



# Patient Dose Calculation: Fluoroscopy and Interventional Radiology

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## Relevant Conflicts of Interest



**Paid Speaker, Bayer**



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## Who Do We Need to Monitor

- Radiology
- Cardiology
- Interventional Endoscopy
- Pain Medicine
- Speech Language Pathology
- Surgery
- List is longer than this



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### Relative Dose Rule-of-Thumb

- 1 min of Cine = 10 min of fluoroscopy
- 1 min of DSA = 30 min of fluoroscopy
- Your mileage may vary



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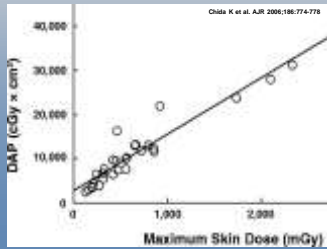
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### DAP/KAP/Area Dose Product

- Total Energy Delivered
  - Best for Effective Dose
- Correct to get field size at patient entrance
- Dicom in  $dGy \cdot cm^2$ 
  - Maybe



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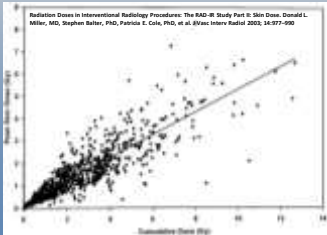
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### $K_{a,r}$ /CD/CAK

- Air Kerma at IRP
- No Backscatter
- Best Correlation with Peak Skin Dose



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**Dose**

- PSD
- 60%

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**Dose Report Sheets**

- Several automated and semi-automated methods currently under construction
- Tedious to try to do it all by hand

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**Relevant DICOM Tags**

- DICOM compliance is the Wild West for IR/Fluoroscopy
- Information missing or wrong
  - Especially outside radiology/cardiology

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## Assumptions

- Backscatter
  - Backscatter from patient
- Air Kerma
  - Patient position relative to IRP
  - Display vs. Measured
- Attenuation/Forward Scatter
  - Table and pad
- Air to Tissue Conversion
- Geometry



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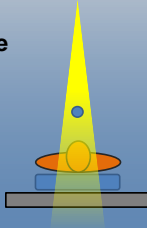
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## Geometry

- IRP
  - 15 cm from iso towards tube
    - . . . most of the time
  - 30 cm thick and set at isocenter



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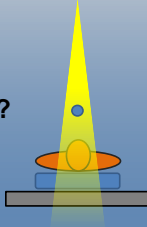
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## Geometry

- Correct for real skin position
  - Inverse square
- Where is the skin position?
  - Table position



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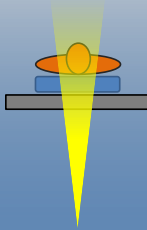
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## Table Attenuation/Forward Scatter

- 0.6 to 0.8 CF
  - Measured?
- Forward Scatter
  - 1.05 – 1.09



Vijayan, S., Xiong, Z., Guo, C., Trowille, J., Islam, N., Rudin, S., & Bednarek, D. R. (2018). Calculation of Forward Scatter Dose Distribution at the skin entrance from the patient table for fluoroscopically guided interventions using a pencil beam convolution kernel. *Proceedings of SPIE--the International Society for Optical Engineering*, 10573, 1057363. <http://doi.org/10.1117/12.2294920>

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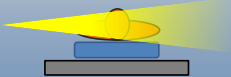
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## Table Attenuation/Forward Scatter



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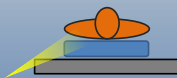
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## Table Attenuation/Forward Scatter



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### When In Doubt . . .

- Put a phantom on the table with a dosimeter and see what you get for similar settings and number of images.
- Fill in unknowns with “typical” for a procedure type

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### When In Doubt . . .

- Group similar angles together and use cumulative values if calculating by hand



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### What We Do Not Know

- Wedges and compensation filters are likely not accounted for
- Lateral and longitudinal patient table motion not accounted for
- Patient motion not accounted for
- Heal effect not accounted for



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## What We Do Not Know

- Error bars exist on every measurement
- Reports likely should include uncertainty



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## The Law



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## Old Joint Commission

The Joint Commission recently added two new items to its list of criteria that are responsible under its Sentinel Event Policy:

- *Excessive patient falls (18 or more times)*
- *Prolonged, Complicated, or fatal events with normal care dose, >1000 units in a single field or any delivery of radiation to the wrong region or >25% above the planned dose.*

- How long?
  - 6 mo . . . Maybe
  - Dose tracking programs . . . If you can get them working



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# New Joint Commission

## Ambulatory Buzz

By [Michael Kuczyk, Executive Director](#), Ambulatory Health Care

Information on all things ambulatory from The Joint Commission

[A Previous Blog Posting](#)

**Provide Fluoroscopy Services? You Need to Know About These New Requirements**

[For US, 2018 JCI Updates](#)

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# New Joint Commission

- 13. For organizations that provide fluoroscopic services: The reference air kerma, cumulative air kerma, or kerma-area product are documented in a retrievable format. For fluoroscopy equipment that is not designed to display reference air kerma, cumulative air kerma, or kerma-area product, fluoroscopy time and number of images acquired are documented in a retrievable format, such as a paper printing and communication system.
- 39. For organizations that provide fluoroscopic services: The organization reviews and analyzes incidents where the reference air kerma, cumulative air kerma, kerma-area product, or fluoroscopy time exceeded expected ranges identified in fluoroscopy imaging protocols. For fluoroscopy equipment that is not designed to display reference air kerma, cumulative air kerma, or kerma-area product, only fluoroscopy times that exceeded expected ranges are reviewed and analyzed by the organization. (See also PC.02.01.01, EP 36)
- For fluoroscopy: Expected ranges for the reference air kerma, cumulative air kerma, kerma-area product, and fluoroscopy time. For fluoroscopy equipment that is not designed to display reference air kerma, cumulative air kerma, or kerma-area product, expected ranges for fluoroscopy time are addressed in protocols.
- 20. For organizations that provide fluoroscopic services: The organization establishes criteria for patient follow-up to assess for adverse reaction effects when the reference air kerma, cumulative air kerma, kerma-area product, or fluoroscopy time exceeded expected ranges identified in fluoroscopy imaging protocols. (See also PC.02.01.01, EP 32)

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# Internal/Regulatory

- 21 CFR 803
  - Report serious injury from a device
  - Unless it is unlikely to happen again

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21 CFR 803.10 (b)(1) When the injury or illness that:
(i) Is life-threatening,
(ii) Results in permanent impairment of a body function or permanent disfigurement to a body
member, or
(iii) Results in hospitalization or requires medical attention beyond the immediate treatment of a body
function or permanent disfigurement to a body member, permanent impairment of a body
function, or hospitalization or requires medical attention beyond the immediate treatment of a body
function, the manufacturer, importer, or distributor, including foreign manufacturer, importer, or
distributor, shall report the injury or illness to the FDA, including the following information:

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## CMS

**For Information Only - Not Applicable to the CDR**

Regulated are encouraged to also address the following when Radiation Services:

- The training, clinical level and other qualifications with privileges to carry out high quality medical procedures that reduce learning radiation to consider health, safety and risk of the patients
- Recording and tracking the dose per beam number. There are several methods recognized – good reference programs developed in order to be able to use resources in developing and maintaining the data including, but not limited to:
  - The University of Utah in Prostate Imaging (Prostate2.org)
  - The Commission on Radiation Control Program Document
  - The American College of Radiology (acrr.org/rt/rt-dose.html) or acrr.org
  - The National Evaluation of X-ray Trends (NET program)

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## States: Ohio

44. Holders of fluoroscopic equipment used for interventional or similar procedures on an patient or inpatient patients shall maintain a record of:

- (a) Cumulative air kerma or dose area product used for each examination, if the display of either is available on the fluoroscopic equipment; or
- (b) The following items if the cumulative air kerma or dose area product is not:

**Maintain records of  
Fluoroscopic  
(3701:1-66-07 (B)(4))  
Patient Dose**

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## States: Texas

25 TEXAS ADMINISTRATIVE CODE  
§299.127  
Use of Radiation Machines in the Healing Arts

**Fluoroscopic  
(289.227(m)(9)(D))  
Patient Dose**

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- Miller DL, Balter S, Cole PE, et al. Radiation Doses in Interventional Radiology Procedures: The RAD-IR Study Part I: Overall Measures of Dose. J Vasc Interv Radiol 2003; 14:977-990.
- Miller DL, Balter S, Cole PE, et al. Radiation Doses in Interventional Radiology Procedures: The RAD-IR Study Part II: Skin Dose. J Vasc Interv Radiol 2003; 14:977-990.
- Jones AK and Pasciak AS. Calculating the peak skin dose resulting from fluoroscopically guided interventions. Part I: Methods. JACR 2011; 12(4): 231-244.
- Jones AK and Pasciak AS. Calculating the peak skin dose resulting from fluoroscopically guided interventions. Part II: Methods. JACR 2011; 13(1): 174-186.

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## Cite This Talk/Handout

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NASA Earth Observatory (Public Domain)



**Thank  
You!**

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