Fluoroscopy Operator Training for Colorado Healing Arts Facilities

Module 6: Patient Dose Reduction Strategies

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The Joint Commission has mandated that any patient dose from a fluoroscopy case that exceeds 1,500 rads be treated as a Sentinel Event with all the associated follow-up by the facility where it occurred. In order to comply, some form of patient dose monitoring and reporting must be in place by the facility.

Joint Commission Sentinel Event

- In 2006, The Joint Commission revised its list of reviewable sentinel events
- The list now includes, “Prolonged fluoroscopy with cumulative dose >1500 rad to a single field…”
- Implicit in this is having a mechanism to know if 1500 rad has been reached
The 1994 FDA advisory concerning fluoroscopy recommended dose rates be measured and modified, if needed, to avoid skin injuries to patients.

FDA Fluoroscopy Advisory

- Published in 1994 following first reports of significant injury
- Major recommendations
  - Establish standard operating procedures
  - Modify procedures as appropriate to limit cumulative skin dose
  - Know radiation dose rates
  - Enlist qualified medical physicist to assist
Fluoroscopy operators must understand the factors that affect fluoroscopy dose rates and how to best control them.

Know Your Dose Rates

- They vary substantially with patient habitus and imaging geometry
- The difference in patient entrance exposure rate between a 20 cm patient and a 30 cm patient is a factor of 2 or more
- Oblique angles can increase the dose rate by a factor of 2 or more
While patient size is not under the operator's control, it is a factor that greatly affects fluoroscopy dose rates and thus must be considered by the operator. Patient dose increases dramatically with increasing patient thickness so the operator must be more observant of dose indicators to avoid causing a skin injury to the patient.
While tube angulation is desirable for certain imaging views and also for "spreading" the radiation dose to various skin areas, fluoroscopy operators should keep in mind that effective patient thickness is increased. Hence, oblique and lateral views can lead to much higher dose rates than would PA views on the same patient.
An example of dose rates to different size patients representing a realistic range of thicknesses. As you can see, the entrance dose rate to patients can differ by a factor of ten or more due to a combination of increased patient thickness and geometrical factors (entrance skin closer to x-ray source)!

Be aware of your dose rates!
With most, but not all, fluoroscopy systems, an increase in electronic magnification will result in a significant increase in dose rate as well. While magnification is sometimes needed during a case, it should not be overused.

Magnification

- Each increase in magnification increases exposure rate, typically, by 50-100%
- As magnification increases, the FOV decreases
- A decrease in FOV means that the exposure rate at the image receptor must increase to maintain noise level
Fluoroscopy system operators should be aware that during archival ("cine") imaging, the exposure rates are much higher than during fluoroscopic imaging. Thus, archival imaging should not be overused. It is quite possible to deliver high patient skin doses during a case where fluoroscopy times are relatively low.

Archival Imaging

- In Cardiology, cine runs tend to have exposure rates 5-10 times higher than fluoroscopic exposure rates
- Digital images can have entrance exposures up to 500 mR per image
Limiting Dose Through Geometry

- Use the LONGEST Source to Image Receptor Distance (SID) available by moving the patient AS FAR FROM THE X-RAY TUBE as possible
- Move the patient AS CLOSE TO THE IMAGE RECEPTOR as possible
Patient dose rates can be reduced by moving the patient and image receptor further from the x-ray tube. In this example, moving the patient and image receptor just 10 cm further from the x-ray tube reduces the dose rate to the patient by 20%.
Dramatic reductions in dose rates can be achieved by moving the image detector as close to the patient as possible. Even relatively small gaps between the patient and detector can mean big dose rate savings.

In this example, a 20 cm gap results in an 80% increase in patient dose rate.

It is always good practice to keep the image detector as close as possible to the patient!
Increasing the filtration in the beam is an effective method of increasing the average energy of the x-rays and thus can reduce the dose to the patient.

**Filtration**

- Many systems now can add Cu or other metal filtration to the beam
- Many do this automatically
- Filter low energy photons from the beam that would only contribute to patient dose
- May see higher generator techniques, but patient dose is still lower
When involved with longer cases, changing the view angle can effectively "spread" the dose to different areas of the patient's skin and avoid skin injuries. One must be careful to avoid overlaps where dose would continue to add to the same area of skin.

View Angle

- If possible, change view for longer cases
- Avoid overlap
- Limits maximum dose to any particular skin location
The fluoroscopy operator must understand the fluoroscopy unit's dose saving features and use them to keep dose ALARA. The clinical goal(s) of the exam may allow the operator to conduct the procedure with a lower dose rate, even though the resulting image may contain more noise.

**System Settings**

- Many systems have exposure rate controls (low, medium, high)
- Use the lowest dose mode available to yield the required image quality
- Many procedures can tolerate higher noise than others
Many fluoroscopy units allow operation in a pulsed mode. If the exam does not need to track rapidly moving anatomy, a lower pulse rate can be used to reduce patient dose.

**Pulsed Fluoroscopy**

- Pulsed fluoroscopy turns the x-ray beam on and off rapidly a specified number of times per second
- Conventional (continuous) fluoroscopy leaves the beam on as long as the pedal is engaged
- Image is refreshed at 30 frames per second
- The eye integrates the pulses to form the moving image
Operating fluoroscopy units in pulsed mode not only can result in significant patient dose reduction, but can also give better image quality due to the fact that the exposure rate per pulse is often higher than when using continuous fluoroscopy mode.

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Pulsed Fluoroscopy

- The exposure rate of each pulse is higher than conventional fluoroscopy, but lasts for only a small fraction of a second
- Properly implemented, pulsed fluoroscopy can yield significantly lower dose, or better image quality at the same dose
CDPHE regulations now require all fluoroscopy units to provide a Last Image Hold feature. This allows the operator to view the last fluoro frame rather than have to maintain an exposure to the patient. In some systems, the last several fluoro image frames are summed, resulting in a superior quality image for viewing.

Last Image Hold

• All modern equipment offers Last Image Hold (LIH)
• The last fluoro frame is held on the monitor, limiting the amount of live fluoro required
• On many systems, this is not the default mode and must be selected
Unless the operator is following anatomic motion or the progress of a catheter, tapping the expose pedal to periodically refresh the displayed image rather than using continuous fluoro is a very effective method of managing overall patient dose.

STEP LIGHTLY!

Time

- Limit the amount of fluoroscopy time used
- Do not engage the pedal unless the live fluoro image is required at that moment
- Step Lightly (www.imagegently.org)
Modern fluoroscopy equipment display an estimate of the patient exposure rate and cumulative exposure. These meters are sometimes called DAP (Dose Area Product) meters and can give the fluoroscopy operator a real-time indication of patient skin dose. Many facilities use the data from these meters to determine if a patient has received a significant skin dose.

Exposure Rate / Exposure Area Product Indication

All equipment manufactured after June 10, 1996 are required to display, visible to the operator:

- the fluoroscopic exposure rate
- the cumulative exposure (often presented as the exposure area product)

Older systems can be retrofitted to provide this
In order to be aware of potentially high patient doses, each facility should establish action levels for notification and action. These procedures can help ensure proper use of equipment and may lead to improvement in patient care during and after fluoroscopy procedures.

Action Levels

- Each facility should establish action levels for cumulative exposure
- Main purpose is to ensure appropriate patient care
- May also find areas to improve use of the equipment
In summary, managing patient radiation dose is the responsibility of the fluoroscopy operator. While patient size is a major dose confounding factor, there are many tools available to the fluoroscopy operator to maintain dose levels well below skin injury thresholds. The fluoroscopy operator must understand these dose control factors and know to use them for each piece of equipment used. In addition, the fluoroscopy operator should be aware of the dose rates they are likely exposing the patient. Action levels should be in place and reporting methods instituted to identify potential skin injuries so that follow-up patient care is possible.