Radiology-The Past

• Radiology is entering its second century of existence at the same time we are entering a new millennium
• 70% of Radiology done today did not exist 30 years ago
• 20% to 30% of Radiology done 30 years ago is not done now
Imaging Studies

- Plain films 48%
- Mammography 9%
- Ultrasound 6.5%
- CT 10.5%
- MRI 3.8%
- NM 5.7%
CT Use in the US from 1980 to 2005

Total CT Scans per Year at S&W from 1991 to 2007

What is the Magnitude of the Problem?

• 3 million CT scans were done in the USA in the year 1980.
• 60 million CT scans were done in the USA in the year 2005.
• 72 million CT scans were done in the USA in the year 2007

CT Scanning is the Major Source of Medical Radiation Today

CT Utilization by Specialty at S&W from 2005 to 2008

Stockburger WT. Personal communication. Jan. 2008
CT Utilization in the ED Elsewhere

- Chapel Hill, North Carolina from 2000 to 2005
- Head CT, up by 51%
- Abdominal CT, up by 72%
- Chest CT, up by 226%
- Miscellaneous (e.g., extremities and face), up by 132%

Computed Tomography — An Increasing Source of Radiation Exposure


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. 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.

CT and Its Use

The basic principles of axial and helical (also known as spiral) CT scanning are illustrated in Figure 1. CT has transformed much of medical imaging by providing three-dimensional views of the organ or body region of interest.
What is the Risk of Carcinogenesis from Medical Radiation?

• From 1.5 to 2% of cancers in the US are attributed to medical radiation.
• Ionizing radiation is being applied to large patient populations with CT scanning.

CT Scan Overuse May Up Cancer Risk
Radiation From Scans May Affect Future Health

Some doctors are worried that regularly used CT scans could expose patients to too much radiation. (Corbis.com)

By CARLA WILLIAMS
ABC News Medical Unit
Nov. 28, 2007

WHAT OTHERS ARE SAYING
42 Comments

Now that you have heard about the (hypothe... top quark Nov-30
The claim that the risk per unit dose from... radiation risk analyst Nov-30
As a health care provider: Many. experts a...sunet1.0000 Nov-30

COMMENT
Radiation Scare

- Atomic Bomb - Hiroshima Aug. 6, 1945
  Nagasaki Aug. 9, 1945
- Three Mile Island - 1979
- Chernobyl - 1986
Atomic Bomb Effects

- Blast - speed of sound 12.5 miles/min
- Heat - fireball vaporizes, inverse square law
- Radiation - prompt, inverse square law
- Radiation - fallout
Fallout Products

- Iodine-131
- Strontium-90
- Cesium-137
- Over 200 radioactive products
Byproducts of A-Bomb

- Radioactive fallout for miles in rain
- Radiation poisoning
- Increased incidence of cancer - leukemia
- Genetics effects on future generations
- Massive disruption of communications, travel and machinery
- Electro - Magnetic pulse scrambles electronics in copper wires - 50 miles
Blast Effects
20 Megatons

- Vaporization 8.75
- Total Destruction 14
- Severe Blast Damage 27
- Severe Heat Damage 31
- Severe Fire, Wind 35
Blast Effects
20 Megatons

- Vaporization 8.75
- Total Destruction 14
- Severe Blast Damage 27
- Severe Heat Damage 31
- Severe Fire, Wind 35
Dirty Bomb

- Uses conventional explosives
- Radioactive material inside
- Most likely radioactive material is Cesium-137 Half life 30 years
- Creates more terror, havoc and panic rather than immediately kill
Radiation - Positive Uses

- Medical Diagnosis
- Medical Treatment
- Food Irradiation
- Mail Irradiation
- Energy
- Defense
- Industrial
Yttrium-90 Microspheres

- 25 um glass microspheres, $^{90}\text{Y}$ an integral component
- Pure beta emitter, half life 2.68 days
- Maximum range in tissue 1 cm
- 15,000 rad (150 Gy)
- Low toxicity profile
- Can stabilize disease, possible survival benefit
Yttrium-90 Brachytherapy

- Selective delivery of high dose XRT to tumor and peritumoral parenchyma
- Sparing of normal hepatic parenchyma from radiation injury
  - 50% incidence of XRT liver damage with external beam at whole liver dose 35-40 Gy
  - $^{90}$Y-microsphere treatment dose: 100-150 Gy
  - Local tumor radiation dose potentially much higher
Pre-embo Branch occlusion
Yttrium-90 Microspheres
Metastatic colorectal CA

Pre

Post 3 month
Radiation Units

- R - Roentgen amount of ionization in air
- Rad - radiation absorbed dose
- Rem - radiation equivalent man
- Sievert (Sv) - international unit of radiation equivalency
- Gray (Gy) - unit for energy absorbed
- $1\text{Gy} = 1\text{Sv} = 100\text{ rad} = 100\text{ rem}$
Curie & Becquerel (Bq)

- 1 Bq is 1 disintegration/sec
- 1 curie = 37 Billion Bq 3.7X10^10
- 1 MBq = 27 microcuries
- 1 GBq = 27 millicuries
- 37 GBq = 1 curies
- 1 TBq = 27 curies
Background Radiation Sources

- Earth - food and water
- Space - cosmic rays
- Atmosphere - Radon gas from earth’s crust
Airport X-Ray Security Scanners

- Backscatter superficial scanning
- Dose - 0.1 microsevert
- Would need to go through the scanner 1000X times to equal a chest X-ray or 200,000 times to equal a CT scan
- Scan daily for your entire life wouldn’t equal a CT scan
Types of Radiation

- Alpha Particles
- Beta Particles
- Gamma & X-Rays
Exposure Pathways

- Inhalation
- Ingestion
- Direct (external) Exposure
Radiation Exposure

- Acute Effects
- Cancer Risk
- Genetic Risks
- Teratogenic Risks
Ionizing Radiation

- **Acute effects**: over 3000 mSv
  - Death
- **Deterministic effects**: over 500 mSv
  - Radiation burn, cataracts.
- **Teratogenic effects**: no known threshold
  - Death, birth defects.
- **Stochastic effects**: no known threshold
  - Carcinogenesis
Who is at the Greatest Risk?

- Fetus: teratogen and carcinogen.
- Children
- Women
- Young adults (under 45 years of age)
- Cancer induction
  - Leukemia: 5-10 years later
  - Solid tumors: 10-20 years later
Radiation Dose - very serious

4 Sievert (Sv) or 400 rad
total body exposure
Radiation Conversions

- 100 rem = 1 sv (sievert)
- 1 mrem = .01 msv
### Acute Effects of Radiation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mrem</th>
<th>Rem</th>
<th>Sv</th>
</tr>
</thead>
<tbody>
<tr>
<td>No observerable effect</td>
<td>5,000</td>
<td>5</td>
<td>0.05</td>
</tr>
<tr>
<td>Blood abnormalities</td>
<td>15,000</td>
<td>15</td>
<td>0.15</td>
</tr>
<tr>
<td>Sperm abnormalities</td>
<td>15,000</td>
<td>15</td>
<td>0.15</td>
</tr>
</tbody>
</table>
## Acute Effects of Radiation

<table>
<thead>
<tr>
<th>Condition</th>
<th>mrem</th>
<th>rem</th>
<th>Sv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausa</td>
<td>100,000</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>Anorexia</td>
<td>200,000</td>
<td>200</td>
<td>2.00</td>
</tr>
<tr>
<td>Bone</td>
<td>300,000</td>
<td>300</td>
<td>3.00</td>
</tr>
<tr>
<td>Marrow</td>
<td>600,000</td>
<td>600</td>
<td>6.00</td>
</tr>
</tbody>
</table>
## Long Term Effects Radiation

<table>
<thead>
<tr>
<th>Effect</th>
<th>mrem</th>
<th>Rem</th>
<th>Sv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal Abnormalities</td>
<td>10,000</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>Cancer</td>
<td>10,000</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>Genetic</td>
<td>25,000</td>
<td>25</td>
<td>0.25</td>
</tr>
</tbody>
</table>
## Long Term Effects Radiation

<table>
<thead>
<tr>
<th>Effect</th>
<th>mrem</th>
<th>rem</th>
<th>Sv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer Death Risk</td>
<td>100,000</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetic Risk</td>
<td>100,000</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cataracts</td>
<td>250,000</td>
<td>250</td>
<td>2.50</td>
</tr>
</tbody>
</table>
## Typical Medical Doses

<table>
<thead>
<tr>
<th>Medical X-Ray</th>
<th>mrem</th>
<th>mSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>4 - 5</td>
<td>.04</td>
</tr>
<tr>
<td>Cervical Spine</td>
<td>11</td>
<td>.11</td>
</tr>
<tr>
<td>Pelvis</td>
<td>27</td>
<td>.27</td>
</tr>
</tbody>
</table>
## Typical Medical Doses

<table>
<thead>
<tr>
<th>Medical</th>
<th>mrem</th>
<th>mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Ray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper GI</td>
<td>117</td>
<td>1.17</td>
</tr>
<tr>
<td>Barium Enema</td>
<td>298</td>
<td>2.98</td>
</tr>
<tr>
<td>CAT Scan</td>
<td>1800</td>
<td>18.00</td>
</tr>
</tbody>
</table>
## Environmental Doses

<table>
<thead>
<tr>
<th>Source</th>
<th>mrem</th>
<th>mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Background</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>Radon Inhalation</td>
<td>200</td>
<td>2.00</td>
</tr>
<tr>
<td>Television</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>Air Flight NY - LA</td>
<td>4</td>
<td>0.04</td>
</tr>
</tbody>
</table>
## Environmental Doses

<table>
<thead>
<tr>
<th>Sources</th>
<th>mrem</th>
<th>mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 miles of nuclear plant</td>
<td>Less than 1</td>
<td>Less than 0.01</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>1,500</td>
<td>15.00</td>
</tr>
<tr>
<td>Average TMI</td>
<td>2</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Yearly Dose Examples

- Living next to nuclear power plant: 0.0001-0.01 mvs
- Sleeping next to a human being 8hrs/night: 0.02 mvs
- Radiation in granite in US Capitol: 0.85 mvs
- NY to Tokyo flights for airline crew: 9 msv/yr.
Yearly Dose Examples

- Background Radiation in US - 3 msv
- Average Radiation Dose for Americans 6.2 msv
Radiation Dose Reduction

- Time
- Distance
- Shielding
“Single Badging” for Fluoroscopy

Wear a single badge (red) at the collar level, outside your shielding apron or thyroid shield.
What Can Be Done?

• Minimize the radiation exposure per exam.
• Do fewer scans.
  – Order appropriately: no shotguns, review protocols.
  – Educate physicians about ionizing radiation.
  – Do not repeat recent outside studies.
  – Use other tests or other imaging methods in higher risk patients.
Minimizing the Radiation Dose Per Exam

http://www.imagegently.org/
Use Alternate Exams in Selected Patients: Kids, Pregnancy, Young Adults.

- Consult the radiologist about options.
  - Radiography
  - Ultrasound
  - MRI
Minimizing Radiation Dose Per Exam

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>kg</th>
<th>mA Chest</th>
<th>mA A/P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-19</td>
<td>4.5-8.9</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>20-39</td>
<td>9.0-17.9</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>40-59</td>
<td>18.0-26.9</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>60-79</td>
<td>27.0-35.9</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>80-99</td>
<td>36.0-45.0</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>100-150</td>
<td>45.1-70.0</td>
<td>100-120</td>
<td>140-150</td>
</tr>
<tr>
<td>&gt; 150</td>
<td>&gt;70</td>
<td>≥140</td>
<td>&gt;170</td>
</tr>
</tbody>
</table>

Matthew B. Crisp, MD
### Clinical Condition: Focal Neurologic Deficit

#### Variant 5:
Unexplained acute confusion or altered level of consciousness.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI head without contrast</td>
<td>8</td>
<td>Include diffusion weighted imaging.</td>
<td>None</td>
</tr>
<tr>
<td>CT head without contrast</td>
<td>8</td>
<td>Screening for hemorrhage.</td>
<td>Low</td>
</tr>
<tr>
<td>MRI head without and with contrast</td>
<td>7</td>
<td>Include diffusion weighted imaging.</td>
<td>None</td>
</tr>
<tr>
<td>MRA head and neck</td>
<td>6</td>
<td>For suspected vascular abnormality.</td>
<td>None</td>
</tr>
<tr>
<td>CTA head and neck</td>
<td>6</td>
<td>For suspected vascular abnormality.</td>
<td>Low</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>5</td>
<td>If MRI unavailable or contraindicated.</td>
<td>Low</td>
</tr>
<tr>
<td>fMRI head</td>
<td>3</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>MRI spectroscopy head</td>
<td>3</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>FDG-PET head</td>
<td>3</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>NUC SPECT head HM/PAO</td>
<td>3</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>NUC SPECT head thallium</td>
<td>3</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>INV angiography cerebral</td>
<td>2</td>
<td></td>
<td>IP</td>
</tr>
<tr>
<td>X-ray skull</td>
<td>1</td>
<td></td>
<td>Min</td>
</tr>
</tbody>
</table>

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

*Kaleitvo
Radiation Level*
Why is There More CT in the ED Now?

- We see more and worse trauma now.
- Surgeons and others demand CT before seeing the patient.
- Very sick patients are referred to the ED by other doctors.
- CT has become the preferred study: appendicitis, ureteral calculus, SBO, diverticulitis, pulmonary embolism.
- Defensive medicine: surgeons, ED physicians.
- Protocols.
How to Do Fewer Exams

• Check the medical record before ordering an exam and look at previous reports.
• Curtail the practice of defensive medicine.
• Providers curtail referrals to the ED.
• Reassess “protocol” ordering.
Attitude

• “Think worst first.”
  – This is a code phrase for defensive medicine.

• Tort reform in Texas **did** pass.

• Be reasonable.
  – Think first.
  – Investigate the patient and medical record second.
  – Order appropriate tests third.
Golden Rule of ordering tests

1) Order a test or procedure only if you would have it done to yourself

Exceptions: If you have financial, research, or educational incentive for performing a test than—

2) Order a test or procedure as if you or the patient had to pay for it out-of-pocket

3) Order a test or procedure only if you would have it done to you or a family member
Healthcare Facts

- 2.3 Trillion per year
- 8,000 dollars per person
- 13,000 per person by 2013
- 800 billion of the 2.3 Trillion is for Imaging, largest share of healthcare cost
Medical Economics

• Average premium $9,086-21% of median household income
• Out of pocket expenses for medical treatment 26%
• US spends more than any country on health care
Ethical Imaging The Facts

• Diagnostic Imaging 10 % of total health care expenditures –or over $800 billion in 2006

• Diagnostic Imaging costs have increased an average of 18% over the past 10 years, compared to 9% for all of healthcare and 4% for the overall economy
Two Edged Sword

• Revolutionized Medical Diagnosis & Treatment
• Costly & Dangerous
Challenges for the Future

- Delivery of Healthcare & Technology
- Improve Quality - training, accreditation, regulation
- Cut Cost
- Reduce Radiation