Computed Tomography in Emergency Medicine: Ensuring Appropriate Use

September 23 – 24, 2009
Bethesda-Chevy Chase Rescue Squad Building
Anastasi Conference Room
5020 Battery Lane
Bethesda, Maryland

agenda
September 23, 2009

8:00 am  Registration and continental breakfast

8:30  Welcome and Introduction
   Thomas S. Tenforde and
   Otha W. Linton

8:40  Self-Introductions of Participants

Exposure of Members of the U.S. Population to Medical Radiation & Growth in Applications of Computed Tomography

9:00  Major Sources of Exposure from Diagnostic Imaging Procedures
   Bruce R. Thomadsen

9:20  Uses and Misuses of CT in Medicine
   James A. Brink

9:50  Coffee break

Applications of Computed Tomography in Emergency Medicine

10:10  CT Imaging Utilization: Emergency Department Perspective
   Scott W. Melanson

10:40  CT Imaging Utilization: Radiology Perspective
   Stuart E. Mirvis
Current Practices in Computed Tomography

- External factors that influence clinical use of CT
- Referral of the patient for CT examination
- Assimilation of clinical diagnostic information into patient management strategy
- Other imaging specialties and their requirements
- Institutional requirements on imaging practices
- Patient expectations

11:10  CT Practices: Emergency Medicine Perspectives
       Louis K. Wagner

11:35  CT Practices: Radiologist Perspectives
       Stephen R. Baker

12:00 pm  Lunch break

Regulatory & Legal Aspects of Computed Tomography Applications in Emergency Medicine Procedures

1:20  Federal (FDA) and State-Level (CRCPD) Requirements on Manufacturers
       Stanley H. Stern

1:50  International Perspectives on Use of CT Imaging (WHO initiative)
       María del Rosario Pérez

2:05  Emergency Radiology: Legal and Regulatory Challenges
       Thomas W. Greeson
Clinical Decision Making & Implications for Reducing or Eliminating Computed Tomography Dose

- Critical patients (e.g., patients with chest or abdominal pain)
- Role of alternative imaging procedures
- Role of decision support systems in determining efficacy (e.g., American College of Radiology appropriateness criteria, European Union referral guidelines)
- Role of portable (electronic) records (current status and new possibilities)
- Evaluation of diagnostic yield (efficiency in achieving clinical results)

2:30 Clinical Decisions: Radiology Perspective
Robert A. Novelline

2:55 Clinical Decisions: Emergency Physician Perspective
Paul R. Sierzenski

3:20 Coffee break

Conduct of Computed Tomography Procedures & Radiation Dose Optimization

3:40 CT Basic Physics, Equipment Operations, and Dose Optimization
Mahadevappa Mahesh

4:10 Radiation Doses and Risks in Medical Imaging of Trauma Patients
Walter Huda

4:25 Technical Imaging Issues, Including Procedures for Adults and Pediatric Patients, Physician Referrals, and Quality Control
Donald P. Frush

4:45 Appropriateness Criteria for CT Procedures
Paul A. Larson

5:00 Adjourn first day
September 24, 2009

Analysis, Perception and Communication of Applications of “As Low as Reasonable Achievable” Principles in Use of Computed Tomography in Emergency Medicine

8:30 am  Potential Health Implications of Dose in CT Imaging
          David J. Brenner

8:45    Views of Emergency Department Physicians and Staff
          Michael Blaivas

9:00    Views of Radiologists
          Fred A. Mettler

9:15    Perceptions of Patients, Parents, and Pregnant Women
          Deborah B. Diercks

Summaries, Conclusions, & Consensus Building

9:30    Rapporteur Summaries and Conclusions
          E. Stephen Amis and Paul R. Sierzenski

10:30   Coffee break

General Question & Answer Session
Approaches to Consensus Building

11:20 Representatives of sponsoring organizations:
  • American College of Radiology, James H. Thrall
  • Society Academic Emergency Medicine, D. Mark Courtney
  • American Association of Physicists in Medicine, J. Anthony Seibert
  • American Society of Emergency Radiology, O. Clark West
  • National Council on Radiation Protection and Measurements, Jerrold T. Bushberg

12:10 pm Concluding Remarks
  Thomas S. Tenforde

12:20 Adjourn meeting

Co-sponsors
American Association of Physicists in Medicine
American College of Emergency Physicians
American College of Radiology
American Society of Emergency Radiology
Center for Disease Control and Prevention
Landauer, Inc.
Society for Academic Emergency Medicine
U.S. Environmental Protection Agency

National Council on Radiation Protection & Measurements
7910 Woodmont Avenue, Suite 400
Bethesda, MD 20814-3095
voice: 301.657.2652
fax: 301.907.8768
http://NCRPonline.org
http://NCRPpublications.org
Welcome to All Workshop Participants, Discussants and Observers from NCRP and Co-sponsoring Organizations:

American Association of Physicists in Medicine
American College of Emergency Physicians
American College of Radiology
American Society of Emergency Radiology
Centers for Disease Control and Prevention
Landauer, Inc.
Society for Academic Emergency Medicine
U.S. Environmental Protection Agency
Workshop History

• Discussions of ACR and NCRP in Fall, 2007 on holding workshop on CT Dose Control [follow up to November, 2002 NCRP symposium – AJR 181: 321-329 (2003)]

• Focus on overutilization of CT in emergency medicine [consistent with recommendations in ACR White Paper on Radiation Dose in Medicine – JACR 4: 272-284 (2007)]

• Program Committee formed with representatives of sponsoring organizations and preliminary agenda was planned during teleconference on February 25, 2009

• Agenda then refined with broad input and the workshop scheduled for September, 2009
Workshop Outcomes and Next Steps

- Workshop summary to be prepared by Otha Linton and Thomas Tenforde for review by co-sponsoring organizations
- Summary intended as framework for preparation of a consensus paper on “Appropriateness Guidelines for Applications of CT in Emergency Medicine”
- Drafting team to be formed and will prepare a consensus paper for review, revisions and final approval by co-sponsoring organizations
- Consensus paper to be published for wide dissemination among emergency medicine physicians and radiologists
Estimate of Medical Radiation Exposure in the U.S. 2006

Results of NCRP SC 6-2 Medical Subgroup:
NCRP Report 160

Bruce Thomadsen, Fred Mettler Jr.,
Mahesh Mahadevappa, Mythreyi Bhargavan,
Debbie Gilley, Joel Gray, Jill Lipoti,
John McCrohan, Terry Yoshizumi
Purpose of NCRP SC 06-02

- Evaluate the collective and effective dose to the US population in 2006
- Last major radiological data 1980 (28 years before) and nuclear medicine 1982.
- Estimate current
  - Number and types of procedures
  - Dose per procedure and collective dose
  - Examine past and future trends
Medical Subgroup SC 6-2

- B. Thomadsen, Chairman, Univ of Wis.
- M. Bhargavan, American College of Radiology
- D. Gilley, State of Florida
- J. Gray, DIQUAD, LLC
- J. Lipoti, State of New Jersey
- M. Mahesh, Johns Hopkins Univ.
- J. McCrohan, U.S. F.D.A.
- F. Mettler, Univ of New Mexico VA
- T. Yoshizumi, Duke Univ.
- M. Rosenstein, Scientific NCRP Consultant
- K. Kase, Stanford SC 6-2 Chair
- Tom Shope, Original Chairman,
- T. Tenforte, President NCRP
Data

- Data sources: No one complete data set. Incomplete data sets require assumptions and cross checking between data sets.
- RBE = 1
- Weighting Factors: Used ICRP 60 (1990). Past reports used older ICRP 26 (1977) and new factors are suggested.
- Issue not examined in this report: Benefit and risk.
Major and minor data sources

- Commercial (IMV Benchmark)
- Medicare payment data (2003-2005)
- VA Health Care System
- Claims data from large national employer plan
- US FDA
- CRCPD
- State radiation programs
- Large hospitals
- American College of Radiology
- Industry sources
- Literature
## Results (2006)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number procedures</th>
<th>%</th>
<th>Collective dose (Person-Sv)</th>
<th>%</th>
<th>Per capita (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td>293 million</td>
<td>74</td>
<td>100,000</td>
<td>11</td>
<td>0.3</td>
</tr>
<tr>
<td>Mammography</td>
<td>34 million</td>
<td>8</td>
<td>3,300</td>
<td>&lt;0.4</td>
<td>0.01</td>
</tr>
<tr>
<td>Dental</td>
<td>125 million</td>
<td>31</td>
<td>2,100</td>
<td>&lt;0.2</td>
<td>0.01</td>
</tr>
<tr>
<td>Interventional</td>
<td>17 million</td>
<td>4</td>
<td>128,000</td>
<td>14</td>
<td>0.4</td>
</tr>
<tr>
<td>CT</td>
<td>67 million</td>
<td>17</td>
<td>440,000</td>
<td>49</td>
<td>1.5</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>18 million</td>
<td>5</td>
<td>231,000</td>
<td>26</td>
<td>0.8</td>
</tr>
<tr>
<td>Radiotherapy</td>
<td>1 million pts</td>
<td>NA</td>
<td>NA</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Total x ray + NM = ~ 395 million  
~ 899,000  
~ 3.0
Changes in U. S. Medical Radiation Exposure

**U.S. 1980**
- Natural: 2.8 mSv
- Medical: 0.54 mSv
- Total: 3.6 mSv per capita

**U.S. 2006**
- Natural: 2.8 mSv
- Medical: 3.2 mSv
- Radiography: 0.3 mSv
- Interventional: 0.4 mSv
- Nuclear medicine: 0.7 mSv
- CT scanning: 1.5 mSv
- All other: 0.12 mSv
- Background: 3.1 mSv
- Total: 6.2 mSv per capita
## Change between Reports

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>0.02</td>
<td>3,700</td>
<td>1.47</td>
<td>440,000</td>
<td>1.32</td>
<td>120</td>
</tr>
<tr>
<td>Radiographic</td>
<td>0.37</td>
<td>83,100</td>
<td>0.33</td>
<td>100,000</td>
<td>1.2</td>
<td>1.2</td>
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<tr>
<td>Interventional</td>
<td>0.02</td>
<td>4,200</td>
<td>0.43</td>
<td>128,000</td>
<td>24</td>
<td>31</td>
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<tr>
<td>Nuclear Medicine</td>
<td>0.14</td>
<td>32,424</td>
<td>0.77</td>
<td>231,000</td>
<td>5.5</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.54</strong></td>
<td><strong>123,424</strong></td>
<td><strong>3.00</strong></td>
<td><strong>899,000</strong></td>
<td><strong>5.7</strong></td>
<td><strong>7.3</strong></td>
</tr>
</tbody>
</table>

### Notes
- **1980/82a** (NCRP, 1989a) NCRP Report No. 100
- **2006** This Report
<table>
<thead>
<tr>
<th>Tissue</th>
<th>Number millions</th>
<th>%</th>
<th>Collective dose Person Sv</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>&lt;0.1</td>
<td>&lt;2</td>
<td>260</td>
<td>0.1</td>
</tr>
<tr>
<td>Thyroid</td>
<td>&lt; 0.1</td>
<td>&lt;2</td>
<td>400</td>
<td>0.2</td>
</tr>
<tr>
<td>Lung</td>
<td>0.74</td>
<td>4</td>
<td>2,000</td>
<td>0.9</td>
</tr>
<tr>
<td>Cardiac</td>
<td>9.80</td>
<td>57</td>
<td>188,000</td>
<td>85.2</td>
</tr>
<tr>
<td>GI</td>
<td>1.21</td>
<td>7</td>
<td>3,500</td>
<td>1.6</td>
</tr>
<tr>
<td>Renal</td>
<td>0.47</td>
<td>3</td>
<td>650</td>
<td>0.3</td>
</tr>
<tr>
<td>Bone</td>
<td>3.45</td>
<td>20</td>
<td>20,500</td>
<td>9.3</td>
</tr>
<tr>
<td>Infection</td>
<td>0.38</td>
<td>2</td>
<td>1,300</td>
<td>0.6</td>
</tr>
<tr>
<td>Tumor</td>
<td>0.34</td>
<td>2</td>
<td>4,000</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>100</td>
<td>220,000</td>
<td>100</td>
</tr>
</tbody>
</table>
Currently approximately 1 nuclear medicine procedure annually per 15 persons
In 1982, there was almost no nuclear cardiology!
## Results for CT

<table>
<thead>
<tr>
<th></th>
<th>Number (millions)</th>
<th>%</th>
<th>Collective dose person Sv</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>19</td>
<td>28</td>
<td>38,000</td>
<td>8.7</td>
</tr>
<tr>
<td>Chest</td>
<td>11</td>
<td>16</td>
<td>74,000</td>
<td>17.0</td>
</tr>
<tr>
<td>Abd/Pelvis</td>
<td>21</td>
<td>32</td>
<td>212,500</td>
<td>48.0</td>
</tr>
<tr>
<td>Extremity</td>
<td>3.5</td>
<td>5</td>
<td>515</td>
<td>0.1</td>
</tr>
<tr>
<td>CT Angiogram</td>
<td>4</td>
<td>6</td>
<td>56,000</td>
<td>12.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>8</td>
<td>11</td>
<td>55,700</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>67</strong></td>
<td><strong>100</strong></td>
<td><strong>437,000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
CT procedures by year (millions)

Annual growth > 10%/yr
U.S. population < 1%/yr
CT scans of abdomen and pelvis
Exam distribution vs U.S. population

<table>
<thead>
<tr>
<th>Age Group</th>
<th>% of CTs</th>
<th>% of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>1.3%</td>
<td>25%</td>
</tr>
<tr>
<td>11-17</td>
<td>15.0%</td>
<td>10.1%</td>
</tr>
<tr>
<td>18-24</td>
<td>10.0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>25-34</td>
<td>7.2%</td>
<td>13.7%</td>
</tr>
<tr>
<td>35-44</td>
<td>12.4%</td>
<td>15.3%</td>
</tr>
<tr>
<td>45-54</td>
<td>18.0%</td>
<td>14.0%</td>
</tr>
<tr>
<td>55-64</td>
<td>19.0%</td>
<td>9.6%</td>
</tr>
<tr>
<td>65-74</td>
<td>19.4%</td>
<td>6.3%</td>
</tr>
<tr>
<td>75-84</td>
<td>16.1%</td>
<td>4.4%</td>
</tr>
<tr>
<td>85 and older</td>
<td>0.7%</td>
<td>1.6%</td>
</tr>
</tbody>
</table>
CT History

- Released in 1972 as head scanners.
- By 1982
  - Body scanners were new and expensive.
  - Mostly still in major centers.
  - Images were great, unless you compare them with modern devices.
  - Most facilities that had one, had…one.
  - They were still sloooow and throughput was low.
Points of interest

- The numbers and percentages of procedures appear robust and consistent across databases.
- Doses of procedures are averages. For an individual procedure the range may vary over a factor of about 3-20.
- Medical exposures have grown greatly since the last report.
- The greatest increases are where procedures did not exist in the early 1980s.
- The effect in medicine and the benefit for patients have been much greater than the increase in dose.
CT as an Exemplar for:
The Use and Misuse of Radiation in Medicine

James A. Brink, M.D.
Yale University School of Medicine
DISCLOSURE

• General Electric: Medical Advisory Board
Acknowledgement

T. Rob Goodman, M.D.
Yale University School of Medicine
Radiation in Medicine

Diagnostic Uses

Therapeutic Uses
Medical Radiation Exposure

See: Fred Mettler, MD: “Magnitude of Radiation Uses and Doses in the US: NCRP Scientific Committee 6-2 Analysis of Medical Exposures”

Tom Tenforde, Ph.D., President, NCRP: “Medical exposures have risen by a factor of at least five since the 1980s, primarily due to the greatly increased use of CT and nuclear cardiology procedures.”
<table>
<thead>
<tr>
<th>Procedures</th>
<th>Number of Procedures (millions)</th>
<th>%</th>
<th>Collective dose (Person-Sv)</th>
<th>%</th>
<th>Per capita (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td>276</td>
<td>52</td>
<td>182,000</td>
<td>19</td>
<td>0.6</td>
</tr>
<tr>
<td>Interventional</td>
<td>13</td>
<td>2</td>
<td>112,000</td>
<td>12</td>
<td>0.4</td>
</tr>
<tr>
<td>CT</td>
<td>67</td>
<td>12</td>
<td>440,000</td>
<td>46</td>
<td>1.45</td>
</tr>
<tr>
<td>Mammography</td>
<td>34</td>
<td>6</td>
<td>3,300</td>
<td>&lt; 0.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Dental</td>
<td>125</td>
<td>23</td>
<td>2,300</td>
<td>&lt; 0.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>21</td>
<td>4</td>
<td>230,000</td>
<td>23</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>~ 544</td>
<td>100</td>
<td>~ 970,000</td>
<td>100</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Europe: 0.7 to 2.0 mSv per capita
Natural 3.0 mSv

Medical 0.54 mSv

Total 3.6 mSv per capita

U.S. 1980

Natural 3.0 mSv

Medical 0.54 mSv

Interventional 0.4 mSv

Radiography 0.6 mSv

Nuclear medicine 0.7 mSv

CT scanning 1.5 mSv

Medical 3.2 mSv

All other <1 mSv

Natural NCRP 3.0

Total ~ 6.2 mSv per capita

U.S. 2006

Medical: 600% increase
Diagnostic Uses for Radiation

Computed Tomography
Nuclear Medicine
Radiography
Fluoroscopy
‘Benefits’ of CT

• Standard Axial Imaging
  – Superb Anatomic Depiction
    • Head to toe
  – Innumerable Diagnoses
    • Confirmed
    • Excluded
‘Benefits’ of MDCT

• New uses of CT imaging
  – Renal/Ureteral Stone CT
  – CT “Virtual” Colonoscopy
  – CT Angiography of Head, Pulmonary Vessels, Aorta and Extremities
  – Coronary CT Angiography
Hybrid Imaging:

- PET/CT
- CT Colon
- CT Angio
Radiation Dose

- CT has grown dramatically:
  - 3 million CT exams in 1981
  - 20 million CT exams in 1995
  - 35 million CT exams in 2000
  - 63 million CT exams in 2005

Mettler FA. Radiation Protection and Dosimetry, 2001
Niagara Health Quality Coalition, 2004
Millions of CT Exams

The graph shows the increase in CT exams from 1981 to 2005, with a significant rise in the number of exams performed over time.
Typical Doses

- Chest study: 0.10 mSv
- Cervical spine: 0.11 mSv
- Pelvis: 0.27 mSv
- Skull: 0.31 mSv
- Upper GI: 1.17 mSv
- Barium enema: 2.98 mSv
- CT scan: 18.0 mSv

Linnemann, 2001. Managing Radiation Medical Emergencies
• Based on the linear, no-threshold hypothesis and empiric data from atomic bomb blast survivors, the fatal cancer risk from a CT scan with a 10 mSv exposure is approximately:
  
  a. 1 in 100
  b. 1 in 200
  c. 1 in 1,000
  d. 1 in 2,000
  e. 1 in 10,000

   Answer: d
Cancer Risk

- **Fatal cancer risk to population**: 5% per Sv
  - Female neonate: 30% per Sv
  - Male neonate: 15% per Sv
  - Late middle-age: 1% per Sv

- **Presuming linear extrapolation to low dose:**
  - Effective dose of 10 mSv: Risk = 1 in 2000

Atomic Bomb Survivor Data

• Biggest longitudinal study to date
  - 35,000 survivors exposed to doses < 150 mSv
  - Followed for cancer incidence over 55 years
  - Direct, statistically significant evidence for risk in the dose range from 5 to 150 mSv

Cancer Risk: No Extrapolation

- Japanese survivors (lowest dose) 5 - 150 mSv
  - Small but statistically significant increased risk of developing cancer due to radiation
- Diagnostic CT 5 - 20 mSv

Excess Relative Risk for Cancer Mortality (1950-1990) in A-bomb Survivors (all ages)

Adapted from Pierce, D.A. and Preston, D.L.
Cancer Risk from CCTA

• Phantom Data and Monte Carlo Simulation
  – BEIR VII report from atomic bomb survivors
  – Lungs: 42 - 91 mSv
  – Breasts: 50 - 80 mSv
  – Lifetime Cancer Risks: w/ gating
    • Male, age 80 1 in 3261 1 in 5017
    • Female, age 20 1 in 143 1 in 219

On the basis of such risk estimates and data on CT use from 1991 through 1996, it has been estimated that about 0.4% of all cancers in the US may be attributed to the radiation from CT studies. By adjusting this estimate for current CT use, this estimate might now be in the range of 1.5 to 2.0%.

Study: Cancer cases could spike as result

By Steve Sternberg
USA TODAY

Overuse of diagnostic CT scans—CT stands for computed tomography—which superimpose multiple X-ray images to make 3-D pictures, rather, they say, CT scanning is an invaluable tool in many cases. The problem is, doctors too often overlook its risks.

"About one-third of all CT scans that are done right now are medically unnecessary," says David Brenner of Columbia University, lead author of the study reported in today's New England Journal of Medicine.

CT scans offer an unparalleled window into the human body, and their use has grown dramatically in recent decades as doctors use them to identify ailments in the head, abdomen and heart.

Today, about 62 million CT scans are performed nationwide every year, up from 3 million in 1980, the authors say. Medical exposure to radiation, mainly through CT scans, has replaced environmental radon as the dominant source of radiation exposure for the U.S. population, the doctors say.

"On average, we now get double the radiation exposure we got in 1980 because of increased CT scans," Brenner says. "Virtually anyone who presents in the emergency room with pain in the belly or a chronic headache will automatically get a CT scan. Is that justified?"

University of New Mexico radiologist Fred Mettler, who was not part of the study, agrees that CT scans are overused. "We're always behind on CT scans because of demand from clinicians," he says.

As many as 5 million scans are now done in children, who are 10 times more sensitive to radiation than adults. The increase was driven by technical advances that allow doctors to capture images in less than a second, eliminating the need for anesthesia to keep a child from moving.

And the use of the scans continues to grow, Brenner says. Doctors are scanning smokers and ex-smokers for early stage lung cancer, a highly controversial practice; they're using non-invasive "virtual colonoscopies to check for colon cancer; and CT angiography is now being tested as a possible complement to ordinary angiography as a way to diagnose blockages in arteries leading to the heart.

In critiquing a study on CT angiography at an American Heart Association meeting in Orlando last month, Michael Lauer of the National Heart, Lung and Blood Institute called that practice into question. He said there is no evidence of benefit from the technology and a real concern for harm.

New machines being developed by Philips and Toshiba for CT angiograms, however, may be safer because they emit 80% less radiation than standard CT scanners, Brenner says.

Brenner and his co-author, Eric Hall, also of Columbia, say many doctors don't realize that just a scan or two can bathe a patient in roughly the same amount of radiation as the atomic bomb delivered to the Japanese survivors of Hiroshima and Nagasaki standing a mile or two from ground zero. And many people receive multiple scans over a lifetime.

The amount of radiation delivered during a single CT scan can range from 1,000 to 10,000 milli-rem, depending on the machine and the protocol. Japanese survivors a mile or two from ground zero received about 3,000 millirems on average.

The cancer rates in the new study were drawn directly from a joint $1 billion study of the bomb survivors financed by the United States and Japan.
Relative Risk

- **To individual:**
  - Lifetime risk of cancer: 20-25% (1 in 4 or 5)
  - Added risk: 0.05% (negligible, 1 in 2000)

- **To population:**
  - 62M CT scans year
  - Without CT: 13.778M will die of cancer
  - With CT: an additional 31K will die of cancer (13.809M)
Question

- Which of the following statements about radiation-induced cancers is incorrect:
  a. The risks persist throughout life
  b. Radiation-induced cancers appear at the same age as spontaneous cancers of the same type
  c. Children and adults are equally susceptible to radiation induced cancers
  d. The bone marrow, thyroid, breast and lung are at greatest risk

Answer: c
Atomic Bomb - Additional Lessons

- Radiation-induced cancers appear at the same age as spontaneous cancers of the same type
- Risks persist throughout life
- Children are 10x more sensitive to radiation induced cancers than adults (girls > boys)
- Bone marrow, thyroid, breast, and lung are at greatest risk
- Risk from acute exposure appears similar to fractionated exposure (fluoro-->breast cancer)
Media attention has heightened awareness of the issues surrounding CT scans in children. David Brenner of Columbia University notes that the radiation doses from these scans can lead to cancer later in life. MDCT has been criticized for excessive radiation dose given to patients. Children have more rapidly dividing cells than adults, which are more susceptible to radiation damage. Children will also live long enough for cancers to develop. Researchers led by Lane Donnelly at Cincinnati's Children's Hospital found that children often get radiation doses six times higher than necessary. Cutting the adult dose in half would yield a clear image and cut the risk a like amount. Brenner says, "Radiologists genuinely believe the risks are small," he says. "I suspect they've never been confronted with numbers like this."
Correct exposure  

Over exposure
Radiation Exposure from CT

Collective dose to population rising

- High radiation dose per examination
- Increasing number of indications
- Increasing availability
- Easier to perform
- Faster
Steps to Control Radiation Exposure

Appropriate Utilization

• CT vs. other imaging tests
• Avoid repetitive studies
• Tailor exam to the patient
• Tailor exam to the application
  – Reduce dose as such as possible
Appropriate Utilization

“I am an adult and a physician! I don’t need your approval for CT scans that are necessary for my patients”

Anon (emergency physician)
“CT should be avoided when an ultrasound or MRI is of comparable diagnostic utility”
RLQ Pain: Pregnant (26 wks)

Appendicoliths
RLQ Pain: Pregnant (32 wks)

Ureteral Calculus
Physician Education

- Adult CT patients for abdominal pain
- Questioned about consent, radiation risk and CXR equivalents
- Same questions asked of ED physicians and radiologists

Physician Education

• 9% of referring physicians believed that there was an increased cancer risk from CT

• CXR Equivalents (%):

<table>
<thead>
<tr>
<th></th>
<th>&lt;1</th>
<th>1-10</th>
<th>10-100</th>
<th>100-250</th>
<th>&gt;500</th>
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</thead>
<tbody>
<tr>
<td>MDs</td>
<td>7</td>
<td>44</td>
<td>22</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>Rads</td>
<td>5</td>
<td>56</td>
<td>15</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Pts</td>
<td>28</td>
<td>64</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Medical Exposures Directive of Council of the European Union**
  - Strict referral criteria
  - Strict justification criteria
  - Dose optimization requirement
  - Dose exposure reference levels

*Ionizing Radiation (Medical Exposures) Regulations
**Council Directive 97/43 Euratom
Appropriate Utilization

“CT should be avoided when prior diagnostic radiation exposure is excessive”
Repetitive CT for Renal Colic

• 6 year period
• 4562 patients
• 5564 CT examinations
• Mean age: 45 years
  – 4% of exams were in children

176 Pts (4%) had 3 or more Flank Pain CTs
Average Flank Pain CT Dose

Mean Dose Length Product (DLP)

15 Randomly Selected Patients

\[
\text{SDCT} = 460 \text{ mGy cm (6.5 mSv)}
\]

\[
\text{MDCT} = 610 \text{ mGy cm (8.5 mSv)}
\]
Estimated Effective Dose

Estimated Risk 1:133

EFFECTIVE DOSE (mSv)

NUMBER OF FLANK PAIN CT EXAM
Appropriate Utilization

“CT technique should be tailored to the patient and his/her body habitus”
Patient Gender

- **Breast Shields (??)**
  - Bismuth latex
  - Several sizes
  - Attenuates primary beam
  - Little effect on image quality
Breast Shields
Breast Shields

- **Reduced dose to:**
  - breasts by 30%
  - lungs by 15%
- **Increase in image noise**
- “Reduction in organ dose could be realized more efficiently with a reduction in tube current”

Appropriate Utilization

“CT technique should be monitored and controlled to insure that dose is as low as reasonably achievable”
Tube Current (mA)
Virtual Colon Phantom, “High Dose”

Courtesy of Beth McFarland, M.D.
Virtual Colon Phantom, “Medium Dose”

Courtesy of Beth McFarland, M.D.
Virtual Colon Phantom, “Low Dose”

Courtesy of Beth McFarland, M.D.
Tube Current Modulation: In Plane
Tube Current Modulation: Through Plane

Dose reduction of > 25%
Tube Current Modulation: Combined

AEC: Automatic Exposure Control

Radiation Dose Savings of up to 50%
Tube Potential (kVp)
Use of a low kVp setting (80 or 100 kVp) as a means to control radiation dose at CT scanning may be appropriate in the following clinical situations except?

a. Thin patients
b. Pediatric patients
c. CT of the pelvis without IV contrast material
d. CT angiography of the thorax

Answer: d
Low kVp: Rationale

- **K-edge of Iodine** 32 keV
- **Mean photon energy**
  - 80 kVp 44 keV
  - 100 kVp 52 keV
  - 120 kVp 57 keV
  - 140 kVp 62 keV

Effect of kV on Dose

Phantom diameter, cm

constant mAs (165)

140 kV
120 kV
100 kV
80 kV

Courtesy of Marilyn Siegel, MD
Effective of kV on Image Noise

Phantom diameter, cm

- 80 kV
- 100 kV
- 120 kV
- 140 kV

Courtesy of Marilyn Siegel, MD
Effect of kV on Iodine Contrast

Phantom diameter, cm

 Courtesy of Marilyn Siegel, MD
Low kV

- **Chest CT: Improved detection of PE**
  - 100 vs. 140 kVp
  - Reduced radiation dose by 3x
    - 140 kVp -- 10.4 mGy
    - 100 kVp -- 3.4 mGy

Low kV

- **Coronary CTA: 100 patients (≤ 85 kg)**
  - Siemens Dual Source 64DCT
  - Retrospective gating
  - 120 kVp / 330 mAs: 12 mSv
  - 100 kVp / 330 mAs: <8 mSv
  - Best for HR < 65 bpm

*Pflederer T, et al. (Univ. of Erlangen). SCCT, 2007*
Dose Monitoring

- **Images**: 1-41, 42-82
- **CTDv (mGy)**: 11.77, 11.77
- **DLP (mGy·cm)**: 207.39, 207.39
- **Dose Efficiency %**: 77.41, 77.41

**Projected series DLP**: 414.79 mGy·cm

**Accumulated exam DLP**: 0.00 mGy·cm
**Gated: No Tube Current Modulation**

Exam Description: CT CHEST/ABD DISSECTIO

<table>
<thead>
<tr>
<th>Series</th>
<th>Type</th>
<th>Scan Range (mm)</th>
<th>CTDIvol (mGy)</th>
<th>DLP (mGy·cm)</th>
<th>Phantom cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scout</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Helical</td>
<td>83.250–1271.750</td>
<td>17.42</td>
<td>591.82</td>
<td>Body 32</td>
</tr>
<tr>
<td>202</td>
<td>Axial</td>
<td>1100.000–1100.000</td>
<td>10.41</td>
<td>5.22</td>
<td>Body 32</td>
</tr>
<tr>
<td>3</td>
<td>Cardiac Helical</td>
<td>12.000–1218.250</td>
<td>68.21</td>
<td>1713.89</td>
<td>Body 32</td>
</tr>
<tr>
<td>3</td>
<td>Cardiac Helical</td>
<td>1219.000–1399.000</td>
<td>50.58</td>
<td>1087.53</td>
<td>Body 32</td>
</tr>
</tbody>
</table>

Total Exam DLP: 3398.46

**Effective Dose = DLP x 0.016 mSv/mGy-cm**

= 54.4 mSv
Effective Dose

**Effective Dose**

Estimate effective dose from DLP

<table>
<thead>
<tr>
<th>Region</th>
<th>mSv / (mGy cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.0023</td>
</tr>
<tr>
<td>Chest</td>
<td>.017</td>
</tr>
<tr>
<td>Abdomen</td>
<td>.015</td>
</tr>
<tr>
<td>Pelvis</td>
<td>.019</td>
</tr>
</tbody>
</table>

*Jessen KA. Applied Radiation and Isotopes, 1999; 165-172*  
(This method is used in the ACR CT Accreditation Program)
‘Broselow/Luten’ Pediatric Emergency System (Color-coded)
‘Color Coding for Kids’ Selection

Name: LightSpeed 1.2
ID: 123-45-6879
Protocol: Yellow Chest
Exam: 34    Series: 2

Dose Information

<table>
<thead>
<tr>
<th>Images</th>
<th>CTDHU mGy</th>
<th>DLP mGy·cm</th>
<th>Dose Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-41</td>
<td>11.77</td>
<td>207.39</td>
<td>77.41</td>
</tr>
<tr>
<td>42-62</td>
<td>11.77</td>
<td>207.39</td>
<td>77.41</td>
</tr>
</tbody>
</table>

Projected series DLP:
Accumulated dose DLP:
One size does not fit all...

There’s no question — CT helps us save kids’ lives!
But...When we image, radiation matters!
Children are more sensitive to radiation.
What we do now lasts their lifetime.
So, when we image, let’s image gently.
More is often not better.
When CT is the right thing to do:
• Child size the kVp and mA
• One scan (single phase) is often enough
• Scan only the indicated area

A timely message from the Alliance for Radiation Safety in Pediatric Imaging.

Visit www.imagedgently.org.
Made possible by an unrestricted educational grant from GE Healthcare.
ACR CT Accreditation

• **Dose data required for:**
  – Adult Head
  – Adult Abdomen
  – Pedi (5yr old) Abdomen

• **Dose metrics to be measured**
  – CTDIw
  – DLP
  – Effective Dose
ACR CT Accreditation

- **Dose metrics to be judged**
  - CTDIw
  - DLP
  - Effective Dose

- **Recommended CTDIw**

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>Revised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>60 mGy</td>
<td>75 mGy</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>35 mGy</td>
<td>25 mGy</td>
</tr>
<tr>
<td>Pedi Abdomen</td>
<td>25 mGy</td>
<td>20 mGy</td>
</tr>
</tbody>
</table>
**European Guidelines**

<table>
<thead>
<tr>
<th>Exam</th>
<th>CTDIw</th>
<th>DLP</th>
<th>Eff. Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>60</td>
<td>1050</td>
<td>2.4</td>
</tr>
<tr>
<td>Chest</td>
<td>30</td>
<td>650</td>
<td>11.1</td>
</tr>
<tr>
<td>Abd</td>
<td>35</td>
<td>800</td>
<td>12.0</td>
</tr>
<tr>
<td>Pelvis</td>
<td>35</td>
<td>600</td>
<td>11.4</td>
</tr>
<tr>
<td>Chest/Abd/Pel</td>
<td>2050</td>
<td></td>
<td>34.5</td>
</tr>
</tbody>
</table>

*From Commissione Europea EUR 16260, EUR 16261, EUR 16262 ed EUR 16263*
Radiation Monitoring and Alerts

Steven Birnbaum, M.D.
Radiation Safety Officer
Southern New Hampshire Medical Center
Steps To Minimize Exposure

Southern NH Med Center Order Requisition

***RADIATION SAFETY ALERT***

ACC #: 293384  Exam: Renal w Contrast CT (74160) (CTRENAL*)

Date: 08/30/2006  7:35

Name:  TEST, EDTEST
MRN:  (SNHMC) XXXXXX

DOB: 07/23/1960  AGF: 46 Y  SEX: M
Visit / Billing #: 75286724

Isolation Indicator:

Patient Status:  E
All mammo, BD and Breast US must only be in status "C"!

Requesting MD: [Redacted]
Dr. Phone: [Redacted]
PCP: [Redacted]
Dr. Phone: [Redacted]

Room: CT-VR
Patient Loc: E343-A
History: abd pain
Diagnosis: KIDNEY PAIN
Comments: 
Patient Allergies:
Elements of a Successful Radiation Protection Program

- **Education of Clinicians and Radiologists**
- **Technical Modifications**
  - Algorithms for Utilizing Non-ionizing Modalities
- **Identification of Patients w/ Elevated Exposure**
  - 5 scans in patients < 40yrs with benign conditions (≥50 mSv)
  - Notification of referring physician
  - Notation in the patient’s imaging record (like contrast allergy)
- **Investigation of Extreme Exposure**
  - Further history and counseling for exposures > 100 mSv

*Courtesy of Steven Birnbaum, MD*
That’s all...
CT Utilization in Emergency Medicine

Scott W. Melanson, MD, FACEP

Program Director,
Emergency Medicine Residency,
St. Luke’s Hospital,
Associate Professor,
Temple University Hospital
CT in EM

• Advances in CT technology → improved imaging

• Expanded ED applications
  – PE: CT better than VQ
  – Appendicitis: had only clinical judgment
  – Spine: CT more accurate than plain films
  – Renal colic: CT more accurate, more info than U/S
  – ACS: stress test / catheterization
Who is Ordering All the CTs?

• Examined CT ordering at community, academic center
  – 500 beds, 70,000 ED patients / year
  – Level 1 Trauma Center, Stroke & Chest Pain Center

• All CTs: December 2006 – December 2007
  – Inpatient and outpatient studies
  – Reviewed to determine ordering physician / dept
Who Is Ordering All the CTs?

Number of CTs Ordered by Department

<table>
<thead>
<tr>
<th>Department</th>
<th>Number of CTs Ordered</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>12,000</td>
</tr>
<tr>
<td>IM</td>
<td>4,000</td>
</tr>
<tr>
<td>Trauma</td>
<td>6,000</td>
</tr>
<tr>
<td>Surgery</td>
<td>4,000</td>
</tr>
<tr>
<td>Unknown</td>
<td>3,000</td>
</tr>
<tr>
<td>Critical Care</td>
<td>3,000</td>
</tr>
<tr>
<td>FP</td>
<td>2,000</td>
</tr>
<tr>
<td>Peds</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Ortho</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>GYN</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Other</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

41% of CTs were ordered by the Emergency Department, followed by Internal Medicine (22%) and Surgery (18%).
EP CT Ordering Variability

- 18.7% ED pts had CT
• Factors responsible for variability
  – Training?
  – Age?
  – Risk tolerance?
  – Malpractice experience?
ED Indications

- Head
- Cervical Spine
- Thoracic & Lumbar Spine
- Chest
- Abdomen / Pelvis
- Extremities
  - CTV
  - Fractures
  - Infections
Head CT

• Most commonly ordered CT in ED
  – Trauma
    • Routine in any anticoagulated elderly pt with CHI
    • Guidelines for adults
      – New Orleans Criteria*
      – Canadian CT Head Rules**
      – Nexus II***
    • Little guidance for very young

*NEJM 2000;343:100
**Lancet 2001;357:1391
*** J Trauma 2005;59:954
Head CT

• Other Indications:
  – Stroke
  – Altered mental status
  – 1st episode of seizure
  – “Worst HA of life”
Head CT: CT Before LP?

• Prospective study, N = 113*
  • Predictors of lesion on CT:
    – Altered mental status (LR 2.2)
    – Focal neurological deficit (LR 4.3)
    – Papilledema (LR 11.1)

• Prospective study, N = 301**
  • CT could be omitted if:
    – Age < 60
    – Not immunocompromised (e.g. HIV, immunosuppressives)
    – No hx of CNS disease (e.g. stroke, mass lesion)
    – No seizure within last week
    – No abnormal results on neurologic examination

*Arch Intern Med 1999;159(22):2681-2685
**N Engl J Med 2001;345(24)1727-1733
Head CT: CT Before LP?

- **IDSA Guidelines**
  - CT recommended before LP if:
    - Immunocompromised
    - History of CNS disease
    - New-onset seizure within 1 week of presentation
    - Abnormal neurologic exam
      - Papilledema
      - Abnormal mental status

*Clin Infect Dis 2004;39(9):1267-1284
Abdomen / Pelvis

• Appendicitis
  – Has become virtually required for surgery
  – Scoring systems being investigated*

• Diverticulitis
  – Dx can be made clinically
  – No guidelines on when CT necessary / helpful

• Renal colic
  – Low dose protocol
  – Necessary with each episode?
    • Recurrent stones?

Acad Emerg Med 2009;16:591-596
• **Bowel obstruction**
  – Compared with plain films, CT
    • More sensitive
    • More specific
    • More accurate at defining point of obstruction
    • More accurate at defining etiology of obstruction

• **Aortic aneurysm**
  – Fast, easily available, broad spectrum test
  – Ultrasound accurate, less available
• Trauma
  – Clinical exam not sensitive or specific for injury
  – FAST helpful in detecting need for immediate laparotomy
    • Not accurate for identifying hollow viscus or solid organ injury
  – CT rapid, readily available
Trauma Patients

• Quantitative Assessment of Diagnostic Radiation Doses in Adult Blunt Trauma Patients
  – Wake Forest University
    • Level 1 trauma center
  – Case series 100 patients
• Median number of CT scans = 3 (range = 2-10)
• Median # of plain series = 9.5 (range = 2-64)
• Median effective dose total dose = 40.2 mSv

Trauma Pan Scan

- Head, C-spine, Chest, Abd/Pelvis CT
- Archives Surgery 2006*
  - Inclusion criteria
    - No visible evidence of chest or abd injury
    - Hemodynamically stable
    - Normal abd exam or unevaluable
    - Significant mechanism of injury
  - 1000 trauma pts
    - 592 mechanism of injury
    - 408 depressed LOC

*Arch Surg. 2006;141:468-473
Pan Scan in Trauma

- Clinically significant abnormalities:
  - 3.5% of head CT scans
  - 5.1% of cervical spine CT scans
  - 19.6% of chest CT scans
  - 7.1% of abdominal CT scans.

Treatment was changed in 18.9% based on abnormal CT scan findings

*Arch Surg. 2006;141:468-473*
• Pulmonary embolism
  – Increased mortality if missed
  – Heightened awareness of PE → increased likelihood to investigate
  – D-dimer helpful in R/O in low risk patients
  – Up to 1/3 will have repeat CTA w/in 5 years*
    • Index scans: 5.3% + for PE
    • Subsequent scans: 3.4% + for PE

Chest

• Aortic dissection
  – Other tests available (e.g., MRI, TEE)
  – None faster, easier, more accurate than CT
  – PE often also in differential

• Cardiac
  – Could have huge impact in utilization

The Holy Grail

Triple Rule Out Protocol
Spine

- Cervical >> lumbar, thoracic
- CT more accurate than plain films
- Some argue that CT should completely replace radiographs
- Definite indications with trauma
  - High risk injury
  - Neurologic deficit
  - Fracture identified on plain film
  - Patients undergoing head CT?
• Many CT scans are ordered from the ED
  – Improved accuracy
  – Increasing number of applications

• Educational efforts to insure appropriate utilization of CT should focus on EM
CT Imaging in Emergency Medicine
Washington D.C. September 23rd, 2009

Stuart E. Mirvis, MD, FACR
Professor of Radiology
Department of Radiology and Maryland Shock-Trauma Center
University of Maryland School of Medicine
CT scans contribute approximately 45% of the U.S. population's collective radiation dose from all medical x-ray examinations. CT is the largest contributor to medical exposure to the U.S. population.
The “trouble maker”!!

Mysterious ray from Hittorf tube caused salt barium platinum-cyanide coating to glow

November 8, 1895, at the University of Wurzburg

He was a productive author of 48 careful, unspectacular papers at the age of 50

By mid-Feb. 1896 X-rays were used to set the broken arm of a young boy in Dartmouth, New Hampshire. Within a year, a thousand papers were published on the phenomenon.

Received the first Nobel Prize for Physics in 1901

Died in poverty during the post-war inflation at the age of 73

William Konrad Roentgen [1845-1923]
One **gray** is the absorption of one joule of radiation energy by one kilogram of matter.

**Absorbed dose** (also known as *Total Ionizing Dose, TID*) is measured in gray (Gy).

The risk of stochastic effects due to radiation exposure can be quantified using the **effective dose**, which is a weighted average of the equivalent dose to each organ depending upon its **radiosensitivity**. Note that the absorbed dose is not a good indicator of the likely biological effect. 1 Gy of alpha radiation would be much more biologically damaging than 1 Gy of photon radiation for example.

A **non-stochastic** or deterministic health effect has a severity that is dependent on dose and is believed to have a *threshold level* for which no effect is seen. **Stochastic** health effects occur by chance, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose, such as cancer and genetic effects.
The equivalent dose ($H_T$) is a measure of radiation dose to tissue where an attempt has been made to allow for the different relative biological effect of different types of ionizing radiation. Equivalent dose is a less fundamental quantity than radiation absorbed dose, but is more biologically significant. Equivalent dose has units of sieverts.

For a given amount of radiation (measured in grays), the biological effect (measured in sieverts) can vary considerably as a result of the radiation weighting factor $W_R$.

The average radiation dose from an abdominal x-ray is 1.4 mGy, that from an abdominal CT scan is 8.0 mGy, that from a pelvic CT scan is 25 mGy, and that from a selective spiral CT scan of the abdomen and the pelvis is 30 mGy.
<table>
<thead>
<tr>
<th>Diagnostic Procedure</th>
<th>Typical Effective Dose (mSv)(^1)</th>
<th>Number of Chest X rays (PA film) for Equivalent Effective Dose(^2)</th>
<th>Time Period for Equivalent Effective Dose from Natural Background Radiation(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x ray (PA film)</td>
<td>0.02</td>
<td>1</td>
<td>2.4 days</td>
</tr>
<tr>
<td>Skull x ray</td>
<td>0.07</td>
<td>4</td>
<td>8.5 days</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>1.3</td>
<td>65</td>
<td>158 days</td>
</tr>
<tr>
<td>I.V. urogram</td>
<td>2.5</td>
<td>125</td>
<td>304 days</td>
</tr>
<tr>
<td>Upper G.I. exam</td>
<td>3.0</td>
<td>150</td>
<td>1.0 year</td>
</tr>
<tr>
<td>Barium enema</td>
<td>7.0</td>
<td>350</td>
<td>2.3 years</td>
</tr>
<tr>
<td>CT head</td>
<td>2.0</td>
<td>100</td>
<td>243 days</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>10.0</td>
<td>500</td>
<td>3.3 years</td>
</tr>
</tbody>
</table>
Radiation dose fears color coronary CTA guidelines

- Heart association science panel warns against modality if no clear clinical benefit can be established
- Recommendations from a 14-member AHA science advisory panel
- The panel reported that the average lifetime risk of developing a malignancy from all causes is 41% and of death from that malignancy is 21%. The typical 10-mSv coronary CT angiogram induces about a 0.05% additional lifetime risk of death from a malignancy
Even very low doses of **radiation** pose a **risk** of cancer over a person's lifetime, a National Academy of Sciences panel concluded. It rejected some scientists' arguments that tiny doses are harmless or may in fact be beneficial.

The panel also said that approximately one person out of 1,000 would develop cancer from exposure to the amount of radiation from a single, average whole body CT-scan.
Do we really have something to worry about?

- No trend in incidence of total cancer, leukemia or solid tumors with increasing radiation dose was observed in the standardized incidence ratio (SIR) or in the multivariate Poisson regression.
- Overall, while no increase in cancer risk with diagnostic radiation was observed, the results are compatible with a broad range of risk estimates.

Relative Risk for Mortality in Radiation Workers (Internal Analysis)

Figure 1: Trends with dose in relative risk (and 90% CI) for mortality from leukaemia excluding CLL.
I always compare a CT ... for instance, coronary CTA to a cardiac stress test; compare it to something of similar information content. Remember, we have all a one-in-three chance, anyway, of getting cancer. And so I used to be the "reduce dose, reduce dose." And I still am. "Reduce dose, reduce dose." But people have to remember the alarmist press is, I think, concerning too many patients. We had an 84-year-old man, with an aortic aneurysm refuse a CT, after The New England Journal paper came out, because he didn't want that cancer-causing stuff. So if it's medically appropriate, we're good. If it's protective medicine, or just triage them through the ER faster, that's what we have to address. But if it's medically warranted, the risk is negligible, or very, very low. But, still, drop the dose.

It has not been scientifically demonstrated that there is any risk at doses below 100 milliseverts. However, for the purpose of erring on the side of safety, we assume there is, and we act as if there is, and we do dose reduction, and we're prudent. If you go to solid-organ tumors, here's the relative risk of one again. A hundred milliseverts. Look where these error bars are. Look at these error bars out here, with 500 milliseverts, and the error bars still include no risk.
In the final analysis, physicians must request the imaging examination that best addresses the specific medical question without allowing worries about radiation to dissuade them or their patients from obtaining needed CT examinations. Ongoing efforts to ensure that CT examinations are both medically justified and optimally performed must continue, and education must be provided to the medical community and general public that put both the potential risks—and benefits—of CT examinations into proper perspective.

ER Patient Exposure to Radiation

- Orlando Regional and Washington Hospital Center
- Patients had an average cumulative estimated effective radiation dose of 45.0 milliseiverts over 5-yrs., CT scans and nuclear medicine studies contributing the most radiation.
- 12% of the sample population was estimated to have received 100 or more millisieverts of radiation.
- If study patients are representative of the general emergency department population, then a substantial number of people may be at increased risk of developing cancer over their lifetime from diagnostic imaging studies as a result of these exposures.
From 2000 to 2006, pediatric ED patient volume increased by 2%, while triage acuity remained stable. During this same period, head CT increased by 23%, cervical spine CT by 366%, chest CT by 435%, abdominal CT by 49%, and miscellaneous CT by 96%. Increases in CT utilization were most pronounced in adolescents ages 13 to 17 years. Increases in CT utilization in this age group met or exceeded increases seen in the adult population.

MDCT exposure vs. treatable/actionable findings

- University Texas – Galveston
- Retrospective analysis 770 emerg. Pts. (total 1094 CT studies)
- Actionable results in 341; treatable finding in 105
- Mean radiation dose 163.27 mGy CTDIvol (Computed Tomography Dose Index) - actionable
- Mean radiation dose 530.23 mGy CTDIvol - emergency treatable


Average CTPA examinations per month increased 227%, from 33.4 to 109.2 for the first and last 24-month periods.

Diagnoses of PE per month increased 89% from 4.0 to 7.5; percentage of positive CTPA examinations dropped from 9.8% to 6.8%.

Availability of CT in the emergency department and lower physician thresholds for test utilization have increased the use of CT pulmonary angiography and increased detection of PE.

Radiation Exposure: Total-Body Screening MDCT

- Average size adult; < 50 yr.
- 1\textsuperscript{st} run arterial phase; 2\textsuperscript{nd} scan - portal venous
- Dry head = 2 mSv eff
- 100 cm scan = 33 mSv eff (120 kV, 250 mAs)
- 100 cm scan = 22 mSv eff or 35 cm scan = 10 mSv eff (120 kV, 200 mAs/slice)
- Total = 45-57 mSv
Shock -Trauma Center CT volume scanned body regions

- 7/06 to 6/07 = 36,461
- 7/07 to 6/08 = 38,422
- 7/08 to 6/08 = 37,391

Stable admission rate and stable use of MDCT
What has gone wrong

- Too much reliance on CT and testing displacing clinical acumen / judgement
- Fear of malpractice
- Little appreciation for risks associated with radiation exposure
- Little reliance on clinical verified diagnostic pathways
- Negative feedback for not getting “studies”
- Knee-jerk reaction to uncertainty
- Patient expectations
# Reasons for Increased CT Utilization in Emergency Radiology

- High confidence in accuracy
- Concern about missing important finding – consequences
- Move patients quickly through the system – rapid triage
- Removes diagnostic uncertainty
- Covers “a lot of waterfront” – abdominal pain/chest pain/headache
- Readily available
Malpractice fear accounts for significant variability in ED decision making and is associated with increased hospitalization of low-risk patients and increased use of diagnostic tests.

Common Good Fear of Litigation Study
The Impact on Medicine Final Report
April 11, 2002
Conducted for: Common Good
March 4-20, 2002

Project Managers:
• Humphrey Taylor, Chairman, The Harris Poll
• David Krane, Senior Vice President
• Amy Cottreau, Project Manager
• Diana Gravitch, Senior Research Associate

commongood.org/assets/attachments/68.pdf
Physicians report that the fear of malpractice claims causes themselves and/or other physicians to order more tests than they would based only on professional judgment of what is medically needed. (91% have noticed other physicians, and 79% report they themselves do this due to concerns about malpractice liability)

*Common Good Fear of Litigation Study*
Advantages of MDCT in ED practice

- Requires decreased use of more invasive, expensive, or difficult to obtain studies (sonography, angiography, nuclear medicine, MRI)
- Low operator dependence
- Probably decreases costs by high negative predictive value and decreasing length of stay and additional testing
- Provides details of diagnosis beyond clinical assessment
Decreasing the Dose – some methods

- Accept more image “noise”
- Avoid overlapping fields
- Tube current modulation
- Gating
- Low-dose technique- adaptive statistical iterative reconstruction (ASIR)
- Table speed
- Scan length
- Higher scan pitch
- Thicker scan collimation
- Shielding
- Body habitus factors
- Beam filtration
CT and Radiation Exposure

- We still do not know the clinical significance, if any, of diagnostic radiation. There are strong arguments on both sides. Radiologists have decided to adopt a conservative approach on this and move to controlling radiation exposure (decrease) as much as possible while performing clinically needed and diagnostically adequate imaging.

- There is a great deal of controversy regarding what we should be measuring to determine biologically meaningful exposure, what terminology should be used in describing radiation exposure, and how standardized guidelines for exposure could or should be established.

- CT manufacturers are targeting radiation measurement and dose optimalization as worthy efforts to promote their machines and are coming up with some very impressive technology that will progressively lower dose for a given study.

- Radiologists, in general, are probably not as familiar with current concepts of radiation biology, dose modulation techniques, and optimizing dose requirements for particular clinical situations as they need to be and mass education efforts require improvement.

Applied Radiology Radiation Utilization Symposium 2009 San Diego
Our clinical referrers, in most cases, have little specific knowledge about the potential harm of medical radiation, the need for tighter control in “susceptible” patients, and the importance of formulating a particular clinical question in the decision to use ionizing radiation, versus other imaging techniques, or to modify the CT dose appropriate to a given clinical issue.

Radiation exposure and dose modulation strategies need to receive more attention during radiology residency training.

Radiology departments should have on-going programs as part of quality control to monitor radiation exposure as compared to national and internationally established ranges for equipment, examination type, and patient specific factors. They should have an on-going policy of achieving an exposure as low as possible.

A method to track individual patient dose overtime is necessary to guide future use of medical radiation.
How do we educate referring physicians and the public about risk?

Should we be doing fewer CT scans? Who decides which scans are medically indicated?

Will we create an “over-reaction” concerning CT radiation risk that precludes performing necessary studies?

Should we limit our radiation concerns mainly to the “young” and fertile/pregnant population?
What is the best way to determine “biologically relevant” dose?

How do you track patients’ accumulated dose? When do we say... “no more CT scans for you”?

How can we best modify CT studies to obtained with lower dose without compromising diagnostic accuracy?

How do you obtain “informed consent” for radiation exposure?

Should everyone undergoing CT get informed consent? Under what circumstances?
CT and Emergency Medicine

The Impress of Malpractice Considerations
A Skeptical Radiologist’s View

Dr. Stephen R. Baker
A Common Perception

The function of the treating physician in the ER is to be risk averse.
Yet the responsibility of all physicians caring for ER patients is to be mindful of the principles of Evidence-Based Medicine.
How frequent are malpractice claims related to CT use or their avoidance in the E.R. setting involving radiologists and the implications for the potential concomitant liability of E.R. physicians?
The interrelationship of ER physicians and radiologist can be assessed from three vantage points:
1) What is the data regarding malpractice claims against radiologists, and how do they relate to the frequency of specific ER CT examinations?
# Top Five Medical Misadventures

All specialties 1985-2003

<table>
<thead>
<tr>
<th>Misadventure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper performance</td>
<td>50,000</td>
</tr>
<tr>
<td>No misadventures</td>
<td>40,000</td>
</tr>
<tr>
<td>Error in diagnosis</td>
<td>40,000</td>
</tr>
<tr>
<td>Failure to supervise or monitor</td>
<td>12,000</td>
</tr>
<tr>
<td>Medication error</td>
<td>6,800</td>
</tr>
</tbody>
</table>

PIAA
# Closed Claims between 1985-2002

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>OB/GYN</td>
<td>25,594</td>
</tr>
<tr>
<td>Int. Med.</td>
<td>24,791</td>
</tr>
<tr>
<td>Gen/Fam. Practice</td>
<td>21,483</td>
</tr>
<tr>
<td>General Surgery</td>
<td>20,157</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>18,157</td>
</tr>
<tr>
<td>Radiology</td>
<td>10,473</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>7,424</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>7,232</td>
</tr>
</tbody>
</table>

PIAA
% of Claims Paid to Close

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentists</td>
<td>42.84%</td>
</tr>
<tr>
<td>OB/GYN</td>
<td>36.06%</td>
</tr>
<tr>
<td>General Surgery</td>
<td>35.47%</td>
</tr>
<tr>
<td>Radiology</td>
<td>29.78%</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>29.78%</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>27.06%</td>
</tr>
<tr>
<td><strong>PIAA</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Average Indemnity – 2001 to 2003

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Average Indemnity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiology</td>
<td>300,000</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>465,000</td>
</tr>
<tr>
<td>OB/GYN</td>
<td>440,000</td>
</tr>
<tr>
<td>Cardiology</td>
<td>417,000</td>
</tr>
<tr>
<td>GI</td>
<td>265,000</td>
</tr>
</tbody>
</table>
Most prevalent patient conditions

- Malignant neoplasm of female breast
- Lung cancer
- Vertebral fracture
- Fracture of foot
- Fracture of wrist
## Top Five Medical Conditions Claims Closed for All Specialties 1985-2003

<table>
<thead>
<tr>
<th>Condition</th>
<th>All specialties Closed Claims</th>
<th>Ave. Indemnity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Cancer</td>
<td>3,717</td>
<td>223,380</td>
</tr>
<tr>
<td>Brain damaged infant</td>
<td>3,700</td>
<td>509,280</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>3,198</td>
<td>194,094</td>
</tr>
<tr>
<td>MI</td>
<td>2,634</td>
<td>206,880</td>
</tr>
<tr>
<td>Slipped disc</td>
<td>2,479</td>
<td>221,226</td>
</tr>
<tr>
<td><strong>PIAA</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1997 Survey of Most Common Causes of Claims-Radiology PIAA

- Errors in diagnosis
- Improper performance
- Complication of treatment-failure to recognize
- Performed test when not indicated or contraindicated
- Failure to supervise or monitor case
• Performed test when not indicated or contraindicated – 4th most common
• Did not perform test – rare cause
- Radiologists = 30,000
- Cardiologists = 16,000
- Gastroenterologists = 8,000
If the number of radiologists, gastroenterologists and cardiologists were equal, radiologists would have approximately 67\% more claims than cardiologists and 90\% more claims than gastroenterologists.
With respect to paid claims, radiologists would have had 3.6 times more adverse judgments than gastroenterologists and 4 times more adverse judgments than cardiologists.
Closed claims between 1985-2005

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiology</td>
<td>10,473</td>
</tr>
<tr>
<td>Cardiology</td>
<td>3,814</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>1,610</td>
</tr>
</tbody>
</table>
Ratio % Paid to Closed Claims

Radiology 29.78%
Cardiology 18.58%
Gastroenterology 19.01%
Why is there such a marked difference between the frequency of suits against radiologists and the frequency of suits against gastroenterologists and cardiologists?
It is because of suits involving breast disease.
Our Studies

Credentialing Data 14% of radiologists
One Call Medical Inc.

A specialty PPO network for MR and CT services
One Call Medical

• Three year credentialing cycle
• Malpractice History
  – National Practitioner Data Bank
  – Usually several sentence summary
  – Salient feature of claim
  – Claim need not result in suit
  – Announcement – not resolution
Every radiologist’s file is assessed. Radiologists are not consulted personally.
Data Assessed for...

- Overall percentage of radiologists with at least one malpractice claim.
- Relationship between locational differences likelihood of claim (by state)
- Causes of claims
- Changes in claim profile through time (Pre and Post 1995)
- Relationship between gender differences and likelihood of claims
  - claims per radiologist
  - claims per exam performed
<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiologists</td>
<td>3937</td>
</tr>
<tr>
<td>Without Claim(s)</td>
<td>2600</td>
</tr>
<tr>
<td>With Claims(s)</td>
<td>1337</td>
</tr>
<tr>
<td>% With Claim(s)</td>
<td>33.9%</td>
</tr>
<tr>
<td>Total Claims</td>
<td>3231</td>
</tr>
</tbody>
</table>
The number of radiologists in the One-Call Network and thus those available for review of malpractice history is approximately one-seventh of all American radiologists (3,900 vs. 29,000)
GEOGRAPHIC VARIATIONS BY STATE

Percent of Radiologists with at least one malpractice claim
Percent of Radiologists with at least One Malpractice Claim
Causes of Malpractice Claims All Years, Both Genders
Predominant cause for Malpractice Claims determined from narrative summary in NPDB and supplemented by additional information supplied in the Radiologist’s credentialing or re-credentialing application to further explain reasons for the claim.
• For most claims, failure to diagnose is the primary allegation
  • Others include failure to communicate, procedure complications, and the lack of follow-up
<table>
<thead>
<tr>
<th>Failure to Diagnose</th>
<th>1752</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications of Therapy</td>
<td>204</td>
</tr>
<tr>
<td>Failure to Communicate</td>
<td>75</td>
</tr>
<tr>
<td>Negligence</td>
<td>183</td>
</tr>
<tr>
<td>Peripheral Role</td>
<td>328</td>
</tr>
<tr>
<td>Contrast Reaction</td>
<td>52</td>
</tr>
<tr>
<td><strong>Failure to do additional testing</strong></td>
<td><strong>21</strong></td>
</tr>
<tr>
<td>Other</td>
<td>616</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3231</td>
</tr>
</tbody>
</table>
## Disaggregation of Claims against Radiologists- Primary Causes (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>100</td>
</tr>
<tr>
<td>Unknown</td>
<td>25.4</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>10.3</td>
</tr>
<tr>
<td>FTD-illness unknown</td>
<td>9.8</td>
</tr>
<tr>
<td>Peripheral Role</td>
<td>8.5</td>
</tr>
<tr>
<td>Fracture (mostly wrist &amp; rib, spine third commonest)</td>
<td>7.4</td>
</tr>
<tr>
<td>Fracture (other sites)</td>
<td>6.5</td>
</tr>
<tr>
<td>Failure to diagnose (Vascular)</td>
<td>4.7</td>
</tr>
<tr>
<td>Failure to diagnose (Lung Cancer)</td>
<td>2.4</td>
</tr>
<tr>
<td>Failure to diagnose (Ob/Gyn)</td>
<td>1.4</td>
</tr>
</tbody>
</table>
### Disaggregation of Claims against Radiologists- Primary Causes (%)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural Complications</td>
<td>6.7</td>
</tr>
<tr>
<td>Failure to communicate results</td>
<td>3.4</td>
</tr>
<tr>
<td>Contrast Reaction</td>
<td>1.6</td>
</tr>
<tr>
<td>Neurologic disease</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Failure to do additional testing</td>
<td>&lt; 1.0</td>
</tr>
</tbody>
</table>
Why are Radiologists Sued?

- Of the various organ systems, breast disease comprises the majority of all claims against radiologists
- Thoracic disease is second
- Third most common is the extremities, with fracture most frequent
- Fourth most common is the G.I. Tract
Thoracic Cases

- 3231 – Claims – All conditions
- 310 – Thoracic causes

9.4% of claims involve chest conditions
<table>
<thead>
<tr>
<th>Issue</th>
<th>Total claims</th>
<th>Average Award</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to diagnose</td>
<td>217</td>
<td>262,582</td>
</tr>
<tr>
<td>Communication Insufficiency</td>
<td>22</td>
<td>197,443</td>
</tr>
<tr>
<td>Peripheral Issue</td>
<td>17</td>
<td>48,341</td>
</tr>
<tr>
<td>Proc. Complication</td>
<td>10</td>
<td>268,750</td>
</tr>
</tbody>
</table>
Most lung cancer cases result from misdiagnoses of a nodule on chest X-ray, often compounded by delayed communication of results and inadequate call back system.
## Thoracic Malpractice Cases

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Total</th>
<th>% Settled</th>
<th>% Dismissed</th>
<th>Average Award</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung Cancer</td>
<td>109</td>
<td>45%</td>
<td>19%</td>
<td>262,371</td>
</tr>
<tr>
<td>Aortic Dissection</td>
<td>9</td>
<td>44%</td>
<td>22%</td>
<td>751,250</td>
</tr>
<tr>
<td>Tube position</td>
<td>9</td>
<td>33%</td>
<td>11%</td>
<td>36,667</td>
</tr>
<tr>
<td>Line position</td>
<td>8</td>
<td>38%</td>
<td>50%</td>
<td>172,787</td>
</tr>
<tr>
<td>PE</td>
<td>8</td>
<td>50%</td>
<td>25%</td>
<td>455,275</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6</td>
<td>67%</td>
<td>17%</td>
<td>71,667</td>
</tr>
</tbody>
</table>
PE and Aortic Dissection (likely acute presentations) requiring CT comprised only 15 malpractice claims of >3000 radiologists registered over their entire careers.
# Types of GI Claims

<table>
<thead>
<tr>
<th>Allegation</th>
<th># of cases</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to Diagnose</td>
<td>124</td>
<td>63%</td>
</tr>
<tr>
<td>Peripheral Involvement</td>
<td>21</td>
<td>11%</td>
</tr>
<tr>
<td>Procedure Complication</td>
<td>16</td>
<td>8%</td>
</tr>
<tr>
<td>Communication Deficiency</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Pathology Associated with GI Claims</td>
<td># of cases</td>
<td>% of total</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Cancer</td>
<td>46</td>
<td>23%</td>
</tr>
<tr>
<td>Perforated Viscus</td>
<td>19</td>
<td>10%</td>
</tr>
<tr>
<td>Abscess</td>
<td>7</td>
<td>4%</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Bowel Obstruction</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Tube position</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Foreign body</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>Sites of Neoplastic Lesions</td>
<td># cases</td>
<td>% of total</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>Colon</td>
<td>28</td>
<td>14%</td>
</tr>
<tr>
<td>Gastric</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Liver</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Rectal</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Pancreatic</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Esophageal</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Metastasis</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>23%</td>
</tr>
</tbody>
</table>
All Cancers

• For approximately 67% of cancer related GI claims, the final result of the claim is known.

• 54% of all cancer related claims resulted in an adverse outcome for the radiologist.

• The average payout in all these cases was $247,109 including settlements and trials.
Colon Cancer

• For approximately 71% of colon cancer related claims, the final result of the claim is known.

• 64% of all colon cancer related claims resulted in an adverse outcome for the radiologist.

• The average payout in these cases was $289,156
G.I. Cases

Of the GI cases, only some cancers are diagnosed in ER presentations and only some by CT. Perforated viscus, abscess, appendicitis and bowel obstruction and other ER CT diagnoses totaled just 32 cases for these same radiologists.
Perforated Viscus

- For all cases related to perforated viscus, 47% of the studied claims have a known result.
- 26% of all claims related to perforation resulted in an adverse outcome for the radiologist.
- The average payout was $858,333.
Limitations of these data

- Claims only to 2005 (from 1975 – 2005)
- Before recent acceleration of CT use
- Possible disjunction of claims against Radiologists from claims against Emergency physicians, or are they often co-defendants?
These data relate to all practice venues – outpatient, inpatient, and E.R. Thus the fraction of cases that are E.R. based suits cannot be known precisely
Further Limitations

• Criticism - Use of CT “maxed” out.
• Hence, there are many instances of doing a test even when evidence-based studies indicate it should not be done.
• But are there locations where it is likely to not do a test when not indicated? For this to be possible or frequent, one must demonstrate regional variations in utilization.
“Exposure to Low dose Ionizing Radiation from Medical Imaging Procedures”
5 Health Care Markets

- Annual effective doses of ionizing radiation analyzed for age and sex
- CT and Nuclear- 75% of cumulative effective dose
## Rates of Exposure - Number/1000 enrollees

<table>
<thead>
<tr>
<th>Market</th>
<th>Mod dose 3-20 mSv</th>
<th>High dose 20-50 mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>132.3</td>
<td>12.8</td>
</tr>
<tr>
<td>Dallas</td>
<td>125.2</td>
<td>12.7</td>
</tr>
<tr>
<td>Orlando</td>
<td>147.6</td>
<td>14.4</td>
</tr>
<tr>
<td>S. Florida</td>
<td>168.5</td>
<td>15.4</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>105.6</td>
<td>9.4</td>
</tr>
</tbody>
</table>
South Florida vs. Wisconsin

• There is approximately 67% greater dose deposition in South Florida for moderate and high dose CTs
• Consequently, if E.R. utilization is reflective of total utilization, some CT examinations done for emergency patients in South Florida are not performed routinely in Wisconsin.
2) What are the virtues and drawbacks of the American College of Radiology appropriateness initiative in general and specifically?
Appropriateness Criteria- ACR

Recommendations for an optimal evaluation paradigm using imaging tests pertinent to a specific clinical presentation.
Purpose

• Conceived to be advisory in intent
• Designed to be applied often even without discussion with a radiologist prior to implementation
Effect

• Inferred as a “standard” by plaintiff lawyers
• Limited direct relevance in contemporary E.R. practice
• Excellent example of the substitution of proxy proclamations for consultation by direct communication
Conceptual andSemantic Issues with Appropriateness Criteria

• What is a deviation from what is considered
  – Inappropriate?
  – Appropriate?
  – Or possibly not appropriate in context
Major Issue

Appropriateness criteria presume only a “horizontal” interaction. No consideration for “vertical” characteristics of the presentation and progression or resolution of an illness or injury.
Appropriateness Criteria ignore historical, episodic antecedents, patient participation, referrer's experience and judgment. And they also ignore diagnostic radiation exposure records by encounter and dose!
Example - ACR criteria for Small Bowel Obstruction.
S.B.O Considerations

- Presence – Always
- Site - Sometimes
- Cause - Sometimes
• For site and cause, CT superior to radiography
• But for presence alone the plain film and CT are similar in sensitivity (Maglinte 1996)
• Consider, the patient with recurrent S.B.O. due to adhesions
3) If the use (or overuse) of CT is based on either clinical parameters, personal predilections or perceptions of evidence-based protocols related to the ER, what is the participation of the radiologist in validating or substantiating them?
The Role of the Radiologist as a participant in the decision making process for E.R. CT utilization- A study of the test ordering practice of ER physicians and college physicians.
Two Clinical Scenarios

1) Suggestive of Appendicitis
2) One day of Abdominal Pain- no sign of disease
   - Both genders
   - Age 18-21
   - College Physicians- E.R. Physicians
   - ACR Appropriateness Criteria only for appendicitis and not for the one day of abdominal pain presentation
Table 1. Affirmative responses to ordering CT per clinical presentation

<table>
<thead>
<tr>
<th>Clinical Presentation</th>
<th>Emergency department (622 total)</th>
<th>College health service (208 total)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLQ pain, tenderness, fever, increased white count, male pt</td>
<td>426 (68%)</td>
<td>157 (75%)</td>
<td>.069</td>
</tr>
<tr>
<td>RLQ pain, tenderness, fever, increased white count, female pt</td>
<td>516 (83%)</td>
<td>158 (76%)</td>
<td>.033</td>
</tr>
<tr>
<td>Diffuse pain, no guarding, normal white count, male pt</td>
<td>216 (35%)</td>
<td>22 (11%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Diffuse pain, no guarding, normal white count, female pt</td>
<td>210 (34%)</td>
<td>28 (13%)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Seven Possible Influential Factors Regarding CT Choice

- Physical Exam
- Parental Influence
- Protocol
- Costs
- Insurance Considerations
- Medical Literature
- Relationship with Radiologist
<table>
<thead>
<tr>
<th>Factor Importance</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Important</td>
<td>1</td>
</tr>
<tr>
<td>Little Importance</td>
<td>2</td>
</tr>
<tr>
<td>Some importance</td>
<td>3</td>
</tr>
<tr>
<td>Very Important</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 2. Level of importance of factors influencing CT ordering, Male patients

<table>
<thead>
<tr>
<th></th>
<th>Emergency Department</th>
<th>College Health Service</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results of Physical Exam</td>
<td>3.88</td>
<td>3.90</td>
<td>.470</td>
</tr>
<tr>
<td>Parental Complaints/Influence</td>
<td>2.49</td>
<td>2.39</td>
<td>.101</td>
</tr>
<tr>
<td>Protocol</td>
<td>2.08</td>
<td>2.85</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Costs</td>
<td>2.10</td>
<td>3.10</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Insurance/Reimbursement considerations</td>
<td>1.42</td>
<td>2.67</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Medical Literature</td>
<td>3.24</td>
<td>3.51</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Relationship with Radiologist</td>
<td>1.63</td>
<td>1.72</td>
<td>.180</td>
</tr>
<tr>
<td>Factor</td>
<td>Emergency Department</td>
<td>College Health Service</td>
<td>P value</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>----------------------</td>
<td>------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Results of Physical Exam</td>
<td>3.86</td>
<td>3.92</td>
<td>.072</td>
</tr>
<tr>
<td>Parental Complaints/Influence</td>
<td>2.50</td>
<td>2.39</td>
<td>.106</td>
</tr>
<tr>
<td>Protocol</td>
<td>2.09</td>
<td>2.86</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Costs</td>
<td>2.10</td>
<td>3.11</td>
<td>&lt;.001</td>
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<td>Insurance/Reimbursement considerations</td>
<td>1.42</td>
<td>2.69</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Medical Literature</td>
<td>3.24</td>
<td>3.51</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Relationship with Radiologist</td>
<td>1.63</td>
<td>1.75</td>
<td>.083</td>
</tr>
</tbody>
</table>
Inferences

1) The decision to seek CT by E.R. physicians is not based on evidence derived from large scale controlled studies.
Inferences

2) The often uncritical decision to seek CT by E.R. physicians certainly increases collective dose to ER patients.
Inferences

3) “Possible” risks of this widespread practice is passed onto patients to “minimize” putative, heightened risks to E.R. physicians which may not be significant in the aggregate to the extent that a defensive posture is validly career-protective as well as psychologically self-serving.
Inferences

4) The number of instances of career E.R. based malpractice claims involving CT misdiagnosis is low when compared with the number of radiologists (24,000) and E.R. physicians (22,000).
These slides were prepared with the assistance of John Cho, Kim Clarkin, and Tim Meehan.
FDA Promotion of CT Radiation Safety: Federal Regulations, IEC Standards, Research, Outreach

Stanley H. Stern, Ph.D.
Stanley.Stern@FDA.HHS.gov

Food and Drug Administration
Center for Devices and Radiological Health
Office of Communications, Education, and Radiation Programs
Division of Mammography Quality and Radiation Programs
Radiation Programs Branch

NCRP Workshop on CT in Emergency Medicine, September 23-24, 2009
Federal Radiation Protection

Current U.S. Standard for CT Equipment

• **21 CFR 1020.33** (since 1984): for mfrs, *not* clinical facilities

• No ceiling on patient dose or dose rate

• Mfrs must **provide users with info** for each CT scanner model
  
  *CTDI, dose profile, sensitivity profile*

• Mfrs must **certify equipment** and **submit reports** to FDA

• **Few technical requirements:**
  • Visual indication of beam on, pre-selected conditions of operation
  • Indication, positioning, alignment of tomographic plane
  • Emergency termination of x-ray exposure
  • Minimum HVL

• **Has not been updated for**
  
  *electron-beam, spiral, multi-slice, fluoroscopic, cone-beam CT*
U.S. Medical Device Law

**Medical Device Amendment, FFDCA (1976)²**

CT imaging systems are class-II (medium risk) devices
- Mfrs, importers must register their companies, list their devices with FDA
- Mfrs need FDA clearance of device as “substantially equivalent” in its characteristics, performance, safety to predicate device (510(k), 21 CFR 807)

*FDA cleared 320-slice, dual source, and dual-energy scanners*
- Mfrs must comply with the quality system regulation and good manufacturing practices (QSI/GMP) in designing, manufacturing, labeling, storing, installing, servicing equipment (21 CFR 820)
- Equipment may be subject to general and special control requirements

**FDA Modernization Act (1997)³**

In lieu of submitting independently generated safety data to support pre-marketing notifications, mfrs can certify CT-equipment compliance with standards officially recognized by FDA
Most Important Radiation-Safety Features

- Automatic Exposure Control (AEC)
- Standardization, display, recording of dose indices
- Radiation geometrical efficiency
- Other significant features
Automatic Exposure Control (AEC) e.g. Anatomically Adapted X-Ray-Output Modulation

• CT system would **automatically adjust** x-ray emissions to amounts **needed** to image particular patient anatomy
• Pediatric, thinner adult patients: lower doses than thicker patients

IEC 60601-2-44 Ed. 3: 203.106 Control of radiation output....

On each CT scanner, **Automatic Exposure Control (AEC)** shall be provided as a **MODE(S) OF OPERATION** alternative to the manual selection of **CT CONDITIONS OF OPERATION**.  

- **Potential impact:** reduce patient CT dose ~ **30%**

Cross section, torso

thicker arrows: more radiation needed to penetrate cross section

thinner arrows: less radiation need to penetrate cross section

z-axis

x-ray output rate

NCRP CT-ER 9/23/09

Promotion of CT Radiation Safety
Patient Examination Dose-Indices

Display and Recording for QA

IEC 60601-2-44 Ed. 3: 203.112 Display and recording of $CTD_\text{vol}$ and $DLP$.

The actual mean values of $CTD_\text{vol}$ and $DLP$ along with the PHANTOM type shall be recorded according to the DICOM CT radiation dose structured report (SR) templates of ISO 12052.  

- Facilities could audit indices versus “reference values”  

  compare dose indices to norms from which facilities could investigate anomalies and optimize CT settings, protocols.

- Potential impact: reduce patient CT dose on average $\sim 15\%$
Radiation Geometric Efficiency
“Over-beaming” in Multi-slice CT

**Single-slice CT**
1 image, 5-mm section

- z-collimation: 5 mm

**Multi-slice CT**
4 images, 1.25-mm sections

- z-collimation: 15 mm

Patient-incident exposure profiles:
- Umbra regions
- Penumbra regions

---

IEC 60601-2-44 Ed. 3: 203.113 Geometric efficiency in the z direction

For those CT CONDITIONS OF OPERATION with a GEOMETRIC EFFICIENCY IN THE Z DIRECTION of less than 70%, the value shall be displayed. Additionally, under this condition, there shall be a warning on the OPERATOR’S CONTROL PANEL, and the OPERATOR shall be required to confirm before continuing.

A table of GEOMETRIC EFFICIENCY IN THE Z DIRECTION at all beam collimations shall be provided in the ACCOMPANYING DOCUMENTS.4

NCRP CT-ER 9/23/09
Promotion of CT Radiation Safety
IEC CT 60601-2-44: Other Radiation-Safety Features

- Definition of Computed Tomography Dose Index $CTD_{100}$ extended to accommodate wider collimations

- Reproducibility of radiation output tightened from ± 20% to ± 10%

- Following scanning, any CT condition of operation that has varied or changed during scan must be displayed

- The accompanying documents must contain a cautionary statement regarding the potential detrimental interaction of CT x radiation with electronically active medical devices either implanted or worn by a patient

- More information regarding stray radiation
What’s missing from the IEC standards?

• $CTD_{100}$ underestimates body-scanning dose by 20-40% \(^{23}\)

  \[
  pD_{eq} = \frac{p}{\Delta d} \int_{-\infty}^{\infty} D(z)dz
  \]

  AAPM TG 111 new dose metric: \(^{24}\)

• No pediatric or patient-specific (gender, height, weight) dosimetry

• Inadequate metrics for image quality

• Inapplicability to cone-beam or portable systems without a toroid-shaped gantry cover

• Should automatic exposure control be “on” by default and require a technologist to turn it “off” to enable manual-mode operation?

FDA initiative\(^{25,26}\) for IEC
FDA Initiative\textsuperscript{25,26} for IEC

Decouple Dose Metrics: Quality Assurance, Safety

• **Q/A: testing and display**
  - table moves (helical or axial CT): $pD_{eq}$
  - table stays put (fluoroscopic or cone-beam CT): $ND(z = 0)$
  - long, physical phantoms with compartments for $NPS$, $MTF$

• **Safety: radiation risk to patients**
  - *Organ doses*: anthropomorphic, computational phantoms $\leftrightarrow$ patients
  - Record in DICOM Dose Structured Report
    - *All organ doses*, $pD_{eq}$ and $ND(z = 0)$
Conference of Radiation Control Program Directors, Inc.  

- Non-profit, non-govt organization promoting radiological health
  
  _membership: state and local radiation control personnel_

- Supported in part via FDA cooperative agreement
  - Nationwide Evaluation of X-Ray Trends Program (_NEXT_)
  - Suggested State Regulations for the Control of Radiation (_SSRCR_)

- States license and regulate _users_, not _mfrs_, of x-ray equipment
  - CT _equipment_ requirements are _identical_ to those of 21 CFR 1020.33
  - For CT, _SSRCR_ contain additional requirements
    - Facility design: aural communication, viewing systems between patient and operator
    - Med physics survey, periodic calibration, spot checks of rad output, phantom images
    - Operating procedures: user training, availability of operational information

- States can require CT dose estimates from facilities and can exercise control over the business and practice of medicine
CT-related Research at FDA/CDRH

- Office of Science and Engineering Laboratories
  - Theory, computer simulation, measurement methodology for image quality, assessment of diagnostic efficacy of radiological equipment\textsuperscript{28-41}
  - FDA Office of Women’s Health sponsoring study\textsuperscript{42}

\textit{Radiation Dose and Excess Cancer Risk in Women Undergoing X-Ray Computed Tomography: Quantification and Risk Mitigation}

Bench-top cone beam CT scanner
CT-related Research at FDA/CDRH

• Office of Communication, Education, and Radiation Programs

  • Nationwide Evaluation of X-Ray Trends: Computed Tomography\textsuperscript{43,44}

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{chart.png}
\caption{Distribution of Adult Collective Effective Dose per week per most frequently used CT unit per facility (\(S_n\), hospitals and other facilities)\textsuperscript{1}}
\end{figure}

\textsuperscript{1}Distribution of Total \(S_n = 756\) person-mSv per week per most frequently used CT unit per facility. See Table 2.4.

• FDA Commissioner’s Fellowship Program sponsoring project\textsuperscript{45}

  \textit{Development of a Handbook of Radiation Doses in Organs of Patients undergoing X-ray Computed Tomography}
Outreach: Professional Organizations and the Public

• IEC, CRCPD, AAPM, NEMA/MITA, Alliance for Radiation Safety in Pediatric Imaging

• FDA Public Health Notifications
  • Reducing Radiation Risk from Computed Tomography for Pediatric and Small Adult Patients,\textsuperscript{46} November 2001
  • Possible Malfunction of Electronic Medical Devices Caused by Computed Tomography (CT) Scanning,\textsuperscript{47} July 2008

• FDA web pages: information and resource links
  • CT Whole-Body Screening and Risk,\textsuperscript{48} April 2002, updated July 2009
  • Radiation Dose Reduction,\textsuperscript{49} updated May 2009: link to ACR appropriateness criteria

• FDA-convened stakeholders’ meeting, Nov 2005
  suggested educational initiatives, collaborations for efficient regulations, sharing of information to monitor high-risk procedures\textsuperscript{50}

• We welcome comments, suggestions, and ideas for collaboration!
References and Notes


2. For an overview of FDA regulation of medical devices, see [http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/Overview/default.htm](http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/Overview/default.htm).


7. The percentage dose reduction projected to follow implementation of an automatic exposure control feature corresponds approximately to the mid-range of values cited in item nos. 5, 6, and 8 of these references and notes.


9. Patient dose norms are called “reference values,” and they correspond to the 75th percentile of the distribution of measured values for particular radiological procedures. They were introduced in the United Kingdom (NRPB/RCR, "Patient Dose Reduction in Diagnostic Radiology," *Doc. NRPB* Vol. 1, No. 3, pp. 1-46, 1990, and item nos. 10, 11 of these references and notes), and they are being adopted throughout western Europe (item nos. 12, 13). They have been introduced in the U.S. under the auspices of the American College of Radiology by a task group of the American Association of Physicists in Medicine (item no. 14). Reference values are benchmarks to which a facility’s practice may be compared in a radiation-protection quality assurance program: When reference levels are exceeded in any particular examination, the facility may investigate to see if it’s possible to reduce exposure without adversely affecting image quality. As a component of a quality assurance program, a display of dose-index values would fulfill an essential need in the first place for having a quantitative indication of patient dose per exam.


16. The percentage dose reduction projected to follow implementation of a display/record feature is assumed. The percentage corresponds approximately to one-half the difference between 1995 UK survey levels (item no. 19 of these references and notes) and 1985 values (item no. 18) for modalities other than CT. See R.H. Corbett, "A European Radiologist's View of Diagnostic Reference Levels," in *European Radiation Protection, Education and Training (ERPET), ERPET Course for Medical Physicists on Establishment of Reference Levels in Diagnostic Radiology*, Passau, Germany, 13-15 September 1999, *Proceedings*, edited by H. Gfirtner et al., EC Directorate General Science, Research and Development, Doc. RTD/0034/20, (BfS-ISH, Oberschleissheim/Neuherberg, July 2000), pp. 83-91, and item no. 17 of these references and notes. “Reference levels” based on the 1985 data were introduced into the UK in 1990 (item nos. 9-11). It is assumed that one-half of the UK dose reduction from 1985-1995 is due to technology improvements alone (e.g., faster film-screen combinations and the use of digital spot films), whereas the other half of dose savings stems from the quality-assurance use of reference levels and patient dose evaluation. The estimated dose reduction projected for a display/recording feature in CT thus presumes (1) facility implementation of a quality assurance program making use of patient doses and reference levels and (2) consequent dose reductions from improved techniques.


27. See www.crcpd.org.


42. Iacovos S. Kyprianou and Stanley H. Stern are co-principal investigators for the study which involves a collaboration between FDA/CDRH/OSEL and Marquette University.


45. Thalia T. Mills, FDA Commissioner’s Fellow, is leading the developmental work for the prospective CT dose handbook, intended to be the latest in a series of organ-dose handbooks ([http://www.fda.gov/RadiationEmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/MedicalX-Rays/ucm117898.htm](http://www.fda.gov/RadiationEmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/MedicalX-Rays/ucm117898.htm)).

46. [http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062185.htm](http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062185.htm).

47. [http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm061994.htm](http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm061994.htm).


International Perspectives on Use of CT Imaging: the WHO Global Initiative in Radiation Safety in Health Care Settings

Dr Maria del Rosario Pérez
Department of Public Health and Environment

Computed Tomography in Emergency Medicine-Ensuring Appropriate Use
Bethesda, Maryland, US - September 23-24, 2009
Radiation in Health Care

The use of radiation in health care is by far the largest contributor to the exposure of the general population from artificial sources.

Annually worldwide

3,600 million X-ray exams (> 300 million in children)

37 million nuclear medicine procedures

7.5 million radiation oncology treatments
Radiation in Health Care

- As the benefits for patients gain recognition, the use of radiation in the diagnosis and treatment of human diseases increases.

- While the development of modern health technology makes new applications safer, their inappropriate use can lead to unnecessary or unintended radiation doses, and can imply potential health hazards for patients and staff.
Global health is receiving unprecedented attention.

Clear signs of willingness to work together in building sustainable health systems.

PRIMARY HEALTH CARE

Primary Health Care (PHC) Reform

- **Primary health care** as a set of values and principles for guiding the development of health systems (4 sets of reforms)

Emphasis on 4 areas of strategic importance to deal with current and future challenges to health:

- addressing health inequalities;
- people-centred care;
- better public policies;
- stronger leadership

Workshop on Computed Tomography in Emergency Medicine
September 23-24, 2009
Mobilization of all forces in society – government, health professionals, institutions and civil society – around an agenda to transform health systems, driven by the values of ethics, equity, solidarity, social justice and participation.
The challenge

Although individual risks associated with diagnostic exposures are rather low, the wide use of radiation in medicine calls for a public health approach to control and minimize health risks, while maximizing the benefits.
The two principles of radiation protection in medical exposures are implicit in the hippocratic oath taken by doctors swearing to ethically practice medicine:

"… I will *prescribe* regimens for the good of my patients according to my ability and my judgment and *never do harm* to anyone…"

“Primum non nocere” ("First do no harm")

Hippocrates
(460 BC - 377 BC)
Medical exposure of patients calls for a different and more detailed approach to the process of justification. The medical use of radiation should be justified, as is any other planned exposure situation, although that justification lies usually with the medical profession rather than with government or regulatory authorities. The principal aim of medical exposures is to do more good than harm to the patient, subsidiary account being taken of the radiation detriment from the exposure of the radiological staff and of other individuals. The responsibility for the justification of the use of a particular procedure falls on the relevant medical practitioners. Justification of medical procedures therefore remains a principal part of the Commission’s Recommendations.
Justification: ICRP Recommendations (II)

(331) The principle of justification applies at three levels in the use of radiation in medicine.

- At the first level, the use of radiation in medicine is accepted as doing more good than harm to the patient. This level of justification can now be taken for granted and is not discussed further below.
- At the second level, a specified procedure with a specified objective is defined and justified (e.g., chest radiographs for patients showing relevant symptoms, or a group of individuals at risk to a condition that can be detected and treated). The aim of the second level of justification is to judge whether the radiological procedure will usually improve the diagnosis or treatment or will provide necessary information about the exposed individuals.
- At the third level, the application of the procedure to an individual patient should be justified (i.e., the particular application should be judged to do more good than harm to the individual patient). Hence all individual medical exposures should be justified in advance, taking into account the specific objectives of the exposure and the characteristics of the individual involved.
Justification: appropriateness criteria

Systematically developed statements to assist practitioner and patient decision about appropriate healthcare for specific clinical circumstances

- To adopt such evidence-based decision-aiding tools in diagnostic imaging may reduce 20-40% unjustified procedures. Need to advocate for their wider use into day-to-day practice, raising awareness of the impact of such behavior on population radiation dose and health costs.

- The use of educational reminders on the radiological reports contributes to the reduction in referrals for investigations of limited value (feedback strategy).

- Clinical audits for quality improvement should include evaluation of compliance with referral guidelines.
Optimization of protection

Optimization of protection in medical exposures requires the management of the **radiation dose** to the patient to be commensurate with the medical purpose.

**Diagnostic reference levels** are useful tools for optimization of protection in diagnostic applications: do the physicians understand how to use DRLs? (need for education, training, guidance)

Methods for **dose reduction** (operational parameters, equipment and software design); to tailor the protocols according to patient size and level of acceptable noise for a given clinical indication (important in paediatric CT).
The number of CT studies performed in ED showed a **five-fold increase** over one decade. Over half of ED CT studies are performed during the shift hours, involving smaller and less experienced teams.

The "Golden Hour’ rule" for **trauma** patients: ED doctors seem to feel more comfortable with CT images than with ultrasound.

In addition to trauma, the most common **clinical reasons** given by adult patients for visiting the ED include: chest pain, abdominal pain, back pain, headache and shortness of breath.

Higher increase in **body CT studies** (e.g. renal colic, appendicitis, acute abdomen, bowel obstruction) **over neurological CT**.
Time per CT examination has decreased, resulting in increased throughput.

However, the radiologist's reading & reporting time is prolonged (i.e. more images to read, more reconstructions to perform).

CT velocity of execution and accuracy make it an ideal tool for emergency use, particularly beneficial in the investigation of high-speed trauma patients including mass casualties events (quick mode to evaluate the extent of injury, shrapnel localization and detection of unsuspected injuries).
CT in the ED: an example

- Major life-threatening causes of chest pain (i.e. acute coronary syndrome, acute aortic syndrome and pulmonary embolism) can simultaneously be assessed now by the so-called "triple rule-out" CT angiography with a single scan (TRO CTA).

- In an appropriately selected ED patient population TRO CTA can safely eliminate the need for further diagnostic testing in over 75% of patients (e.g. "low to intermediate risk for acute coronary syndrome and whose symptoms may also be attributed to acute pathologic conditions of the aorta or pulmonary arteries"). **Need to consider appropriateness criteria.**

- Once the procedure is justified, a process of **optimization** can significantly reduce radiation dose without loss of image quality (e.g. **more than 50% dose reduction can be achieved for TRO CTA with ECG-based tube current modulation**).
CT scan utilization in the pediatric ED has dramatically increased during the last years (wider availability & improved diagnostic capability).

CT implies a higher radiation exposure to children, who are especially vulnerable to environmental threats and have longer life-span to develop long-term radiation induced health effects like cancer.

Justification of such procedures is essential. In addition, dose protocols and techniques have to be adapted to children and young adult patients to reduce radiation dose while providing the required diagnostic information (optimization).
## CT in paediatric ED

### CT utilization: the emergency department perspective

**Joshua Seth Broder**

<table>
<thead>
<tr>
<th>Type of CT</th>
<th>Percent increase, patient age 0-2 years</th>
<th>Percent increase, patient age 3-12 years</th>
<th>Percent increase, patient age 13-17 years</th>
<th>Percent increase, patient age ≥18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2</td>
<td>8</td>
<td>62</td>
<td>66</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>180</td>
<td>175</td>
<td>731</td>
<td>557</td>
</tr>
<tr>
<td>Chest</td>
<td>100</td>
<td>283</td>
<td>675</td>
<td>309</td>
</tr>
<tr>
<td>Abdomen</td>
<td>-31</td>
<td>41</td>
<td>72</td>
<td>104</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>-50</td>
<td>34</td>
<td>217</td>
<td>280</td>
</tr>
</tbody>
</table>

Percentage increase in CT utilization in the ED by patient age (2000-2006)
Use of CT in ED: driving forces

- New/sophisticated technology & vendor marketing
- Self-referral and other financial incentives
- Defensive medicine
- High valuation placed on imaging (instead of "touching/ asking the patient")
- Consumer model (patient's and/or family's expectations)
- Lack of awareness about CT radiation doses & associated risks
- Insufficient clinical knowledge/expertise in ED referrers
- Appropriateness criteria/referral guidelines not available/ignored
- Absence of radiologists for consultation during nightshifts
- Pressure from other specialists e.g. "What does the CT shows?"; "Repeat the CT scan"; "Request a CT scan prior patient release from the ED" … etc.
Diagnostic imaging & health care costs

- US medical imaging annual cost: almost $100 billion;
- Medicare pays for US$ 14 billion of that;
- Medical imaging: one of the fastest growth rates (~10% / year)
- Annual imaging costs per capita: $229 in 1997 to $443 in 2006

"OVERUSE"?

"Application of an imaging procedure where it is unlikely to improve patient outcome" (unnecessary, unjustified).

The increasing use of radiation in healthcare "per se" cannot be taken as evidence of "OVERUSE"

However ...
Turf Wars in Radiology: The Overutilization of Imaging Resulting from Self-Referral

David C. Levin, MDa,b, Vijay M. Rao, MDa

A recent report by the Medicare Payment Advisory Commission to Congress indicated that the utilization of diagnostic imaging is growing more rapidly than that of any other type of physician service. This has engendered concern among those who pay for health care. In this article, the authors review the role of self-referral in driving up imaging utilization.

A number of studies of the self-referral factor in imaging have been conducted over the past three decades. These have consistently shown that when nonradiologist physicians operate their own imaging equipment and have the opportunity to self-refer, their utilization is substantially higher than among other physicians who refer their patients to radiologists. It has also been shown that the vast bulk of the recent increases in imaging utilization are attributable to nonradiologists who self-refer. The authors estimate that the cost to the American health care system of unnecessary imaging resulting from self-referral by nonradiologists is $16 billion per year.

Key Words: Medical economics, diagnostic radiology, radiology, radiologists, departmental management, socioeconomic issues

"Physicians may respond to the perceived threat of litigation by ordering more referrals and more tests, some of which may be recommended by clinical guidelines and beneficial, but others might be wasteful and harmful."

Massachusetts Statewide Survey on DM (3650 physicians; 2007-2008)

- 83% reported that they practiced DM;
- Plain film X-rays: 22%;
- CT scans: 33% among emergency physicians & obstetrics/gynaecologists and 20% in other specialties;
- Laboratory tests: 18%;
- Hospital admissions: 13%
## Doctors' knowledge of radiation doses

Dose for chest x ray used as single unit dose of radiation; figures are numbers (percentage) of doctors with correct answer for each investigation


<table>
<thead>
<tr>
<th>Radiological investigation</th>
<th>Equivalent No of chest x rays</th>
<th>No of correct answers (n=130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal x ray</td>
<td>75</td>
<td>2 (1.5)</td>
</tr>
<tr>
<td>Lumbar spine x ray</td>
<td>120</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Thoracic spine x ray</td>
<td>50</td>
<td>4 (3)</td>
</tr>
<tr>
<td>Barium swallow</td>
<td>100</td>
<td>6 (5)</td>
</tr>
<tr>
<td>CT of abdomen</td>
<td>400</td>
<td>8 (6)</td>
</tr>
<tr>
<td>Spiral CT of abdomen</td>
<td>300</td>
<td>9 (7)</td>
</tr>
</tbody>
</table>
Risk communication

- Lack/insufficient awareness of radiation doses & risks among ED physicians and other referrers, and even among radiological practitioners.

- Informed consent: when it might be waived in ED? is the information understood? (need for guidance)

- Deficiencies in risk communication e.g. plain language, tailored messages to reach the target audience, use variety of channels, to develop a strategy:
  - What must be communicated?
  - Who is/are the target audiences?
  - How can they best be reached?
  - What actions/activities should take place?
  - What are the resources needed?
  - How can we monitor output & impact?
Improving **RP culture** in health care settings: a culture shift to change practice

- Three organizational **culture** levels:
  - Basic underlying assumptions (beliefs, perceptions, unconscious thoughts);
  - Espoused/adopted shared values (strategies, objectives, operating principles, recommendations, standards, guidelines); and
  - Artifacts/visible products (behaviour, practices, decisions, attitudes)

- **RP culture** as part of good medical practice (for both users and prescribers of radiation in health-care).

- Creating a strong **RP culture** in hospitals is today a challenging task for health policy- and decision-makers.
How to improve **RP culture** in health care?

Ensuring that underlying assumptions line up with espoused values, which in turn line up with behaviour.

Weak!!

**Underlying assumptions**

**Espoused shared values**

**Behaviour decisions**

Strong

**Underlying assumptions**

**Espoused shared values**

**Behaviour, decisions**

Practice: appropriate use

Referral guidelines, norms, standards

Advocacy, awareness raising, education

Workshop on Computed Tomography in Emergency Medicine
September 23-24, 2009
WHO Global Initiative on Radiation Safety in Health Care Settings

Diagnostic radiology  
Interventional radiology  
Radiotherapy  
Nuclear Medicine

Focusing on **Public Health** aspects related to the risks and benefits of the use of radiation in health care

Workshop on Computed Tomography in Emergency Medicine  
September 23-24, 2009
Strategic Approach

Translate the scientific evidence into policies and programmes

Risk assessment
Assess risks and potential impacts

Risk management
Implement policies, health interventions

Risk communication
Engage and communicate with stakeholders
The activities

Risk assessment
- Collect and share information on the use of radiation in health care, including surveys on population dose distribution.
- Shape and promote a research agenda on health effects of medical radiation exposure (focusing on children)

Risk management
- Reduction on unnecessary radiation exposures: justification of medical procedures (i.e. appropriateness criteria) and optimization of protection (diagnostic reference levels)
- Advocacy tools and guidance for health authorities and policy makers (including regulatory aspects)
- Clinical audit and quality improvement
- Occupational health focused on interventional radiology
- Education, training, staffing needs (medical physicists, radiographers, radiation technologists)
- Harmonization of error reporting systems and severity scale grades

Risk communication
- Communication strategy for information and awareness raising (including informed consent)
Stakeholder engagement

Referrers
- GPs, paediatricians, other specialists

Consumers
- Patients, families, general public

Regulators
- Governments, health authorities, radiological competent authorities

Providers
- Radiological practitioners (team), other specialists

Payers
- Public/private insurers, social services, others

Others
- Professional, academic & scientific societies
- Medical defence organizations
- International agencies
- Manufacturers

Radiation in health care

Workshop on Computed Tomography in Emergency Medicine
September 23-24, 2009

World Health Organization
Global Initiative: work plan and timeline

Step 1
Outline of the strategy
- Develop proposal
- Internal/external consultation
- Identify/consult stakeholders
- Build partnership

Step 2
Development of the work plan
- Platform
- Terms of reference
- Projects/activities
- Working groups
- Task Coord. Team
- Budget, fundraising

Step 3
Implementation of the GI
- Priorities
- Pilot experience
- Task execution
- Working groups operating

Step 4
Monitoring, evaluation
- Monitor implementation
- Evaluate the impact
- Feedback and results communication

Thank you very much


perezm@who.int
Computed Tomography in Emergency Medicine — Ensuring Appropriate Use

Bethesda, Maryland
September 23-24, 2009
Today’s Presentation:

Emergency Radiology — Legal/Regulatory Challenges
Overview of Today’s Talk

1) Ordering Diagnostic Tests
2) Anti-Markup Rule
3) International Teleradiology
4) Medicare Reimbursement for Emergency Radiology Services – Current Status
5) New Medicare HOPPS supervision “clarification”
6) Joint Commission Standards on Credentialing and Privileging
Ordering Diagnostic Tests

- 42 C.F.R. 410.32
- Medicare Benefit Policy Manual, Chapter 15, Section 80.6
- General rule, only treating physician may order
- Does not apply to hospitals
Ordering Tests Rule

- What is the rule for tests ordered in hospitals?
- Medicare Conditions of Participation 42 C.F.R. 482.26(b)(4)
Ordering Diagnostic Tests

- Prior authorization
- Radiology Benefit Managers
- Appropriations criteria
- Computerize Order Entity Processes
Anti-Markup Rule

- 42 C.F.R. 414.50
- TC and PC Billing
International Teleradiology

SSA § 1862(a)(4). Prohibits Medicare payment for items and services furnished outside the U.S., except for certain limited services in Canada or Mexico.
International Teleradiology

On Feb. 23, 2007 CMS issued transmittal (R66BP) on "Services Not Provided Within United States." The transmittal states:

"Payment may not be made for a medical service (or a portion of it) that was subcontracted to another provider or supplier located outside the United States. For example, if a radiologist who practices in India analyzes imaging tests that were performed on a beneficiary in the United States, Medicare would not pay the radiologist or the U.S. facility that performed the imaging test for any of the services that were performed by the radiologist in India."
International Teleradiology

Transmittal reflects no change in CMS policy.

CMS has not indicated that a preliminary interpretation cannot be followed by an official interpretation by the local radiologist.

The official interpretation by the local radiologist is payable by Medicare – must be real!
Letter from CMS…

December 4, 2007 Letter from CMS Director of Technical Payment Policy, Donald H. Romano:

“…the radiologist in the United States must actually perform the entire service and not simply rely on or ‘rubber stamp’ the interpretation of the radiologist in India.”
OIG 2009 Fiscal Year Work Plan

Payments for Diagnostic X-Rays in Hospital Emergency Departments

“We will review a sample of Medicare Part B paid claims and medical records for diagnostic x-rays performed in hospital emergency departments to determine the appropriateness of payments. Radiology services furnished by a physician are reimbursed by the Medicare Physician Fee Schedule provided the conditions for payment for radiology services at 42 CFR § 415.102(a) and 42 CFR § 120 are met. The Medicare Payment Advisory Commission (MedPAC), in its March 2005 testimony before Congress, reported concerns regarding the increasing cost of imaging services for Medicare beneficiaries and potential overuse of diagnostic imaging services. In 2004, approximately 4.7 million diagnostic x-rays were performed in Medicare-certified hospitals with emergency departments, a 9.6-percent increase since 2001. Medicare spent approximately $48.3 million for these services in 2004. We will determine the appropriateness of payments for diagnostic x-rays and interpretations.”

(OEI; 00-00-00000; expected issue date: FY 2009; new start)
Medicare Rule

Professional component of radiology service requires written report of findings. See 42 CFR 415.120.
Medicare Reimbursement Issue

Issue is whether the Medicare carrier will reimburse radiologist or emergency physician for physician service.
Medicare Reimbursement Issue

Currently, Medicare billing policy allows carrier to reimburse radiologist for a physician service. But also possible that carrier reimburse emergency physician for physician service, precluding reimbursement to radiologist.
OIG Concern

OIG has, in the past, raised the question whether interpretations of emergency department diagnostic tests produced after an emergency physician has made treatment decisions are appropriately payable by Medicare as physician services.
OIG Concern

- Office of Evaluation and Inspection study entitled "Diagnostic Testing in Emergency Rooms."
- Work plan for 2009.
OIG Recommendations

OIG Recommendations

1993 report criticized then-current Medicare payment policy for x-rays in hospital emergency rooms.
OIG Recommendations

Then CMS Policy:

Medicare’s 1993 policy:

Section 2020G of the Medicare Carriers Manual, when a hospital radiologist interpreted an x-ray that had already been interpreted by another physician, the service of the radiologist almost always constituted a physician service and was payable by the Medicare carrier. (cont’d)
OIG Recommendations

CMS 1993 Policy:

...In those situations where the radiologist’s interpretation was for quality control purposes, the service was to be considered a hospital service instead of a physician service and was to be reimbursed to the hospital by a fiscal intermediary under Medicare Part A.
OIG Recommendations

CMS 1993 Policy:
Policy based on three assumptions:
(1) reinterpretations almost always constituted patient care.
OIG Recommendations

CMS 1993 Policy:

(2) Radiologists are recognized experts, therefore, x-rays should be read by them.
OIG Recommendations

CMS 1993 Policy:

(3) The qualifications of the interpreting physician are more important than the exact timing of the interpretation in determining whether a substantive physician service had been provided.
OIG Recommendations

OIG stated in 1993 report that when patients discharged before, or on the same day as, radiologist’s final interpretation did not constitute patient care because no effect on the treatments provided by emergency physicians.
OIG Recommendations

OIG recommended in 1993 Medicare pay for reinterpretations of x-rays only when attending physicians specifically requested a second physician’s interpretation in order to render appropriate medical care before patient discharged.
OIG Recommendations

OIG also recommended that any other reinterpretation of the attending physician’s original interpretation should be treated and reimbursed under Part A as hospital quality assurance program.
OIG Recommendations

HCFA (now CMS) responded to OIG recommendations. Their response is current Medicare payment policy.
Current CMS Policy

Medicare Claims Processing Manual; Chapter 13; Section 100.1, *et seq.*

Carrier pays for only one interpretation and report of x-ray procedure furnished to emergency patient.
Current CMS Policy

Note that carrier will pay for interpretations of radiology examinations only if there is written report prepared for inclusion in patient's medical record. See 42 CFR 415.120. See also Medicare Claims Processing Manual Ch. 13, Section 20.1.
Current CMS Policy

If multiple claims submitted for payment for interpretations of same diagnostic test, policy is to pay only for interpretation and report that directly contributed to diagnosis and treatment of patient.
Current CMS Policy

In practice, default assumption for carrier is that the first claim received should be paid.
Current CMS Policy

Hospitals are also required by Medicare’s Conditions of Participation for Hospitals to maintain reports signed by the interpreting physician. See 42 CFR 482.26.
Value of Teleradiology

Availability to teleradiology services has enhanced the availability of "contemporaneous" interpretations – even if "preliminary" and "non-official."
Q: Can local radiologist simply sign-off on Preliminary Interpretation?

A: “No.” The interpretation must be “real.”
Medicare New HOPPS Supervision Rule “Clarification”

• General
• Direct
• Personal

Long applied only to physician offices, IDTFs and off-campus provider-based entities.
Medicare New HOPPS Supervision Rule “Clarification”

- General
- Direct
- Personal

Now applies to all Medicare outpatient tests – **off-campus** AND **on-campus**.
Medicare New HOPPS Supervision Rule “Clarification”

Impact:
1) Contrast studies
2) Fluoroscopy
Joint Commission Standards

Leadership Standard LD 3.50

- Permits proxy credentialing and privileging when hospital contracts for interpretation services with Joint Commission accredited organization.
Joint Commission Standards

CMS (unofficially) takes a different view.

- CMS opposes proxy credentialing.
- Believes Medicare Conditions of Participation (42 C.F.R. 482.22) require medical staff to examine credentialing of all staff members.
Joint Commission Standards

LD 3.50 revised effective January, 2008. Hospital may continue to relay on proxy credentials.
Joint Commission Standards

Revised LD 3.50

Hospital that contracts with Joint Commission accredited organization should:

• Determine that the care, treatment, or services are included in the scope of the accreditation or certification of contracting entity; and
• Ensure that contracted entity policies and practices meet hospital’s requirements for staff qualifications and competence and for providing care, treatment, and services.
Joint Commission vs. CMS

- An open issue
- Things could change when Joint Commission files its “Deemed Status” application in January with CMS
In sum...

Radiologist’s official interpretation following preliminary interpretation by teleradiology company:

- Must be standard report documenting all findings!
- *Not* an overread.
- *Not* a confirmation
- It is a *real* interpretation.
Section 5: Clinical Decision Making and Implications for Reducing or Eliminating Imaging Done

Clinical Decisions: Radiology Perspective

Robert A. Novelline, MD
Professor of Radiology, Harvard Medical School
Director of Emergency Radiology, Massachusetts General Hospital
novelline.robert@mgh.harvard.edu
CT of Emergency Department Patients
Goals of Radiologist for Reducing Radiation

1. Perform CT scans only on ED patients in whom a CT scan is truly indicated
2. Utilize precise knowledge of clinical presentation to plan the optimal CT protocol for resolving the clinical question
3. Perform the CT scan with the minimum radiation exposure for obtaining a diagnostic quality examination
How Common are CT Examinations on ED Patients at the Massachusetts General Hospital?
2008 Statistics
MGH Emergency Radiology Division

• Fiscal year 2008:
  – 94,431 imaging exams on 84,539 ED patients
  – 34,121 (36%) imaging exams were CT scans
• CT volume on ED patients has been increasing by more than 5% annually
• Current ED CT volume is >100 scans/day
Number of imaging exams now exceeds the number of ED patients visits

Massachusetts General Hospital

Emergency Radiology vs. Emergency Dept.
exams / visits

- Emergency Dept.
- Emergency Radiology

<table>
<thead>
<tr>
<th>Year</th>
<th>Emergency Radiology</th>
<th>Emergency Dept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY '01</td>
<td>73,504</td>
<td>61,543</td>
</tr>
<tr>
<td>FY '02</td>
<td>75,869</td>
<td>67,010</td>
</tr>
<tr>
<td>FY '03</td>
<td>75,859</td>
<td>72,011</td>
</tr>
<tr>
<td>FY '04</td>
<td>87,329</td>
<td>76,118</td>
</tr>
<tr>
<td>FY '05</td>
<td>88,354</td>
<td>78,465</td>
</tr>
<tr>
<td>FY '06</td>
<td>88,447</td>
<td>79,176</td>
</tr>
<tr>
<td>FY '07</td>
<td>91,789</td>
<td>80,728</td>
</tr>
<tr>
<td>FY '08</td>
<td>94,431</td>
<td>84,539</td>
</tr>
</tbody>
</table>
CT has been increasing >5% per year  
Massachusetts General Hospital

Emergency Radiology Modality Volume FY01-FY08

CT has been increasing >5% per year.
Radiography Volume Decreasing as Radiographic Exams Replaced with CT
Decreasing ED CT Radiation Exposure by Optimizing Clinical Decision Making
Causes of Unnecessary CT Radiation Exposure in ED Patients

1. Repeating CT scans which have already been performed
2. Performing CT when the results are unlikely to affect patient management
3. Investigating with CT too frequently
4. Performing the wrong imaging exam
5. Performing incorrect CT protocol from communication failure of true clinical presentation, resulting in repeat CT
6. Over-investigating
Causes of Unnecessary CT Radiation Exposure in ED Patients

1. Repeating CT scans which have already been performed:
   - Outside CT scan from referring hospital not sent with the patient
   - Outside CT satisfactory, but referring physician requests repeat to get patient’s CT scan on PACS

Repeating outside CT may be indicated for problems with scan or clinical changes in patient
   - Cannot view outside scan; software problem
   - No IV contrast
   - Wrong contrast timing
   - Wrong slice thickness
   - No multiplanar or volumetric reformations
Causes of Unnecessary CT Radiation Exposure in ED Patients

2. Performing CT scans when the results are unlikely to affect patient management
   - Venous CT requested with a PECT in patient with a positive venous US for DVT
   - Extremity CT requested for a shaft fracture of a long bone
   - Chest CT requested for confirmation of a pneumothorax shown on a chest radiograph
Causes of Unnecessary CT Radiation Exposure in ED Patients

3. Investigating with CT too frequently
   - Serial CT scans over several days or weeks to follow the progress of a ureteral stone
   - Thoracolumbar spine CT requested every time a patient with a chronic back condition comes to ED with back pain
   - Chest CT requested for suspected pneumonia every time a patient with cystic fibrosis comes to ED with cough or fever
   - Abdominal CT requested every time a patient with Crohn’s Disease comes to ED with abdominal pain
Causes of Unnecessary CT Radiation Exposure in ED Patients

4. Performing the wrong imaging exam
   - Abdominal CT requested for a gynecological problem rather than pelvic US
   - CT requested for suspected avascular necrosis of hip rather than an MR scan
   - Abdominal CT requested for RUQ pain (suspected cholecystitis) rather than US
5. Performing incorrect CT protocol from communication failure of true clinical presentation, resulting in a repeat CT scan

- Non-contrast chest CT requested in patient with chest pain in whom the real concern was suspected PE
- Non-contrast abdominal CT requested in patient in whom the real concern was trauma, not ureteral stone
- Non-contrast cervical spine CT requested when real concern was neck abscess
Causes of Unnecessary CT Radiation Exposure in ED Patients

6. Over-investigating
   - Performing unnecessary pre-contrast and delayed scans of the abdomen and chest
   - Performing a “total body” trauma CT scan (Pan-Scan) of head, face, cervical spine, chest, abdomen and pelvis when on clinical exam the patient only needs scans of the head and abdomen
   - CT scan of the entire abdomen rather than only peri-appendiceal area in young male with acute RLQ pain
Faulty equipment and poorly trained technologists can also contribute to repeat CT scanning of ED patients.
Guidelines for the CT Imaging of Emergency Department Patients:

Trauma Rules
ACR Appropriateness Criteria
European Referral Guidelines
Judicious Use of CT in Trauma

Is the CT exam indicated?

- **Head CT**
  - Canadian Head CT Rule for minor head injuries
- **Face CT**
  - Cosmetic deformity, functional impairment
- **Cervical Spine CT**
  - Canadian Spine Rules
  - NEXUS Criteria
- **Chest CT**
  - Major trauma history
  - Abnormal chest film
  - Abnormal clinical examination
- **Abdomen/Pelvis CT**
  - Major trauma history
  - Abnormal ultrasound/pelvis film
  - Abnormal clinical examination
Canadian Head CT Rule for Minor Head Injuries

Panel 1: Canadian CT Head Rule

CT Head Rule is only required for patients with minor head injuries with any one of the following:

High risk (for neurological intervention)
- GCS score <15 at 2 h after injury
- Suspected open or depressed skull fracture
- Any sign of basal skull fracture (haemotympanum, ‘racon’ eyes, cerebrospinal fluid otorrhoea/rhinorrhoea, Battle’s sign)
- Vomiting ≥two episodes
- Age ≥65 years

Medium risk (for brain injury on CT)
- Amnesia before impact >30 min
- Dangerous mechanism (pedestrian struck by motor vehicle, occupant ejected from motor vehicle, fall from height >3 feet or five stairs)

Minor head injury is defined as witnessed loss of consciousness, definite amnesia, or witnessed disorientation in a patient with a GCS score of 13–15.

*Steill IG, PI, The Ottawa Health Research Institute
Cervical Spine CT for Trauma
*Nexus Low Risk Criteria (NLC)

<table>
<thead>
<tr>
<th>Table 1. The NEXUS Low-Risk Criteria.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical-spine radiography is indicated for patients with trauma unless they meet all of the following criteria:</td>
</tr>
<tr>
<td>No posterior midline cervical-spine tenderness,†</td>
</tr>
<tr>
<td>No evidence of intoxication,‡</td>
</tr>
<tr>
<td>A normal level of alertness,§</td>
</tr>
<tr>
<td>No focal neurologic deficit,¶ and</td>
</tr>
<tr>
<td>No painful distracting injuries.‖</td>
</tr>
</tbody>
</table>

*National Emergency X-Radiography Utilization Study (NEXUS)
Cervical Spine CT for Trauma

*Canadian C-Spine Rule*

*Steill IG, PI, The Ottawa Health Research Institute*
ACR Appropriateness Criteria
Official Statements

• ACR Appropriateness Criteria® are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision.

• By employing these guidelines, providers enhance quality of care and contribute to the most efficacious use of radiology.

• The guidelines are developed by expert panels in diagnostic imaging, interventional radiology, and radiation oncology.

• Each panel includes leaders in radiology and other specialties.
ACR Appropriateness Criteria

www.acr.org

159 topics with over 800 variants
ACR Appropriateness Criteria

List of Imaging Topics

[Website screenshot showing a list of topics including:
- ACR Homepage
- Cardiac Imaging
- Electromagnetic Imaging
- Interventional Radiology
- Musculoskeletal Imaging
- Neurologic Imaging
- Pediatric Imaging
- Thoracic Imaging
- Vascular Imaging
- Women's Imaging
- Women's Imaging - Breast
- Radiation Oncology - Bone Metastases
- Radiation Oncology - Brain Metastases
- Radiation Oncology - Breast
- Radiation Oncology - Hodgkin's
- Radiation Oncology - Lung
- Radiation Oncology - Prostate
- Radiation Oncology - Rectal-Anal]
ACR Appropriateness Criteria
Exams Scored in Appropriateness from 1-10

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray cervical spine lateral only</td>
<td>1</td>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth</td>
<td>1</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques</td>
<td>1</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques flexion/extension</td>
<td>1</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>CT cervical spine with sagittal and coronal reformat</td>
<td>1</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>CT myelography cervical spine</td>
<td>1</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>CTA head and neck</td>
<td>1</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>MRI cervical spine</td>
<td>1</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>MRA neck</td>
<td>1</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>INV arteriography cervicocerebral</td>
<td>1</td>
<td></td>
<td>Med</td>
</tr>
</tbody>
</table>

Rating Scale: 1 = Least appropriate, 9 = Most appropriate

Cervical spine imaging not indicated by NEXUS or CCR clinical criteria. Patient meets low-risk criteria.
**ACR Appropriateness Criteria**

**CT Highest if no Neurological Deficits**

---

**Variant 2:**

Suspected acute cervical spine trauma. Imaging indicated by clinical criteria (NEXUS or CCR). Not otherwise specified.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT cervical spine with sagittal and coronal reformat</td>
<td>9</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>X-ray cervical spine lateral only</td>
<td>6</td>
<td>Useful if CT reconstructions are not optimal.</td>
<td>Min</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth</td>
<td>2</td>
<td>Might be appropriate in addition to CT, but not instead of CT.</td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques</td>
<td>2</td>
<td>Might be appropriate in addition to CT, but not instead of CT.</td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques flexion/extension</td>
<td>1</td>
<td>Flexion/extension contraindicated until other imaging studies are performed.</td>
<td>Low</td>
</tr>
<tr>
<td>CT myelography cervical spine</td>
<td>1</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>CTA head and neck</td>
<td>1</td>
<td>See variant 6.</td>
<td>Med</td>
</tr>
<tr>
<td>MRI cervical spine</td>
<td>1</td>
<td>See variant 3.</td>
<td>None</td>
</tr>
<tr>
<td>MRA neck</td>
<td>1</td>
<td>See variant 6.</td>
<td>None</td>
</tr>
<tr>
<td>INV arteriography cervicocerebral</td>
<td>1</td>
<td>See variant 6.</td>
<td>Med</td>
</tr>
</tbody>
</table>
**ACR Appropriateness Criteria**

**MR Scored High with Myelopathy**

---

**Clinical Condition:** Suspected Spine Trauma

**Variant 3:** Suspected acute cervical spine trauma. Imaging indicated by clinical criteria (NEXUS or CCR). Myelopathy.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT cervical spine with sagittal and coronal reformat</td>
<td>9</td>
<td>MRI and CT provide complementary information. It is appropriate to perform both exams.</td>
<td>Med</td>
</tr>
<tr>
<td>MRI cervical spine</td>
<td>9</td>
<td>MRI and CT provide complementary information. It is appropriate to perform both exams. See comments regarding contrast in text under “Anticipated Expectations.”</td>
<td>None</td>
</tr>
<tr>
<td>X-ray cervical spine lateral only</td>
<td>6</td>
<td>Useful if CT reconstructions are not optimal.</td>
<td>Min</td>
</tr>
<tr>
<td>CT myelography cervical spine</td>
<td>5</td>
<td>If MRI is contraindicated or inconclusive.</td>
<td>Med</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth</td>
<td>1</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques</td>
<td>1</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>X-ray cervical spine AP lateral open mouth obliques flexion/extension</td>
<td>1</td>
<td>Flexion/extension contraindicated.</td>
<td>Low</td>
</tr>
</tbody>
</table>
Problems with Cervical Spine Radiographic Exams; More than 30% of Cervical Spine Injuries Missed by Radiography

*NEXUS Data:
– 34,069 patients with suspected c-spine injury:
  • 1,496 had c-spine injury:
    – 932 (62%) identified by radiography
    – 564 (38%) were missed by radiography

**Meta-analysis of 7 reports by Holmes:
– Pooled sensitivity for detecting c-spine injury:
  • 52% for radiography
  • 98% for CT

*National Emergency X-Radiography Utilization Study (NEXUS)
European Union Referral Guidelines for Imaging

“Booklet of referral guidelines for health professionals qualified to refer patients for imaging, in order to ensure that all examinations are well justified and optimized”

“Adapted by experts representing European radiology and nuclear medicine, in conjunction with the UK College of Radiologists”

Published in 2001
A useful imaging examination is one in which the result, positive or negative, will alter the management of the patient and add confidence to the clinician diagnosis.

Imaging exams that do not fulfill these aims should not be performed and may add unnecessary radiation to the patient.
European Guidelines
Table of Contents

Clinical problems, investigations, recommendations and comments

A. Head (including ENT problems) ........................................ 32
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D. Musculoskeletal system .................................................... 45
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K. Trauma ............................................................................ 84
L. Cancer ............................................................................. 99
M. Paediatrics .................................................................. 110
### European Guidelines

**Suspected Cervical Spine Injury**

<table>
<thead>
<tr>
<th>CLINICAL PROBLEM</th>
<th>INVESTIGATION (DOSE)</th>
<th>RECOMMENDATION (GRADE)</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cervical spine</strong>&lt;br&gt;Conscious patient with head and/or face injury only</td>
<td><strong>XR C spine (I)</strong></td>
<td><strong>Not indicated routinely (B)</strong></td>
<td>In those who meet all of the following criteria:&lt;br&gt;(1) Fully conscious.&lt;br&gt;(2) Not intoxicated.&lt;br&gt;(3) No abnormal neurological findings.&lt;br&gt;(4) No neck pain or tenderness.</td>
</tr>
<tr>
<td><strong>K10</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unconscious head injury</strong>&lt;br&gt;(see K3/4)</td>
<td><strong>XR C spine (I)</strong></td>
<td><strong>Indicated (B)</strong></td>
<td>Must be of good quality to allow accurate evaluation. But radiography may be very difficult in the severely traumatised patient and must avoid manipulation (see also K12).</td>
</tr>
<tr>
<td><strong>K11</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Neck injury: with pain</strong></td>
<td><strong>XR C spine (I)</strong></td>
<td><strong>Indicated (B)</strong></td>
<td>Cervical spine XRs can be very difficult to evaluate. Radiography also difficult and:&lt;br&gt;1. Must show C7/T1.&lt;br&gt;2. Should show odontoid peg (not always possible at time of initial study).&lt;br&gt;3. May need special views, CT or MRI especially when XR equivocal or complex lesions.</td>
</tr>
<tr>
<td><strong>K12</strong></td>
<td><strong>CT (II) or MRI (I)</strong></td>
<td><strong>Specialised investigation (B)</strong></td>
<td>Discuss with department of clinical radiology.</td>
</tr>
</tbody>
</table>
## European Guidelines

### Suspected Cervical Spine Injury

<table>
<thead>
<tr>
<th>Neck injury: with neurological deficit</th>
<th>XR (I)</th>
<th>Indicated (B)</th>
<th>For orthopaedic assessment. Some constraints with life support systems. MRI best and safest method of demonstrating intrinsic cord damage, cord compression, ligamentous injuries and vertebral fractures at multiple levels. CT myelography may be considered if MRI not available.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MRI (0)</td>
<td>Indicated (B)</td>
<td></td>
</tr>
<tr>
<td><strong>K13</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck injury: with pain but XR initially normal; suspected ligamentous injury</td>
<td>XR C spine; flexion and extension (I)</td>
<td>Specialised investigation (B)</td>
<td>Views taken in flexion and extension (consider fluoroscopy) as achieved by the patient with no assistance and under medical supervision. MRI may be helpful here.</td>
</tr>
<tr>
<td><strong>K14</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thoracic and lumbar spine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma: no pain, no neurological deficit</td>
<td>XR (II)</td>
<td>Not indicated routinely (B)</td>
<td>Physical examination is reliable in this region. When the patient is awake, alert and asymptomatic, the probability of injury is low.</td>
</tr>
<tr>
<td><strong>K15</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma: with pain, no neurological deficit or patient not able to be evaluated</td>
<td>XR painful area (II)</td>
<td>Indicated (B)</td>
<td>A low threshold to XR when there is pain/tenderness, a significant fall, a high impact RTA, other spinal fracture present or it is not possible to clinically evaluate the patient. Increasing use of CT and MRI here.</td>
</tr>
<tr>
<td><strong>K16</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## European Guidelines
### Suspected Cervical Spine Injury

<table>
<thead>
<tr>
<th>Clinical Problem</th>
<th>Investigation (Dose)</th>
<th>Recommendation (Grade)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma: with neurological deficit — pain</td>
<td>XR (II)</td>
<td>Indicated (B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MRI (I)</td>
<td>Indicated (B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>K17</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelvis and sacrum</td>
<td>XR pelvis (I) plus lateral XR hip (I)</td>
<td>Indicated (C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>K18</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urethral bleeding and pelvic injury</td>
<td>Retrograde urethrogram (II)</td>
<td>Indicated (C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>K19</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma to coccyx or coccydynia</td>
<td>XR coccyx (I)</td>
<td>Not indicated routinely (C)</td>
<td>Normal appearances often misleading and findings do not alter management.</td>
</tr>
<tr>
<td></td>
<td><strong>K20</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MGH Decision Support
Physician Dialogue for ED CT
Computerized for Outpatient CT
Decision Support with Conversation
CT Scheduling in MGH ED

- E.D. physician initiates CT request on computer
- Computer requesting program solicits clinical information and initiates examination scheduling
- Discussion with radiologist for CT protocol selection
Requests for CT require discussion with the on-duty Emergency Radiology staff or resident

- Communication of clinical presentation, physical exam and labs permits confirmation of exam appropriateness and selection of optimum exam protocol
- Confirms responsible referring physician
- Permits inquiry regarding possible pregnancy, contrast allergy, renal function
- Permits inquiry about special post-processing: 3D, CTA
- Finalized CT protocols are entered on a QuickBase computer log which is available for viewing by radiologists and technologists
CT Protocols Entered on a QuickBase: Dashboard

### Resident Dashboard

**TO BE PROTOCOLLED**
Displays any exam that has been scheduled by the RSR but still needs to be protocolled...

<table>
<thead>
<tr>
<th>Neuro Exam?</th>
<th>Time</th>
<th>Patient Name</th>
<th>MRN</th>
<th>Exam Type</th>
<th>Exam Description</th>
<th>History</th>
<th>Ordering Physician</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No records found

**ED EXAM LIST**
Displays any scheduled exam that has yet to be marked as "Dictated"

<table>
<thead>
<tr>
<th>Neuro Exam?</th>
<th>Date</th>
<th>Time</th>
<th>Patient Name</th>
<th>MRN</th>
<th>History</th>
<th>Exam Description</th>
<th>Ordering Physician</th>
<th>Cleared for OOC?</th>
<th>Protocol</th>
<th>Physician Consulted</th>
<th>Pager#</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No records found

**MESSAGES**
Displays any outstanding request for a Consult, Exam Approval or Wet Read...

<table>
<thead>
<tr>
<th>Time</th>
<th>Patient Name</th>
<th>MRN</th>
<th>Exam Description</th>
<th>Type of Request</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No records found
## Request Specifics

<table>
<thead>
<tr>
<th>Date</th>
<th>09-27-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>9:00 am</td>
</tr>
<tr>
<td>Origin of Request</td>
<td>Order Entry</td>
</tr>
<tr>
<td>Needs Protocol?</td>
<td>YES</td>
</tr>
<tr>
<td>* Current Status</td>
<td>Scheduled</td>
</tr>
</tbody>
</table>

## Patient and Exam Specifics

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Smith, John</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRN</td>
<td>1111</td>
</tr>
<tr>
<td>History</td>
<td>s/p MVA Neck Pain'</td>
</tr>
<tr>
<td>Accession Number</td>
<td>111111</td>
</tr>
<tr>
<td>* Ordering Physician</td>
<td>Dr. Jones</td>
</tr>
<tr>
<td>* Ordering Physician's Pager#</td>
<td>1-2345</td>
</tr>
<tr>
<td>* Exam Type</td>
<td>CT</td>
</tr>
<tr>
<td>* Exam Description</td>
<td>CTSPN-</td>
</tr>
<tr>
<td>* Protocol</td>
<td>I-</td>
</tr>
<tr>
<td>* Protocolled By</td>
<td>JOJ</td>
</tr>
<tr>
<td>Is this a CT of the C-Spine?</td>
<td>YES</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
</tr>
</tbody>
</table>
QuickBase Patient Queue with CT Protocols Displayed for Physicians and Technologists

Consultation Room

CT Control Room
MGH Computerized Decision Support Radiology Order Entry (ROE) for Outpatients Provides Feedback for Physician Requests
Request for a Spine MR Exam

EXAM REQUESTED Pick only ONE of the Following
- Musculoskeletal Interpretation
- Neuroradiology Interpretation

At least one box MUST be selected from either of the following groups

LOW BACK SIGNS / SYMPTOMS
- Back Pain
- Back pain improved with exercise
- Sciatic leg pain (sciatica)
- Radiculopathy (such as pain, numbness, abnormal reflexes)
- Pain in the legs relieved when sitting
- Neurogenic Claudication
- Symptoms of Cauda Equina syndrome such as: Urinary retention, Fecal incontinence, Saddle anesthesia
- Lower extremity weakness (hemiparesis)

KNOWN DIAGNOSES (NOT Rule/out!)
- Cauda Equina syndrome
- Demyelinating disease with spinal cord syx (type)
- Disc disease
- Kyphosis
- Osteoporosis
- Scoliosis
- Spinal Stenosis
- Spine fracture (Traumatic) specify location
- Spondylolisthesis
- Congenital spine malformation (specify)
- Demyelinating disease without spinal cord syx
- Known primary tumor (specify)
- Metastases to spine
- Primary spine tumor
- Spinal cord injury
- Spine fracture (pathological) (specify cause)
- Spine infection (specify)

ABNORMAL PREVIOUS EXAMINATIONS
- Abnormal bone scan
- Abnormal x-ray bone destruction
- Abnormal x-ray DJD
“Appropriateness” Values

1-3
Low Utility

4-6
Intermediate

7-9
High Utility
**Decision Support**

**MGH Radiology Order Entry - Microsoft Internet Explorer provided by Partners HealthCare System**

**Patient Name:** ROSENTHAL, DANIEL  
**MRN:** 2219795  
**Ordering Physician:** Rose

---

### Lumbar Spine MRI

Lumbar Spine MRI has low utility for the clinical indications provided.

<table>
<thead>
<tr>
<th>Score</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Indicated 7-9</td>
</tr>
<tr>
<td>8</td>
<td>Marginal 4-6</td>
</tr>
<tr>
<td>7</td>
<td>Low Utility 1-3</td>
</tr>
</tbody>
</table>

### Alternate procedures to consider:

- **X-Ray**  
  - Score: 7
- **CT**  
  - Score: 2

### Options:
- **Proceed** with exam
- **Cancel** or select new exam
- **Change** indications and resubmit

---

**Additional Information:**

- When imaging is helpful for Back Pain
- Patient Information on Back Pain
- Vertebroplasty
"Radiation Alert"

- Notifies ordering physician of ALL CT scans that the patient has had at ALL Partners facilities
Precise communication of clinical presentation and a dialogue between emergency physicians and radiologists can help ensure that ED CT scans are:

1. Performed only on those ED patients in whom a CT scan is truly indicated
2. Performed utilizing the optimal CT protocol for diagnosing the patient’s clinical condition
3. Performed with the minimum radiation exposure for obtaining a diagnostic quality examination
Clinical Decision Making for ED CT

Role of the Emergency Physician

- Provide the radiologist with relevant clinical information to assist in the selection of optimal imaging procedure, and when CT is indicated, the optimal CT protocol
- Utilize evidence-based imaging guidelines
- Be willing to communicate in conversation with the radiologist
- Be willing to participate in decision support
Clinical Decision Making for ED CT

Role of the Radiologist

Take advantage of all patient care information resources as well as communications with referring physicians to obtain the relevant clinical information to provide optimal advise on emergency imaging procedures, and when CT is indicated, to advise on the most optimal CT protocol.

Utilize evidence based imaging guidelines

Consider instituting decision support
Thank You!

Robert A. Novelline, MD
Professor of Radiology, Harvard Medical School
Director of Emergency Radiology, Massachusetts General Hospital

novelline.robert@mgh.harvard.edu
Clinical Decisions: The Emergency Physician Perspective

Paul R. Sierzenski, MD, RDMS, FACEP
Chief, Emergency Ultrasound Section
Director, EM, Trauma & Critical Care Ultrasound
Christiana Care Health System
Newark Delaware
A Unique Environment

Loud-Fast-Limited Info

Quiet-Calm-Ample Info

Our two hospital ED system sees 160,000 ED patients per year with 3,500 level one traumas. That’s over 400 patients per day!
Emergency Medicine

• “Emergency medicine is the medical specialty dedicated to the diagnosis and treatment of unforeseen illness or injury.”

• EM is the safety net

• EM physicians hold the net

• The ED is the most federally regulated department within any hospital by EMTALA (speaks to our duty public health duty)
“EMTALA”: The Facts

- Emergency Medical Treatment & Active Labor Act
- Enacted by Congress in 1986
- Address “patient dumping” by emergency departments.
- EMTALA has two principal categories:
  1) ensure an appropriate medical screening
  2) require stabilization before transfer or discharge

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
“EMTALA”- ED Issue # 1

• The impact of EMTALA is real and applies to all Medicare accepting hospitals with EDs

• Ensure an “appropriate medical screening”

• “an appropriate medical screening exam” is still ill defined by EMTALA
“EMTALA”: ED Issue # 2

- Require “stabilization” before transfer / discharge

- Unlike the screening requirement, the language of the stabilization requirement does not qualify the care to be given as “appropriate.”

- No “improper motive” need be alleged to show a violation of EMTALA’s stabilization provisions.

- Places a federal mandate on our level of care

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
“EMTALA”: The Concern

- Stabilization has occurred when there is a “reasonable assurance” that no material deterioration would result from that individual’s transfer or discharge from the hospital.

- CT is often the most effective & efficient means to accurately and rapidly “assure” that deterioration will not occur. (excellent negative predictive value)

- To realistically affect CT usage, EMTALA scope and impact must be addressed, and potentially narrowed respective to stabilization in the ED (this was discussed by the EMTALA-TAG in April 2009).
"EMTALA": So What?

- Based on the Supreme Court, if there is a deterioration of a patient, emergency physicians *MAY* be open to EMTALA violations.
- These fines ($50,000.00 per violation) would not be covered by medical malpractice insurance!
- So would you order the CT?

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
Clinical Decisions Making

Physician
- Experience & Biases
- Knowledge

Patient
- Symptoms
- History

Diagnosis
- Diagnostics
Clinical Decision Making

“Above all else, emergency physicians must not miss critical diagnoses”

ACAD EMERG MED • November 2002, Vol. 9, No.

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
Clinical Decision Making

- Multiple factors to be discussed by Drs. Blaivas, Melanson and McCarthy

- Hypothetical-Deductive Model
  - Hypothesis Generation
    - Clinical presentation, Prevalence of Disease, experience/knowledge, acuity
  - Hypothesis Evaluation: for the EP this is the “elimination” not the hypothesis confirmation.
  - EP’s goal is to identify, treat or exclude life or limb threatening conditions
Retrospective Reviews: Flawed

- 29 yo patient with HTN, Migraines c/o HA with vomiting
- Lights out, states acute “thunder clap”, “worst every”. HO HTN
- Based on **prevalence** migraine is most likely
- Based on **symptoms** “worse ever” “thunderclap”, Subarachnoid Hemorrhage should be excluded...CT head...lumbar puncture
- If the work up is negative that does not mean the work up was not needed.

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
PAIN MANAGEMENT/CLINICAL POLICY


From the American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Critical Issues in the Evaluation and Management of Adult Patients Presenting to the Emergency Department with Acute Headache:
Jonathan A. Edlow, MD (Chair)
Peter D. Panagos, MD
Steven A. Godwin, MD
Tamara L. Thomas, MD
Wyatt W. Decker, MD

Members of the American College of Emergency Physicians Clinical Policies Committee (Oversight Committee):
The Paradox: Emergency Care

• “One of the important features of the availability heuristic (pattern recognition) is its dependence on personal experience...applications of Rule Out Worse Case Scenerio may lead to over utilization of resources.”

• However this is the ethical, legal (EMTALA) obligation of EM and a societal expectation
CDM Errors Do Occur

- Errors often are the result as an act of omission
- Negative reinforcement increased utilization as a result

<table>
<thead>
<tr>
<th>TABLE 3. Failed Heuristics, Biases, and Cognitive Dispositions to Respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate bias</td>
</tr>
<tr>
<td>Anchoring</td>
</tr>
<tr>
<td>Ascertainment bias</td>
</tr>
<tr>
<td>Availability and non-availability</td>
</tr>
<tr>
<td>Base-rate neglect</td>
</tr>
<tr>
<td>Commission bias</td>
</tr>
<tr>
<td></td>
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</table>
Noncontroversial Solutions

- Electronic medical records
- Medical homes without boarders
- Increased communication with consultants
- Improved communication with patients
- Staged Imaging (US before CT, etc.)
- Multi-specialty guideline development
Controversial Solutions

- Medical liability reform
- Patient expectations
- EMTALA modifications
- Increased error transparency
- Clinical decision support systems
Clinical Decision Support Systems: State of the Art

Prepared for:
Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
www.ahrq.gov

Prepared by:
Eta S. Berner, Ed.D.
Department of Health Services Administration
University of Alabama at Birmingham

AHRQ Publication No. 09-0069-EF
June 2009
The Paradox: Emergency Care

- Computerized clinical decision support systems (CDS) have shown promise in reducing variance in care and resource utilization.
- Most of these scenarios are limited to care “post diagnosis” care (e.g. diabetes, not in a diagnostic algorithm).
- Emergency medicine often cares for the acutely “undiagnosed patient”.
- However, small changes can have significant positive impact (renal colic, suspected appendicitis).

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
Conclusions

• As the emergency physician who is treating the patient we are ultimately responsible

• Our specialty was designed to be a safety net

• The environment and external factors affecting EP CDM are real and significant and affect CT usage

• Real solutions will need to address transformation of legal, regulatory, communication and medical care issues.
EM Physicians are Learning

How Much Is Too Much? The REAL Risks of X-Rays and CTs (WE-227) Wednesday, October 7, 3:00 PM - 3:50 PM

“How much radiation is my baby going to get?”
“Will this CT scan give me brain cancer?”
These questions and more will be answered during this lecture.

Objectives:
Total RAD dosages of imaging radiography to CT scanning.
Discuss risks of renal failure associated with contrast imaging.
Explain ways to avoid certain high RAD imaging studies.
Questions?
Since 8 am today nearly 100,000 patients have been treated by emergency physicians throughout the USA
References

• CRS: EMTALA: Access to Emergency Medical Care, May 8, 2008. CRS report number: RS22738


• Final Report of The Emergency Medical Treatment and Labor Act Technical Advisory Group To the Secretary U.S. Department of Health and Human Services

CT Basic Physics, Equipment Operations and Dose Optimization

Mahadevappa Mahesh, MS, PhD, FAAPM, FACR.
Associate Professor of Radiology & Cardiology
Chief Physicist - Johns Hopkins Hospital

The Russell H. Morgan Department of Radiology and Radiological Science
Johns Hopkins University, Baltimore, MD

CT in Emergency Medicine – Ensuring Appropriate Use
NCRP Meeting, Washington DC, September 23-24, 2009
Computed Tomography (CT)

- Method for acquiring and reconstructing an image of a thin cross-section of an object
- Based on measurements of x-ray attenuation through section plane from many projections
- Achieved by rotating both x-ray tube and detectors around the patient
- CT is consistently rated in the top 5 medical innovations over the past 35 years
Number of CT procedures in US

Annual growth ~10%

IMV Benchmark Report on CT, 2008
### MDCT growth in US as percent CT scanner

<table>
<thead>
<tr>
<th>Survey Year</th>
<th>2004</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CT installed in US</td>
<td>9,380</td>
<td>10,110</td>
<td>10,300</td>
</tr>
<tr>
<td>MDCT</td>
<td>51%</td>
<td>71%</td>
<td>81%</td>
</tr>
<tr>
<td>SDCT</td>
<td>42%</td>
<td>28%</td>
<td>18%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

MDCT Physics: The Basics…, Lippincott, 2009
Basic Principles
The Physics: X-ray Attenuation

• When an x-ray beam passes through an object, photons are removed by:
  – Photoelectric Effect
  – Compton Scattering
  – Coherent Scattering
The CT Signal

- Tissue discrimination due to variations in attenuation between voxels depends on differences in:
  - Density
  - Atomic number of elements present
  - Influenced by detected mean photon energy
Fundamental Measurement of Attenuation

\[ I_t = I_o e^{-\mu \Delta x} \]
\[ H = \ln \left( \frac{I_o}{I_t} \right) = \mu \Delta x \]

- \( I_o \) = Input x-ray intensity
- \( I_t \) = Transmitted x-ray intensity
- \( \mu \) = Linear attenuation coefficient
Ray Sum of X-Ray Attenuation

\[ I_t = I_o e^{-\mu \Delta x} \]

\[ I_t = I_o e^{-\sum_{i=1}^{k} \mu_i \Delta x} \]

\[ \sum_{i=1}^{k} \mu_i \Delta x = \ln \left( \frac{I_o}{I_t} \right) \]
CT Image Reconstruction

- Process of deriving average attenuation coefficient ($\mu$) values for each voxel in the cross section using many rays from many different projections
CT Numbers in Hounsfield Units
Normalized to Voxel containing Water

CT # = k \left( \frac{\mu - \mu_w}{\mu_w} \right)

k = Scaling factor = 1000

By definition CT # of water = 0, CT # of air = -1000

Tissues: Denser than water → positive CT #s
Less dense than water → negative CT #s
Single-row vs Multiple-row Detector CT

Mahesh M. MDCT Physics: The Basics…, Lippincott, 2009
CT Equipment Operations
Early Experiments

Sir Godfrey N. Hounsfield*

Original lathe bed scanner used in early CT experiments

* 1979 Nobel Prize in Medicine
Scan Types: Sequential and Helical

Sequential or ‘Step and Shoot’ scan

Helical or Spiral scan

Mahesh M. MDCT Physics: The Basics..., Lippincott, 2009
Scan Modes: Partial and Dynamic

Partial scan mode – Half-scan plus fan angle

Dynamic scan mode – Multiple continuous rotation of x-ray tube at same table position

Mahesh M. MDCT Physics: The Basics..., Lippincott, 2009
CT Gantry with major components

- X-ray Tube
- Flat Filter
- Bowtie Filter
- Pre-patient collimator
- Gantry Opening ~ 70 cm
- Scan Field of View (SFOV) ~ 50 cm
- Center of Rotation
- Post-patient collimator
- X-ray Detectors

Frontal View
In-plane direction

Lateral View
Longitudinal direction

Mahesh M. MDCT Physics: The Basics..., Lippincott, 2009
CT Gantry

User defined scan field of view

Maximum sampling region ~50 cm, less than gantry opening

CT Gantry opening ~ 70 cm in diameter

CT Table with patient load capacity up to 500 lbs

MDCT Physics: The Basics..., Lippincott, 2009
CT Dose Optimization
## CT: Numbers vs Collective Dose

<table>
<thead>
<tr>
<th></th>
<th>Number (millions)</th>
<th>%</th>
<th>Collective dose (person Sv)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>19.0</td>
<td>28</td>
<td>38,000</td>
<td>8.7</td>
</tr>
<tr>
<td>Chest</td>
<td>10.6</td>
<td>16</td>
<td>74,000</td>
<td>17.0</td>
</tr>
<tr>
<td>Abd/Pelvis</td>
<td>25.4</td>
<td>39</td>
<td>254,000</td>
<td>58.0</td>
</tr>
<tr>
<td>Extremity</td>
<td>3.5</td>
<td>5</td>
<td>500</td>
<td>0.1</td>
</tr>
<tr>
<td>CT Angiography</td>
<td>4.3</td>
<td>6</td>
<td>56,000</td>
<td>12.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4.2</td>
<td>6</td>
<td>15,000</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>67</strong></td>
<td></td>
<td><strong>438,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Numbers**

- Head: 28%
- Chest: 10%
- Abd/Pelvis: 38%
- Extremity: 5%
- CT Angiography: 13%
- Miscellaneous: 3%

**Collective Dose**

- Head: 28%
- Chest: 10%
- Abd/Pelvis: 58%
CT Dose Modulation

- X-ray attenuation lower in AP and higher in lateral projection
- Dose reduction based on patient anatomy
- Lower mA in AP, higher mA in lateral directions
CT Dose Modulation

MDCT Physics: The Basics..., Lippincott, 2009
## Typical Effective Dose Values

<table>
<thead>
<tr>
<th>CT Protocol</th>
<th>Effective dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head CT</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Chest CT</td>
<td>5 - 7</td>
</tr>
<tr>
<td>Abdomen &amp; Pelvis CT</td>
<td>8 - 11</td>
</tr>
<tr>
<td>Calcium Scoring</td>
<td>1 - 6</td>
</tr>
<tr>
<td>Cardiac CT Angiography (helical)</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Cardiac CT Angiography*</td>
<td>2 - 7</td>
</tr>
<tr>
<td>Typical Chest x-ray</td>
<td>0.1 – 0.2</td>
</tr>
<tr>
<td>Average US natural background radiation per year</td>
<td>~3.0 mSv</td>
</tr>
</tbody>
</table>

* Prospectively triggered, DSCT, 320 MDCT
# Adult Effective Doses for Various CT Procedures

<table>
<thead>
<tr>
<th>Examination</th>
<th>Effective dose (mSv)</th>
<th>Range in literature (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2</td>
<td>0.9 – 4.0</td>
</tr>
<tr>
<td>Neck</td>
<td>3</td>
<td>…</td>
</tr>
<tr>
<td>Chest</td>
<td>7</td>
<td>4.0 – 18.0</td>
</tr>
<tr>
<td>Chest for Pulmonary Embolism</td>
<td>15</td>
<td>13 – 40</td>
</tr>
<tr>
<td>Abdomen</td>
<td>8</td>
<td>3.5 – 25</td>
</tr>
<tr>
<td>Pelvis</td>
<td>6</td>
<td>3.3 – 10</td>
</tr>
<tr>
<td>Three-phase liver study</td>
<td>15</td>
<td>…</td>
</tr>
<tr>
<td>Spine</td>
<td>6</td>
<td>1.5 – 10</td>
</tr>
<tr>
<td>Coronary angiography</td>
<td>16</td>
<td>5.0 – 32</td>
</tr>
<tr>
<td>Calcium scoring</td>
<td>3</td>
<td>1.0 – 12</td>
</tr>
<tr>
<td>Virtual colonoscopy</td>
<td>10</td>
<td>4.0 – 13.2</td>
</tr>
</tbody>
</table>

Topics of Concern in CT

- Multiple CT scans within a CT exam
- Radiation dose per CT scan
- Repeat CT exams
**CT exam of abdomen and pelvis: Sample dose reports**

**Arterial and Venous scan series**

<table>
<thead>
<tr>
<th>Scan</th>
<th>KV</th>
<th>mAs / ref.</th>
<th>CTDIvol</th>
<th>DLP</th>
<th>TI</th>
<th>cSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topogram H-SP</td>
<td>120</td>
<td>450</td>
<td>32.31</td>
<td>1063</td>
<td>0.33</td>
<td>0.6</td>
</tr>
<tr>
<td>ARTERIAL</td>
<td>120</td>
<td>450</td>
<td>32.24</td>
<td>1883</td>
<td>0.33</td>
<td>0.6</td>
</tr>
<tr>
<td>VENOUS</td>
<td>120</td>
<td>450</td>
<td>32.24</td>
<td>1883</td>
<td>0.33</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Total mAs: 20002
Total DLP: 2736

**Arterial, Venous and Delay scan series**

<table>
<thead>
<tr>
<th>Scan</th>
<th>KV</th>
<th>mAs / ref.</th>
<th>CTDIvol</th>
<th>DLP</th>
<th>TI</th>
<th>cSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topogram H-SP</td>
<td>120</td>
<td>534</td>
<td>38.34</td>
<td>1212</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>ARTERIAL</td>
<td>120</td>
<td>530</td>
<td>38.02</td>
<td>1437</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>VENOUS</td>
<td>120</td>
<td>500</td>
<td>35.96</td>
<td>1224</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>DELAY</td>
<td>120</td>
<td>500</td>
<td>35.96</td>
<td>1224</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Total mAs: 28164
Total DLP: 3873

52 mSv

74 mSv
Radiation Dose Report - CT Angiography Exam

<table>
<thead>
<tr>
<th>Patient Position</th>
<th>mAs</th>
<th>mAs / ref.</th>
<th>CTDIvol</th>
<th>DLP</th>
<th>TI</th>
<th>CSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topogram</td>
<td>1</td>
<td>80</td>
<td>135</td>
<td>9.73</td>
<td>140</td>
<td>5.3</td>
</tr>
<tr>
<td>CaScSeq</td>
<td>2</td>
<td>120</td>
<td>135</td>
<td>6.62</td>
<td>27</td>
<td>0.5</td>
</tr>
<tr>
<td>TestBolus</td>
<td>10</td>
<td>120</td>
<td>40</td>
<td>26.62</td>
<td>24</td>
<td>0.5</td>
</tr>
<tr>
<td>TestBolus-use</td>
<td>21</td>
<td>120</td>
<td>40</td>
<td>24.20</td>
<td>24</td>
<td>0.5</td>
</tr>
<tr>
<td>CorCTA</td>
<td>31</td>
<td>120</td>
<td>850</td>
<td>65.78</td>
<td>1075</td>
<td>0.33</td>
</tr>
</tbody>
</table>

- Effective dose (mSv)
  - 2.4 mSv
  - 1.0 mSv
  - 18.3 mSv

Total effective dose (mSv) 21.7 mSv
CT Dose Optimization

- Alter CT scan parameters based on patient size, weight and type
- Adopt CT dose modulation techniques
  - Variation during routine scans
  - ECG dose modulation during cardiac scans
- Increased awareness about CT dose
- Apply ‘Image Gently’ campaign advice
CT Dose Optimization

• ‘Image Gently’ campaign advice
  – Child-size the amount of radiation used
  – Scan only when needed
  – Scan only indicated region
  – Scan once – avoid multi-phase scanning

• Avoid unnecessary CT scans
  – Especially scans performed due to insufficient image quality or due to difficulty in timely access of images
Conclusions

- **Understanding CT physics basics benefits efforts in dose optimization and reducing overall CT dose**
- **Justifying appropriateness of CT exam is critical!**
MDCT Physics
The Basics
Technology, Image Quality and Radiation Dose

Mahadevappa Mahesh

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Radiation Doses and Risks from Medical Imaging of Trauma Patients

Walter Huda PhD, Tyler Scimeca MD
William Conway MD, Eugene Mah MS

Radiology and Radiological Science
Medical University of South Carolina
PURPOSE
Determine patient effective doses (and carcinogenic risks) to trauma patients
METHOD
26 consecutive patients treated in MUSC ED

Injury Severity Score > 15
Medical records

→

Number/Type of examinations

→

Cumulative Effective Dose
Radiography
Dose Conversion Factors

~ 0.036 $\mu$Sv/cm$^2$
CT Dose Conversion Factors

~ 18 \( \mu \text{Sv/mGy-cm} \)

Radiology 248 (2008) 995-1003
Doses corrected for patient weight

Patient weight (kg)

Relative dose

Huda/McCollough; Cardiac CT Dosimetry CT of the Heart (UJ Schoepf) 2nd Edition
Effective dose quantify the patient risk of cancer

Accounting for patient age and sex
RESULTS
Average age 41 ± 16

9/26 (35%) females
During ED visit, on average

4.9 radiographic images

4.1 CT scans
Average Effective Dose

68 ± 29 mSv

~ 98% from CT
Average Risk of Cancer

Males ~ 0.47%

Females ~ 0.54%
US Cancer Incidence ~ 42%
Trauma Patients in ED (MUSC)

Relatively Young

Receive ~ 70 mSv from medical imaging (ISS > 15)

(~100% from CT)
Radiation Risks from Medical Imaging Need to be Justified By a Corresponding Patient Benefit
CT Protocols
Ensure Patient Exposures As Low As Reasonably Achievable (ALARA)
Thank You

huda@musc.edu
Conduct of CT: Techniques and Tactics for Dose Management

Donald P. Frush, MD
Division of Pediatric Radiology
Department of Radiology
Duke University Medical Center
I consider the radiologist’s responsibility with (radiation) dose to be the same as any physician’s with (medication) dose.

Over (or under) dosing is a medical error.
"This is the city. Los Angeles, California. I work here... I'm a radiologist."

“The story you are about to hear...”
Conduct of CT
Outline

• Background
• Justification
• Optimization
  – dose reduction strategies
Radiation Dose Reduction Strategies for CT

- Judicious use of CT
- Adjusted techniques
- Other
Background
PEM Malpractice Lawsuits: Most Common Diagnoses

- Meningitis
- Appendicitis
- Fractures
- Testicular torsion

SM Selbst. Pediatric Radiology November 2008
Isn’t it easier just to get a CT?
“The final common pathway of the radiological examination is the radiologist, who has the right and the duty to refuse studies, particularly when they involve risk to the patient”

Ferris Hall, 1976
Recurrent CT, Cumulative Radiation Exposure, and Associated Radiation-induced Cancer Risks from CT of Adults

**Purpose:** To estimate cumulative radiation exposure and lifetime attributable risk (LAR) of radiation-induced cancer from computed tomographic (CT) scanning of adult patients at a tertiary care academic medical center.

**Methods:** This HIPAA-compliant study was approved by the institutional review board with waiver of informed consent. The cohort comprised 31,462 patients who underwent diagnostic CT in 2007 and had undergone 330,781 CT examinations over the prior 22 years. Each patient's cumulative CT radiation exposure was estimated by summing typical CT effective doses, and the Biological Effects of Ionizing Radiations (BEIR VII) methodology was used to estimate LAR on the basis of sex and age at each exposure. Billing CPT codes and electronic order entry information were used to stratify patients with LAR greater than 1%.

**Results:** Thirty-three percent of patients underwent five or more lifetime CT examinations, and 5% underwent between 22 and 322 examinations. Fifteen percent received estimated cumulative effective doses of more than 100 mSv, and 4% received between 200 and 1275 mSv. Associated LAR had mean and maximum values of 0.3% and 12% for cancer incidence and 0.2% and 6.8% for cancer mortality, respectively. CT exposures were estimated to produce 0.1% of total expected baseline cancer incidence and 1% of total cancer mortality. Seven percent of the cohort had estimated LAR greater than 1%, of which 40% had either no malignancy history or a cancer history without evidence of residual disease.

**Conclusion:** Cumulative CT radiation exposure added incrementally to baseline cancer risk in the cohort. While most patients accrue low radiation-induced cancer risks, a subgroup is potentially at higher risk due to recurrent CT imaging.

---

1 From the Department of Radiology and Center for Evidence-Based Imaging (A.S., F.T.A., K.A., L.A.P., R.A.), Brigham and Women's Hospital, 75 Francis St, Boston, MA 02115; and Harvard Medical School, Boston, Mass. (A.S., F.T.A., L.A.P., R.A.). From the 2008 RSNA Annual Meeting. Received July 16, 2008; revision received August 29; revised version accepted September 22; accepted October 28. Final revision accepted November 3. Address correspondence to A.S. (e-mail: asullman@partners.org).

© RSNA, 2009
Number of CT Examinations

- 33% ≥ 5 CTs
- 5% 22-132

Figure 3: Histogram of total number of CT examinations per patient, over the 22-year study period in the cohort of 31,463 patients. The inset includes an expanded y-axis to display the right tail and contains the top percentile of per-patient examination counts; 33% of patients underwent more than five lifetime CT scans, 5% underwent more than 22 scans, and 1% underwent more than 38 scans.
Estimated Cumulative Dose

- 15% ED > 100 mSv
- 4% 250 - 1375 mSv
- 1% > 399 mSv
Increased Pediatric CT in the Emergency Department

Radiation Dose Reduction Strategies for CT

- Judicious use of CT
- Adjusted techniques
- Other
Must not forget the basics!!!

e.g., positioning, external material, immobilization, contrast
Radiation Dose Reduction Strategies for CT

- Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
  - size
  - CT scanner technology
"Single pass"

17% decreased dose

# Methods

<table>
<thead>
<tr>
<th>TYPE</th>
<th>BRAIN</th>
<th>CSPINE</th>
<th>CHEST</th>
<th>ABDOMEN/PELVIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Axial Full 1 sec</td>
<td>Helical Full 0.5 sec</td>
<td>Helical Full 0.4 sec</td>
<td>Helical Full 0.4 sec</td>
</tr>
<tr>
<td>mA</td>
<td>220</td>
<td>230</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>kVp</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>PITCH</td>
<td>-</td>
<td>0.969:1</td>
<td>1.375:1</td>
<td>1.375:1</td>
</tr>
<tr>
<td>SFOV</td>
<td>Small</td>
<td>Small</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Results

Effective Dose

<table>
<thead>
<tr>
<th>Overlapping</th>
<th>Non overlapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlap MOSFET</td>
<td>8.25 mSv</td>
</tr>
<tr>
<td>Overlap DLP</td>
<td>7.86 mSv</td>
</tr>
<tr>
<td>No overlap MOSFET</td>
<td></td>
</tr>
<tr>
<td>NO overlap DLP</td>
<td></td>
</tr>
</tbody>
</table>
Radiation Dose Reduction
Strategies for CT

• Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
  - size
  - CT scanner technology
Radiation Control: Adjustable CT Parameters

- Tube Current (mA)
- Gantry cycle time (0.5 – 1.0 seconds)
- Kilovoltage (kVp)
- Pitch
340 mA  75% of mA
Conventional and Reduced Radiation Dose of 16-MDCT for Detection of Nephrolithiasis and Ureterolithiasis

Erik K. Paulson\textsuperscript{1}
Carolyn Weaver\textsuperscript{1,2}
Lisa M. Ho\textsuperscript{1}
Lucie Martin\textsuperscript{1,3}
Jianying Li\textsuperscript{1}
James Darsie\textsuperscript{1}
Donald P. Frush\textsuperscript{1}

\textbf{OBJECTIVE.} Our purpose was to prospectively compare the reader compatibility and acceptability of a range of reduced-dose 16-MDCT images with standard-dose 16-MDCT images for the detection of nephroureterolithiasis using a dose reduction simulation technique.

\textbf{SUBJECTS AND METHODS.} The study was HIPAA compliant and institutional review board approved. Fifty consecutive patients with suspected nephrolithiasis were recruited to undergo conventional renal stone unenhanced 16-MDCT with at least 160 mAs. Noise was then artificially introduced to simulate levels of 70, 100, and 130 mAs. Three blinded independent readers interpreted the original and simulated-dose scans for the location and number of renal and ureteral calculi and secondary signs of obstruction using a 5-point confidence scale.

\textbf{RESULTS.} Reader acceptability of scans was inversely related to noise. There was no significant reduction in readers’ confidence in detection or exclusion of renal collecting system calculi with simulated reduction of mAs of 70, 100, and 130 compared with the standard-dose study. However, for ureteral calcifications, there was a decrease in confidence for the detection or exclusion of ureterolithiasis at an mAs of 70 (35 mAs).

\textbf{CONCLUSION.} An mAs as low as 70 (35 mAs) is acceptable for evaluation of nephrolithiasis. However, the evaluation of ureterolithiasis is compromised with an mAs of 70.

\textbf{Keywords:} helical CT, nephrolithiasis, radiation dose, ureterolithiasis

\textbf{C T has been used extensively for the examination of patients with suspected urinary obstruction from ureterolithiasis and for the detection of nephrolithiasis. In many practices, CT has virtually replaced conventional radiography for these indications [1–4]. For [8, 9] However, to our knowledge, it is not known what minimum dose is required for adequate stone detection using 16-MDCT. Our purpose was to prospectively compare the reader acceptability and confidence of a range of reduced-dose 16-MDCT images with standard-dose 16-MDCT images for
Original: 380 mA
Simulated: 70 mA
18% of dose!

AJR January 2008: 190
130 mAs  40 mAs*  20 mAs*

* Simulated, by adding noise

Karmazyn, B et al. AJR January 2009
Radiation Dose Reduction Strategies for CT

- Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
  - size
  - CT scanner technology
Figure 1: Flowchart depicts patient demographics in the three phases of incremental dose reduction for implementation of new pediatric CT protocols. MDCT = multidetector CT scanner, N = number of CT examinations.
Radiation Dose Reduction Strategies for CT

- Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
    bones, lungs, CT angiography
Radiation Dose Reduction Strategies for CT

• Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
  - size
  - CT scanner technology
Color Coding for KIDS
Weight-Based Pediatric Protocols

Selecting a Pediatric Anatomical Region brings up color selector.
## AEC Guidelines for Pediatric MDCT

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wt</th>
<th>Length</th>
<th>Age</th>
<th>Noise Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chest</td>
</tr>
<tr>
<td>PINK</td>
<td>5.5 – 7.4 kg</td>
<td>60-67 cm</td>
<td>2.5 – 5.5 mo</td>
<td>9.5</td>
</tr>
<tr>
<td>RED</td>
<td>7.5 – 9.4 kg</td>
<td>67-75 cm</td>
<td>5.5 – 11.5 mo</td>
<td>10.0</td>
</tr>
<tr>
<td>PURPLE</td>
<td>9.5 – 11.4 kg</td>
<td>75-85 cm</td>
<td>11.5 – 22 mo</td>
<td>10.5</td>
</tr>
<tr>
<td>YELLOW</td>
<td>11.5 – 14.4 kg</td>
<td>85-97 cm</td>
<td>22 mo – 3yr, 2 mo</td>
<td>11</td>
</tr>
<tr>
<td>WHITE</td>
<td>14.5 – 18.4 kg</td>
<td>97-109 cm</td>
<td>3 ys, 2 mo – 5 yr, 2 mo</td>
<td>12</td>
</tr>
<tr>
<td>BLUE</td>
<td>18.5 – 23.4 kg</td>
<td>109-121 cm</td>
<td>5 yr, 2 mo – 7 yr, 4 mo</td>
<td>13</td>
</tr>
<tr>
<td>ORANGE</td>
<td>23.5 – 29.4 kg</td>
<td>121-133 cm</td>
<td>7 yr, 4 mo – 9 yr, 2 mo</td>
<td>14</td>
</tr>
<tr>
<td>GREEN</td>
<td>29.5 – 36.4 kg</td>
<td>133-147 cm</td>
<td>9 yr, 2 mo – 13 yr, 6 mo</td>
<td>15</td>
</tr>
<tr>
<td>BLACK</td>
<td>36.5 – 55 kg</td>
<td>&gt;147 cm</td>
<td>&gt;13 yr, 6 mo</td>
<td>16</td>
</tr>
</tbody>
</table>

*GE LightSpeed, VCT*
Radiation Dose Reduction Strategies for CT

- Adjust scanning by:
  - appropriate coverage
  - minimizing overlap
  - indication
  - region/organ system
  - size
  - CT scanner technology
Dose Reduction Technology

- Tube current modulation
- Iterative reconstruction
- New detector technology
- Adaptive collimation
- Increasing detector rows
- Surface based modulation
Tube Current Modulation (ATCM)

Angular (x, y) Z-axis

IR Shoulder: Bone Window

Normal

IR

Technology in development that represents ongoing research and development efforts. These technologies are not products and may never become products. Not for sale. Not cleared or approved by the FDA for commercial availability.

Courtesy GE Healthcare
IR Shoulder: Soft Tissue Window

Normal

IR

Technology in development that represents ongoing research and development efforts. These technologies are not products and may never become products. Not for sale. Not cleared or approved by the FDA for commercial availability.

Courtesy GE Healthcare
Radiation Dose Reduction Strategies for CT

- Judicious use of CT
- Adjusted techniques
- Other: education
“But I thought that the ED was different than the clinic…. and we should order more [CTs]”

resident, June 4th, 2008
The ALARA* Concept in Pediatric Imaging

Building Bridges Between Radiology and Emergency Medicine:
Consensus Conference on Imaging Safety and Quality for Children in the Emergency Setting

As Low as Reasonably Achievable

Hyatt Regency Orlando International Airport
Orlando, Florida

This program is sponsored by:
American Academy of Pediatrics
American College of Radiology
American Society for Radiologic Technologists
National Council on Radiation Protection & Measurements

Supporting Organizations:
Joint Commission Resources

Program
FRIDAY, FEBRUARY 23
4:00 - 6:00 pm Registration

SATURDAY, FEBRUARY 24
7:30 - 8:30 am Registration and Continental Breakfast
8:30 - 8:45 am Program Introduction, Welcome, and Announcements
Donald P. Frush, M.D., Karen S. Frush, M.D.
8:45 - 9:45 am “Sleeping with the Enemy?” Expectations and Reality in Imaging Children in the Emergency Setting
Donald P. Frush, M.D., Karen S. Frush, M.D.
9:45 - 11:00 am Standards of Care in the Emergency Setting
9:45 - 10:15 am Standards for Radiology Interpretation and Reporting in the Emergency Setting
Leonard Berlin, M.D., F.A.C.P.
10:15 - 10:30 am Break
10:30 - 11:00 am Standards for Clinical Evaluation and Documentation by the LM Provider
Shreve M. Salter, M.D., F.A.A.P.
11:00 am - 12:00 pm The Art of Communication: Strategies to Improve Patient and Information Flow
11:00 - 12:10 pm Radiology Perspective
Thomas L. Skov, M.D.
11:30 - 12:00 pm ED Perspective
Steven E. Knop, M.D., F.A.A.P.
12:00 - 1:15 pm Lunch
1:15 - 2:00 pm Imaging Utilization
1:15 - 1:45 pm Imaging Utilization: Radiology Perspective
Martin H. Reit, M.D., F.A.A.P.
1:45 - 2:05 pm Imaging Utilization: ED Perspective
Joshua Broder, M.D.
2:05 - 2:30 pm Imaging Utilization: What We Need to Do
Nathan Koppelman, M.D., F.A.A.P.
2:30 - 3:00 pm Contemporary Imaging: Technology and Controversies
Carlos J. Sivit, M.D.
3:00 - 3:30 pm Bedside Pediatric Emergency Evaluation Through Ultrasonography
Ann H. Dietrich, M.D., F.A.A.P., F.A.C.E.P.
Let's Image gently when we care for kids! The Image gently Campaign is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The campaign goal is to change practice by increasing awareness of the opportunities to lower radiation dose in the imaging of children.

ONE SIZE DOES NOT FIT ALL...

There's no question: CT helps us save kids' lives!

But, when we image, radiation matters.
* Children are more sensitive to radiation
* What we do now, lasts their lifetimes

So, when we image, let's image gently
* More is often not better
* When CT is the right thing to do:
  * Child size the kVp and mA
  * One scan (single phase) is often enough
  * Scan only the indicated area

Let's image gently....
What’s Needed ... Quality Improvement

- Multidisciplinary collaboration
  - investment and responsibility
- IT!!!
  - EMR
    - Radiology data transfer, storage, reading
- Appropriateness criteria
- Evidence-based research
Cumulative Radiation Exposure and Cancer Risk Estimates in Emergency Department Patients Undergoing Repeat or Multiple CT Scans

Objective. The purpose of our study was to define a conservative estimate of the number of patients undergoing repeat or multiple emergency department CT scans and to estimate their cumulative radiation doses and lifetime attributable risk of developing cancer.

Materials and Methods. We identified all patients at a tertiary care academic medical center with at least three emergency department visits within a 3-year period who had undergone CT imaging of the neck, chest, abdomen, or pelvis. We calculated cumulative radiation doses by summing typical effective doses of the anatomic regions scanned, and we estimated attributable risk using the population-averaged dose-to-risk conversion factors per 1,000 patients receiving a 10-mSv dose, in accordance with the seventh report of the Ionizing Radiation (BEIR VII) panel.

Results. One hundred thirty emergency department patients met the inclusion criteria. Over the 77-year period, median, mean, and maximum values for the study cohort were 13, 70, and 110 CT scans, respectively. Emergency department patients in the study had 55% of the CT scans performed at the same institution. Repeat imaging of the same study type represented 72% of the cohort and all of the imaging for 12%.

Conclusion. A small proportion (1.9%) of emergency department patients undergoing CT of the neck, chest, abdomen, or pelvis have high cumulative radiation doses that may be associated with an increased risk of cancer. Individualized radiation risk assessment to identify and risk stratify such patients on the basis of cumulative dose estimates is one way of informing clinicians at the point of ordering how further imaging impacts the risk-to-benefit equation. At that point, recommendations for imaging with another technique or the use of established institutional protocols for addressing such scenarios may offer options to the clinician faced with the decision of whether to image again.

In many ways, CT has transformed care for emergency department patients and is the technique of choice for a wide range of indications because of the timely and reliable diagnostic information it provides. The use of CT, particularly in the emergency department, has grown dramatically in the past decade [1-3], spurred by rapid technological advances and patient safety initiatives. CT has become a central component of emergency department care, with 30% of all patients in the emergency department receiving a CT scan during their visit [8]. However, the cumulative radiation doses and associated risks are significant. In our study, the median patient received 13 CT scans, with a maximum of 110 scans, over a 77-year period. The attributable risk of cancer from cumulative CT radiation exposure in this cohort of patients is estimated to be 72% for the study cohort and 12% for repeat imaging of the same study type.
• “Repeat scans might have been avoided in as many as 25% of rescanned patients (35% of repeat examinations) because they were performed solely for imaging or information technology reasons (inadequate imaging, compact disc inoperability, or unavailable images within the hospital’s picture archiving and communication system).”

• “Rescanned trauma patients in particular had a high per patient rate (32%) of potentially avoidable reasons, with a lower rate (11%) in nontrauma patients.”
Appropriateness Criteria for CT Procedures

Paul A. Larson, MD, FACR
Chair, ACR Commission on Quality and Safety

CT in Emergency Medicine – Ensuring Appropriate Use

Bethesda, MD
September 23, 2009
Financial Disclosures

- No personal financial disclosures
- Volunteer member American College of Radiology (ACR) Board of Chancellors
  - ACR offers various Quality and Safety products for a fee
  - ACR licenses its Appropriateness Criteria® for commercial adaptation
Objectives

1) Provide overview of ACR Appropriateness Criteria®
2) Show examples of ACR Appropriateness Criteria®
3) Discuss relevance of ACR Appropriateness Criteria® to Emergency Medicine
4) Discuss possible uses of ACR Appropriateness Criteria® by Emergency Departments and physicians
ACR Appropriateness Criteria® Overview

- First version released 1995
- Recognized by National Guidelines Clearinghouse
- Used by radiologists and referring clinicians
- Help make well-informed decisions about initial radiologic tests
- Reviewed biennially, updated as needed
- Available on ACR web site
- PDA application coming soon
- Format of AC works from clinical presentation to imaging modalities
18 Expert Panels

- 10 Diagnostic
  - Breast, Cardiac, Gastrointestinal, Musculoskeletal, Neurological, Pediatric, Thoracic, Urologic, Vascular, Women’s Imaging
- 1 Interventional Radiology
- 7 Radiation Oncology
  - Brain, Breast, Bone, Hodgkin’s, Lung, Prostate, Rectal/Anal

Clinical Conditions

- Criteria developed for more than 160 clinical conditions
  - Over 800 variants (patient presentations)
Selection of Clinical Conditions

- Disease prevalence
- Economic impact of the condition
- Potential for morbidity/mortality
- Potential for improved care

*Pertinent variations developed to encompass the entire spectrum of each condition*
Criteria Development

- Based on principles developed by Institute of Medicine (IOM) and used by Agency for Health Care Research and Quality (AHRQ)
- Panels include Radiologists and other clinical specialists
- Review scientific literature
- Consensus techniques used to complement scientific data (modified Delphi methodology)
- Modalities ranked on a 1-9 scale
  - 9 is most appropriate, 1 is least appropriate
# Sample Evidence Table

## Left Lower Quadrant Pain

<table>
<thead>
<tr>
<th>Reference</th>
<th>Type of Study Design</th>
<th>Number of Patients</th>
<th>Study Problem</th>
<th>Study Results</th>
<th>Strength of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ajaj W, Ruehm SG, Lauenstein T, et al. Dark-lumen magnetic resonance colonography in patients with suspected sigmoid diverticulitis: a feasibility study. <em>Eur Radiol</em> 2005; 15(11):2316-2322.</td>
<td>9</td>
<td>40</td>
<td>A prospective study to assess dark-lumen magnetic resonance colonography (MRC) for the evaluation of patients with suspected sigmoid diverticulitis, by comparing the results to conventional colonoscopy (CC).</td>
<td>CC confirmed the presence of light inflammatory signs in 4 patients which were missed in MRC. MRC correctly identified wall thickness and contrast uptake of the sigmoid colon in the patients with diverticulitis. In 3 of these patients false-positive findings were observed, and MRC classified the inflammation of the sigmoid colon as diverticulitis whereas CC and histopathology confirmed invasive carcinoma. MRC detected additionally relevant pathologies of the entire colon and could be performed in cases where CC was incomplete. MRC may be considered a promising alternative to CC for the detection of sigmoid diverticulitis.</td>
<td>3</td>
</tr>
<tr>
<td>2. Buckley O, Geoghegan T, McAuley G, Persaud T, Khosa F, Torreggiani WC. Pictorial review: magnetic resonance imaging of colonic diverticulitis. <em>Eur Radiol</em> 2007; 17(1):221-227.</td>
<td>12</td>
<td>N/A</td>
<td>To illustrate the emerging role of MRI in the diagnosis and evaluation of colonic diverticulitis.</td>
<td>MRI has a major advantage over CT in that there is no ionizing radiation. In one institution, MRI has increasingly been used as a complimentary imaging modality to CT in the diagnosis and evaluation of diverticulitis and its complications.</td>
<td>4</td>
</tr>
</tbody>
</table>

Total of 25 entries in this table
## Relative Radiation Level

<table>
<thead>
<tr>
<th>Relative Radiation Level*</th>
<th>Effective Dose Estimate Range</th>
<th>Example Examinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>Ultrasound, MRI</td>
</tr>
<tr>
<td>Minimal</td>
<td>&lt; 0.1 mSv</td>
<td>Chest radiographs, hand radiographs</td>
</tr>
<tr>
<td>Low</td>
<td>0.1 - 1 mSv</td>
<td>Pelvis radiographs, mammography</td>
</tr>
<tr>
<td>Medium</td>
<td>1-10 mSv</td>
<td>Abdomen CT, barium enema, nuclear medicine bone scan</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 10 mSv</td>
<td>Abdomen CT without and with contrast, whole body PET</td>
</tr>
</tbody>
</table>

*RRL assignments are not included for some examinations. These are designated as IP (in progress) or NS (not specified). The RRL assignments for the IP exams will be available in future releases. The RRL assignments for the NS exams cannot be made because the RRL depends on the region of the body exposed to ionizing radiation, and the body part will vary as a function of the clinical situation.
# AC Relevance in Emergency Medicine

<table>
<thead>
<tr>
<th>Panel</th>
<th>Topics</th>
<th>ED</th>
<th>Panel</th>
<th>Topics</th>
<th>ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>4</td>
<td>1</td>
<td>Urologic</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Cardiac</td>
<td>9</td>
<td>7</td>
<td>Vascular</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>GI</td>
<td>15</td>
<td>10</td>
<td>Women’s Imaging</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>22</td>
<td>13</td>
<td>Interventional</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Neurological</td>
<td>14</td>
<td>12</td>
<td>Radiation Oncology</td>
<td>34</td>
<td>0</td>
</tr>
<tr>
<td>Pediatric</td>
<td>10</td>
<td>9</td>
<td>TOTAL</td>
<td>163</td>
<td>80</td>
</tr>
</tbody>
</table>

As of October 2008 release
ACR Appropriateness Criteria®
Clinical Condition: Left Lower Quadrant Pain
Variant 1: Older patient with typical clinical presentation for diverticulitis.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT abdomen and pelvis with contrast</td>
<td>8</td>
<td>Oral and/or colonic contrast may be helpful for bowel luminal visualization.</td>
<td>High</td>
</tr>
<tr>
<td>CT abdomen and pelvis without contrast</td>
<td>6</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>X-ray contrast enema</td>
<td>5</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>US abdomen transabdominal graded compression</td>
<td>4</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>US abdomen transrectal or transvaginal</td>
<td>4</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>X-ray abdomen and pelvis</td>
<td>4</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>MRI abdomen and pelvis with or without contrast</td>
<td>4</td>
<td>See comments regarding contrast in text under “Anticipated Exceptions”</td>
<td>None</td>
</tr>
</tbody>
</table>
ACR Appropriateness Criteria®
Clinical Condition: Left Lower Quadrant Pain
CT abdomen and pelvis with contrast ratings by variant

<table>
<thead>
<tr>
<th>Variant</th>
<th>CT Appropriateness Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Older patient with typical clinical presentation for diverticulitis.</td>
<td>8</td>
</tr>
<tr>
<td>2 - Acute, severe, with or without fever.</td>
<td>9</td>
</tr>
<tr>
<td>3 - Chronic, intermittent, or low grade.</td>
<td>8</td>
</tr>
<tr>
<td>4 - Woman of childbearing age.</td>
<td>7</td>
</tr>
<tr>
<td>5 - Obese patient.</td>
<td>8</td>
</tr>
</tbody>
</table>
ACR Appropriateness Criteria®
Clinical Condition: Right Lower Quadrant Pain
Highest rated exam by variant

<table>
<thead>
<tr>
<th>Variant</th>
<th>Exam</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Fever, leukocytosis, and classic presentation clinically for appendicitis in adults.</td>
<td>CT abdomen and pelvis with contrast</td>
<td>8</td>
</tr>
<tr>
<td>2 - Fever, leukocytosis; possible appendicitis, atypical presentation, adults and adolescents.</td>
<td>CT abdomen and pelvis with contrast</td>
<td>8</td>
</tr>
<tr>
<td>3 - Fever, leukocytosis, pregnant woman.</td>
<td>US abdomen RLQ</td>
<td>8</td>
</tr>
<tr>
<td>4 - Fever, leukocytosis, possible appendicitis, atypical presentation in children (less than 14 years of age).</td>
<td>US abdomen RLQ</td>
<td>8</td>
</tr>
</tbody>
</table>
Expanding Appropriateness Criteria

- Appropriateness criteria can be used in Computerized Physician Order Entry (CPOE) systems
- ACR has licensed its Appropriateness Criteria
- Companies have expanded the AC for completeness in CPOE
- CPOE systems give the immediate feedback needed in the emergency situation
- Physician is allowed to order exam even if it doesn’t “meet criteria”
Uses in Emergency Medicine?

- Individual case guidance
- Protocol development
- Education – residents, medical students
- Quality review of practitioners
- Research
Conclusions

• Appropriateness criteria can help assure appropriate utilization of imaging in the Emergency Department, including CT
• Eliminating inappropriate use of CT will reduce radiation dose
• Appropriateness criteria and/or computerized physician order entry can be used promptly in the Emergency Department setting.
• Appropriateness criteria are designed to provide educational feedback to the practitioner.
Potential health implications of dose from CT imaging

David J. Brenner
Columbia University,
New York, NY
djb3@columbia.edu
Typical organ doses from single diagnostic x ray examinations

<table>
<thead>
<tr>
<th>Examination</th>
<th>Relevant organ</th>
<th>Relevant organ dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental x ray</td>
<td>Brain</td>
<td>0.005</td>
</tr>
<tr>
<td>PA Chest x ray</td>
<td>Lung</td>
<td>0.01</td>
</tr>
<tr>
<td>Lateral chest x ray</td>
<td>Lung</td>
<td>0.15</td>
</tr>
<tr>
<td>Screening mammogram</td>
<td>Breast</td>
<td>3</td>
</tr>
<tr>
<td>Adult abdominal CT (200 mAs)</td>
<td>Stomach</td>
<td>11</td>
</tr>
<tr>
<td>Adult head CT (200 mAs)</td>
<td>Brain</td>
<td>13</td>
</tr>
<tr>
<td>Child abdominal CT (50 / 200 mAs)</td>
<td>Stomach</td>
<td>8 / 30</td>
</tr>
<tr>
<td>Child head CT (100 / 200 mAs)</td>
<td>Brain</td>
<td>18 / 35</td>
</tr>
</tbody>
</table>
There is a considerable variation in CT doses from institution to institution.

From the 2000-01 FDA NEXT CT survey
Multiple CT examinations

- 30% of patients who have CT scans have at least 3 scans
- 7% of patients who have CT scans have at least 5 scans
- 4% of patients who have CT scans have at least 9 scans

(Mettler et al 2000)

- Median number of CT scans delivered to trauma patients in their initial evaluation: 3

(Winslow et al 2008)
Among patients who had a CT scan in 2007:

- 33% had more than 5 CT scans in the previous 20 yrs
- 5% had more than 22 CT scans in the previous 20 yrs
- 1% had more than 38 CT scans in the previous 20 yrs

(Sodickson et al 2009)
So a significant population is being exposed to comparatively high doses from CT

Of the ~25 million people who have CT scans this year in the US, ~250,000 of them will have more than 40 CT scans in their lifetime, with a corresponding total effective dose of >0.4 Sv

(Sodickson et al 2009)
The most likely organ dose range for CT is 5 - 100 mSv.

Taking onto account:

* Machine variability,
* Usage variability,
* Age variability,
* Multiple scans (median 2-3)
Low dose radiation risks
Hiroshima and Nagasaki

5-100 mSv
Number of solid cancers in A-bomb survivors exposed to doses from 5-100 mSv

Small but statistically significant increase in risk

<table>
<thead>
<tr>
<th>Study population (5-100 mSv)</th>
<th>Cancer incidence (1958-98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solid cancers observed</td>
<td>4,406</td>
</tr>
<tr>
<td>Solid cancers expected (controls)</td>
<td>4,325</td>
</tr>
<tr>
<td>Radiation-related excess solid cancers</td>
<td>81</td>
</tr>
</tbody>
</table>

Preston et al 2007
The A-bomb data are for individuals of all ages... what about just children?
Estimated radiation-induced lifetime cancer risks as a function of age at exposure

From BEIR-VII (2006)
Pediatric CT Scans in the USA

1989: ~½ million

2007: ~3½ to 7 million

(5 to 10% of total number of CTs)

(of these, ~¾ to 1.5 million are on children under 5)
For a given mAs, doses from CT are larger for children than for adults.

But there is the potential to reduce the mAs for children, by factors of 2-4, without losing diagnostic information.
Estimating the radiation-induced cancer risk for a CT exam,

1. Estimate the dose to each organ, as a function of age, gender, and type of CT exam

2. Apply estimates of age-, gender-, and organ-specific risks-per-unit dose
   (low-dose risks from A-bomb survivors, “transferred” to a Western population)

3. Sum the estimated risks for all organs
Estimated % lifetime attributable cancer mortality risk, as a function of age at exam, for a single CT exam.
What are the uncertainties associated with these risk estimates?

About a factor of 3 in either direction
Epidemiological studies of cohorts of patients who had pediatric CT

- Ongoing or just starting:
  - UK  ~200,000 children
  - Ontario ~270,000 children
  - Israel  ~80,000 children
  - Australia

Courtesy, Elizabeth Cardis
Will these studies have enough power?

- The studies are large, but expected numbers of cases is still small
- Power may be sufficient to identify an increased risk of leukemia in young people
- But need larger sample size:
  - To precisely quantify risk
  - To evaluate host modifying factors (age, sex, etc)
  - To study solid tumors in adults
# CHILD-MED-RAD - an EC Proposal

<table>
<thead>
<tr>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Agency for Research on Cancer</td>
<td>France</td>
</tr>
<tr>
<td>Johannes Gutenberg-Universität Mainz</td>
<td>Germany</td>
</tr>
<tr>
<td>Säteilyturvakeskus</td>
<td>Finland</td>
</tr>
<tr>
<td>Karolinska Institutet</td>
<td>Sweden</td>
</tr>
<tr>
<td>University of Newcastle upon Tyne</td>
<td>UK</td>
</tr>
<tr>
<td>Centre de Recerca en Epidemiologia Ambiental</td>
<td>Spain</td>
</tr>
<tr>
<td>Institut Gustave Roussy</td>
<td>France</td>
</tr>
<tr>
<td>Kraeftens Bekaempelse (Danish Cancer Society)</td>
<td>Denmark</td>
</tr>
<tr>
<td>Het Nederlands Kanker Institute</td>
<td>Netherlands</td>
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</tbody>
</table>
Individual risks vs population risks

The individual risks from CT are small, so the benefit / risk ratio for any indicated study will typically be large.

But the exposed population is large (5 million children, ~65 million adults / yr in the US).

Even a very small individual radiation risk, when multiplied by a large (and increasing) number of individuals, has the potential to produce a significant long-term public health concern.
Are CT risks real?

- The suggestion that CT doses will produce a small increase in individual cancer risk…
  - Based directly on epidemiological evidence?
  - “Extrapolated from high radiation dose exposures studied in the Atomic Bomb experience”?

- The typical organ dose range for CT (5 to 100 mSv) is the same dose range for which there is a statistically significant increase in risk in A-bomb survivors

- That being said, we await the results of the epidemiological studies over the next few years….
Views of Emergency Department Physicians and Staff

Michael Blaivas, MD, FACEP
Professor of Emergency Medicine
Associate Professor of Internal Medicine
President, WINFOCUS
Department of Emergency Medicine
Northside Hospital Forsyth
Atlanta, Georgia
My Perspective

• 15 years of academics
• Now 2.5 years in pure community clinical practice
• Point of care ultrasound is my passion
• Research, education, policy, equipment development...
My Perspective

- Ultrasound anything and everything
- Battle to keep patients away from CT
- Huge cultural shock in private practice
- Dinosaurs still roam freely and rule over the land
Who Cares About Community EDs...

- About 5500 ED in USA
- 200 to 250 are academic in some way
- The rest are all community
- Lots of patients are seen here
- Do community docs care about academicians?
Major Issues For Emergency Departments

- Many patients
- Some hiding deadly problems
- So much to test... So little time...
- Some patients will not have a safety net to fall back on, so no second chance
Is There Any Room for Error?

- Many physicians feel error is not acceptable
- Felt most in ED
- Litigation and tort reform attempt trends suggest this
- “I just cannot afford to make a mistake”
Concerns

• Litigation
  – Top 3 source of litigation is ruptured appendicitis
  – No more wait and see
  – Perception is one can acquire definitive answer
  – Patients do not understand nor accept “go home and return if pain is worse”
Concerns

• Litigation
  – Another top 3 source of litigation is chest pain
  – Pulmonary embolism “miss it and people could die”
  – Old rules are gone for PE presentation
  – Dissection: any pain in the chest can be dissection
Taking a Risk?

  - Prospective study
  - Non-traumatic abdominal pain
  - 838 patients with abdominal pain
  - Analyzed decisions regarding imaging
Taking a Risk?

- 487 (58%) received imaging studies
- 395 (47%) received CT
- Imaging lower among attendings who were least risk-averse
Other Influences

- Hospital administration
  - Hospitals are focused on patient service when in competitive area
  - People complain, you lose your contract
  - Everything is a mute point when you are out of a job
  - Well known in EM circles that contracts are lost easily and people are fired easily
Outside Influences

• Hospital administration
  – Large difference between academic and community setting
  – In community setting administrators will not listen to the latest literature or findings
  – Laws and money are kings
  – Reason and data will not help you
Outside Influences

- Patient complaints
  - Patient frequently insist on studies
  - Use inaccurate information from internet
  - Australian study results
    - Accuracy for major ailments from web is 50%

*Rationing? Not My Kid!*
Adopting treatment guidelines based on studies of what actually works is downright un-American.

By Sharon Begley | Newsweek Web Exclusive
Sep 18, 2009

With concerns over health-care rationing reaching near-hysterical levels, imagine this scenario in an ER in the not-too-distant future. A 4-year-old suffers minor head trauma, perhaps from falling off a swing and hitting her head on the ground. She is dazed, and although she doesn’t lose consciousness her worried parents—visions of *subdural hematoma* and *concussion* dancing in their own heads—rush her to the local emergency room, expecting that the doctors there will immediately do a CT scan.
Outside Influences

- Primary care complaints
  - No understanding of emergency medicine
  - Call and insist on studies
  - Tell patients to expect to receive certain studies
  - Most of these are CTs
  - Frequently the patient has not even been examined or seen by the PMD
Specialist Issues

- If they are called, best tactic is to stall
  - Order a CT
- There is a practical side to this
  - Avoid false positive trips to ED
- NEXUS is ignored by trauma
Outside Influences

- D-dimer ordered on all chest pain and SOB patients admitted to hospital
- Massive waste
- Large number positive and thus get CTA
- Outside of our control
Barriers To Lowering CT Use

• New data does not filter down to community practice quickly
• Institute of Medicine states average of 17 years for new development to get into broad practice
• Things that are old to academics are soon to be new in community
Knowledge in Choosing Tests

- Not always aware of current data
- What did training 20 years ago say about CT for all abdominal pain or every headache?
- New technology means using it?
  - CT increase 227% in 24 months of new CT scanner
Problems With Physical Examination

- Probably never any good for most pathology
- Investigated in 1800s, no way to prove contrary
- Detection of AAA: 50% by PE
- Presence of Becks triad in Tamponade: 15%
- Abscess vs Cellulitis: about 50%
- Pneumonia on PE vs CXR vs US vs CT
- PTA
CT Cervical Spine

• You think there is a spike now after the NEXUS Study?
• Community docs will learn about this over the next 10 years
• Then you will really see a spike!
Test Results

• Clinical relevance of some tests like CTA showing tinny insignificant PEs has hidden value
• This PE may not have hurt him/her, but the next one may kill them
• Work up for serious hypercoagulability syndrome may not be done
Dirty Topic: Drug Seeker

• Don’t really exist according to pain treatment radicals
• Huge number of tests to prove nothing is wrong
• 4 CT in one day?
September 20\textsuperscript{th} in my ED

- 5 pm to 1 am shift
- 36 patients
- 12 CT scans
- 3 head, 3 chest, 2 renal colic, 4 abdomen with contrast
- Prior to ordering 3 were justified
- After ordering: same
Total Body Scan

- Some say this as a joke
- Would be very convenient and is highly anticipated by others
- Cardiac CT has real potential
- Order from triage on all CP to rule out triple threat
- Forget d-dimer or MD
Relationship Between Rads and EM

- Right now too adversarial
- Lots of finger pointing
- This is only natural
Relationship Between Rads and EM

- We are in a partnership in patient care and patient safety
- Must look at this issue jointly and in a different way
- Physicians are weakest when they fight among themselves
ACR Appropriateness Criteria and Community EM

- Asked some colleagues
- Variety of responses after topic described
- Impolite to actually mention any of them
- Aerospace engineer and pilot in distress analogy
- Must be a joint effort to have any chance
What Will Effect Use

- Must have teeth
  - Education alone will not effect change fast enough
  - Suggestions don’t help, not fast enough
What Will Effect Use

• Must have teeth
  – Suggestions don’t effect patient desires
  – Must make decision “not to CT” defensible
    • Before patient
    • Before lawyer
    • Before hospital
  – Some hoops to jump through may not be all bad
What Will Effect Use

• Army experiment with free ED care delivery
  – Added $.25 co-pay
  – Unneeded visits dropper dramatically
  – Decompressed ED for appropriate visits

• Even a mild computer ordering algorithm might make an impact

"I'll have someone come in and prep you for the bill."
Conclusions

• EPs feel they are in the crosshairs from many angles
• Little room for error
• Advanced imaging seen as protective and is part of an evolution
• Education will not help alone
• Regulation (laws?)
Conclusions

• Go after the low lying fruit
• There is a lot of it and it is safe to reach for
• Almost everyone will agree on this
• Will not impact safety
• Must be joint project
Questions?

• mike@blaivas.org
Benefit-risk analysis and perception and communication of applications of ALARA principles:

Views of Radiologists

Computed Tomography in Emergency Medicine-Radiation, Roles and Responsibility
Bethesda, MD, Sept 23-24, 2009

Fred A. Mettler Jr, MD, MPH.
NM VAHCS, Albuquerque, New Mexico
Benefit-risk analysis and perception and communication of applications of ALARA principles:
"The doses can approach or exceed levels known with certainty to increase the probability of cancer"
Annals of the ICRP

ICRP Publication 102

Managing Patient Dose in Multi-Detector Computed Tomography (MDCT)
• Physicians really do have the patient’s best interests in mind and they have a myriad of factors to balance

• Any proposed radiation protection system must work within existing medical system rather than try to change medical practice
Benefit

• In Emergency Medicine it may be:
• Making an accurate diagnosis
• Selecting the correct therapy
• Leading to improved life span or quality of life
• Very difficult to quantitate
Risk

- “to expose to danger”
- “potential of an undesirable event”
- Can usually be quantitated

- Risks include those from radiation

- Risks also include other factors e.g. **not** making the diagnosis or **not** getting the necessary procedure because of radiation fear or lack of resources
Examples of potentially fatal non-radiation risks

Oxygen tank and large 50 kg floor polisher and sucked into magnetic resonance scanner
Benefit/Risk Ratio

- What are the factors that affect this ratio?
• Benefit/risk ratios are virtually impossible to quantitate and even for a specific procedure there is wide for each individual patient

• There are persistent differences in opinion about such issues as D-dimer and PE where there is no true consensus in practice
The ideal world (MGH)

- EM physician examines patient
- Confers with radiologist who is there 24 hours

- They consider the benefits and risk
- They actually know the benefit and risk and are NCRP literate
- Order the “appropriate” “justified” exam
• Exam order is entered in computer

• Exam is tailored /optimized to the patient (ALARA), pitch, kVp, contrast, timing etc

• Radiologist interprets exam and communicates results

• Specialist is called as needed depending on the diagnosis
What really happens ??
The waiting room is filled with 90 patients who have been there at least 4 hours and who are not happy….

the young, the old and the homeless….
The ambulance and helicopter arrive with “incoming unstable”
The EM physicians here are not too concerned about a stochastic risk of 1/2000 10+ years from now.
What does “ABC” stand for

Airway
Breathing
Circulation
What does “ABC” stand for

Airway
Breathing
CT
CT scan results

- Fetus
- Skull
- Ribs
- Blood
Free blood

Kidney ripped off aorta (no contrast in it)

Splenic laceration

3 min exam and off to the OR

She and the child survived
More of the real world

• The urologist refuses to come see the renal stone patient until a CT is ordered

• A nurse tries to triage the other patients before the EM physician sees them and orders a CT scan using a protocol
New computer security of “physician only” order entry and 60 second timeout of computer is solved by the clerks using the “D solution”
If we say “r/o bleed” for head CT and “r/o appendicitis” for abdominal CT, the computer or radiologist always approves it.
Order is processed by radiology clerks and forwarded to CT technologists
CT technologists are often left holding the bag as to whether things actually make sense and how to tailor the exam.
The images are sent to a PACS system and may be read by radiologists who are a 1000 miles away.
Reality is ..... 

Risk/benefit analysis is only roughly done, primarily by indication/protocol ordering or by the ordering physician 

Communication with the radiologist is rare. Probably less than 5% of the time
How does an ordering physician really “calculate” the benefits and risks?

How bad is the patient bleeding?
Will the test or therapy affect outcome?
Is it available?
What is my experience?

What is the downside if I don’t order it?
Have I seen anything in the literature lately?
What is my gut feeling?

Radiation risk?? Is that an issue??
What are the views of radiologists I surveyed?
“We don’t have time to discuss all CT scans”

• True - A typical department doing 35,000 CT scans per year = 5-6 phone calls per hour for CT alone

• 70 million CT scans annually in the US would mean 70 million phone calls

How about MRI and NM calls?
“EM physicians don’t usually think radiation is an significant issue and most of the time I suspect they are right”

“More than half the time I call the EM physicians to discuss things, they have not seen the patient and don’t know who I am talking about, but they try to be helpful and at least listen”
• “The EM docs say that it is hard to find a radiologist/resident after hours and it slows up their work. Some view residents as obstructionist and they are sometimes right”

• “All the residents do is listen for the indication and choose a numbered protocol off the menu for the techs based on the symptoms/indication. Why can’t the ER docs do that directly?”
• “Techs tell me if there is a problem”

• “Never heard of the NCRP”

• “I don’t know where to look up CT risk”
  ...........“ maybe the NRC website ???”
ACR Appropriateness Criteria® October 2008 Version

The ACR Appropriateness Criteria® are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision. By employing these guidelines, providers enhance quality of care and contribute to the most efficacious use of radiology.

The guidelines are developed by expert panels in diagnostic imaging, interventional radiology, and radiation oncology. Each panel includes leaders in radiology and other specialties. There are currently 159 topics with over 300 variants. For more information on the background and development process, click here.

Personal use of the ACR Appropriateness Criteria® is permitted for research, scientific, and/or informational purposes only. Those with other interests in the ACR Appropriateness Criteria® should contact the ACR at acr_ac@acr.org or (703) 648-8908 for permission and licensing information.
to the higher level. These assignments will be periodically updated to reflect improved risk assignments and further information becomes available.

Table 1. Relative radiation level designations along with common example examinations for each classification

<table>
<thead>
<tr>
<th>Relative Radiation Level*</th>
<th>Effective Dose Estimate Range</th>
<th>Example Examinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>Ultrasound, MRI</td>
</tr>
<tr>
<td>Minimal</td>
<td>&lt;0.1 mSv</td>
<td>Chest radiographs, hand radiographs</td>
</tr>
<tr>
<td>Low</td>
<td>0.1-1 mSv</td>
<td>Pelvis radiographs, mammography</td>
</tr>
<tr>
<td>Medium</td>
<td>1-10 mSv</td>
<td>Abdomen CT, barium enema, nuclear medicine bone scan</td>
</tr>
<tr>
<td>High</td>
<td>10-100 mSv</td>
<td>Abdomen CT without and with contrast, whole body PET</td>
</tr>
</tbody>
</table>

*RRL assignments are not included for some examinations. These are designated as IP (in progress) or NS (not specified). The RRL assignments for the IP examinations will be available in future releases. The RRL assignments for the NS examinations cannot be made because the RRL depends on the region of the body exposed to ionizing radiation, and the body part will vary as a function of the clinical situation.

The primary risk associated with exposure to ionizing radiation is cancer. Based on the BEIR VII report, it is estimated that approximately 1 in 1,000 individuals will develop cancer from an exposure of 10 mSv. This risk level is relatively small in comparison to approximately 420 out of 1,000 individuals expected to develop cancer from all other causes combined [11]. Keep in mind that cancer, regardless of the etiologic process, has a latent period of 10-20 years. Further, it is important to remember that in addition to radiation exposure from imaging procedures, individuals are exposed to background radiation from natural sources, including radon, cosmic rays, soil, building materials, and food. The average annual amount of natural background radiation for someone living in the United States is approximately 3 mSv [12].

The RRL designations specified in these guidelines assume an average adult patient size (or applicable pediatric size) and
Potential solutions

- Keep the message very simple
- Information technology
- **Computer alerts** when ordering: May be one of the true viable solution
  - Alert by recent similar exam
  - Alert by patient age
### Warning-Similar Names

<table>
<thead>
<tr>
<th>Name</th>
<th>DOB</th>
<th>SSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenforde Thomas</td>
<td>July 23, 1898</td>
<td>144-45-6929</td>
</tr>
<tr>
<td>Tenforde, Tom</td>
<td>July 14, 1945</td>
<td>144-36-8729</td>
</tr>
</tbody>
</table>
Warning - Possible radiation issue

Tenforde, Tom
DOB: July 14, 2004
SSN: 144-36-8729
Age 17
6 CT scans done in last 3 months
Continue to order ??
There is a clear break in the risk
Age discrimination
Breast shields-who gets them?
“If I am 60 and wear a helmet to ski, why don’t I get breast shields for my CT?”
Hospital specific protocols for ordering and performance
CT/MRI/NUC MED Ordering Protocols

The spreadsheets below show various clinical indications with the accompanying Vista ordering information and necessary patient preparation for ordering CT, MRI and NM studies.

Additional information also includes:
- contraindications for various examinations,
- indications for after-hours urgent and emergent examinations
- patient preparation for contrast allergies is also presented below.

It is also imperative that the ordering clinician assess appropriate laboratory values, allergy history, contraindications and order the necessary prior examination.

After consulting with these spreadsheets, if there remains confusion about which study to order, Radiologists will be available.

Nuclear Medicine Indications & Ordering
MRI Indications & Ordering
CT Indications & Ordering

Reviewed / Updated Date: July 7, 2009
Content Owner: (Michael F. Hartshorne)
Appropriateness criteria are not enough

• Physicians order an “abdominal/pelvic CT”

• There is no such thing anymore
  – Liver 3-phase
  – Pancreas
  – Appendicitis
  – Kidney
  – Aortic aneurysm
  – Aortic stent evaluation in pt with renal failure

Different protocols that are symptom/indication driven
<table>
<thead>
<tr>
<th>Body part and indication</th>
<th>What to order in the computer</th>
<th>Pre-scan requirements and preparation</th>
<th>CT protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ABDOMEN AND PELVIS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indication - Routine, Abdomen Pain also Default protocol</td>
<td>CT Abdomen w/cont</td>
<td>NPO 4 hours</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>CT Pelvis w/cont</td>
<td>2 hours Oral Contrast Gastrografin 30mL in 800 H2O, 200mLg30m Peripheral IV Patient alert and oriented or Consent for contrast</td>
<td></td>
</tr>
<tr>
<td>Indication - Acute Abdomen, r/o Appendiceal Abscess, Diverticulitis</td>
<td>CT Abdomen w/cont</td>
<td>NPO 4 hours</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>CT Pelvis w/cont</td>
<td>2 hours Oral Contrast Gastrografin 30mL in 800 H2O, 200mLg30m Peripheral IV Patient alert and oriented or Consent for contrast</td>
<td></td>
</tr>
<tr>
<td>Indication - AAA, Post Graft Placement</td>
<td>CTA Aorta-Iliofemoral Runoff w/o, w contrast</td>
<td>NPO 4 hours</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18G ANTECUBITAL IV</td>
<td>Patient alert and oriented or Consent for contrast</td>
<td></td>
</tr>
</tbody>
</table>
• Diagnostic reference levels (DRL’s)
• Provider Education/Awareness all levels
• Patient education
• Informed consent > Participating in decision
• Certification/Recertification
• Culture changes in institution
Will recording doses in the computer of having a dose card help?

- 200 coulombs/kg
- 14 mSv Eff dose
- 180 DLP
“There is a patient in the waiting room with an international ‘dose card’.

“Call radiology and ask what we do with it”

It says 13.2 mSv. Can we order a CT scan ????
Radioprotectants

- Being seriously looked at for terrorist events
- Would solve a lot of issues if could be given prior to a CT etc.
- Being “promoted” now for Radiology Depts.
- Investigational! Not ready for prime time
Can the government help us?

Should we ask for a call to action from the policy makers?

Be careful what you wish for.
Cutting reimbursement in half will certainly affect these issues
“The ____ panel has decided that Granny (who is in the ER) does NOT get a CT”
Why are we here ???

What exactly is the basic underlying problem from a radiation protection point of view ?
Is this bad?

U.S. 1980

- Natural: 2.4 mSv
- Medical: 0.54 mSv
- Total: 3.0 mSv per capita

U.S. 2006

- Natural: 2.4 mSv
- Medical: ~3.0 mSv
- Interventional: 0.4 mSv
- Radiography: 0.3 mSv
- Nuclear medicine: 0.8 mSv
- CT scanning: 1.5 mSv
- Total: ~5.4 mSv

All other: ?? mSv
• The problem is that few had any idea that radiation dose was increasing 700%  
• (possibly ~15,000 future annual fatal cancer deaths)  

...and

we have little real evidence that this resulted in a significant difference in outcome
• CT technology has moved incredibly fast

• The uses are fantastic

• We were sort of lulled into ignoring the radiation dose increase
Where do we go?

- **Guidelines??** EM and radiology
  - d-dimer/PE (pulmonologists ??)
  - renal stones (urologists ??)
What do we really need to do?

• “Justify” going forward
  need evidence based data on benefit
  awareness of risk

• “Optimize” ALARA. Push manufacturers

• Regular EM/Rad meetings to keep improving the
  process. Will be hospital variable

• Not really reduce CT scan frequency unless it comes
  from the justification process

• Find out if there is a measurable risk from CT
What would we do without CT?
How did we make clinical decisions?

If the basis wasn’t evidence, what was it?

expert recommendations
Perceptions of Patients, Parents, and Pregnant Women

Deborah B. Diercks, MD, MSc
Professor of Emergency Medicine
University of California, Davis
Medical Center
Clinical decision-making

- evidence is never enough
  - values and preferences

- In the clinical setting
  - Multiple factors involved
Factors in Medical Decision Making

1. Empirical evidence
2. Experience and Local Standards
3. Physiologic principles
4. Patient and professional values
5. System features
6. Resource allocation
7. Customer service
8. Cognitive Errors
Factors in Medical Decision Making

Systems Factor: the CT scanner is broken
Factors in Medical Decision Making

Evidence Factor: Thrombolysis for Acute MI
Factors in Medical Decision Making

Customer Service Factor: “My doctor sent me in for an X-ray.”
Model of evidence based clinical decisions

Clinical circumstances

Clinical expertise

Patient preference

Research evidence
A patient/parent dilemma

• 3 year old
  - Fell out of shopping cart and hit his head
  - examination frontal contusion in a child acting normal

• which of you:
  - treat kids with head injury?
  - have kids who have had with head injury?

• Does this child need a head CT?
Parent View

• The want to know their child is ok!
• How can we convince them it is ok not to have a CT?
  - Just talk to them?
  - Share data with them?

We have to convince the parent that the risk is greater than the benefit from the CT
**Patient Perspective**

- Often come with a test in mind
  - Internet
  - Friend
  - Doctor
- Come to different setting with different expectations
  - Pain relief
  - Diagnosis
  - Magic medicine
- May not be concerned about future as they are focused on current issue.

After address acute pain and symptoms may be more willing to listen to risk of certain tests.
**Pregnant Patient**

- We are concerned about the patient
- She is concerned about the baby
- Different approach
  - May need to convince them to have a test
    - Explain risk of harm for no test
    - Risk of test
Conclusions

• Medical decisions are not only based on evidence
• We have to realize part of clinical practice is addressing patient expectations
• To allow a change we have to be armed with the tools to
  - Change local standards
  - Expand our understanding of the evidence
  - Learn how to communicate risk/benefit evidence to our patients
CT in Emergency Medicine: Ensuring Appropriate Use

September 23-24, 2009
Bethesda, MD

Rapporteur Summary
Imaging, especially CT, has revolutionized the practice of medicine
CT is consistently rated in the top 5 medical innovations over the past 35 years
CT Can Provide Quick and Accurate Diagnoses in ED Setting

- **Trauma**
  - Head or body
- **Chest pain**
  - Aortic dissection, PE, MI
- **Abdominal pain**
  - Bowel obstruction, bowel necrosis, ureteral stone, appendicitis, pancreatitis, diverticulitis, pyelonephritis, etc.
That said, X-rays (CT) and gamma rays (nuclear medicine) are ionizing electromagnetic radiation—both are designated as *carcinogens*. 
FDA Oversight of CT (Be careful what you wish for…Mettler)

- **No ceiling on patient dose**
- However, since Feb. 2009 the following are required:
  - Automatic Exposure Control (AEC)
    - Dose adjusted for patient size
  - Standardization, display and recording of dose indices

- **However**, states (via Radiation Control Program Directors) can require CT dose estimates from facilities, and can exercise control over the practice of medicine.
But, x-rays and gamma rays are weak carcinogens (low LET or Linear Energy Transfer)....

Even so, it is possible to link effective dose with increased cancer risk
**Number of solid cancers in A-bomb survivors exposed to doses from 5-100 mSv**

<table>
<thead>
<tr>
<th>Study population (5-100 mSv)</th>
<th>Cancer incidence (1958-98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solid cancers observed</td>
<td>4,406</td>
</tr>
<tr>
<td>Solid cancers expected (controls)</td>
<td>4,325</td>
</tr>
<tr>
<td>Radiation-related excess solid cancers</td>
<td>81</td>
</tr>
</tbody>
</table>

Small but statistically significant increase in risk

Preston *et al* 2007
Excess Relative Risk for Cancer Mortality (1950-1990) in A-bomb Survivors (all ages)

Adapted from Pierce, D.A. and Preston, D.L.
Significant increase in use of CT and cardiac nuclear medicine studies is creating a risk to the U.S. population
# Imaging Growth

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>3,000,000</td>
<td>70,000,000*</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>7,000,000</td>
<td>20,000,000</td>
</tr>
</tbody>
</table>

*6-10% are in the pediatric age group*
BACKGROUND RADIATION (NCRP Report #160)

U.S. 1980

- Natural: 3.0 mSv
- Medical: 0.54 mSv
- Total: 3.6 mSv per capita

U.S. 2006

- Natural: 3.0 mSv
- Nuclear medicine: 0.7 mSv
- Radiography: 0.6 mSv
- CT scanning: 1.5 mSv
- Interventional: 0.4 mSv
- All other: <1 mSv
- Medical: 3.2 mSv
- Total: ~6.2 mSv per capita

Medical: 600% increase
## Comparison of Effective Radiation Doses

<table>
<thead>
<tr>
<th>Event</th>
<th>Mean Effective Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year background</td>
<td>6.2 mSv</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>0.1 mSv</td>
</tr>
<tr>
<td>Mammogram</td>
<td>0.4 mSv</td>
</tr>
<tr>
<td>Head CT</td>
<td>2 mSv</td>
</tr>
<tr>
<td>Barium Enema</td>
<td>4 mSv</td>
</tr>
<tr>
<td>Chest/Abdomen CT</td>
<td>10 mSv</td>
</tr>
<tr>
<td>Procedure</td>
<td>% of procedures</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Radiography</td>
<td>74</td>
</tr>
<tr>
<td>CT</td>
<td>17</td>
</tr>
<tr>
<td>Nuclear Med (cardiac)</td>
<td>5</td>
</tr>
</tbody>
</table>
The individual risks from CT are small, so the benefit / risk ratio for any indicated study will typically be large.

But the exposed population is large (5 million children, ~65 million adults / yr in the US).

Even a very small individual radiation risk, when multiplied by a large (and increasing) number of individuals, has the potential to produce a significant long-term public health concern.
The Challenge (WHO)

Although individual risks associated with diagnostic exposures are rather low, the wide use of radiation in medicine calls for a public health approach to control and minimize health risks, while maximizing the benefits.
So a significant population is being exposed to comparatively high doses from CT.

Of the ~25 million people who have CT scans this year in the US, ~250,000 of them will have more than 40 CT scans in their lifetime, with a corresponding total effective dose of >0.4 Sv.

(Sodickson et al 2009)
Children and young women have the greatest cancer risk from radiation exposure during imaging (longer life expectancy, tissues more radiation-sensitive)
Bier VII allows quantification of cancer risk based on age and sex of patient
Pediatric CT Scans in the USA

1989: ~½ million

2007: ~3½ to 7 million

(5 to 10% of total number of CTs)

(of these, ~¾ to 1.5 million are on children under 5)
Present company excluded, neither clinicians nor radiologists appreciate the radiation dose associated with CT
<table>
<thead>
<tr>
<th>Respondent Group</th>
<th>CT ≤ CR</th>
<th>CT &gt; CR &lt; 10 × CR</th>
<th>CT ≥ 10 × CR &lt; 100 × CR</th>
<th>CT = 100–250 × CR*</th>
<th>CT ≥ 500 × CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n = 67)</td>
<td>19 (28)</td>
<td>43 (64)</td>
<td>5 (7)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>ED Physicians (n = 45)</td>
<td>3 (7)</td>
<td>20 (44)</td>
<td>10 (22)</td>
<td>10 (22)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Radiologists (n = 39)</td>
<td>2 (5)</td>
<td>22 (56)</td>
<td>6 (15)</td>
<td>5 (13)</td>
<td>4 (10)</td>
</tr>
</tbody>
</table>

Note.—Data are the number of respondents. Numbers in parentheses are percentages. χ² test result, 67.04; P < .001. CR = chest radiograph.

* Accurate range.
There is *no* histologic marker to differentiate radiation-induced malignancies from those that arise de novo.
Computed Tomography — An Increasing Source of Radiation Exposure
David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phal., D.Sc.

The advent of computed tomography (CT) has revolutionized diagnostic radiology. Since the inception of CT in the 1970s, its use has increased rapidly. It is estimated that more than 62 million CT scans per year are currently obtained in the United States, including at least 4 million for children.¹

By its nature, CT involves larger radiation doses than the more common, conventional x-ray imaging procedures (Table 1). We briefly review the nature of CT scanning and its main clinical applications, both in symptomatic patients and, in a more recent development, in the screening of asymptomatic patients. We focus on the increasing number of CT scans being obtained, the associated radiation doses, and the consequent cancer risks in adults and particularly in children. Although the risks for any one person are not large, the increasing exposure to radiation in the population may be a public health issue in the future.

1.5-2.0% of new cancers each year in the U.S. may be due to CT
Of 1.4M cases/year in the U.S., perhaps 28,000 due to CT!
This seminar highlighted two points of view, both valid…
Between 8AM and 4PM today, nearly 100,000 patients will have been treated by emergency physicians throughout the USA
“EMTALA”- ED Issue # 1

The impact of EMTALA is real and applies to all Medicare accepting hospitals with EDs

Ensure an “appropriate medical screening”

“an appropriate medical screening exam” is still ill defined by EMTALA

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
Radiologists are rarely sued for failure to perform additional testing, but no data presented re ED physicians....
Given all this, why do we have a disconnect? Perhaps radiologists have been a bit too critical of our colleagues on the front line in the ED?
Use of CT in ED: driving forces

New/sophisticated technology & vendor marketing
Self-referral and other financial incentives
Defensive medicine
High valuation placed on imaging (instead of "touching/ asking the patient")
Consumer model (patient's and/or family's expectations)
Lack of awareness about CT radiation doses & associated risks
Insufficient clinical knowledge/expertise in ED referrers
Appropriateness criteria/referral guidelines not available/ignored
Absence of radiologists for consultation during nightshifts
Pressure from other specialists e.g. "What does the CT shows?"; "Repeat the CT scan"; "Request a CT scan prior patient release from the ED" … etc.
What has gone wrong

- Too much reliance on CT and testing displacing clinical acumen / judgement
- Fear of malpractice
- Little appreciation for risks associated with radiation exposure
- Little reliance on clinical verified diagnostic pathways
- Negative feedback for not getting “studies”
- Knee-jerk reaction to uncertainty
- Patient expectations
ALARA

• “As Low As Reasonably Achievable”
  – *Controversial* (sparked a lot of debate)
  – With regard to performing exam, should we use “dose optimization” instead?
  – With regard to justifying performance of an exam, the operational term should be “risk/benefit” analysis for each individual patient
Have to look at *both* benefit and risk in our patients...should we consider AHARA as opposed to ALARA?
There is *likely excess use of CT*, providing an opportunity for optimizing utilization…
"OVERUSE"?

"Application of an imaging procedure where it is unlikely to improve patient outcome" (unnecessary, unjustified).

The increasing use of radiation in healthcare "per se" cannot be taken as evidence of "OVERUSE"
HOWEVER, **Defensive medicine**

'Physicians may respond to the perceived threat of litigation by ordering more referrals and more tests, some of which may be recommended by clinical guidelines and beneficial, but others might be wasteful and harmful''

**Massachusetts Statewide Survey on DM (3650 physicians; 2007-2008)**

- 83% reported that they practiced DM;
- Plain film X-rays: 22%;
- **CT scans**: 33% among emergency physicians & obstetrics/gynaecologist and 20% in other specialties;
- Laboratory tests: 18%;
- Hospital admissions: 13%
Causes of Unnecessary CT Radiation Exposure in ED Patients

1. Repeating CT scans which have already been performed
2. Performing CT when the results are unlikely to affect patient management
3. Investigating with CT too frequently
4. Performing the wrong imaging exam
5. Performing incorrect CT protocol from communication failure of true clinical presentation, resulting in repeat CT
6. Over-investigating
However, if the work-up is negative, that does not mean that the work-up was not needed!
So, where do we go from here?
If both radiologists and ED physicians agree we have a problem, both need to step up to the plate...
I consider the radiologist’s responsibility with (radiation) dose to be the same as any physician’s with (medication) dose.

Over (or under) dosing is a medical error.
Original: 380 mA

Simulated: 70 mA

18% of dose!

AJR January 2008: 190
Guidelines for the CT Imaging of Emergency Department Patients:

Trauma Rules
ACR Appropriateness Criteria
European Referral Guidelines
Multiple recent publications
<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT abdomen and pelvis with contrast</td>
<td>8</td>
<td>Oral and/or colonic contrast may be helpful for bowel luminal visualization.</td>
<td>High</td>
</tr>
<tr>
<td>CT abdomen and pelvis without contrast</td>
<td>6</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>X-ray contrast enema</td>
<td>5</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>US abdomen transabdominal graded compression</td>
<td>4</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>US abdomen transrectal or transvaginal</td>
<td>4</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>X-ray abdomen and pelvis</td>
<td>4</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>MRI abdomen and pelvis with or without contrast</td>
<td>4</td>
<td>See comments regarding contrast in text under &quot;Anticipated Exceptions&quot;</td>
<td>None</td>
</tr>
</tbody>
</table>
It’s clear that guidelines already exist for appropriate use of CT in ED setting

**BUT, they are not consensus guidelines.** We heard loud and clear that ED physicians want ownership in the process
What Will Effect Use

• Must have teeth
  – Suggestions don’t help, not fast enough
  – Suggestions don’t effect patient desires
  – Must make decision not to CT defensible
    • Before patient
    • Before lawyer
    • Before hospital
Diagnostic Algorithm for Suspected PE

Suspect PE
Non Pregnant

Use CCSS
D-dimer/thrombosis
screen to calculate
pre-test probability

Kline neg
and Wells ≤ 2

Kline pos
or Wells > 2

D-dimer

CXR
Optional

UNSTABLE PATIENTS

> 380 lbs

Clinical Assessment

PREGNANT PATIENT

Doppler US Legs
inform OB at discretion of
ED Physician
ED consent

TREAT

Stabilize

Consider Bedside ECHO

Consider:
Heparin + TPA 100 mg/2hrs
iv filters,
CT Surgical consult

Contraindication* to contrast
Less than 280 lbs

VQ Scan

Normal or Low
and Wells ≤ 2

High

Indeterminate
or Low
Wells > 2

Positive

Negative

Indeterminate

Technical

Interpretation

Consult chest radiologist attending

Repeat, if no contraindication at discretion of Radiologists
* In obese pt, reconstruc@2.5mm

Doppler US Legs +/- consider treatment/admission

STOP

TREAT

BRINK

*Contraindications
- Severe allergic reaction
- Renal Failure
  - Creatinine > 1.6
- Inadequate IV smaller than 20g
MAHESH (Apologies to Dr. Brink)

TOMORROW WE'LL TAKE A LOOK AT THE REST OF MY SLIDE.
Suspected PE

- Chest X-ray
  - Negative: Ventilation/Perfusion Scan (lower dose than CT)
  - Positive: Pulmonary CT Angiogram

AMIS
Elements of Successful Radiation Protection Program

• Education of both clinicians and radiologists
• Imaging algorithms that emphasize modalities that do not use ionizing radiation
• Protocols that minimize dose when CT necessary
• Identification of patients with elevated dose exposure
• Investigation of extreme dose exposures
Education of Physicians

• “image gently”
  – Emphasis on pediatric patients

• ACR/RSNA Joint Task Force on Radiation Exposure in Adults (Brink/Amis)
  – First meeting Nov. 2009

• CMSS (Council of Medical Specialty Societies)
  – Educational session on radiation associated with imaging will occur at fall meeting in Nov. (Chicago)

• More and more articles in medical literature
The ideal world

- EM physician examines patient
- Confers with radiologist

Night coverage by nighthawk radiologists via teleradiology doesn’t facilitate consultation…real problem!

- Consider the benefits and risk
- They actually know the benefit and risk and are NCRP literate
- Order the “appropriate” “justified” exam
Bottom Line…

- CT employs ionizing radiation (x-rays), a weak carcinogen.
- Dramatically increased use of CT will likely increase the incidence of cancer in the U.S. and individual patients will also be at risk.
- Many physicians don’t understand radiation risk.
- ED physicians function in a high pressure, highly regulated environment and need clinical answers that CT can quickly and accurately provide.
- Given the best intent of the ED physicians, there is likely overuse of CT for several reasons (Novelline).
- Diverse guidelines for CT use exist, but there is the need for a set of ED/Radiology consensus guidelines.
Summary and Conclusions
From the NCRP Medical Radiation and CT Utilization in the ED Conference

Paul R. Sierzenski, MD, RDMS, FACEP
Member, CMS MEDCAC
Chief, Emergency Ultrasound Section
Director, EM, Trauma & Critical Care Ultrasound
Christiana Care Health System
Newark Delaware
Issues

- Imaging is an effective and critical tool for risk stratification and patient care in the Emergency Department
- Medical radiation exposure has increased over the last decade
- CT utilization in the ED has increased above other modalities
- Multiple factors impact CT ordering
- Variance is physician CT utilization and clinical decision making exists

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
The ED is Different

Small Changes can make big impact

Paul R. Sierzenski, MD, RDMS, FACEP. Sept 2009
Experiences Easily Affect Behavior

ER Death Points to Growing Wait-Time Problem
Family, Doctors Say Deadly 19-hour Wait Is an Example of a Nationwide Problem

Michael Herrera, left, died after waiting 19 hours to see a doctor in a Dallas Hospital emergency room. His family and emergency physicians say the wait in U.S. emergency rooms is a dangerous problem. (WFAA News)

EVBM often does not!
Areas of Opportunity

- Behavior
- Technical Factors
- Regulatory Issue
- Communication
Areas of Opportunity

Behavior

Technical Factors

Communication

Regulatory Issue

Lets try Low Hanging Fruit First…

NOT any forbidden fruit. (high risk)
Behavior

- Education (Risk/Benefit)
- Provide Transparent Information (EMR)
- Increase ED-Radiology POC Communication
- Multiple factors impact diagnostic WU and CT ordering
- Variance is physician CT utilization and clinical decision making exists
The word is getting out

Patients in the Emergency Department Exposed to High Doses of Radiation

For immediate release
March 3, 2008

Washington, DC - The amount of radiation that adult trauma patients typically receive in the emergency department is significant, with the median radiation exposure equal to 1,005 chest X-rays, according to a study appearing online today in the *Annals of Emergency Medicine* ("Quantitative Assessment of Diagnostic Radiation Doses in Adult Blunt Trauma Patients").

Julie Lloyd - (202) 728-0610 x3010
Technology

• CT technology to affect dose
• EMR to aid in diagnostic work up
• EMR to aid in radiation exposure
• Increase ED-Radiology POC

Communication
Regulatory

- Defensive medicine is real
- Malpractice modulation is essential
- ED regulatory statutes can be addressed to benefit patients and providers (EMTALA)
- Discussions of pathways to address patients that are extreme exposure outliers should begin
Communication

- Significant opportunity
- Global / International lessons
- Patient awareness
- Recognition of physician protection when diagnostic testing is excluded
"We are concerned about the comparisons, generalizations and gross oversimplifications being made by the study, which could have grave consequence for patients facing emergency care," said Dr. Lawrence. "In addition, the fear of lawsuits is another reason CT scans are conducted by many physicians. Multiple successful lawsuits have been won against physicians for not performing CT scans, and the nation needs to reform the litigious system in which physicians are punished for using good judgment and not testing."

According to ACEP, one positive result of the study is that it further reveals the need to create a personal radiation exposure profile as part of a patient’s medical record – to avoid excessive cumulative radiation exposure over a lifetime, and to foster discretion in using CT scans, particularly in pediatric patients. To that end, ACEP supports the proposed use of electronic medical records to supply emergency physicians with patient information (provided standards and cost issues are addressed). The study, "Computed Tomography — An Increasing Source of Radiation Exposure," was published in the Nov. 29 issue of the New England Journal of Medicine.

Common Ground

- Agreement that inclusion of radiation exposure potential by diagnostic imaging is essential *(Risk Benefit)*
- Information gaps exist for all healthcare personnel
- Multiple factors impact diagnostic WU and CT ordering
- Variance is physician CT utilization and clinical decision making exists
  - Unique populations: Peds, Trauma
- Further research is needed!
Town Hall Issues

- Gate-keeping will not fly!
- Finger pointing
- Perception IS reality! (Wording matters)
- “Group Hug!”
Action Points to Consider

• Joint summary of NCRP proceedings

• Development of joint educational ventures Risk/benefit the simplest least expensive start. Pathway to mutual understanding

• A joint research approach for low lying fruit is key (renal colic / pediatrics / trauma / high users)

• Increase awareness of staged imaging

• Joint Guidelines discussions need to advance with discussions on CPOE inclusion
...AND THAT IS WHY WE LIFT ON THREE...