But I already have a full-time job!

A Radiation Oncology Medical Physicist as Radiation Safety Officer

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Chief Medical Physicist
Radiation Safety Officer
Conflicts of Interest

- None
Learning Objectives

1. To review common imaging procedures with expected ranges of exposure.
2. To discuss strategies for the reduction of exposure.
3. To discuss real-life scenarios that illustrate the range of physics consults that might be encountered in diagnostic imaging.
I work in Radiation Oncology, these Imaging doses are puny.
Think again...
I am a stranger in your area

- What is my authority?
- Who are my “customers”?
- What types of procedures do you do?
- What are the ranges of patient dose?
- What are the potential side effects?
- What are your workflows?
RSO Authority (10CFR35.24)

- (g) A licensee shall provide the Radiation Safety Officer sufficient authority, organizational freedom, time, resources, and management prerogative, to--
  - (1) Identify radiation safety problems;
  - (2) Initiate, recommend, or provide corrective actions;
  - (3) Stop unsafe operations; and,
  - (4) Verify implementation of corrective actions.
Who are your “customers”? 

- Patients 
- Family members of patients 
- General public 
- Staff 
- Physicians 

- You MUST be seen by your customers.
Communication is the key
Communicating with patients

PC Symposium: Communicating with patients, a vital skill for a medical physicist, Sunday, July 30

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30</td>
<td>Welcome and opening remarks</td>
<td>Dan Pavord</td>
</tr>
<tr>
<td>9:35</td>
<td>How to speak to patients</td>
<td>Bob Pizzutiello</td>
</tr>
<tr>
<td>10:00</td>
<td>Strategies for learning and teaching patient communication skills.</td>
<td>Derek Brown</td>
</tr>
<tr>
<td>10:15</td>
<td>Q&amp;A</td>
<td></td>
</tr>
</tbody>
</table>
Are patients aware of the risk?

• “The majority of patients were unaware of the radiation-induced cancer risk, with a weighted average of 7% (30/434; range, 3–13%) reporting that there was an increase in risk of cancer from ionizing radiation.”

What do units of radiation mean to patients?

- Ὅτι μὲν ὑμεῖς, ὦ ἀνδρεῖς Αθηναῖοι, πεπόνθατε ὑπὸ τῶν ἐμῶν κατηγόρων, οὐκ σῶθα: ἐγὼ δ' οὐν καὶ αὐτὸς ὑπ' αὐτῶν ὀλίγου ἐμαυτοῦ ἐπελαθόμην, οὕτω πιθανῶς ἔλεγον. Καίτοι ἀληθὲς γε ὃς ἔπος εἰπεῖν οὐδὲν εἰρήκασιν.

- from the beginning of Apology by Plato:
From Image Wisely

- D.1. How to Convey Technical Information to the Public
- Avoid using technical/medical jargon
- Translate technical/medical terms (e.g., dose) into everyday language
- Write short sentences that convey a single point
- Use headings and other formatting techniques to provide a clear and organized structure to the presentation of information

Communicating with staff

- Wear your badges!
- Wear them in the right location
- Use shielding
- Use proper techniques
Communicating with Physicians

- Wear your badges!
- Wear them in the right location
  - EDE 1, EDE 2
- Use shielding
Range of doses in Diagnostic Imaging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Average Effective Dose</th>
<th>Annual Effective Dose per Person</th>
<th>Proportion of the Total Effective Dose from All Study Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial perfusion imaging</td>
<td>15.6†</td>
<td>0.540</td>
<td>22.1</td>
</tr>
<tr>
<td>CT of the abdomen</td>
<td>8</td>
<td>0.446</td>
<td>18.3</td>
</tr>
<tr>
<td>CT of the pelvis</td>
<td>6</td>
<td>0.297</td>
<td>12.2</td>
</tr>
<tr>
<td>CT of the chest</td>
<td>7</td>
<td>0.184</td>
<td>7.5</td>
</tr>
<tr>
<td>Diagnostic cardiac catheterization</td>
<td>7</td>
<td>0.113</td>
<td>4.6</td>
</tr>
<tr>
<td>Radiography of the lumbar spine</td>
<td>1.5</td>
<td>0.080</td>
<td>3.3</td>
</tr>
<tr>
<td>Mammography</td>
<td>0.4</td>
<td>0.076</td>
<td>3.1</td>
</tr>
<tr>
<td>CT angiography of the chest (noncoronary)</td>
<td>15</td>
<td>0.075</td>
<td>3.1</td>
</tr>
<tr>
<td>Upper gastrointestinal series</td>
<td>6</td>
<td>0.058</td>
<td>2.4</td>
</tr>
<tr>
<td>CT of the head or brain</td>
<td>2</td>
<td>0.049</td>
<td>2.0</td>
</tr>
<tr>
<td>Percutaneous coronary intervention</td>
<td>15</td>
<td>0.043</td>
<td>1.8</td>
</tr>
<tr>
<td>Nuclear bone imaging</td>
<td>6.3</td>
<td>0.035</td>
<td>1.4</td>
</tr>
</tbody>
</table>

CT with all procedures combined is ~50%
A dose received in shorter time is more effective in causing tissue reactions than the same dose protracted in time. This is due to the fact that when dose is received during a longer period of time tissue cells have the time to repair themselves through cellular repair mechanisms between successive irradiations.
Radiation Side Effects

- Late effects
  - Cancer
  - Skin burns
  - Cataracts
  - Sterility
Timing of skin injury

Induction of Cancer

- Most common types are breast, thyroid, leukemia
- Lowest observed cancer induction \( \sim 100 \text{ mSv (10 cGy)} \)
Balancing image quality with radiation dose (from IAEA)

- Medical imaging is used to accurately and timely diagnose health problems, allowing for a more effective treatment of patients. The use of ionizing radiation for imaging has seen a dramatic increase in recent years but is also associated with some amount of risk. Unfortunately, improving the quality of medical images always means increasing the radiation dose to the patient, which in turn increases the radiation risks.
- For this reason, the objective of medical imaging is not to deliver the perfect image but one that is diagnostically adequate for the specific health problem. This is the essence of optimization: balancing image quality with radiation dose.
- The application of this optimization principle to medical exposure requires a special approach, since too low a radiation dose could be as bad as a too high one: the images obtained could be of unsuitable diagnostic quality.

https://www.iaea.org/topics/optimising-image-quality
Dose reduction

- FDA Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging
  - Through this initiative, the FDA strives to promote patient safety through two principles of radiation protection developed by the International Commission on Radiological Protection
  - Justification
  - Dose optimization

Multidisciplinary Effort

Imaging Physicians
Radiologists make daily decisions about how to balance effective studies and treatment with safe radiation dose. The information provided here focuses on the aspects of imaging of greatest relevance to imaging physicians and which influence dose, either directly or indirectly.

Medical Physicists
Medical physicists contribute valuable knowledge and experience to the maintenance of quality in CT images and to reducing radiation dose to patients from CT examinations. Medical physicists help design and select optimum imaging protocols to acquire necessary information at the lowest possible radiation dose.

Imaging Technologists
Imaging technologists carry out the vital role of dispensing the ionizing radiation necessary for producing image data. The resources presented here cover the physics and principles of operating modern CT devices, best practices for CT exam protocols, and peer-to-peer discussion boards.

http://www.imagewisely.org/Imaging-Modalities/Computed-Tomography
Justification

- ACR Appropriateness Criteria
  - https://www.acr.org/Quality-Safety/Appropriateness-Criteria
### Table 10: Acute Abdominal Pain and Fever

**Patient presenting with fever, non-localized abdominal pain and no recent operation**

<table>
<thead>
<tr>
<th>Exam</th>
<th>Rating</th>
<th>RRL scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT abdomen and pelvis w/contrast</td>
<td>8</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>CT abdomen and pelvis w/o contrast</td>
<td>6</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>US abdomen</td>
<td>6</td>
<td>None</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>6</td>
<td>🌟🌟🌟🌟</td>
</tr>
<tr>
<td>X-ray upper GI series with small bowel</td>
<td>5</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>X-ray colon contrast enema</td>
<td>5</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Nuclear ImagingGa-67 of abdomen</td>
<td>5</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Nuclear Imaging Tc99m WBC abdomen and pelvis</td>
<td>5</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>MRI abdomen and pelvis w/o contrast</td>
<td>5</td>
<td>None</td>
</tr>
<tr>
<td>MRI abdomen and pelvis w/contrast</td>
<td>5</td>
<td>None</td>
</tr>
<tr>
<td>Interventional arteriography visceral</td>
<td>2</td>
<td>🌟🌟🌟🌟</td>
</tr>
</tbody>
</table>

*adapted from ACR Appropriateness Criteria October 2008.

[Source](http://www.imagewisely.org/imaging-modalities/computed-tomography/medical-physicists/articles/how-to-understand-and-communicate-radiation-risk)
## Table 11: Acute Abdominal Pain and Fever in a *Pregnant Patient*

Patient presenting with fever, non-localized abdominal pain and no recent operation*

<table>
<thead>
<tr>
<th>Exam</th>
<th>Rating</th>
<th>RRL scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>US abdomen</td>
<td>8</td>
<td>None</td>
</tr>
<tr>
<td>MRI abdomen and pelvis w/o contrast</td>
<td>7</td>
<td>None</td>
</tr>
<tr>
<td>MRI abdomen and pelvis w/contrast</td>
<td>7</td>
<td>None</td>
</tr>
<tr>
<td>CT abdomen and pelvis w/contrast**</td>
<td>5</td>
<td>⚠️⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>CT abdomen and pelvis w/o contrast</td>
<td>5</td>
<td>⚠️⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>4</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>X-ray upper GI series with small bowel</td>
<td>2</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>X-ray colon contrast enema</td>
<td>2</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>Nuclear Imaging Ga-67 of abdomen</td>
<td>2</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>Nuclear Imaging Tc99m WBC abdomen and pelvis</td>
<td>2</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
<tr>
<td>Interventional arteriography visceral</td>
<td>2</td>
<td>⚠️⚠️⚠️⚠️</td>
</tr>
</tbody>
</table>

*adapted from ACR Appropriateness Criteria® October 2008

** only after all exams that do not use ionizing radiation have been used or ruled out as possible.

Dose Optimization

Journal of Applied Clinical Medical Physics

AAPM Reports & Documents

AAPM Medical Physics Practice Guideline 1.a: CT Protocol Management and Review Practice Guideline

First published: 6 September 2013  Full publication history
Dose Reduction: CT

- Reduce scan volume
- Smaller kV for smaller patients
- Use appropriate filters
- Use larger pitch if possible (peds 0.9-1.5)
- Shorter rotation times
- Dose modulation
Dose Reduction: Fluoro

http://www.imagewisely.org/Imaging-Modalities/Fluoroscopy/Articles/Huang-Checklists
Pre-Procedure (READ-DO)

1. Prior Radiation
2. For cases in which high radiation exposure is expected, informed consent should include discussion of radiation risk.
3. Use ultrasound, if possible.
4. Wear appropriate radiation protection.
5. Wear radiation dosimeters
7. Appropriate anatomical program set for the desired study.
8. Determine if patient is pregnant.
Intra-Procedure (DO-CONFIRM)

1. Use proper collimation.
2. Use last image hold.
3. Use largest source-to-object distance possible.
4. Place II as close to patient as possible.
5. Minimize path length through patient.
7. Use tubing extensions for hand injections.
8. Use power injector if possible.
9. Communicate with team about technical factors.
10. All unnecessary personnel behind shields or outside room.
11. If dose levels are exceeded, reduce exposures and consider delaying completion.
Post-Procedure (READ-DO)

1. Review and record dose metrics.
2. If dose metrics are exceeded, advise patient of risk and instruct on proper follow-up.
Dose Reduction: Nuclear Medicine

- Radiopharmaceutical Selection
- Injected Radioactivity
- Collimator selection and imaging time
- Image restoration (filters)

http://www.imagewisely.org/imaging-modalities/nuclear-medicine/articles/dose-reduction
Real-life Scenarios

- Time for a Medical Physics Consult