Patient Dose with Fluoroscopy – Evolving Tools and Technologies

William Pavlicek
July, 2014 Austin Texas
Why Track Patient Dose?
CONCLUSION: Radiation doses from commonly performed diagnostic CT examinations are higher and more variable than generally quoted, highlighting the need for greater standardization across institutions.
Tenets of Quality (Deming)

- Belief that things can be improved
- It is the process that creates variability
- A blameless environment is needed for team solutions
- People closest to the product are most able to affect quality
“Inventor” of Six Sigma
W. Edwards Deming

• Physicist PhD (Yale, 28)
• Taught engineering, physics in the 1920s
• Long career in government statistics, USDA, Bureau of the Census
• Worked with Japan post war.

W. Edwards Deming, 1900 – 1993
Individuals closest to ‘product’ most affect quality

Toyota Assembly Line worker STOPS the Line!
Operating Room – “Procedural Pause”
DOSE ALERT
A dose alert value will be exceeded!
The prescribed scan parameters result in a projected exam dose exceeding the user configured Alert Value. Select Cancel to go back to Viewedit and adjust scan parameters if clinically appropriate to set below the Alert Value. An authorized user name and password must be entered to select Confirm. Selecting Confirm will proceed to scan and log user confirmation of scan parameters exceeding the Alert Value.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>CTDIvol (mGy)</td>
<td>1000</td>
</tr>
<tr>
<td>Projected/Accumulated</td>
<td>1792.56</td>
</tr>
<tr>
<td>Start</td>
<td>12.5</td>
</tr>
<tr>
<td>End</td>
<td>537.5</td>
</tr>
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</table>

Logon Name: 
Password:
Diagnostic Reason:

Confirm  | Cancel
Toyota reduced Variation ..Improved Quality 1960s

The Motorola Six-Sigma Concept 1980 - pagers

- Motorola found disturbances cause shifts as much as 1.5 standard deviations off target.
- No process or system is ever truly stable!

* From Montgomery
"The mean never happens," — a 4-day delivery time on one order, with an awful 20-day delay on another, and no real consistency! This customers in this chart feel nothing. Their life experience hasn’t changed; one bit. The customer only feels the variance that we have not yet removed. ... Variation is evil in any customer-touching process. *

What do diagnostic medical physicists (traditionally) measure?

\[ \sigma^2_{\text{Measurement}} = \sigma^2_{\text{Repeatability}} + \sigma^2_{\text{Reproducibility}} \]
Accuracy of Air Kerma?
Accuracy of KAP?
These devices had reasonably accurate (and highly repeatable) AK and KAP!
Different Procedures/Protocols, Operator Training, Patients!
Variability with Fluoroscopy

- Different pulse and frame rate by physicians
- Different added spectral filters on device protocols
- Different behaviors of Tap and Pause
- Different behaviors of detector/table positioning
- Different size patients
Measure, Analyze and Improve!
Reduce Variability….per Patient!
Fluoroscopy Tracking

BEFORE

ALARA I
>5Gy Exceeded!
It is About People
There is No Such Thing as Operator Error

➢ It is **PROCESSES** – not **PEOPLE** that Fail.

➢ This maps to one of Deming’s 14 Points for Management: “**DRIVE OUT FEAR**”.

➢ **Focus on Processes** implies that people are not accused, but rather, that they are able to investigate processes and be “part of the solution.”

http://www.framtidenssjukvard.se/groenbok-vaard-av-idéer.aspx
http://www.1000advices.com/guru/quality_tqm_14points_deming.html

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Value with Tracking Dose?

- Patients have a ‘right’ to feel safe with x-ray exams and procedures.
- It is the process that creates variability – uncertainty of ‘being safe’
- People closest to the product/process are most able to affect quality
- *Identify and promote tools that empower operators!*
Dose Tracking
56 CT, 35 Fluoro, PET/Nucs, MR, Mammo etc. ~7 years

Tracker: Dose Tracking System Architecture

Table Positioning
Equipment Mapping
Physician Reports

Skin Dose Calculations
Equipment Calibrations
Dose Alerts

Oracle

Patient Report
Patient ID for Individual Report
Report Type
Individual
Date From: 1/1/2012
To: 9/3/2013
Modality: ALL
Department: ALL
Campus: ALL-All Camps

Generate
Three (new) Tools for Users of Fluoroscopy

- Event Geometry Review
- Table and Detector Positioning
- Tap and Pause Tool
Procedure
Positioning
NEW TOOL!

Do you get asked about positioning?

- Acquisition
- Detector
- Skin
- IRP
- Focal Spot
NEW Event Geometry Tool (Post-Procedure Review)

Available from RDSR!

Focal Spot    IRP   Skin   Detector    Acquisition

PATIENT INFO
NAME: ID: SEX: ACCESSION: DATE OF EXAM:
Number of Events: 84 Number of Acquisitions: 7
Table Position: 100%
Req Procedure: IR Angio Visceral wo+w/Flush
Cumulative Skin Dose: 711 mGy
Acq Dose: 324 mGy
Fluoro Dose: 387 mGy
Fluoro Time: 18.8 Min
Peak Skin Dose including Fluoro: 440 mGy
Skin area with more than 95% of the peak skin dose: 28 cm²

Ant   Pos
Event Geometry Tool

Excellent Table Height.

Good Detector Positioning.

Focal Spot    IRP   Skin   Detector    Acquisition

Event

PATIENT INFO
NAME:  ID:  SEX:  ACCESSION:  DATE OF EXAM:
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Ant  Pos
Possible Poor Positioning

(operators need real time!)

PATIENT INFO
Number of Events: 214
Number of Acquisitions: 17
Table Position: 0%
Req Procedure: V&IRAD
Cumulative Skin Dose: 8025 mGy
Acq Dose: 1664 mGy
Fluro Dose: 6362 mGy
Fluro Time: 74.8 Min
Peak Skin Dose: 10730 mGy
Skin area with more than 95% of the peak skin dose: 22 cm^2
Possible Poor Positioning

(operators need real time!)

Detector Too High?

Focal Spot    IRP    Skin    Detector    Acquisition

PATIENT INFO
Number of Events: 214
Number of Acquisitions: 17
Table Position: 0%
Req Procedure: V&IRAD
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New Tools for Users of Fluoroscopy

• Event Geometry Review

• Table and Detector Positioning
Real time!

- 77.1kV DSA
- 496.6mA 2f/s
- Aorta
- FL LD LOW
- 705mGy/min
- 3347Gym²
- 003.3min
- 22cm FOV
- Aorta
- FL LD LOW
- 705mGy/min
- 3347Gym²
- 003.3min
- 22cm FOV
- Positioning:
  - Table
  - Detector
New Tools for Users of Fluoroscopy

- Event Geometry Review
- Table and Detector Positioning
- Tap and Pause
Real time!

77.1kV  DSA
496.6mA  2f/s

Aorta
FL LD LOW
705mGy/min
3347Gym^2

Σ 003.3min
22cm FOV

Fluoro:
Event Time >90s
FLUOROSCOPY

Tracking Found Variability:

1. Pulse and frame rates
2. Use of Cu Filter
3. C-arm Position
4. Tap and Pause Behavior
# Review of High Exposures

## Highest Skin Exposures

From: 6/2012 to 6/2013  
Average Dose: 0.5Gy for 1,768 patients

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<tr>
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<td>7.45</td>
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<td>312.5</td>
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### ALARA I

>5Gy Exceeded!
# Review High Exposures

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*Use 7.5 not 15 pps.*
## Review High Exposures

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**Add 0.1mm Cu All procedures.**
~40% Lower Skin Dose with 0.1mm Cu!
# Review High Exposures

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**Average Dose:** 0.5Gy for 1,768 patients

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*Too LONG! Use ‘Tap and Pause’!*
## Highest Skin Exposures

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**WHAT IF?**  
+ ‘Tap and Pause’  
+ 0.1mm Cu  
+ 7.5 pps
BEFORE

Sentinel Event (15,000 mGy)

Date of IR procedure

- Radiation dose in mGy
- Yellow
- Red
- Sentinel Event

Maximum Weekly Skin Exposure

2013

Gy

Week
New Tools Can Assist (just Blind Spot warning)
Tools Do Assist!

Blind Spot Monitor!
Thank You!

I only have the key ring!