KEY POINTS

- **Fluoroscopy time** is **not correlated** with PSD and **should not be used as a primary dose metric** if other metrics are available.

- $P_{KA}$ is most closely related to the risk for **stochastic effects**. It is **not a good predictor of the PSD** unless the X-ray field size is known.

- $K_{a,r}$ is the **preferred** dose metric for fluoroscopy.

- The **relationship** between $K_{a,r}$ and PSD is **influenced** by factors such as procedural geometry and technical factors. It is not necessarily 1:1.

---

Preferred dose metrics

The different dose metrics available have different uses related to fluoroscopy. These uses are highlighted in the table on this slide.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Setting notification levels/SRDL</th>
<th>Assessing risk of skin injury</th>
<th>Estimating effective dose</th>
<th>Estimating occupational dose</th>
<th>Quality improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoro time</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>****</td>
</tr>
<tr>
<td>$P_{KA}$</td>
<td>++</td>
<td>++</td>
<td>***</td>
<td>****</td>
<td>****</td>
</tr>
<tr>
<td>$K_{a,r}$</td>
<td>****</td>
<td>***</td>
<td>++</td>
<td>++</td>
<td>****</td>
</tr>
<tr>
<td>PSD*</td>
<td>****</td>
<td>****</td>
<td>**</td>
<td>**</td>
<td>****</td>
</tr>
</tbody>
</table>

*Most fluoroscopes do not currently report the peak skin dose (PSD). This capability may become more widespread in the future.
A three-pronged approach to patient safety

Patient safety should be considered in all phases of a fluoroscopically guided procedure — before the procedure, during the procedure, and after the procedure. Simple actions can be taken during each phase of the procedure to increase patient safety. These phases and actions will be discussed in detail in this section.

More information about patient safety programs, including some of the forms discussed in this module, can be found in Quality initiatives: Establishing an interventional radiology patient radiation safety program.*


KEY STEPS: PRE-PROCEDURE

• Educate and privilege users of fluoroscopy.

• Include information about potential tissue effects when consenting patients for potential high-dose procedures.

• Identify high-risk patients and modify the procedure appropriately.

• Use available information to plan the procedure.
Timing of serial irradiations of the same site

Sufficient time* for repopulation of skin cells should be allowed between irradiations of the same skin site.

<table>
<thead>
<tr>
<th>Procedure 1 dose (Gy)</th>
<th>Suggested waiting time before Procedure 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10 Gy</td>
<td>4-6 weeks</td>
</tr>
<tr>
<td>&gt; 10 Gy</td>
<td>8-12 weeks</td>
</tr>
</tbody>
</table>

The Joint Commission, in their FAQ† following their classification of radiation overdose as a reviewable sentinel event, requires that doses from procedures irradiating the same skin site be summed if they have occurred within 6 months to 1 year. Therefore, it may be advisable to examine a patient’s medical history beyond 12 weeks prior.


KEY STEPS: INTRA-PROCEDURE

- Have reduced dose exam sets available for use for high-risk patients.
- Configure notification levels to monitor the use of radiation during procedures.
- Practice situational awareness and be on the lookout for unsafe situations when they exist.
KEY STEPS: INTRA-PROCEDURE

- The **projected size** of the X-ray field on the **patients’ skin** is the **major factor** that determines whether or not C-arm rotation is **beneficial**
- The **projected field** is affected by the **FOV** selected by the operator, **collimation**, and the **distance of the patient from the X-ray source**

### Notification levels by lab/fluoroscope type

Differences in notification levels reflect differences, technical and geometric, in how fluoroscopically-guided procedures are performed. A number of factors influence the ratio of peak skin dose (PSD) to $K_p$: procedural geometry, backscatter, and attenuation by the patient support and pad.

Each notification level should involve a procedural pause and communication of the radiation dose status to the operator.

<table>
<thead>
<tr>
<th>Lab/fluoroscope type</th>
<th>Typical ratio of PSD/$K_p$*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular/interventional radiology</td>
<td>1.0</td>
</tr>
<tr>
<td>Cardiac catheterization</td>
<td>1.3-1.4</td>
</tr>
<tr>
<td>Interventional neuroradiology</td>
<td>1.0-1.3</td>
</tr>
<tr>
<td>Mobile C-arm</td>
<td>1.0-1.5</td>
</tr>
</tbody>
</table>

*Note: These ratios are **typical** ratios for a **PA** projection only.*

Copyright © 2016 FluoroSafety. All Rights Reserved.
Setting notification levels – a clinical example

<table>
<thead>
<tr>
<th>$K_{sa}$ notification level (mGy)</th>
<th>Corresponding PSD (mGy)</th>
<th>Suggested action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,500</td>
<td>2,500</td>
<td>Verify Good Practice is being used.</td>
</tr>
<tr>
<td>5,000</td>
<td>5,000</td>
<td>Substantial radiation dose level. Flag patient for f/u. Measure and record table height.</td>
</tr>
<tr>
<td>7,500</td>
<td>7,500</td>
<td>Verify Good Practice. Re-evaluate risk/benefit pace of procedure, entering range of potential skin injury.</td>
</tr>
<tr>
<td>10,000</td>
<td>10,000</td>
<td>Verify Good Practice. Re-evaluate risk/benefit pace of procedure. Skin injury more likely.</td>
</tr>
</tbody>
</table>

*And every 1,000 mGy above 10,000 mGy. These notification levels are for illustration purposes only and the numbers are approximate.

The use of a non-isocentric geometry means that PSD is often similar to $K_{sa}$ for VIR procedures.

KEY STEPS: POST-PROCEDURE

• Establish **Substantial Radiation Dose Levels (SRDL)**.

• **Record available dose metrics** at the conclusion of a procedure.

• **Initiate** an appropriate **follow-up protocol** when the **SRDL is reached or exceeded**.
SRDL recommended in NCRP Report 168

<table>
<thead>
<tr>
<th>Metric</th>
<th>SRDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSD</td>
<td>3 Gy</td>
</tr>
<tr>
<td>$K_{a,r}$</td>
<td>5 Gy</td>
</tr>
<tr>
<td>$P_{KA}^*$</td>
<td>50,000 cGy-cm²</td>
</tr>
<tr>
<td>Fluoroscopy time†</td>
<td>60 min</td>
</tr>
</tbody>
</table>

* $P_{Ka}$ depends strongly on X-ray field size, which should be considered as a factor
† The mix of fluoroscopy and acquisition used during a case is highly variable

---

Characteristics of radiation injury

For an observed skin reaction to be considered as possibly being radiogenic, several characteristics of radiation injury should be present*:

- High absorbed dose to the skin, with the X-ray beam fixed mainly on the affected site
- Affected site corresponds with the entrance site of the X-ray beam, and not the exit site
- Temporal progression of the injury matches with known timelines of radiation injury†
- Shape of the injury is consistent with the collimated size and shape of the X-ray beam, with consideration given to movement of the C-arm and patient table during the procedure

Management of radiation injury

It is important that suspected radiation injuries not be biopsied. A biopsy of the affected skin site will likely result in a non-healing wound that can initiate further skin breakdown or lead to infection.

A patient with a suspected radiation injury should be referred to a radiation oncologist. Radiation oncologists have experience managing late radiation effects in the skin.

The radiation oncologist may prescribe a number of treatments, including:

- Steroids
- Vitamin E
- Silvadine cream
- Other topical treatments
- Skin grafts may be required in cases of severe radiation injury

KEY POINTS

- Use recorded dose metrics to drive the quality improvement process in fluoroscopy.

- Advisory data sets (ADS) can be established within a healthcare system, or published data can be used instead.

- Facility data sets (FDS) should be compared regularly to ADS, and areas for improvement identified.
The “Tetrad”
The four most important things to remember before starting a fluoroscopic procedure

Raise the patient table to the highest comfortable working height

Lower the image receptor as much as practicable

Take one step back away from the fluoroscope

Collimate the X-ray field to the area of interest

Also, don’t forget to check the reference air kerma ($K_{a,r}$) occasionally!
Dose Reduction Opportunities from the Advanced Training Program on the Safe Use of Fluoroscopy

1. Maintain the patient as far as practicable from the X-ray source. This means raising the patient support to the highest comfortable working level.
2. Maintain the image receptor as close to the patient as practicable.
3. Always use the spacer cone.
4. Use a PA projection whenever possible. Lateral and oblique projections increase patient and operator dose.
5. Remove the grid when performing procedures on small patients (less than 50 lbs).
6. Use the least amount of magnification necessary to perform the procedure.
7. Always collimate to the anatomical area of interest.
8. Use pulsed fluoroscopy instead of continuous fluoroscopy. Ensure that the pulse rate in fluoroscopy mode and the frame rate in acquisition mode are as low as practicable.
9. Become familiar with the vendor-specific dose reduction features of your fluoroscope.
10. Pregnant and pediatric patients require special consideration. Use the pregnant and pediatric patient checklists included in this booklet on every patient, every time.
Pediatric patient checklist

☐ Anti-scatter grid removed if patient weighs less than 50 lbs.
☐ If available, reduced dose pediatric program selected, including pediatric AEC control curve
☐ Lowest practicable fluoroscopic pulse rate and DSA frame rate selected
☐ Use of digital acquisition restricted or eliminated, use Store Monitor/Store Fluoro
☐ Patient as far from X-ray source as practicable
☐ Image receptor as close to the patient as practicable
☐ Lowest magnification practicable selected
☐ X-ray beam collimated tightly to area of interest
Pregnant patient checklist

☐ Apron positioned on X-ray tube side of patient to identify the level of the conceptus
☐ Conceptus maintained outside FOV
☐ Lowest practicable fluoroscopic pulse rate and DSA frame rate selected
☐ Use of digital acquisition restricted or eliminated, use Store Monitor/Store Fluoro
☐ Patient as far from X-ray source as practicable
☐ Image receptor as close to the patient as practicable
☐ Lowest magnification practicable selected
☐ X-ray beam collimated tightly to area of interest