Contrast and Radiation Management

William Lombardi MD
PUFF

• A story of how an operator can grow and change to the betterment of patients, staff and themselves
Types of Radiation Injury

- **Stochastic**
  - Ca Risk (observed)
  - Genetic Risk (not observed)
  - (Natural Ca Rate)

- **Deterministic**
  - Skin Damage {burn}
  - Hair Loss
  - Chronic Changes
  - (No Natural Occurrence)
In-lab Cumulative Radiation Displays

System is set for low dose rate fluoroscopy using 15 fps

Totals from the start of the procedure:

- Fluoroscopy time
- Air Kerma Area Product
- Air Kerma at the reference point

Provided so that the operator can track total radiation used as each procedure progresses!
CA Risk Varies with Age and Gender

Population average: 0.5% for 100 mSv
Lifetime: 20-25% without radiation
1. Maximize distance between the X ray tube and the patient to the extent possible

2. Minimize distance between the patient and the image receptor

3. Minimize fluoroscopy time
   Keep records of fluoroscopy time and DAP/KAP (if available) for every patient
   Pulsed fluoroscopy reduces exposure

4. Use pulsed fluoroscopy with the lowest frame rate possible to obtain images of acceptable quality

5. Avoid exposing the same area of the skin in different projections
   Vary the beam entrance port by rotating the tube around the patient

6. Larger patients or thicker body parts trigger an increase in entrance surface dose (ESD)
   ESD: 1 unit 2-3 units 4-6 units 8-12 units

7. Oblique projections also increase ESD
   Be aware that increased ESD increases the probability of skin injury
   \[ h_4 < h_3 < h_2 \]

8. Avoid the use of magnification
   Decreasing the field of view by a factor of two increases dose rate by a factor of four

9. Minimize number of frames and cine runs to clinically acceptable level
   Avoid using the acquisition mode for fluoroscopy
   Cine dose rate = (10-60) x normal fluoroscopy dose rate
   Documentation should be performed with last image hold whenever possible and not with cine images

10. Use collimation
    Collimate the X ray beam to the area of interest
### Clinical Selections

#### Radiation Data

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Fluoro Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>RP Dose Rate (mGy/min)</td>
</tr>
<tr>
<td>2453</td>
<td>RP Dose (mGy)</td>
</tr>
<tr>
<td>10.8</td>
<td>DAP (Gy cm²)</td>
</tr>
</tbody>
</table>

#### Anatomical Mode

- **Electrophysiology**
  - Coronary
    - a) Very Low
    - b) Low
    - c) Medium
    - d) High
    - e) Factory Default

- **Head**
- **Chest**
- **Abdomen**
- **Extremities**

#### Image Display

#### Control Panel

- X-RAY
- CINE LOW
- CINE HIGH
- Fluoro LOW
- Fluoro Medium
- Fluoro High
- STORE Fluoro
- Fluoro 10 fps
- CINE 15 fps

#### Table Side
# Relative Effects of Different Maneuvers

<table>
<thead>
<tr>
<th>Decreasing</th>
<th>Skin Dose</th>
<th>Relative Ca Risk</th>
<th>Image Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default to minimum</td>
<td>37%</td>
<td>37%</td>
<td>Increased image noise</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Different display functions</td>
</tr>
<tr>
<td>FOV</td>
<td>190%</td>
<td>30%</td>
<td>Decreased anatomy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improved spatial resolution</td>
</tr>
<tr>
<td>Collimation (1/2)</td>
<td>100%</td>
<td>25%</td>
<td>Decreased anatomy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improved contrast resolution</td>
</tr>
<tr>
<td>Low/Normal</td>
<td>43% Flu</td>
<td>43% Flu</td>
<td>Increased image noise</td>
</tr>
<tr>
<td></td>
<td>58% Cine</td>
<td>58% Cine</td>
<td></td>
</tr>
<tr>
<td>SID</td>
<td>68%</td>
<td>68%</td>
<td>Increased anatomy</td>
</tr>
<tr>
<td>Patient</td>
<td>60%</td>
<td>60%</td>
<td>Improved contrast resolution</td>
</tr>
<tr>
<td>Cine-Fluoro</td>
<td>12%</td>
<td>12%</td>
<td>Typical Patient (FDA phantom)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum Patient /angles</td>
</tr>
<tr>
<td>C-F &amp; SID</td>
<td>3%</td>
<td>3%</td>
<td>Heavy patients usually increase SID</td>
</tr>
</tbody>
</table>
DRAFT Physician Checklist

PREPROCEDURE
- Radiation history - Skin check (if positive)
- Extend consent (when appropriate)
- Plan alternative beam orientation (if appropriate)

TIME-OUT
- Fluoroscopic system settings
- Personal radiation monitors
- Radiation shielding devices

POSTPROCEDURE
- Patient dosimetry recorded in medical record
- Substantial dose use justified in medical record (when appropriate)
- Initiate follow-up process (when appropriate)
CUMC Radiation Protocol

- Pre: Awareness of prior exposure and look at patients back
- Post: If >5 Gy: Have a family member look at back 30 days from now
- We call at day 30 if > 7 Gy
- Call us (lab’s 24 hour PA emergency number) if there is a red patch the size of your hand
- Have only seen effects at 6.5 Gy
- Always have gotten call first when over 7 Gy
Global Columbia Radiation Experience

Median Value per procedure by Year for ALL Labs (2007-2014)

100% = Median of all procedures 2007-2014
The Effect of Entrance Port Awareness

Notification Report for System 212305CATH1
Date: 06/21/10  Time: 16:31 - 18:50  Avg EPT: 23 cm

Notification Report for System 212305CATH1
Date: 06/21/10  Time: 16:31 - 18:50  Avg EPT: 23 cm

Cumulative Dose-ESD Incidence Map

9774

9347
Contrast-Induced Acute Kidney Injury

- New onset or exacerbation of renal dysfunction after contrast administration without other identifiable causes:
  - Increase by >25%
    absolute ↑ of >0.3 mg/dL
  - Occurs 24-48 hrs post-contrast exposure, with creatinine peaking 5-7 days later and normalizing within 7-10 days in most cases
Prognostic Significance of CIN

Amount of Contrast Dye and Nephrotoxicity

- Maximum Contrast Dose: 5 x Weight/ sCr
- Contrast Dose-Ratio: Actual /Theoretical

Freeman RV et al. 
AJC 2002; 90: 1068
## Schema for the Assessment of CIN Risk Score

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Integer Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension</td>
<td>5</td>
</tr>
<tr>
<td>IABF</td>
<td>5</td>
</tr>
<tr>
<td>CHF</td>
<td>5</td>
</tr>
<tr>
<td>Age &gt; 75 years</td>
<td>3</td>
</tr>
<tr>
<td>Anemia</td>
<td>3</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3</td>
</tr>
<tr>
<td>Contrast volume</td>
<td>1 for 100cc³</td>
</tr>
<tr>
<td>Serum creatinine &gt; 1.5mg/dl OR eGFR (ml/min/1.73²) = 186x(SCR)⁻¹.¹⁵⁴x(Age)⁻⁰.²⁰³</td>
<td>4, 2 for 40 – 60, 4 for 20 – 40, 6 for &lt; 20</td>
</tr>
</tbody>
</table>

### Risk Score, Risk of CIN, Risk of Dialysis

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Risk of CIN</th>
<th>Risk of Dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 5</td>
<td>7.5%</td>
<td>0.04%</td>
</tr>
<tr>
<td>6 to 10</td>
<td>14.0%</td>
<td>0.12%</td>
</tr>
<tr>
<td>11 to 16</td>
<td>26.1%</td>
<td>1.09%</td>
</tr>
<tr>
<td>&gt; 16</td>
<td>57.3%</td>
<td>12.6%</td>
</tr>
</tbody>
</table>

Recalculate
Frequency Distribution of Total Contrast Volume Used During the Procedures

J-CTO Contrast Volume

GW Success

GW Failure

P=0.22

Morino et al, *JACC Intv* 2010;3:143-51
Other Considerations

• Use IVUS to guide stent placement and expansion to minimize contrast
• Use superselective collateral injections (e.g., Finecross)
• Use distal retrograde wire as a guide if easy access
Conclusions

• Contrast media and radiation are potentially toxic and CTO patients are at particular risk
• 7.5 fr/sec flouro
• Increase field of views
• Don’t use contrast
• Practice in every case, get better everyday
• Be like Puff
Contrast and Radiation Management

William Lombardi MD