Estimating the peak skin dose resulting from FGI

A. Kyle Jones, Ph.D.
Assistant Professor
MD Anderson Cancer Center
Disclosure

• I am a co-owner and co-founder of Fluoroscopic Safety, LLC, a company that provides online educational materials for didactic training of users of fluoroscopy
Learning objectives

1. Learn how to find data related to peak skin dose
2. Learn how to use these data to estimate the peak skin dose resulting from a fluoroscopically guided intervention (FGI)
3. Learn how to measure peak skin dose directly
SOURCES OF INFORMATION
Sources of information

• DICOM header
• Proprietary dose report
• DICOM Radiation Dose Structured Report (RDSR)
• Machine-reported metrics
  – DAP, $K_{a,r}$, fluoro time
• Interviews with care providers
The DICOM header

- The DICOM header contains the *metadata*, information describing the image and how it was acquired/processed.

- The DICOM header is used by PACS systems and other viewers to calibrate distance, render grayscale, etc.
Accessing the DICOM header

• Most PACS systems allow the user to view the DICOM header (metadata)
  – Some tags (esp. private) may not be displayed
  – Tag names are often displayed, this is helpful
• Freely-available software can be used to view the header
  – Often displays private tags
  – Examples include
    • ImageJ
    • Osirix (FDA-approved versions not free)
• High-level programming languages often display the most information
  – Matlab
  – IDL
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Interpreting the DICOM header

• Once we have figured out how to access the header and the information contained within, we have to figure out what it means
• Tag names give some clue, but often not enough information
• There are two sources of information that are valuable
  – DICOM standard
  – Manufacturer’s DICOM Conformance Statement
The DICOM Standard

- http://www.dclunie.com/dicom-status/status.html
- David Clunie’s website is often easier to navigate/interpret, and in the end links to the NEMA ftp server
  - Also contains links to all supplements
## Base Standard - 2011

### Release Notes

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<th>Title</th>
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### Differences in Base Standard - 2009 to 2011

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The DICOM Standard

- Part 3: Information Object Definitions
- Gives tag names, descriptions, and units for required and optional tags
The DICOM Conformance Statement

• Manufacturers of medical imaging equipment provide a DICOM Conformance Statement that describes how their equipment complies with the DICOM standard
• Tag names, descriptions, and units for private tags are also provided
• Be sure to download the conformance statement that applies to your software version
Disclaimer

• The information contained in the DICOM Conformance Statement is not always correct
  – And information stored in the DICOM header does not always comply with the DICOM standard

• Positions
  – E.g., table position

• Units

• When acceptance testing a new piece of equipment, verify key pieces of information that you will be using
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Proprietary dose reports

• Some manufacturers create proprietary dose reports
• Exporting options may be limited
  – Paper printer
• Gradually being replaced by DICOM Dose SR
  – Steve Balter’s efforts with NEMA
• If your system creates this report, one of your actions after a high-dose case is flagged should be to print this report
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### Exam Protocol

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<td>4</td>
<td>DR</td>
<td>FIXED</td>
<td>1F/s 17-Apr-09 14:33:19</td>
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***Accumulated exposure data***

- Phys: 2.0min Total: 769.4mGy
- Fluoro: 22.9mGy
Proprietary dose reports

• Information is sufficient to perform a fairly detailed reconstruction of the PSD
• Extracting the data is probably going to be a manual task
  – OCR might be used in an automated system

• The one question everyone asks themselves (or should be asking): The information is there, why not store it electronically?
DICOM RDSR

• Manufacturers are finally including the RDSR in their newest equipment versions
  – Supplement 127 was published in 2007

• Basic structure includes
  – Container with summary and demographic data
  – Item for each irradiation
Machine reported dose metrics

• After June 10, 2006 all fluoroscopic equipment in U.S. must display $K_{a,r}$
  – Only required to be accurate to within +/- 35%
• Equipment in Europe must comply with IEC standards
  – Drives adoption elsewhere
• Common dose metrics include
  – $K_{a,r}$
  – DAP
  – Fluoroscopy time
• Can be recorded in paper or electronic logs
Machine reported dose metrics

• Depending on your system and the options you purchased, this information may only be available until you load the next patient

• Be sure you have a plan for who should record this information and where it should be recorded
Interviews with care providers

• Certain information, depending on your system, may only be available from staff involved in the case
  – E.g., table height if not recorded in DICOM header, or not accurate in DICOM header

• Consider this when you are formulating your policy for recording information for FGI
USING THE INFORMATION TO ESTIMATE PSD
GET TO PEAK ENTRANCE AIR KERMA
Complexity

• Methods for estimating the PSD range from basic to complex
• Does a more complex method yield more accurate results?
• When is additional detail worthwhile and when is it unnecessary?
Contributors to PSD

• All imaging modes that contribute to PSD must be considered in some way
  – Fluoroscopy
  – Acquisition
  – Rotational angiography/FPCT
  – Runoff
  – Etc.
Wholesale vs. piecemeal

• Complexity also depends on how many pieces the calculation is broken in to
• Each event considered individually
  – Automated analysis
• Each DAS considered individually
• ACQ/Fluoroscopy considered individually
• RPAK as a whole
ACQUISITION IMAGING
Step 1 – Getting to RPAK

• Scenario 1 – Reference point air kerma available
• Scenario 2 – RPAK not available, KAP available
• Scenario 3 – RPAK not available, images available for review
• Scenario 4 – No images available
Scenario 2

• RPAK can be estimated, or directly calculated, from the KAP

• While KAP is constant along the source to image receptor axis, RPAK decreases with the inverse square of the distance from the source

• If the x-ray field size can be determined at any point along this axis, the RPAK can be calculated from the KAP
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00181164 (33) - Imager Pixel Spacing: 0.37296874797903/0.37296874797903
00181190 (3) - Focal Spot(s): 0.3
00181500 (6) - Positioner Motion: STATIC
00181510 (4) - Positioner Primary Angle: -8.5
00181511 (4) - Positioner Secondary Angle: -2.7
00181600 (11) - Shutter Shape: RECTANGULAR
00181602 (3) - Shutter Left Vertical Edge: 125
00181604 (3) - Shutter Right Vertical Edge: 899
00181606 (2) - Shutter Upper Horizontal Edge: 11
00181608 (4) - Shutter Lower Horizontal Edge: 1012
00181700 (11) - Collimator Shape: RECTANGULAR
00181702 (3) - Collimator Left Vertical Edge: 125
00181704 (3) - Collimator Right Vertical Edge: 899
00181706 (2) - Collimator Upper Horizontal Edge: 11
00181708 (4) - Collimator Lower Horizontal Edge: 1012
00185100 (3) - Patient Position: HFS
00200012 (2) - Acquisition Number: 21
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0x00181020 (12) - Software Version(s): VB31E 080813
0x00181030 (11) - Protocol Name: SPINAL EMBO
0x00181048 (6) - Contrast/Bolus Ingredient: IODINE
0x00181063 (15) - Frame Time: 133.3333333333
0x00181110 (4) - Distance Source to Detector: 1143
0x00181111 (15) - Distance Source to Patient: 808.9999943127
0x00181114 (14) - Estimated Radiographic Magnification Fac: 1.4128555386734
0x00181150 (3) - Exposure Time: 160
0x00181151 (3) - X-ray Tube Current: 527
0x00181154 (4) - Average Pulse Width: 40.2
0x00181155 (2) - Radiation Setting: GR
0x0018115a (6) - Radiation Mode: PULSED
0x0018115e (5) - Image Area Dose Product: 49.77
0x00181162 (3) - Intensifier Size: 480
Scenario 3 – with headers

• Much of the information contained within the DICOM RDSR can be gleaned from the DICOM header

• The big exception is contributions from fluoroscopy
  – Unless stored retrospectively

• Extracting the data can be time consuming if process is not automated
Scenario 3 – without headers

• In some cases you may know the number of images/runs and not have the physical images or you may not have time to comb through headers

• In this case, you can use QC measurements or perform measurements to gather data
  – RPAK per acquisition frame for imaging protocol used during the case
  – Patient size estimated from prior cross-sectional imaging study
  – Use exact mode – e.g., DSA involves acquisition of mask images and may use higher IAKR

• Keep in mind that additional images may have been acquired and not archived to PACS
Scenario 4 – No images available

• In this case accurate estimation of the PSD is not possible

• Fluoroscopy time SHOULD NOT be used as a starting point for estimating PSD
  – And only as a last resort should it be used as a trigger threshold in a dose tracking program
Calculation of peak ESAK

• Step 2 – Inverse square law correction
• Step 3 – Correction for attenuation of table and table pad
Inverse square law correction

• To perform this correction, the distance from the IRP to the patient must be known
  – IRP location can be found in equipment manual

• Location of patient can be determined in one of several ways
  – DICOM header or RDSR
  – Measurement by technical staff
  – Assume isocentric

\[ K_{a,\text{table}} = K_{a,r} \times \left( \frac{d_{\text{source-to-IRP}}}{d_{\text{source-to-patient}}} \right)^2 \]
0x00181020 (12) - Software Version(s): VB31E_080813
0x00181030 (11) - Protocol Name: SPINAL EMBO
0x00181048 (6) - Contrast/Bolus Ingredient: IODINE
0x00181053 (15) - Frame Time: 133.33333333333
0x00181110 (4) - Distance Source to Detector: 1143
0x00181111 (15) - Distance Source to Patient: 808.9999443127
0x00181114 (14) - Estimated Radiographic Magnification Fac: 1.412855386734
0x00181150 (3) - Exposure Time: 160
0x00181151 (3) - X-ray Tube Current: 527
0x00181154 (4) - Average Pulse Width: 40.2
0x00181155 (2) - Radiation Setting: GR
0x0018115a (6) - Radiation Mode: PULSED
0x0018115e (5) - Image Area Dose Product: 49.77
0x00181162 (3) - Intensifier Size: 480
Correction for table/pad attenuation

• A thick, viscoelastic table pad can substantially attenuate the x-ray beam
• It is important to determine how your manufacturer calibrates the KAP meter
  — w, w/o table and/or table pad
• Correction factor should be measured using a broad beam geometry and technical factors used during procedures
  — At acceptance test and when pad is replaced
• Table/pad may not be in beam path in some circumstances
Correction for table/pad attenuation

• Typical factors I have measured:

  • ~ 0.8 (thick Tempurpedic Siemens pad)
    – ACQ or fluoro

  • ~ 0.9 (thin Tempurpedic Siemens pad)
    – ACQ or fluoro
Calculation of PSD

• Step 4 – Application of the backscatter factor
• Step 5 – Application of the “f-factor”
The BSF

• The BSF depends on several factors
  – Beam quality
    • kVp
    • Added filtration
    • Inherent filtration
  – X-ray field size
  – Tissue type
• Effect of table pad depends on added filtration
• These data can be gathered from previously discussed sources
• Tip: “Effective” field size for procedure can be calculated by dividing the KAP by the RPAK and correcting to the location of the patient
The f-factor

- The f-factor is (actually) the conversion factor from exposure to dose to tissue
- Different materials absorb energy from radiation more or less efficiently than others
- The f-factor is a weak function of beam quality
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</tr>
<tr>
<td>5.0 - 5.5</td>
<td>1.062</td>
</tr>
<tr>
<td>5.5 - 6.0</td>
<td>1.063</td>
</tr>
<tr>
<td>6.0 - 6.5</td>
<td>1.066</td>
</tr>
<tr>
<td>6.5 - 7.0</td>
<td>1.068</td>
</tr>
</tbody>
</table>

x 4.75 for bone tissue!!!
FLUOROSCOPY
Methods for considering fluoroscopy

• Method 1 – Wholesale consideration
• Method 2 – Separation of fluoroscopic and digital acquisition air kerma
• Method 3 – Measurement of fluoroscopic air kerma rate

• Remember – digital acquisition imaging is often the largest contributor to PSD, but not always
Method 1

- Wholesale consideration is simple but may reduce the overall accuracy of the dose estimate as not only are acquisition and fluoroscopy not separated but all acquisition series are considered together as well.
Method 2

• Separation of fluoroscopic and acquisition air kerma

• Use of this method requires that both $K_{a,r}(t)$ and $K_{a,r}(d)$ from acquisition imaging be known
  – $K_{a,r}(f)$ can then be calculated

• Likely not necessary to consider individual fluoroscopy series separately
  – Although possible if the RDSR is available
Method 3

• Measurement of fluoroscopic air kerma rate
• Similar to strategy of measuring acquisition air kerma per frame
• Using known technical factors, patient information, equipment configuration, use suitable phantom to measure fluoroscopic AKR
• Multiply AKR by fluoroscopy time to determine contribution of fluoroscopy to $K_{a,r}(t)$
\[ PSD = SD_{\text{acquisition}} + SD_{\text{fluoroscopy}} \]
SOURCES OF ERROR
Distribution of dose over multiple skin sites

• It is often asserted that dose can be “spread” over the skin by rotating the C-arm
• We recently demonstrated that this is generally* not true outside of cardiology and neurology
• Recommend that all dose be assigned to a single skin site unless it can be demonstrated that significant overlap does not exist
  – Have capability to create “dose map”
  – Procedures performed in “biplanar” fashion

Pasciak AS, Jones AK. Does “spreading” skin dose by rotating the C-arm during an intervention work? 2011; 22:443–452
Figure 5. Zero-overlap angle as a function of patient size for rotation from initial posteroanterior projection. (a) Abdominal interventions. (b) Pelvic interventions. Lines show the minimum angle to which the C-arm must be rotated, as a function of patient size, to avoid completely overlap between the x-ray field entrance sites on the patient’s skin. Each different line corresponds to a different x-ray field size or shape or both.

Pasciak AS, Jones AK. Does “spreading” skin dose by rotating the C-arm during an intervention work? 2011; 22:443–452
Table 4. Efficacy of C-arm Rotation Angles for Prophylactic Approach for Abdominal Interventions

<table>
<thead>
<tr>
<th></th>
<th>Octagonal XRII (cm)</th>
<th>Rectangular Flat Panel (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>±30 degrees RAO/LAO</td>
<td></td>
</tr>
<tr>
<td>Octagonal XRII</td>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>22</td>
</tr>
<tr>
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<td>14</td>
<td>16</td>
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<tr>
<td></td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>95th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>90th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>50th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>10th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>±20 degrees RAO/LAO</td>
<td></td>
</tr>
<tr>
<td>Octagonal XRII</td>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>22</td>
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<tr>
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<td>14</td>
<td>16</td>
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<td>7</td>
<td>7</td>
</tr>
<tr>
<td>95th percentile</td>
<td>Y</td>
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<tr>
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<td>Y</td>
<td>Y</td>
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<tr>
<td>50th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>10th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>±10 degrees RAO/LAO</td>
<td></td>
</tr>
<tr>
<td>Octagonal XRII</td>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>22</td>
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<td></td>
<td>14</td>
<td>16</td>
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<td></td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>95th percentile</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<tr>
<td>50th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>10th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5th percentile</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Note: Y indicates that there is overlap between opposed oblique projections; N indicates no overlap. The minimum angle for which no overlap is present considering patient and x-ray field size should be used.

LAO = left anterior oblique, RAO = right anterior oblique, XRII = x-ray image intensifier.

Pasciak AS, Jones AK. Does “spreading” skin dose by rotating the C-arm during an intervention work? 2011; 22:443–452
Distribution of dose over multiple skin sites

• Important caveat: rotating the C-arm can reduce the 95% area load
Pasciak AS, Jones AK. Does “spreading” skin dose by rotating the C-arm during an intervention work? 2011; 22:443–452
Distribution of dose over multiple skin sites

• If rotation of the C-arm is to be considered, a common approach is to distribute fluoroscopy contributions in proportion to ACQ contributions
Rotational angiography

• Many modern angiographic systems offer an adjunct imaging mode that is used to reconstruct CT images (FPCT/rot. angiography)
• When using this mode, dose is distributed over a wide angular range of the patient’s skin
• The acquisition of a number of these series can result in the $K_a,r$ overestimating the PSD
• Approaches to account for this effect
  – Empirically determined reduction factor
  – Ignore contribution from these series
  – Do nothing
  – “Dose index”
Accuracy of reported dose metrics

• Performance standards for dose measuring/monitoring equipment in the U.S are quite weak
  – +/- 35%
• The accuracy of these metrics should be verified regularly
  – Must understand how equipment works
    • kV dependence, X-ray field size dependence
• Confirm accuracy/correctness of DICOM header
Errors in perspective

• We must keep in mind the end goal of estimating the PSD
  – Determine appropriate medical management of patient
• Accuracy to within 10% is probably not necessary
  – But may be achievable
• Most recent information on effects of radiation on the skin and hair stratifies effects into broad dose “bands”

<table>
<thead>
<tr>
<th>Band</th>
<th>Single-Site Acute Skin-Dose Range (Gy)*</th>
<th>NCI Skin Reaction Grade†</th>
<th>Approximate Time of Onset of Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0–2</td>
<td>NA</td>
<td>Prompt: No observable effects expected</td>
</tr>
<tr>
<td>A2</td>
<td>2–5</td>
<td>1</td>
<td>Transient erythema</td>
</tr>
<tr>
<td>B</td>
<td>5–10</td>
<td>1–2</td>
<td>Transient erythema</td>
</tr>
<tr>
<td>C</td>
<td>10–15</td>
<td>2–3</td>
<td>Transient erythema</td>
</tr>
<tr>
<td>D</td>
<td>&gt;15</td>
<td>3–4</td>
<td>Transient erythema; after very high doses, edema and acute ulceration; long-term surgical intervention likely to be required</td>
</tr>
</tbody>
</table>

Note: — Applicable to normal range of patient radiosensitivities in absence of mitigating or aggravating physical or clinical factors. Data do not apply to the skin of the scalp. Dose and time bands are not rigid boundaries. Signs and symptoms are expected to appear earlier as skin dose increases. Prompt is <2 weeks; early, 2–8 weeks; midterm, 6–52 weeks; long term, >40 weeks.

* Skin dose refers to actual skin dose (including scatter). This quantity is not the reference point air kerma described by Food and Drug Administration (21 CFR § 1020.32 [2006]) or International Electrotechnical Commission (55), Skin dosimetry is unlikely to be more accurate than ± 50%.

† NCI = National Cancer Institute

‡ Telangiectasia is associated with area of initial moist desquamation or healing of ulceration may be present earlier.
$K_{a,r}$ thresholds

- All equipment manufactured after June 2006 is required by law to display $K_{a,r}$
- Alerting the physician at certain thresholds guarantees there are no surprises at the end of a case
- Decisions can be made based on medical management at each threshold
  - Pace of procedure
  - Good practice – YDNKWIHUYKWIH
  - Continuation of procedure at a later time
Establishing $K_{a,r}$ thresholds
<table>
<thead>
<tr>
<th>Threshold</th>
<th>Actions Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>2000 mGy</strong> has been reached. Radiologist will ensure that radiation is being used appropriately and sparingly. Procedure continues normally.</td>
</tr>
<tr>
<td>3000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>3000 mGy</strong> has been reached. Radiologist will ensure that radiation is being used appropriately and sparingly. <strong>Case should be flagged upon completion.</strong></td>
</tr>
<tr>
<td>4000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>4000 mGy</strong> has been reached. Radiologist will ensure that radiation is being used appropriately and sparingly.</td>
</tr>
<tr>
<td>6000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>6000 mGy</strong> has been reached. Threshold for erythema may have been reached, depending on the position of the patient relative to the IRP and orientation of the C-arm during the procedure. Radiologist will assess risk/benefit pace of procedure. Radiologist will ensure that radiation is being used appropriately and sparingly. <strong>Technologist considers paging on-duty medical physicist.</strong></td>
</tr>
<tr>
<td>7000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>7000 mGy</strong> has been reached. Radiologist will ensure that radiation is being used appropriately and sparingly.</td>
</tr>
<tr>
<td>8000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>8000 mGy</strong> has been reached. <strong>Threshold for severe skin effects may have been reached.</strong> Radiologist will assess risk/benefit pace of procedure and consider continuing the procedure at a later time, depending on patient’s condition. If procedure continues, radiologist will ensure that radiation is being used appropriately and sparingly. Extreme caution should be exercised past this point, and all possible dose reduction methods used, including restricting use of acquisition mode and DSA.</td>
</tr>
<tr>
<td>+1000 mGy</td>
<td>Technologist will notify radiologist that a CD of <strong>x000 mGy</strong> has been reached. Radiologist will ensure that radiation is being used appropriately and sparingly.</td>
</tr>
</tbody>
</table>

*DynaCT runs do not contribute significantly to peak skin dose (PSD). This should be considered in cases that utilize DynaCT heavily. An average DynaCT run contributes approximately 200 mGy to the displayed CD.*
Published recommendations

Table 3
Summary of Radiation Monitoring Dose Notification Thresholds

<table>
<thead>
<tr>
<th>Parameter</th>
<th>First Notification</th>
<th>Subsequent Notifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak skin dose (PSD)</td>
<td>2,000 mGy</td>
<td>500 mGy</td>
</tr>
<tr>
<td>Reference point air kerma (Kₐ,r)</td>
<td>3,000 mGy</td>
<td>1,000 mGy</td>
</tr>
<tr>
<td>Kerma-area-product (Pₖₐ)</td>
<td>300 Gy · cm²×</td>
<td>100 Gy · cm²×</td>
</tr>
<tr>
<td>Fluoroscopy time (FT)</td>
<td>30 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

* Assuming a 100-cm² field at the patient’s skin. The value should be adjusted to the actual procedural field size.


<table>
<thead>
<tr>
<th>Air kerma at the IRP (Gy₂)</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Advise physician that IRP air kerma is 2 Gy₂ so that he/she can assess the benefit/risk pace of the procedure.</td>
</tr>
<tr>
<td>4</td>
<td>Advise physician that IRP air kerma is 4 Gy₂ and that the threshold for erythema might have been reached, depending on how the beam is oriented and how often it has been rotated. Consider moving the projected view to a different skin site.</td>
</tr>
<tr>
<td>6</td>
<td>Advise physician that IRP air kerma is 6 Gy₂ and that the threshold for moderate to severe skin effects might have been reached, depending on how the beam is oriented and how often it has been rotated. Consider moving the projected view to a different skin site.</td>
</tr>
<tr>
<td>8</td>
<td>Advise physician that IRP air kerma is 8 Gy₂ and that beyond this point there is a potential for severe skin effects, depending on how the beam is oriented and how often it has been rotated. Benefit-risk depends on how critical the patient’s condition is.</td>
</tr>
</tbody>
</table>


6/26/2012
A. Kyle Jones, Ph.D. AAPM SS 2012
An approach to thresholds

• Use phantom representing typical patient
  – Depends on lab
• Place ion chamber/transparent detector directly under phantom
• Irradiate phantom using a variety of modes until RPAK displayed is 100-200 mGy
• Use ion chamber reading to calculate PSD per RPAK
• Derive thresholds
MEASUREMENT OF THE PSD
Measuring the PSD

• Occasionally one may wish to measure the PSD
  – Repeated procedures
  – Extremely complex case
  – Determine typical doses in labs without dose measuring equipment

• This is most easily accomplished using radiochromic film
Using radiochromic film

• Gafchroomic® is the most commonly available radiochromic film
  – XR-RV3

• Manufacturer supplies a calibration “tablet” at additional cost
  – But recommends against its use for calibrating film for use with flatbed scanner (????)
    • Printed, not irradiated

• Film must be calibrated before use
Calibration of radiochromic film

- Cut 8 or so small pieces of film
- Stack 4 and 4
- Place close to x-ray source, avoiding heel effect
- Place ionization chamber in beam path
- Irradiate, removing top film at desired accumulated dose, repeating for all 8 films
- Scan films and fit
  - All scanner corrections off, use red channel
Using film

• Place sheet between patient and bed (under sheet)
• Remove, let sit for a week
  – In the dark
• Scan film using same scanner/mode as calibration
• Apply calibration fit to “decalibrate” film into dose space
• Identify PSD
Further reading

• www.gafchromic.com


• Giles ER and Murphy PH. Measuring skin dose with radiochromic dosimetry film in the cardiac catheterization laboratory. Health Physics 82(6):875-880, 2002