Optimizing Dose in the Interventional Suite:
Do you really need that image quality?

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University of North Carolina
Financial Disclosure

Educational Consultant for Bard Access Systems
Personal Disclosure
What can I teach a room full of physicists?

http://theinvisibleagent.wordpress.com/tag/physics/
Two Perspectives

Physicist

Interventional Radiologist

$$CNR^2(f) = \frac{C^2(f)MTF^2(f)}{NPS(f)} = C^2(f)SNR^2(f)$$
Two Perspectives

Physicist

\[ \text{CNR}^2(f) = \frac{C^2(f) \text{MTF}^2(f)}{NPS(f)} = C^2(f) \text{SNR}^2(f) \]

Interventional Radiologist
Learning Objectives

• Appreciation of the clinical perspective
  • Need for operator education

• Simple techniques to optimize dose

• Discuss the question: “Do I really need all that image quality?”
Wide Range of Dose

**Table 3**

<table>
<thead>
<tr>
<th>Examination</th>
<th>Average Effective Dose (mSv)*</th>
<th>Values Reported in Literature (mSv)</th>
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<tr>
<td>Head and/or neck angiography</td>
<td>5</td>
<td>0.8–19.6</td>
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<td>Coronary angiography (diagnostic)</td>
<td>7</td>
<td>2.0–15.8</td>
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<td>Coronary percutaneous transluminal angioplasty, stent placement, or radiofrequency ablation</td>
<td>15</td>
<td>6.9–57</td>
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<td>Thoracic angiography of pulmonary artery or aorta</td>
<td>5</td>
<td>4.1–9.0</td>
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<td>Abdominal angiography or aortography</td>
<td>12</td>
<td>4.0–48.0</td>
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<td>Transjugular intrahepatic portosystemic shunt placement</td>
<td>70</td>
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<td>Pelvic vein embolization</td>
<td>60</td>
<td>44–78</td>
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</table>

* Values can vary markedly on the basis of the skill of the operator and the difficulty of the procedure.

Mettler et al. Radiology 2008
### Exam Protocol

**Patient Info:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
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| Patient Position: | HFS |

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<td>0.1Cu</td>
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<td>1141.1μGy²</td>
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Exam Protocol

Patient Info:
Name:                        Sex: M ID:

10 DSA FIXED LOW DOSE BODY 3 9s 3F/s 23-Sep-11 13:36:56
A 76kV 384mA 50.3ms 0.7CL small 0.1Cu 42cm 650.6μGy² 39.5mGy 21RAO 1CRA 26F

***Accumulated exposure data***
Phys: YU                   Exposures: 9 Fluoro: 30.7min Total: 20486μGy² 1399mGy
A Fluoro: 30.7min 11916μGy² 978.8mGy Total: 20486μGy² 1399mGy
What should we teach them?

1. Basic, simple techniques
2. Target the young physicians
Things you know

- Increase table height
- Add Barriers
- Exit the room for DSA runs
- Limit magnification
Increase the Table Height

Why?
Source to Skin Distance

- SSD: determined by table height the operator’s height
- Skin dose decreases as SSD increases
- Therefore, maximize SSD within reason
  - 700 mm (27.6 inches)
  - 600 mm (23.6 inches): increase dose 17-29%
  - Simple 10 cm (4 inch) maneuver

Wagner LK, Archer BR Cohen Am.JVIR 2000;11:25-33
20% Savings
Vary the technique

- Operator is in control
  - Vary:
    - Frame Rates
    - Gantry Position
    - Protocol Used
    - Collimation
Optimize

- Prior to the case
- During the case
Prior to the case

- Review old studies
  - CT
  - MRI
  - US
- Review prior Interventional Procedures
- Have a clear plan
During the case

- Ask: do I need great quality to...
  - Gain access to the celiac artery
  - Demonstrate IVC Filter Position
  - Insert a port
  - Drain an abscess
  - Perform cerebral angiography
  - Embolize a bleeding visceral artery
Use it if you need it
Use it if you need it
Consider alternatives if you don’t
Save Fluoro

- LIH
- Fluoro Video Clips
Last Image Hold

Last Image Hold Spot Radiograph
Slow the Frame Rate

- Fluoroscopic Frame Rate
- DSA acquisition Frame Rate
Pulsed Fluoroscopy

15 – 30 pps for critical procedures where precision required

7.5 pps used for many cases
   Up to 70% dose savings compared with continuous fluoro *

3 pulses per second
   Used when dose savings are paramount or for simple procedures

75 yo male ESRD

Left Arm Fistula
Following Angioplasty
High Dose Procedures

- Embolization
- TIPS
- Renal/Visceral stent placements
- Cardiac RFA
- Coronary angioplasty/stent
- Biliary procedures
TIPS
Protocols
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<tr>
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<td></td>
<td>FL - Ang 7.5 P/s</td>
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<td>FL Angio 3 P/s</td>
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<td>RENAL 3 F/s</td>
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<tr>
<td>FL Angio</td>
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<td>3 P/s</td>
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</table>
Eyes: Protect Them!
Cataracts
Ocular Guidelines

- Previously - Deterministic Effect:
  - 2 – 5 Gy for protracted exposure

- Early Studies
  - Short follow up
  - Lacked sufficient sensitivity
  - Few subjects with dose < few Gy
Worse Case Scenario

• Source above table
• No Barrier Protection
• Dose to the eye 450 – 900 mSv/yr

Vano Br J Radiol 1998
Schueler et al. Radiographics 2006
Eye Protection

Typical workloads: dose to eye may exceed the threshold for cataracts after several years of work if radiation protection tools are not used.

Vano et al. Radiology 2008;248:945-953
Newer Data

- Opacification of the lens at lower doses
- Based on
  - Patients: CT scans, radiation therapy
  - Atomic-bomb survivors
  - Residents of contaminated buildings
  - Chernobyl accident liquidators
  - Radiologic technologists
Newer Data

- Chernobyl workers: <1 Gy
- Rad Techs: risk increases linearly with no apparent threshold
- These challenge prior recommendations

NCRP 168
Worgul et al; Radiat Res 2007
ICRP

• Lens of the eye: threshold for tissue reaction in absorbed dose is now considered to be 0.5 Gy

• Occupational exposure:
  • Now recommend an equivalent dose limit of 20 mSv/yr (avg over 5 yrs)
  • Previously 150 mSv/yr
  • No single year > 50 mSv

www.ICRP.org – statement on tissue reaction.2011
Lens Exposure Cardiology

- Retrospective cumulative lens dose
- Avg: 22 years working/ 51 years old
- 25 mSv – 1600 mSv
- New Annual dose limit 20 mSv/yr
  - Exceeded by 60% of cardiologists

Jacob et al. Radiat Prot Dosimetry 2012
Lens Exposure Cardiology

- Several years + no protection may exceed ICRP lifetime dose threshold of 500 mSv
- Risk for developing radiation-induced cataracts

Jacob et al. Radiat Prot Dosimetry 2012
Operator Eye Protection
Comparing Strategies

- Leaded Glasses:
  reduced by a factor of 5 - 10

- Scatter Shielding Drapes:
  reduced by a factor of 5 - 25

- Both Together:
  reduced by a factor of >25

- Suspended Shielded:
  Undetectable

Thornton, Dauer et al. JVIR 2010
CT Suite
15 yo with post-op abscess
### CT Abdomen and Pelvis

14-Dec-2011 14:19

**Ward:** 7CH&7 Children's Hospital  
**Physician:**  
**Operator:**

Total mAs 1173  Total DLP 198

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15-Dec-2011 10:39

Ward: 7CH&7 Children's Hospital
Physician: eg
Operator:  

Total mAs 360  Total DLP 34

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Lung Cancer
Lung Cancer
Lung Cancer
### Lung Cancer

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Summary

• Appreciation of the clinical perspective
  • Need for operator education
  • Target the young physicians

• Simple techniques to optimize dose

• Discuss the question: “Do I really need all that image quality?”