Implementing Low Dose Principles with Fluoroscopically Guided Interventional Procedures

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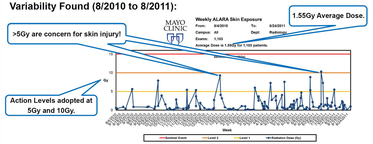
Goals: Using a dose tracking system, we created tools that provide actionable physician specific information that lowered patient dose during fluoroscopic procedures.

- Identify factors that lead to high patient skin exposures
- Empower physicians with dose savings approaches
- Leverage user specific ALARA practices as a way to ingrain a culture of safe use with fluoroscopy

1. PILOT

Between August 2010 and August 2011, a total of 1,103 fluoroscopic procedures were collected in Radiology, which was the template for baseline patient skin exposure data.

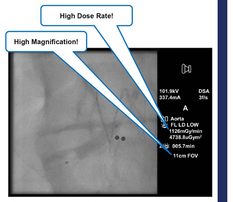
Variability Found (8/2010 to 8/2011):



The fluoroscopy process was observed in order to identify areas where skin exposure levels could be reduced while preserving image quality. Note the average dose for the 1,103 exams is 1.55Gy.

Follow up of patients resulted in 34 self reported indications of skin injury:

- Patient reported cellulitis with "peeling skin" to both lower extremities.
- Patient's wife noticed a mild redness patch 3x3 inches on patient's back.
- Patient noticed hair was falling out on left side of head.
- Patient noticed skin in lower back was sensitive to clothing.
- Patient stated itchiness in the armpit, with mild redness.
- Daughter stated dad had hair loss on left side of head.



A single frame of DSA notes:

- High exposure rate due to high magnification.
- High rate adds little image quality.
- High rate too quickly increases total exposure to actionable levels, reducing the number of minutes for safe fluoroscopy use.
- Large patient size elevates skin exposure.
- Not shown - patient positioned below the IRP (patient too close to x-ray tube).

2. DEFINE – Key ALARA Elements

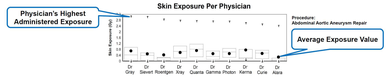
Key elements of ALARA (As Low As Reasonably Achievable):

1. Promote low fluoroscopy pulse rate as a standard (3 to 15 pps max).
2. Promote low DSA frame rate as a standard (2 to 3 fps max).
3. Physicians must use of 'Tap and Pause'.
4. Promote use of normal field of view (LIMIT high mag).
5. Collimate to area of clinical interest.
6. Use 'Fluoro Save' in lieu of a 'Digital Spot'.
7. Standardize device procedure descriptions for all fluoroscopy units.
8. Standardize technologist positioning of patient of table height at IRP.
9. Technologist announces dose at 1Gy intervals.
10. Every procedure has Cu filtration (0.1mm min).
11. Promote use of low room light level.

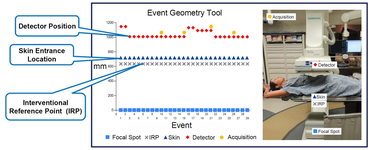
3. MEASURE – Baseline Data

TRACKER: Dose Tracking System Architecture

Thirty-two fluoroscopy units from Radiology, Cardiology, Urology, Gastroenterology, and Surgery provided 15,210 patient procedures for analysis. Dose engines calculate skin dose and provide web reports for timely, actionable use by fluoroscopists and QA review.



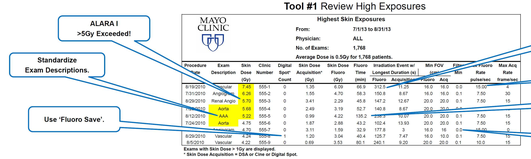
This QA tool depicts fluoroscopy use by physician by procedure.



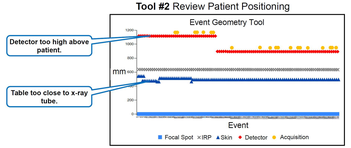
The Event Geometry Tool reports the actual position of the patient, detector and x-ray tube for every irradiation event in a procedure. All data are with the c-arm in the vertical position and the tube under the table.

4. ANALYZE – What are the opportunities for improvement?

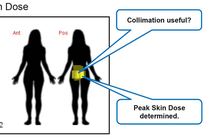
Tool #1 Review High Exposures



Tool #2 Review Patient Positioning



Tool #3 Calculate Peak Skin Dose



Three primary tools provided valuable, physician-specific information that is actionable. Improvements that reduce skin dose were put into practice.

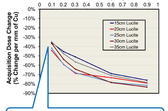
5. IMPROVE – What key behaviors were instituted?

Key Physician Practice Improvements:

1. 'Tap and Pause' is an essential behavior.
2. Fluoroscopy with 7.5pps to 10pps is suitable for all adult imaging.
3. Fluoroscopy with 2pps to 3.5pps is helpful with patients larger than 35cm and for urology procedures.
4. DSA rate of 2fps is in standard use.
5. 'Fluoro Save' is used in lieu of 'Digital Spot'.

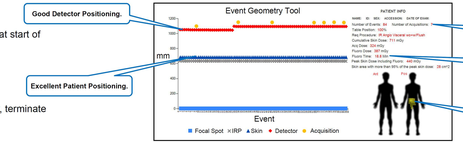
Key Fluoroscopy Device Settings:

1. Standardize tableside program names.
2. Standardize x-ray prescription per procedure.
3. Lower fluoroscopy pulse rate.
4. Lower DSA frame rate.
5. Ensure all fluoro, DSA, cine, and spot acquisitions use 0.1mm Cu minimum.
6. Incorporate audible alerts at 1, 2, and 3 Gray.

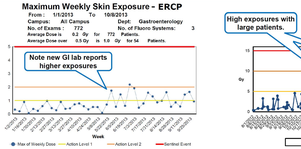


Key Technologist Behaviors:

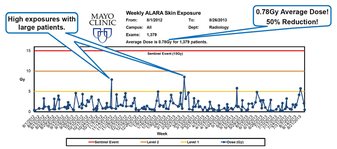
1. Standard practice of table height set to IRP at start of procedure.
2. Keep detector within 10cm of patient.
3. Collimate to area of clinical interest.
4. Contact supervisor at 1Gy reached at IRP.
5. With x-ray technologist assisted fluoroscopy, terminate fluoroscopy if monitor not being viewed.
6. Keep room light level down.



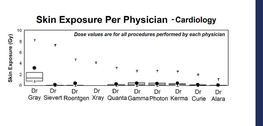
6. CONTROL – Monitoring and Implementing



GI Physician staff reduced patient skin exposure about 40%. Note new GI lab data sending to TRACKER June 1, 2013.



Noticeable decrease in skin exposures during the year post improvements. Overall, a reduction of 50%. Individual cases of high skin exposure (>5Gy) dropped from 12 to 4.



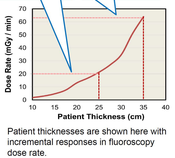
Data are for 8,311 patients having cardiac cath procedures. Physicians having the 10 highest average patient skin dose are reported.

7. CHALLENGES

Patients with Large AP Dimensions

Large patients are more likely to have high skin exposures. Large tissue thickness greatly attenuates the beam. 200 CT exams gave an average anterior-posterior (AP) dimension of 25cm.

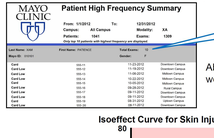
Early reaction to high skin exposure is erythema and at higher levels, moist desquamation is possible.



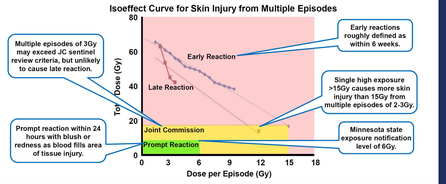
Patient thicknesses are shown here with incremental responses in fluoroscopy dose rate.

NOTE: Complicated procedures with large patients will benefit with using highly reduced fluoroscopic rates (3 to 5 fps) and 0.1mm Cu added filtration.

Patients with Multiple Episodes of Fluoroscopy



About 18% of patients undergoing fluoroscopy were found to have had a prior fluoroscopy.



KEY FINDINGS

- Patient skin dose was reduced by 50% and up to 80% by procedure and department.
- Physician acceptance of reduced frame rate, "It is about seeing what is needed; not if you can see the frame to frame jitter".
- Physician acceptance of 'Tap and Pause', rare to need more than 90sec continuous event.
- Technologist standards for patient, table, detector positioning and announcing 1Gy trigger intervals.
- Every device and procedure setting has 0.1mm Cu minimum.
- Three Tools provide the physician and technologist with actionable information.

Gordon Tannahill, Glenn Sturchio, *Impact of State of Minn Dept of Health 2008 Fluoroscopy Event Rule* presented at HPS 2013, Madison, WI

Yasaman Khodadadegan, et al. *Validation and Initial Clinical use of an Automatic Peak Skin Dose Localization with Fluoroscopic and Interventional Procedures*, Radiology, Vol 266, p246, Jan 2013.

Rodney Withers, *Biologic Basis for Altered Fractionation Schemes*, Cancer May 1 Suppl, p 2088 1985

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