IMAGE WISELY

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ORGANIZATIONS
PROGRAM INTRODUCTION
RADIATION SOURCES/LEVELS
IMAGING EXAMINATIONS
APPROPRIATENESS
OVERUTILIZATION

Radiology
ORGANIZATIONS

• American College of Radiology
  www.acr.org

• Radiologic Society of North America
  www.rsna.org

• American Association of Physicists in Medicine
  www.aapm.org

• American Society of Radiologic Technologists
  www.asrt.org

PROGRAM INTRODUCTION

• Imagewisely.org

• Imaging Physicians/Medical Physicists/Radiologic Technologists

• Equipment Resources

• Patient Medical Imaging Record
EQUIPMENT RESOURCES

• GE Healthcare
• Hitachi
• Philips
• Siemens
• Toshiba

RCM
Radiation Units

- Radiation Exposure: Gray (Gy)
- Tissue Dose: Gray (Gy)
- Effective Dose: Sievert (Sv)
- R: rad
- rem
Approximate Effective Dose

- Chest X-ray – 0.1 mSv
- Abdomen X-ray – 0.7 mSv
- Chest CT – 7 mSv
- Nuc Med Perfusion Stress – 12 mSv
- Whole Body CT – 30 mSv
- PET/CT – 45 mSv

Response vs Dose

BB

Natural Incidence

Deterministic

Stochastic
Response Dose

Deterministic
Stochastic
Natural Incidence

20%
0%
50 mSv

Sources of Radiation Exposure (360 mrem)

Radon 55%
Cosmic 12%
Natural 50%
Medical 11%
Consumer Products 3%
Other 1%

Source: National Council on Radiation Protection and Measurements
Response

Dose

Deterministic

Stochastic

Natural Incidence

20%

0%

50 mSv

100 mSv

Lymphocyte Depression

Local Tissue Effects

1000 mSv

Natural Incidence
Deterministic:
- Non-Linear
- Threshold
- Severity increases with dose

Response vs. Dose:
- Lymphocyte Depression
- Local Tissue Effects

Deterministic Effects:
- Natural Incidence
- 20% at 50 mSv
- 0% at 100 mSv

Stochastic Effects:
- Natural Incidence
- 1000 mSv
Stochastic
- Linear
- Non-Threshold
- Incidence increases with dose

Response vs. Dose
- Deterministic
- Stochastic
- Lymphocyte Depression
- Local Tissue Effects
- Stochastic Effects
- Deterministic Effects
- Hormesis

Natural Incidence vs. Dose
- Medical Imaging
RADIATION SOURCES/LEVELS

- Radon
- Natural Background (GMIS)
- Medical Imaging
- Consumer Products

TOTAL

6.3 mSv

NATURAL
3 mSv

MEDICAL IMAGING
3.2 mSv

TOTAL
6.3 mSv

Sources of Radiation Exposure (360 mrem)

Nuclear Medicine
2.0 mSv

Radon
1.8 mSv

Interventional Radiography
1.5 mSv

CT Scanning
0.7 mSv

Other Medical CT/Non-CT
0.6 mSv

CT Non-CT
0.3 mSv

Other Medical Procedures
0.2 mSv

Medical Imaging
3.2 mSv

Cosmic Ray
0.1 mSv
RADIATION SOURCES/LEVELS

- Radon
- Natural Background (GMIS)
- Consumer Products
- Medical Imaging

**TOTAL**

6.3 mSv

Radon

2.0 mSv

TOTAL

6.3 mSv
Radon
- Discovered by Dorn in 1900 during his experiments with radium
- Naturally occurring radioactive gas
- Colorless, odorless & tasteless

21,000 lung cancer deaths attributable to radon in the US annually
- Radon is the 2nd leading cause of lung cancer, after smoking
- Radon is the 6th leading cause of cancer deaths in the US
Invigorating Water

- From 1919 to 1922, the Great Radium Spring Water Company sold bottle water that ostensibly provided some of the same health benefits as radium springs in nearby places like Saratoga Springs, New York.
- The water contained dissolved radon.

Radium Glass

![Radium Glass Image]
RADIATION SOURCES/LEVELS

- Radon
- Natural Background (GMIS)
- Consumer Products
- Medical Imaging

TOTAL
6.3 mSv

NATURAL
3 mSv

MEDICAL IMAGING
3.2 mSv

- External 6.4 mSv
- Internal 1.5 mSv
- Other 0.6 mSv
- Radon 0.3 mSv
- Nuclear Medicine 0.3 mSv
- Radiography 2.0 mSv
- CT Scanning 0.1 mSv
- Interventional 0.1 mSv

TOTAL
6.3 mSv
Number of Procedures (2006)

- Radiography – 293 million
- Computed Tomography – 67 million
- Nuclear Medicine – 18 million
- Interventional – 17 million
- Radiotherapy – 1 million

IMAGING EXAMINATIONS

- Computed Tomography
- Radiography
- Fluoroscopy
- Nuclear Medicine

Computed Tomography

TOTAL 6.3 mSv
CT Scan Radiation Overdoses Reported at Cabell Huntington Hospital in West Virginia

Date Published: Monday, March 7th, 2011

Another large hospital is at the center of a scandal involving radiation overdoses. According to The New York Times, CT scan radiation overdoses on Cabell Huntington Hospital in Huntington, West Virginia for more than a year ended last November.

According to The New York Times, to make matters worse, officials at Cabell Huntington said they did not disclose.

The New York Times

October 16, 2009

Radiation Overdoses Point Up Dangers of...

By WADE ROGANSCH

At a time when Americans receive more diagnostic radiation than ever, and large, well-known Los Angeles hospital among other tiny hospitals in the northern part of the state, underscore the potential dangers that these scans pose when used incorrectly.

A week ago, Cedars Sinai Medical Center in Los Angeles, one of that city's leading cancer hospitals, said it had found that it had given some patients excessive CT scans.

BMC
CT DOSIMETRY

- $CTDIs = 1/3$ center + $2/3$ periphery (mGy)
- $CTDI_{vol} = CTDIs / pitch$
- DLP = CTDI x scan length (mGy-cm)
- $E = \sum (D_t + W_t) \ (mSv)$
- $E = CTDI \times W_t \ (mSv)$
- $E = CTDI \times CF_{age/exam} \ (mSv)$

<table>
<thead>
<tr>
<th>Region of body</th>
<th>Conversion factor from CT to effective dose in (mSv)</th>
<th>0 year old</th>
<th>1 year old</th>
<th>5 year old</th>
<th>10 year old</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and neck</td>
<td>0.111</td>
<td>0.068</td>
<td>0.037</td>
<td>0.0025</td>
<td>0.0008</td>
<td>0.0001</td>
</tr>
<tr>
<td>Head</td>
<td>0.111</td>
<td>0.067</td>
<td>0.037</td>
<td>0.0025</td>
<td>0.0008</td>
<td>0.0001</td>
</tr>
<tr>
<td>Neck</td>
<td>0.017</td>
<td>0.012</td>
<td>0.011</td>
<td>0.0079</td>
<td>0.0079</td>
<td>0.0079</td>
</tr>
<tr>
<td>Chest</td>
<td>0.039</td>
<td>0.024</td>
<td>0.018</td>
<td>0.011</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Abdomen and pelvis</td>
<td>0.046</td>
<td>0.028</td>
<td>0.019</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Trunk</td>
<td>0.044</td>
<td>0.028</td>
<td>0.019</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
</tr>
</tbody>
</table>
Typical DLP Values

- Head: 500 – 1000 mGy-cm
- Chest: 450 – 900 mGy-cm
- Lumbar Spine: 400 – 500 mGy-cm
- Abdomen: 500 – 1000 mGy-cm
- Pelvis: 500 – 1000 mGy-cm
- Extremity: 100 – 200 mGy-cm

5. Radiologists can use DLP data from CT scans to estimate patient ED. ED puts CT doses into a useful perspective and permits direct comparisons of CT doses with other types of radiologic examinations, natural background exposures, and regulatory dose limits.
This computed tomography (CT) study of the head registered a dose length product (DLP) of 725 mGy-cm which results in an approximate effective dose of 1.5 mSv.
Discussion and Summary

Overexposure leads to a significant level of radiation outside the planned scan region. Because scans:

1. Helical scanning may not be necessary.
2. It may not be necessary to scan with a large gantry rotation or at the angulated scan length.
3. It may be possible to use a smaller pitch.
4. One should attempt to maximize the distance between harmful organs and the scanned area, keeping in mind that overexposure around the scanned area by several centimeters.

Automated Extraction of Radiation Dose Information for CT Examinations

Tracy L. Jones, MD, MS, Sticht Director, BPE, and J.A. Minneman, PhD, Wayne Ken, MD, William W. Young, MD

Fig 3. Depictional illustration of the mean radiation dose for individuals during January and February 2008. This type of data can help identify where modifications need to be made.
### Nuclear Medicine

**Fig 1. Radiation dose estimates (in milliSieverts) for all CT examinations undergone by patients at the Nuclear Medicine Department. The bars indicate doses for individual studies performed on the indicated dates. The total dose includes examinations performed outside the department.**

<table>
<thead>
<tr>
<th>Exam</th>
<th>Relative Radiation Level</th>
<th>Range of Values (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td></td>
<td>0.0 - 4</td>
</tr>
<tr>
<td>Chest (standard)</td>
<td></td>
<td>4 - 10</td>
</tr>
<tr>
<td>Chest (high resolution, e.g., pulmonary embolisms)</td>
<td>10 - 60</td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td></td>
<td>3.5 - 23</td>
</tr>
<tr>
<td>Pelvis</td>
<td></td>
<td>3.3 - 10</td>
</tr>
<tr>
<td>Coronary angiogram</td>
<td></td>
<td>4 - 12</td>
</tr>
<tr>
<td>Vascular radiology</td>
<td></td>
<td>5 - 12</td>
</tr>
<tr>
<td>Gallium SPECT</td>
<td></td>
<td>1 - 12</td>
</tr>
</tbody>
</table>

**TOTAL**

6.3 mSv
• Administered Radiopharmaceutical Dose
• Critical Organ Radiation Dose
• Whole Body Radiation Dose
• Effective Dose

Whole-Body PET/CT Scanning: 
Estimation of Radiation Dose and Cancer Risk

Advances in Knowledge

- The effective doses from whole-body fluorine-18 fluorodeoxyglucose (FDG) PET/CT studies performed with a 64-detector CT scanner, an administered FDG activity of 370 MBq, and three diagnostic CT protocols were estimated to be 13.43, 24.79, and 31.91 mSv for female patients and 13.65, 24.80, and 32.18 mSv for male patients, respectively, with the CT component contributing between 54% and 81% of the total combined dose.
Patient Radiation Dose

- Bone (Tc-99m phosphate) $8.0 \times 10^{-3}$ mSv/MBq
- Renal (I-131 Hippuran) $6.6 \times 10^{-2}$ mSv/MBq
- Thyroid (I-131 NaI) 15 mSv/MBq
- Liver (Tc-99m HIDA) $2.4 \times 10^{-2}$ mSv/MBq
- Lung (Xe-133 gas) $8.9 \times 10^{-4}$ mSv/MBq
- Brain (F-18 FDG) $2.7 \times 10^{-2}$ mSv/MBq

TOTAL 6.3 mSv
Technique Creep not Dose Creep

<table>
<thead>
<tr>
<th>Optical Density</th>
<th>Log Relative Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>10,000</td>
</tr>
</tbody>
</table>

1.5 mSv
0.7 mSv
0.6 mSv
0.4 mSv
0.3 mSv
2.0 mSv
TOTAL
6.3 mSv

Interventional

TOTAL
6.3 mSv

Table 9: Radiologic Effective Dose In Interventional Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Effective Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/neck angiography</td>
<td>0.5 - 1.8</td>
</tr>
<tr>
<td>Coronary angiography (diagnostic)</td>
<td>1.2 - 4.9</td>
</tr>
<tr>
<td>Coronary angiography (interventional)</td>
<td>1 - 10.9</td>
</tr>
<tr>
<td>Thoracic aorta CT angiography</td>
<td>2 - 15</td>
</tr>
</tbody>
</table>

McDonald's

BCM

8/2/2012
Advice to Patients

- < 2 Gy: No need to inform
- 2-5 Gy: Advise erythema possible
- 5-10 Gy: Self-examination. Return if necessary
- 10-15 Gy: Medical follow-up
- > 15 Gy: Medical follow-up essential
ACR Reference Values

- Head CT – 80 mSv
- Adult Abdomen CT – 25 mSv
- Pediatric Abdomen CT – 20 mSv
- Inflation: 3%/yr
- Healthcare: 9%/yr
- Medical Imaging: 18%/yr

CT, MRI, and PET has balloned to $100 billion/year
Typical Distribution of Utilization

Other Man-made

TOTAL 6.3 mSv

What do you call the area where Penguins nest?

"Curb appeal... it's all about curb appeal!"
CONSUMER RADIATION SOURCES

- Smoke Detectors
- Camp Lanterns
- Microwave Leak Detectors
- Airport Scanners
CONSUMER RADIATION SOURCES

• Smoke Detectors
• Camp Lanterns
• Microwave Leak Detectors
• Airport Scanners
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- Smoke Detectors
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CONSUMER RADIATION SOURCES

- Smoke Detectors
- Camp Lanterns
- Microwave Leak Detectors
- Airport Scanners

AIRPORT SCANNERS

- Hall Effect Metal Detectors (0 uSv)
- Millimeter Wave Scanners (0 uSv)
- Backscatter x-ray scanners (0.1 uSv)
• 10 backscatter scans = 1 day GMIS
• 50 backscatter scans = one way air travel
• 100 backscatter scans = 1 CXR
• 500 backscatter scans = 1 ABD
WADDLE OVER TO MY RAFT AND I’LL ROOK YOU