old male patient

Exposure at detector [mG]

Patient visit number

Variation in Imaging Techniques

Actual radiography exposures vs. target exposures: Single 16-year-old male patient

Exposure at detector [mG]

Patient visit number
Variation in Imaging Techniques

The image on the right has good image quality even with a lower dose.

Highest 3.2mR

Lowest 0.5mR

6x higher dose

Measurement

Starting point for technique standardization
Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage
- **Filter thickness**
- Focal spot size
- Tube current
- Exposure time (manual, 3 factor)
- Manual or AEC mode
- Grid - Yes or No
Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage *(soft tissues)*
  - Higher
    - More scatter
    - Less image contrast
    - Less radiation dose
    - Noisier image
    - Ability to image larger patients

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Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage *(chest)*
  - Higher
    - Some scatter increase
    - Less image contrast of . . . ?
    - Less radiation dose
    - Noisier image
    - Ability to see lung lesions shadowed by bone (ribs)
Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage
- **Filter thickness**
- Most low energy x-rays attenuated
- Some high energy x-rays attenuated
- Technique must be greatly increased, to replace attenuated x-rays.

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Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage
- Filter thickness
- **Focal spot size**
  - Large
  - Less image quality
  - More maximum tube current
Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage
- **Filter thickness**
- Focal spot size
- Tube current
- Exposure time (manual, 3 factor)
  - 7 – 15 msec exposure
  - mAs required to deliver desired IR
Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- AEC mode whenever possible
  - All 3 cells
  - 1 & 3 cells
  - #2 cell only

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Console parameters

Each of the parameters below are uniquely set for the type of examination and the physical thickness of body part being imaged. This should result in good image quality at a properly managed patient radiation dose.

**Buckets programmed with:**
- Source to Image Receptor Distance
- Tube voltage
  - Filter thickness
  - Focal spot size
  - Tube current
  - Exposure time (manual, 3 factor)
  - Manual or AEC mode
  - Grid – Yes: Patient > 12 cm thick
### Sample Technique Chart

<table>
<thead>
<tr>
<th>KV</th>
<th>64</th>
<th>77</th>
<th>79</th>
<th>83</th>
<th>85</th>
<th>89</th>
<th>95</th>
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</thead>
<tbody>
<tr>
<td>mA</td>
<td>200</td>
<td>250</td>
<td>500</td>
<td>800</td>
<td>630</td>
<td>630</td>
<td>630</td>
</tr>
<tr>
<td>msec</td>
<td>10</td>
<td>12.5</td>
<td>12.5</td>
<td>16</td>
<td>40</td>
<td>80</td>
<td>160</td>
</tr>
<tr>
<td>mAs</td>
<td>2</td>
<td>3.1</td>
<td>6.3</td>
<td>12.8</td>
<td>25.2</td>
<td>50.4</td>
<td>100.8</td>
</tr>
<tr>
<td>FOCAL SPOT</td>
<td>S</td>
<td>S</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>AEC</td>
<td>OFF</td>
<td>OFF</td>
<td>AEC</td>
<td>AEC</td>
<td>AEC</td>
<td>AEC</td>
<td>AEC</td>
</tr>
<tr>
<td>SPEED</td>
<td>NA</td>
<td>NA</td>
<td>S400</td>
<td>S400</td>
<td>S400</td>
<td>S400</td>
<td>S400</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>FILTER</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>GRID</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>DOSE (γGy)</td>
<td>2x</td>
<td>1.8x</td>
<td>1.5x</td>
<td>1.4x</td>
<td>1.1x</td>
<td>1.1x</td>
<td>x</td>
</tr>
<tr>
<td>CELLS</td>
<td>NA</td>
<td>NA</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

## Technologist process

**1. Exam verification (4-Please/WWWW)**

- **NAME**
- **DOB**
- **BODY PART and SIDE**
- **REASON for EXAM**
  - **WHAT HAPPENED, WHEN, WHERE pain is, WHO provided history**

This process has been proven to prevent numerous wrong patient, wrong exam and wrong extremity errors without impacting workflow.
Technologist process

2. Measure patient
   • Select SID for requested exam
     • Important for correlating patient dose to our programmed techniques
   • Measure thickness of body part to be imaged with calipers

Measurement Process

• Measure the patient in the imaging position
  • i.e. measure both supine abdomen and upright abdomen
• Measure the thickest part of the anatomy
Inaccurate Measurement

• Accurate measurements and bucket selection are directly related to image quality.
• Tech measurement recorded as 4 using the child bucket
• PACS measurement shows it should have measured into the small bucket with a measurement of 6-7

Resulted in lower technique producing a lower quality image

Technologist process

3. Select bucket

• Select correct bucket based on measurement and technique chart

TECHNIQUE CHART

<table>
<thead>
<tr>
<th></th>
<th>NEWBORN</th>
<th>BABY</th>
<th>CHILD</th>
<th>SMALL</th>
<th>NORMAL</th>
<th>LARGE</th>
<th>X-LARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTREMITIES</td>
<td>1 cm</td>
<td>2 cm</td>
<td>3 - 4 cm</td>
<td>5 - 7 cm</td>
<td>8-10 cm</td>
<td>11-13 cm</td>
<td>14-18 cm</td>
</tr>
<tr>
<td>TRUNK</td>
<td>5-8 cm</td>
<td>9-12 cm</td>
<td>13-17 cm</td>
<td>18-23 cm</td>
<td>24-29 cm</td>
<td>30-36 cm</td>
<td>37-44 cm</td>
</tr>
</tbody>
</table>
Technologist process

4. Using standardized technique (continued)
   - Follow grid prompts
   - Position patient
   - Make exposure

5. Post imaging steps
   - Send images to PACS
   - End exam in Epic
   - Record measurement of patient size in Epic
High Level Technique Development Process

Determine necessary image quality
Determine image receptor (IR) dose required
Draft techniques, size buckets & IR Doses
Phantom testing

Techniques & IR doses verified
Train QI technologists
Limited clinical studies by QI Technologists
Techniques & image quality verified

Train coaches, perform more studies
Verify image quality
Monitor, coach, share success

Process is iterative

Communication

Coaching model:
This model enabled the team to spread new techniques quickly by spreading the word through designated coaches.

Train the trainer (See-Do-Teach)
Technologist trained one-on-one with assigned coach for 1-2 days
Acceptance Plan

• **WHY:** Techs watch physicist presentation on variation
• **FORM HABITS:** Implement abdomen measuring and Epic documentation
• **MOTIVATE:** Share results of new techniques
• **WHEN:** Communication of rollout date
• **HOW:** Techs view step-by-step video/photos
• Address barriers of:
  "I went to school to be able to do this"
  "I’m not a button pusher"
  "This is going to slow us down"
  "This dumbs down the process"

Monitor

Radiology Dose Dashboard
Sustain

Dose & Variation Reduction with Good Image Quality

Then

Now

Project Team

Keith Strauss, FAAPM, FACR, Clinical Imaging Physicist
Erin Adkins, RT (R), Radiography QI Technologist
Chris Alsip, MHA, RT (R) (CT) Former Quality Assurance & Compliance Manager
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