Interventional Fluoroscopy Procedures

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AAPM - August 2013

Learning Objectives

• Effects on patient’s skin, hair, eyes, and other tissues.
• The use of controls and real-time displays of radiation quantities; their relation to radiation risks.
• Adequate communication of radiation risk
  – As part of the informed consent process
  – Post-procedure

Background

• Most FGI procedures have several associated major risks.
• Procedures might require a substantial amount of radiation for their completion.
• Radiation should be regarded as a toxic agent in the same sense as contrast-media and pharmaceuticals.
• Managing all toxic agents should be a part of a continuous benefit-risk assessment.

Some non-radiation risks

• Serious allergic reaction to contrast materials (iodine).
• Kidney injury due to the contrast material.
• Damage to the blood vessel, bruising or bleeding at the puncture site, and infection.
• Blood forms a clot around the tip of the catheter, blocking the artery and making it necessary to operate to reopen the vessel.
• Stroke if the catheter dislodges plaque from a vessel wall that blocks blood flow within the brain.
• The catheter punctures an artery, causing internal bleeding.

Adapted from Cerebral Angiography @ radiologyinfo.org Accessed May 2013

Justification and Optimization

• Operators need to know
  – Biological risks at different dose levels
  – Clinical factors that might modify risk
  – Radiation status during the procedure
• Optimization
  – Equipment construction and configuration
  – Physics QA (beyond regulatory minimum)
  – Operator’s utilization of equipment features
  – Operator’s clinical abilities

BIOLOGY and CLINICAL
Radiogenic Risk

- Hair loss (temporary or permanent)
- Injury of skin and subcutaneous tissues.
- Bone injury
- Radiogenic cataract
- Non-cancer vessel and organ damage

Radiation Effects Chart

Tissue Reactions

Radiation Therapy Injuries

Time sequence

Multiple procedures

- Biology
  - DNA repair complete in 24 hours
  - Skin cell death in approximately 30 days
  - Skin cells replaced in approximately 60 days
  - Microvasculature damage.
- “Routine” interval between stages
  - 4 to 6 weeks for different anatomy.
  - 8 to 12 weeks for same anatomy.
  - Examine patient’s skin immediately before starting a new stage.
Poor practice

2 m p 1
5 m p 1
1 m p 2

6 m p 1
2 m p 2

pre
op

Management of a known reaction

1 m
2 m

TECHNOLOGY

Clinical Selections

Control Panel
Table Side

Head and Neck
Gore
Heart

Low (PA/C Arms)
Medium (PA/C Arms)
High (PA/C Arms)
Special Ultra Low (PA/C Arms)
Special High (PA/C Arms)
Electrophysiology
Great Vessels
Abdomen
Pelvis
Extremities
Special

Dose rates - Mode

1 second of DSA
3-6 seconds of Cine
30-60 seconds of Fluoro
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: 10.6 minutes
  - Air Kerma Area Product (DAP): 122 mGy
  - Air Kerma at the reference point: 1980 mGy

Provided so that the operator can track total radiation used as each procedure progresses!

Fluoroscopy Time

- ≈ 2,100 non-cardiac interventions
- \( K_{a,r} = 0.41 + 0.037 F_{min} \)
- \( R^2 = 0.50 \)
- RAD-IR

- ≈ 1,700 coronary-artery procedures
- \( K_{a,r} = 0.53 + 0.12 F_{min} \)
- \( R^2 = 0.68 \)
- IAEA-SRS 59

Notifications (NCRP-168)

<table>
<thead>
<tr>
<th>Dose Metric</th>
<th>First Notification</th>
<th>Subsequent Notifications</th>
<th>BDCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_{A,eq,min}</td>
<td>2 Gy</td>
<td>0.5 Gy</td>
<td>3 Gy</td>
</tr>
<tr>
<td>K_{a,r}</td>
<td>3 Gy</td>
<td>1 Gy</td>
<td>5 Gy*</td>
</tr>
<tr>
<td>P_{FA}</td>
<td>500 Gy cm^2</td>
<td>100 Gy cm^2</td>
<td>500 Gy cm^2</td>
</tr>
</tbody>
</table>

Fluoroscopy time: 30 min, 15 min, 60 min.

*New additional discussion regarding the value 3 Gy is Section 4.8.4.2.
*Assuming a 100 cm^2 field at the patient's skin. For other field sizes, the P_{FA} value should be adjusted proportionally to the actual procedural field size \( F_{min} \). For a field size of 50 cm^2, the BDCL value for P_{FA} should be 200 Gy cm^2.
**Drilling down to the future?**

**Patient Communication**

**Informed consent considerations**
- Patient’s age
- Patient’s health details
- Patient’s size
- Nature of the planned procedure
- Other irradiation of the same area
  - Previous interventional procedures
  - Previous or planned radiation therapy

**Latent Period (years)**
- Leukemia
  - Min 2 – 4
  - Max 10 – 20
- Solid Cancer
  - Min 10
  - Max > 40

**Possible informed consent topics**
- A slightly elevated risk of cancer several years or decades later in life. This risk is low in comparison to the natural risk of developing cancer.
- Skin rashes occur infrequently; on very rare occasions they may result in tissue breakdown and possibly severe ulcers.
- Hair loss may occur which can be temporary or permanent.
- Cataracts are rarely induced following neurointerventional procedures.
- You or your family will be advised if we actually used substantial amounts of radiation during the case. If this happens, you will be given appropriate instructions prior to discharge.

*Based on NCRP Report 168*

**Substantial Dose Procedures**
- > 5,000 mGy – Less if clinically warranted.
- Lab provides ‘hand-off’ data:
- Patient receives radiation instructions
- Patient calls with possible reaction
  - Clinic visit with operator scheduled if PA can’t absolutely rule out radiation.
- CUMC QA follow-up > 7,000 mGy
  - Proactive 30 – 40 days post procedure.
  - So far all patients contacted by QA with skin changes have already called us.
  - Continuing follow-up of known injuries.
Radiation discharge instructions

• Have a family member look at your back 30 days from now.
• Call us (lab’s 24 hour PA emergency number) if there is a red patch the size of your hand.

Substantial Dose (NCRP-168)

❖ If a substantial radiation dose level is exceeded, the patient and any caregivers should be informed, prior to discharge, about possible deterministic effects and recommended follow-up.
❖ Follow-up for possible deterministic effects shall remain the responsibility of the interventionalist for at least one year after an FGI procedure. Follow-up may be performed by another healthcare provider.

All relevant signs and symptoms shall be regarded as radiogenic unless an alternative diagnosis is established.

Further reading

Guidelines for Patient Radiation Dose Management

Michael J. Hagerty, RN, AAPM, FASRT, VA, Donald R. Trump, MD, FACR, Scott A. Elsasser, MD, FACR, Margaret M. Petraglia, MD, FACR, and the AAPM Guideline Writing Group. Guidelines for Patient Radiation Dose Management. This guideline was conceived and prepared by the AAPM Guideline Writing Group with input from experts in radiation dose management and was approved by the AAPM Board of Directors on 21 September 2006. Published in American Journal of Roentgenology, September, 2006.