What Have We Learned from Children?

Donald P. Frush, MD
Medical Radiation and Children: Accomplishments

- We can lower doses (read noisier exams)
- We should lower doses
- Multiphase exams should be justified
- Awareness has increased
- Model can be successful
Medical Radiation and Children: Accomplishments

• We can lower doses (read noisier exams)
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Simulated Reduced mA (Noise Addition)

340 mA

3/4 mA
Simulated Reduced mA (Noise Addition)

340 mA

¼ of mA
130 mAs  40 mAs*  20 mAs*

* Simulated, by adding noise

Karmazyn, B et al. AJR January 2009
Original: 380 mA
Simulated: 70 mA
18% of dose

AJR January 2008: 190
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Double Scans

Guite and colleagues calculated a mean effective dose in study population of 25.8 mSv, which could have been reduced to 17.9 mSv if patients had received only phases indicated by ACR appropriateness criteria.

Table 1. Number of phases per patient

<table>
<thead>
<tr>
<th>Number of Phases per Study</th>
<th>Number of Patients (n = 500)</th>
<th>Total Number of Phases</th>
<th>Number of Unindicated Phases</th>
<th>% of Total Phases That Were Unindicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>192</td>
<td>192</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>176</td>
<td>350</td>
<td>152</td>
<td>43.4</td>
</tr>
<tr>
<td>3</td>
<td>101</td>
<td>303</td>
<td>146</td>
<td>48.2</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>92</td>
<td>36</td>
<td>39.1</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>40</td>
<td>16</td>
<td>40</td>
</tr>
</tbody>
</table>
Medical Radiation and Children: Accomplishments

• We can lower doses (read noisier exams)
• We should lower doses
• Multiphase exams should be justified
• Increased awareness
• Model can be successful

Other than reimbursement radiation dose and risk is the greatest issue currently facing radiologists

(paraphrased, James Thrall MD, Boston Sept 2011)
Medical Radiation and Children: Accomplishments

• We can lower doses (read noisier exams)
• We should lower doses
• Multiphase exams should be justified
• Awareness has increased
• Model can be successful
“Success” has depended on ...

- **Organization**
  - reputable
  - stakeholder consensus
  - independent

- **Message**
  - important
  - simple
  - *positive*

- **Delivery**
  - media expertise
  - electronic format
  - controlled content
  - controlled access
  - controlled release
Medical Radiation and Children: Needs

• Better dose estimates
• (Helpful) “dose” alerts/notification
• Reference levels
• Improved conversations
• Agreement on “consent”
• Appropriate educational materials
• Accountability: dose tracking
• Consensus
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Pediatric CT Dose Estimation

AAPM TG 204 report
April 2011

http://www.aapm.org/pubs/reports/RPT_204.pdf
Computational patient models representative of public at large from infancy to adulthood across age, gender, size, and length ranges.

Courtesy Ehsan Samei, Duke University
CT

Courtesy Ehsan Samei, Duke University
# Gender and Age Specific Dose and Risk Estimations

<table>
<thead>
<tr>
<th>Gender and Age Specific Dose and Risk Estimations</th>
<th>k (mSv/mGy-cm)</th>
<th>q (cases/10,000 exposed/mGy-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 yr old</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k (mSv/mGy-cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chest-abdomen-pelvis</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>chest</td>
<td>0.025</td>
<td>0.018</td>
</tr>
<tr>
<td>abdomen-pelvis</td>
<td>0.018</td>
<td>0.017</td>
</tr>
<tr>
<td>abdomen</td>
<td>0.023</td>
<td>0.018</td>
</tr>
<tr>
<td>pelvis</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td>adrenals</td>
<td>0.026</td>
<td>0.021</td>
</tr>
<tr>
<td>liver</td>
<td>0.026</td>
<td>0.019</td>
</tr>
<tr>
<td>kidneys</td>
<td>0.020</td>
<td>0.017</td>
</tr>
<tr>
<td>liver to kidneys</td>
<td>0.024</td>
<td>0.018</td>
</tr>
<tr>
<td>kidneys to bladder</td>
<td>0.015</td>
<td>0.017</td>
</tr>
<tr>
<td>head</td>
<td>0.0014</td>
<td>0.0013</td>
</tr>
<tr>
<td>neck</td>
<td>0.0051</td>
<td>0.0043</td>
</tr>
<tr>
<td>head and neck</td>
<td>0.0034</td>
<td>0.0030</td>
</tr>
<tr>
<td>* Per its definition, effective dose was calculated using gender-averaged organ dose values.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*q in units of cases /10,000 exposed /mGy-cm*
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Results: 6 Peds Specialty Hospitals

QuIRC DRL is lower than UK DRL using CTDI_w

RSNA 2011

- Normalized to 32 cm phantom
- 5 yr old abdomen

<table>
<thead>
<tr>
<th>Age Group</th>
<th>QuIRC 3rd quartile</th>
<th>Shrimpton 3rd quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 yr old (20-24 cm)</td>
<td>7.6 mGy</td>
<td>12.5 mGy</td>
</tr>
</tbody>
</table>


Courtesy M. Goske, MD
Medical Radiation and Children: Needs

• Better dose estimates
• (Helpful) “dose” alerts/notification
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• **Improved conversations**
• Agreement on “consent”
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Your child may have a significant brain injury... so we need to do a CT scan

- Question: “I heard that CT scans can cause cancer. Will my son get cancer?”
- Answer: “Probably not but we don’t know for sure.”

- Question: “What is the radiation for the CT?”
- Answer: “I don’t know.”

- Question: “Do you keep track of radiation for patients?”
- Answer: “I don’t know.”

...confidence?
What Do You Say?

1. That is a good question
2. I can answer that
3. We have *(hopefully)* expertise
   - know the doses
   - minimize radiation
4. This is a necessary/important exam
5. Other questions?

*I avoid numbers:*

1 in 2,000 = “my child” AND 1999 others
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Don’t ignore “basics”
Remember…

• CT is extremely helpful
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“I am contacting you to ask about the radiation exposure my son has had when having a CT angiogram … Can I make the radiation exposure request or does his physician need to? Here is my son’s information and the date of his CT angiogram. I am wanting to get his radiation exposure in a file for his health history. Thank you for your time.”
If we don’t control this, someone will for us

We have a responsibility to know individual and cumulative (CT) dose, and what this does or doesn’t signify…

patients

colleagues

regulatory organizations
X-rays, CAT scans, fluoroscopy (including angiography/angioplasty), and nuclear medicine exams all cause ionizing radiation to be delivered to the body, which can cause cancer. Over the last 15 years, the use of medical imaging has been rapidly increasing. There have been recent estimates that up to 1.5-2% of all cancers within the US are caused by radiation from CAT (CT) scans.

The purpose of Radiation Passport is to educate about the radiation and cancer risks associated with medical imaging exams and procedures that physicians (and dentists) want you to undergo, to keep track of radiology and imaging-related exams and procedures, and to provide an estimate of risk of developing cancer because of this radiation.

The radiation exposure and associated risk numbers are based on published scientific journal papers, however, are in each case an estimate. There are different methods by which to estimate the associated risk.
This bill would, commencing July 1, 2012, require hospitals and clinics, as specified, that use computed tomography (CT) X-ray systems for human use to record, if the CT systems are capable, the dose of radiation on every CT study produced during the administration of a CT examination, as specified. The bill would require the dose to be verified annually by a medical physicist, as specified, unless the facility is accredited.

SB 1237, Padilla. Radiation control: health facilities and clinics: records.
Under existing law, the State Department of Public Health licenses and regulates health facilities and clinics, as defined.
Under existing law, the Radiation Control Law, the department licenses and regulates persons that use devices or equipment utilizing radioactive materials. Under existing law the department may also require registration and inspection of sources of ionizing radiation, as defined. Violation of these provisions is a crime.
This bill would, commencing July 1, 2012, require hospitals and clinics, as specified, that use computed tomography (CT) X-ray systems for human use to record, if the CT systems are capable, the dose of radiation on every CT study produced during the administration of a CT examination, as specified. The bill would require the dose to be verified annually by a medical physicist, as specified, unless the facility is accredited.
June 30, 2011

To: Jane Doe
555 Main Street
Anywhere, NC 12345

Dear Ms. Doe,

This letter is to inform you that you had 10 or more CT scans in 2010. This is more than most people get in a year. Medicaid records show that you went through a CT scanner ___ times in 2010.

CT scans, sometimes called CAT scans, expose you to radiation while taking a picture of what is inside your body. Too much radiation can be bad for your health. It can increase your chances of getting some kinds of cancer.

Sometimes CT scans are important for doctors to see what is going on when you are sick or hurt. But sometimes there may be other ways to figure out what is wrong.

If a doctor treating you does not know how well or how many CT scans you have had, it is important for you to remind them of this information. Showing your doctors this letter will help them treat you as safely as possible. Please take this letter with you when you go to the emergency department or doctor’s office.

Call 1-800-662-7030 if you have any questions.

Please call [enrollment office number] for help finding a primary care doctor in your town.

Wishing you the best of health,
A complementary publication of
The Joint Commission

Radiation risk of diagnostic imaging

Diagnostic radiation is an effective tool that can save lives. The higher the dose of radiation delivered, the stronger the disease risk for long-term damage. If a patient receives repeated doses, harm can also occur as the cumulative effect of multiple doses over time. 1-7 Consequently, using insufficient radiation may increase the risk of misdiagnosis, delayed treatment, or, if the initial test is incorrect, repeated testing with the attendant exposure to even more radiation. 1 8 9 10 The risks associated with the use of ionizing radiation in diagnostic imaging include cancer, burns, and other injuries. 1 1-1 2 1 3 1 4 1 5 Patients are officially classified as a “patient at risk” by the World Health Organization’s International Agency for Research on Cancer, the Agency for Toxic Substances and Disease Registry of the Centers for Disease Control and Prevention, and the National Institute of Environmental Health Sciences. 1

Over the past two decades, the U.S. population’s total exposure to ionizing radiation has nearly doubled. 16-18 Diagnostic imaging is used to detect and diagnose cancers, infections, and other conditions. But any radiation carries some risk of harm and some uncertainty about the effects of radiation on human health. 19 20 While the evidence on the risks of the risks of diagnostic imaging is not conclusive, there is agreement that care should be taken to reduce the risk to the patient. 21, 22

Right dose
3. Adhere to ALARA guidelines as required by the Nuclear Regulatory Commission. The ALARA acronym stands for “as low as reasonably achievable” – making sure doses are as low as possible while achieving the purposes of the study.
4. Adhere to the Society for Pediatric Radiology’s Image Gently guidelines when providing imaging radiation (or fluoroscopy) to children 1 9, 1 9, 2 0 and, for adults, adhere to the Image Wisely guidelines (developed by the American College of Radiology and the Radiological Society of North America in collaboration with the American Association of Physicists in Medicine and the American Society of Radiologic Technologists). 2 2
5. Provide physicians and technologists with reference doses based on anatomy, purpose of the study, and patient size. Establish appropriate dose ranges for high-volume and high-dose diagnostic imaging studies.
6. Radiologists should make the proper imaging protocols is in place for the patient being treated.
7. Institute a process for the review of all dosing protocols either annually or every two years to ensure that protocols adhere to the latest evidence.
8. Investigate patterns outside the range of appropriate doses. Track radiation doses from exams repeated due to insufficient image quality or lack of availability of previous studies to identify the causes. Address and resolve these problems through education and other measures.
9. Record the dosage or exposure as part of the study’s summary report of findings.

See relevant Joint Commission requirements:
LD 04 04 07 (hospital and critical access hospital);
LD 04 04 09 (ambulatory)
Cumulative Dose

- Consensus development
- Standardized
- Meaningful
- Consistent
  - across specialties
  - across geographies
- Commutable
- Protected
- EHR
Must become automated...

- Track individual patient doses, and
- Track institutional dose profile
Duke Rad Tracker: QA/QI

[Graph showing data with median, 90th percentile, and maximum values.]

Courtesy Olav Christianson, RAIL
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Conclusions

…The woods are lovely, dark, and deep,
But [we] have promises to keep,
And miles to go before [we] sleep,
And miles to go before [we] sleep.

Robert Frost “Stopping By Woods on a Snowy Evening”