# 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

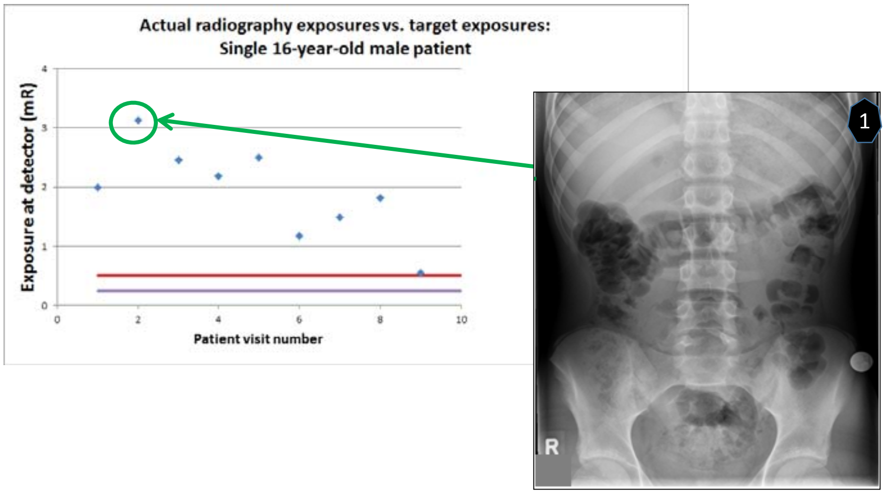
**Radiology Clinical Imaging Physicist reviewed historical:**

- 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

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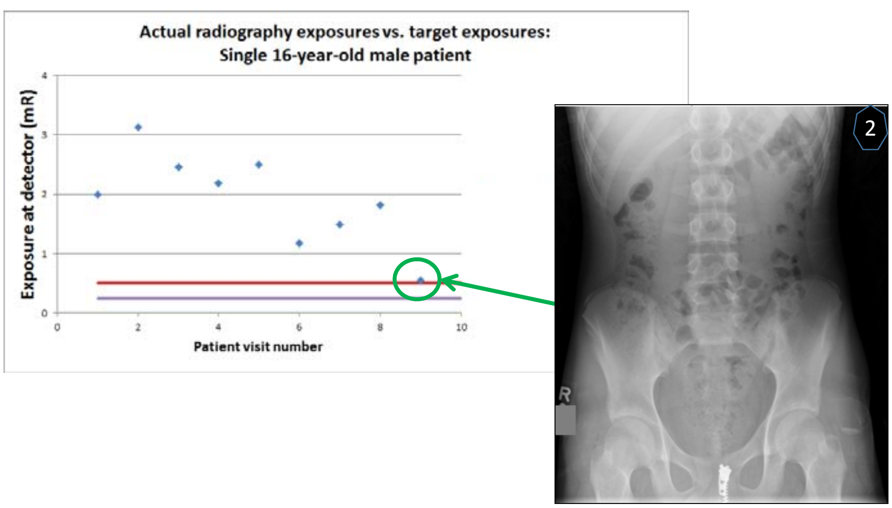
# Variation in Imaging Techniques

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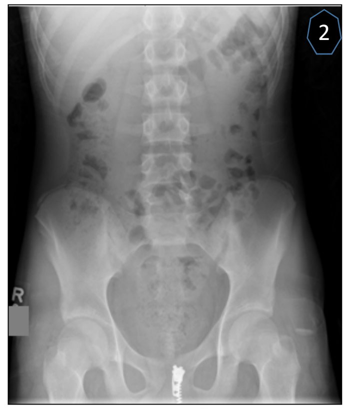
# Variation in Imaging Techniques

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

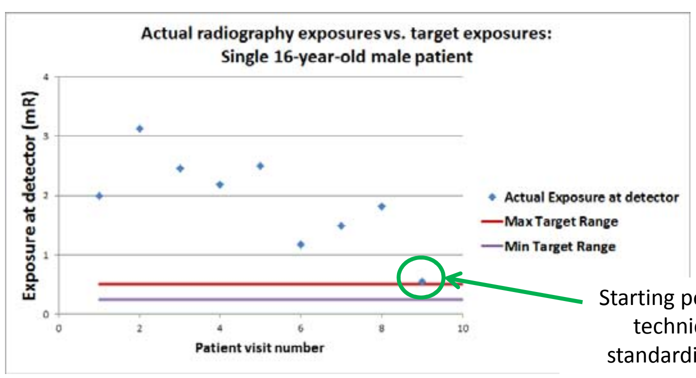
Highest 3.2mR


Lowest 0.5mR




6x higher dose

# Measurement



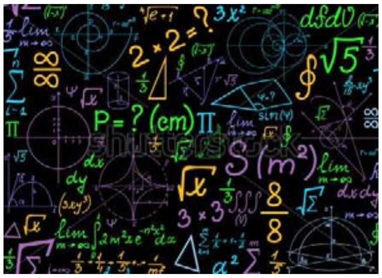

Starting point for technique standardization

# 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

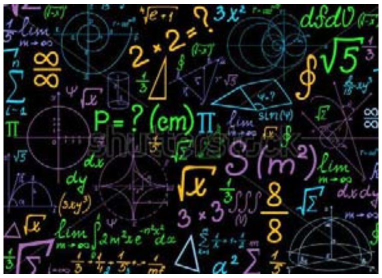


# Console parameters

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
  - 40 inch
  - 48 inch
  - 56 inch
  - 72 inch
  - 102 inch



# 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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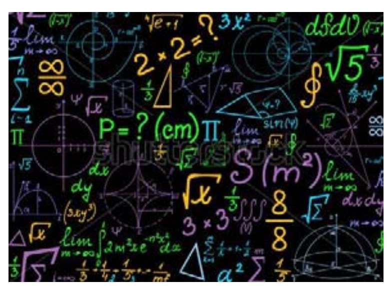
# Console parameters

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)

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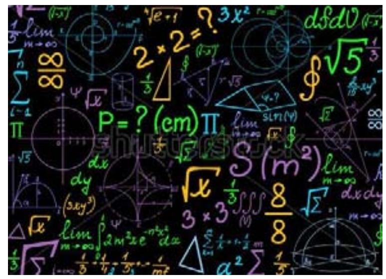
# Console parameters

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
  - 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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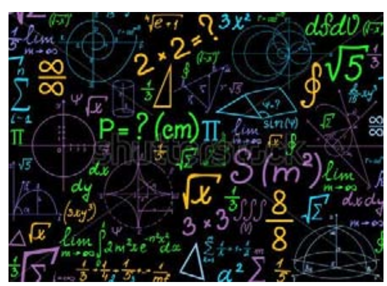
# Console parameters

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

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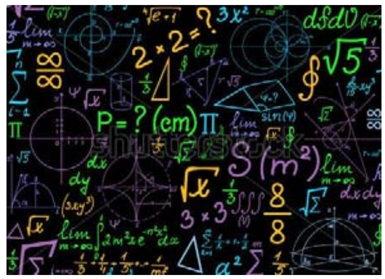
# Console parameters

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)
  - 7 – 15 msec exposure
  - mAs required to deliver desired IR

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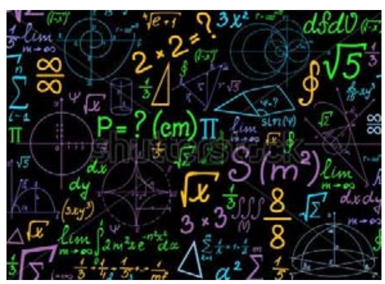
# Console parameters

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
  - AEC mode whenever possible

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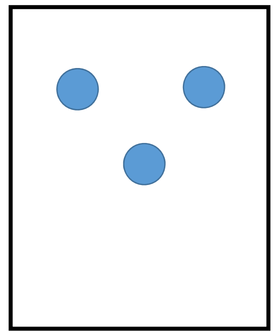
# Console parameters

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:**

- AEC mode whenever possible
  - All 3 cells
  - 1 & 3 cells
  - #2 cell only



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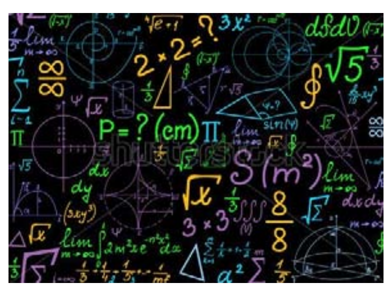
# Console parameters

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



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# Sample Technique Chart

| | Newborn | Baby | Child | Small | Normal | Large | X-Large |
|---|---|---|---|---|---|---|---|
| | 5 - 8 cm | 9 - 12 cm | 13 - 17 cm | 18 - 23 cm | 24 - 29 cm | 30 - 36 cm | 37 - 44 cm |
| KV | 64 | 77 | 79 | 83 | 85 | 89 | 95 |
| mA | 200 | 250 | 500 | 800 | 630 | 630 | 630 |
| msec | 10 | 12.5 | 12.5 | 16 | 40 | 80 | 160 |
| mAs | 2 | 3.1 | 6.3 | 12.8 | 25.2 | 50.4 | 100.8 |
| FOCAL SPOT | S | S | L | L | L | L | L |
| AEC | OFF | OFF | AEC | AEC | AEC | AEC | AEC |
| SPEED | NA | NA | S400 | S400 | S400 | S400 | S400 |
| DENSITY | 0 | 0 | 1.5 | 1 | 0 | -1 | -1 |
| FILTER | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0 |
| GRID | N | Y | Y | Y | Y | Y | Y |
| DOSE (µGy) | 2x | 1.8x | 1.5x | 1.4x | 1.1x | 1.1x | x |
| CELLS | NA | NA | 2 | 2 | 2 | 2 | 2 |

# 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.

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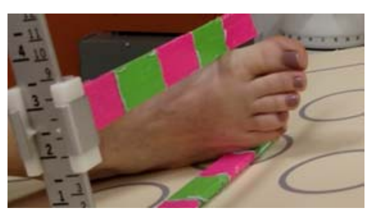
# Technologist process

**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

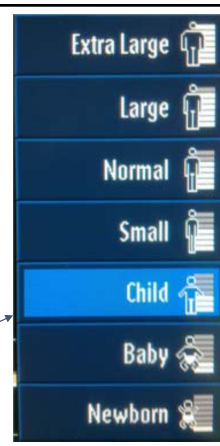
Correct

Incorrect location

# Technologist process

**3. Select bucket**

- Select correct bucket based on measurement and technique chart




**TECHNIQUE CHART**

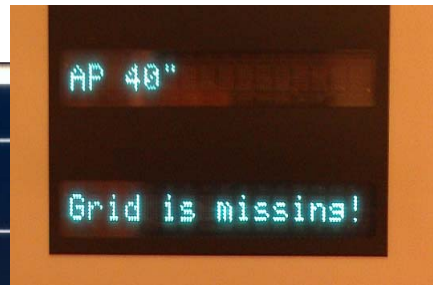
| | NEWBORN | BABY | CHILD | SMALL | NORMAL | LARGE | X-LARGE |
|---|---|---|---|---|---|---|---|
| EXTREMITIES | 1 cm | 2 cm | 3 - 4 cm | 5 – 7 cm | 8-10 cm | 11-13 cm | 14-18 cm |
| TRUNK | 5-8 cm | 9-12cm | 13-17cm | 18-23cm | 24-29cm | 30-36cm | 37-44cm |

# Technologist process

**4. Using standardized technique (continued)**

- Follow grid prompts
- Position patient
- Make exposure

On the tube head



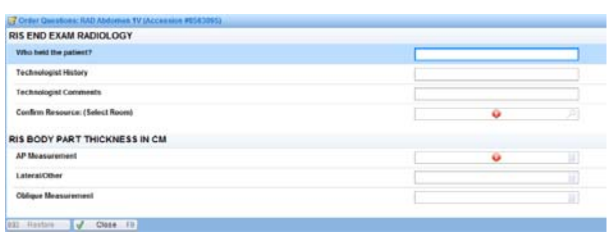


At the console

# Technologist process

**5. Post imaging steps**

- Send images to PACS
- End exam in Epic
- Record measurement of patient size in Epic



RIS END EXAM RADIOLOGY

Who held the patient?

Technologist History

Technologist Comments

Confirm Resource: (Select Room)

RIS BODY PART THICKNESS IN CM

AP Measurement

Lateral/Other

Oblique Measurement

Close

## 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*

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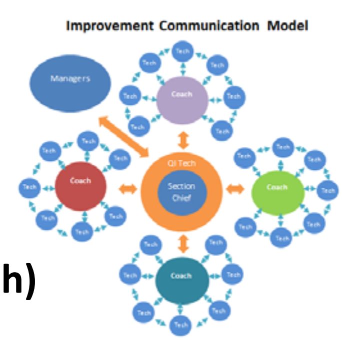
# Communication

## 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

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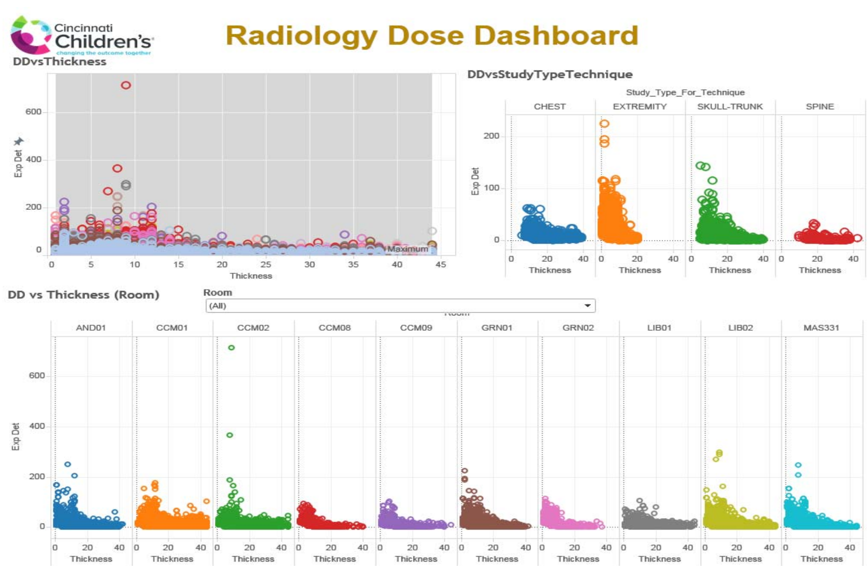
# Acceptance Plan

- **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:

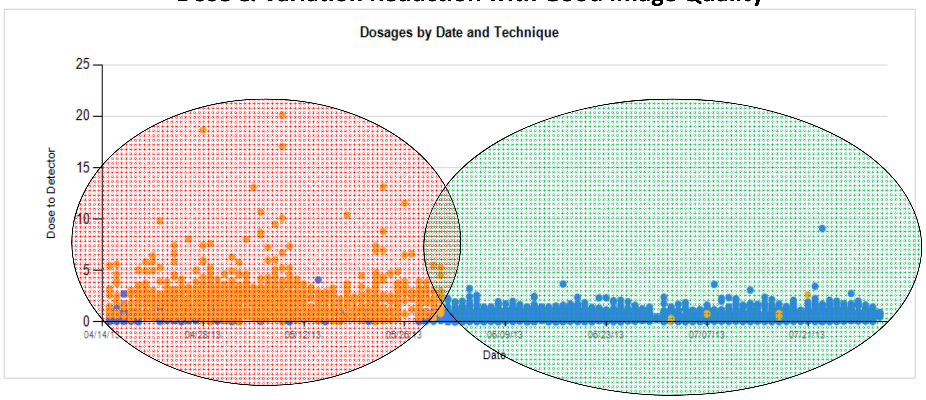
“I went to school to be able to do this”
“I’m not a button pusher”
“This is going to slow us down”
“This dumbs down the process”

# Monitor



# 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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Pavan Chundi, Analyst, Quality and Transformation
David Larson, MD, MBA, Former Quality and Safety Chair
Alan Leach, Senior Analyst, Quality and Transformation
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Susan Smith, RT (R), Radiography Manager