

**IMAGE WISELY**

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**ORGANIZATIONS**  
**PROGRAM INTRODUCTION**  
**RADIATION SOURCES/LEVELS**  
**IMAGING EXAMINATIONS**  
**APPROPRIATENESS**  
**OVERUTILIZATION**

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**Radiology**

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**Image Wisely: A Campaign to Increase Awareness about Adult Radiation Protection<sup>1</sup>**

**W**ith the benefits of medical imaging we well know, increase awareness about the radiation risks and radiologic procedures used in the United States. Radiologists, radiologic technologists, and other medical imaging professionals have long been educating the public about the risks of radiation. However, in the past few years, there has been a significant increase in the use of medical imaging, particularly CT scans. This has led to a corresponding increase in the amount of radiation exposure that patients receive. It is important for patients to be aware of the risks of radiation and to take steps to minimize their exposure. The Image Wisely campaign is a national effort to educate the public about the risks of radiation and to encourage medical imaging professionals to use radiation protection techniques. For more information, visit [www.imagewisely.org](http://www.imagewisely.org).

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Radiation Safety in Adult Medical Imaging

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## ORGANIZATIONS

- American College of Radiology  
[www.acr.org](http://www.acr.org)
- Radiologic Society of North America  
[www.rsna.org](http://www.rsna.org)
- American Association of Physicists in Medicine  
[www.aapm.org](http://www.aapm.org)
- American Society of Radiologic Technologists  
[www.asrt.org](http://www.asrt.org)

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## PROGRAM INTRODUCTION

- [Imagewisely.org](http://Imagewisely.org)
- Imaging Physicians/Medical Physicists/Radiologic Technologists
- Equipment Resources
- Patient Medical Imaging Record

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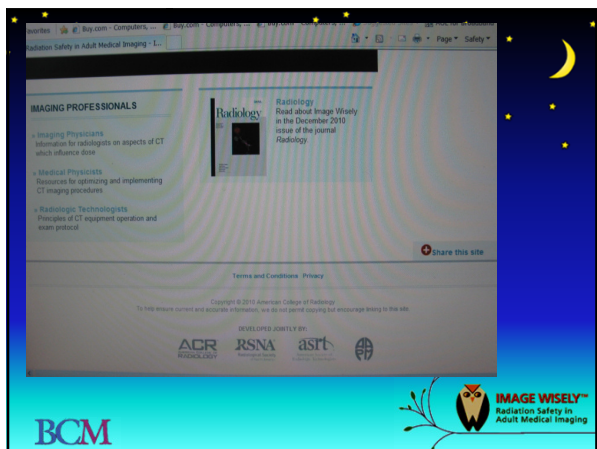
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**Saints**

- The primary risk to the irradiated fetus is carcinogenesis
- The relative risk of childhood cancer may be as much as doubled in an irradiated fetus, but
- Iodinated contrast (unlike gadolinium) appears safe to use in pregnancy, but
- The fetus is exposed to a significant dose during a CT exam only when the fetus is within the primary beam.

**IMAGE WISELY™**

**The Pregnant Patient: Alternatives to CT and Dose-Saving Modifications to CT Technique**

Fergus V. Coakley, MD University of California, San Francisco, CA  
 Dianna D. Cody, PhD The University of Texas MD Anderson Cancer Center, Houston, TX  
 Mahadevappa Mahesh, PhD, FACR Johns Hopkins University School of Medicine, Baltimore, MD

Overview

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**Saints**

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    graph TD
      A[Radiation Interacts with Tissue] --> B[Formation of Free Radicals]
      A --> C[No Permanent Damage]
      B --> D[Body Repairs Damage]
      B --> E[DNA Damage]
      D --> F[Cell Death (Apoptosis/Death)]
      E --> F
      E --> G[Permanent DNA Alteration (Mutagenic Effect)]
    
```

**IMAGE WISELY™**

**How to Understand and Communicate Radiation Risk**

Donald J. Peck, PhD Henry Ford Health System, Detroit, MI  
 Ehsan Samei, PhD Duke University Medical Center, Durham, NC

Many medical imaging examinations involve exposure to ionizing radiation. The exposure amount in these exams

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**Saints**

**Table 5: Relative Radiation Level Scale**

Relative Radiation Level	Effective dose range
None	0
Minimal ☢	Less than 0.1 mSv
Low ☢☢	0.1 – 1.0 mSv
Medium ☢☢☢	1.0 – 10 mSv
High ☢☢☢☢	10 – 100 mSv

\* Adapted from ACR Appropriateness Criteria, Radiation Dose Assessment Introduction 2008

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# EQUIPMENT RESOURCES

- GE Healthcare
- Hitachi
- Philips
- Siemens
- Toshiba



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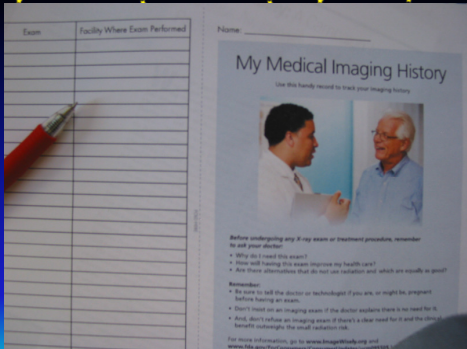
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Exam \_\_\_\_\_ Facility Where Exam Performed \_\_\_\_\_ Name \_\_\_\_\_

### My Medical Imaging History

Use this handy record to track your imaging history.



Before undergoing any X-ray exams or treatment procedures, remember to ask your doctor:

- Why do I need this exam?
- How will having the exam improve my health care?
- Are there alternatives that do not use radiation and which are results to good?

Remember:

- Be sure to tell the doctor or technologist if you are, or might be, pregnant before having an exam.
- Don't insist on an imaging exam if the doctor explains there is no need for it.
- Don't allow anyone to image you if there's a clear need for it and the exam's benefits outweigh the small radiation risk.

For more information, go to [www.imagewisely.org](http://www.imagewisely.org) and [www.fda.gov/oc/ohrt/ohrtfaq.html](http://www.fda.gov/oc/ohrt/ohrtfaq.html)



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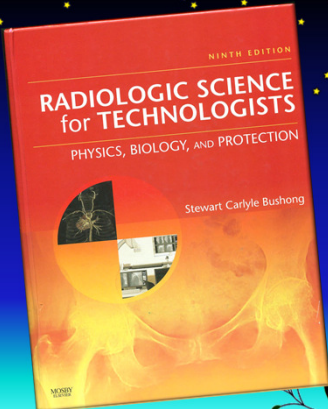
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NINTH EDITION

## RADIOLOGIC SCIENCE for TECHNOLOGISTS

PHYSICS, BIOLOGY, AND PROTECTION

Stewart Carlyle Bushong



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**A Penguin Tale by Benjamin Archer**

In the vast and beautiful expanse of the Antarctic region, there was once a great, isolated iceberg floating in the serene sea. Because of its location and accessibility, the great iceberg became a Mecca for penguins from the entire area. As more and more penguins flocked to their new home and began to cover the slopes of the ice field, the iceberg began to sink further and further into the sea. Penguins kept climbing on, forcing others off the iceberg and back into the ocean. Soon, the iceberg became nearly submerged owing to the sheer number of penguins that attempted to take up residence there.

**Moral:** The PENGUIN represents an important fact or bit of information that we must learn to understand a subject. The brain, similar to the iceberg, can retain only so much information before it becomes overloaded. When this happens, concepts begin to become dislodged, like penguins from the sinking iceberg. So, the key to learning is to reserve space for true "penguins" to fill the valuable and limited confines of our brains. Thus, key points in this book are highlighted and referred to as "PENGUINS."



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**Estimated Risks of Radiation-Induced Fatal Cancer from Pediatric CT**

David J. Brenner<sup>1</sup>  
Carl D. Johnson<sup>1</sup>  
Eric J. Hall<sup>2</sup>  
Walter E. Barlow<sup>3</sup>

**OBJECTIVE:** To study of the rapidly increasing frequency of pediatric CT examinations and their potential to induce fatal cancer.

**MATERIALS AND METHODS:** Case-based analysis of radiation-induced fatal cancer risk was estimated for different organ sites and estimated absolute lifetime cancer mortality risk (per 100,000) for different organ sites and estimated absolute lifetime cancer mortality risk (per 100,000) for different organ sites and estimated absolute lifetime cancer mortality risk (per 100,000) for different organ sites.

**RESULTS:** The lower doses associated with low-dose CT scans (less than 10 mSv) are associated with a lower risk of radiation-induced fatal cancer compared with higher doses (10-20 mSv). The risk of radiation-induced fatal cancer is higher for children than for adults.

**CONCLUSION:** The risk of radiation-induced fatal cancer is higher for children than for adults.

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**USA TODAY**

Let the Super Bowl begin

**Election still splits court**

Bush debuts with education push

CT scans in children linked to cancer later

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# CT scans in children

By Steve Sternberg  
USA TODAY

Each year, about 1.6 million children in the USA get CT scans to the head and abdomen — and about 1,500 of those will die later in life of radiation-induced cancer, according to research out today.

What's more, CT or computed tomography scans given to kids are typically calibrated for adults, so children absorb two to six times the radiation needed to produce clear images, a second study shows. These doses are "way bigger than the sorts of doses that people at Three Mile Island were getting,"

David Brenner of Columbia says. "Most people got a tenth the dose of a CT."

Both studies appear in the *American Journal of Roentgenology*, one of the nation's leading medical journals.

The first to show that CT scans induced fatal cancer from scans. Until a decade ago, scans were too long to perform on children, giving them anesthesia.

Today's scanners speed up the scan, patient in seconds, providing "slices" of anatomy.

Doctors use CT scans



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## Radiation Units

Radiation Exposure... Gray (Gy<sub>a</sub>)

Tissue Dose ..... Gray (Gy<sub>t</sub>)

Effective Dose ..... Sievert (Sv)

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rad  
rem



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### 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



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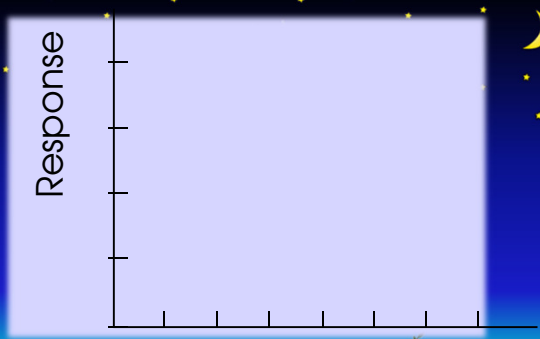
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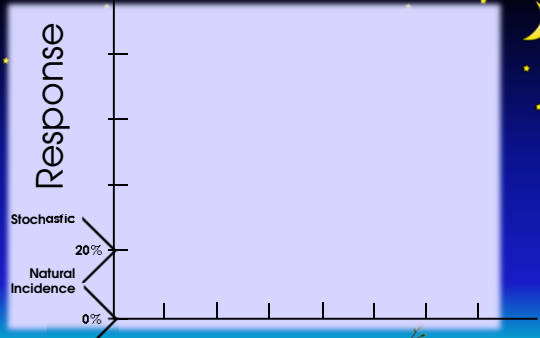
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Stochastic

20%

Natural Incidence

0%

Deterministic



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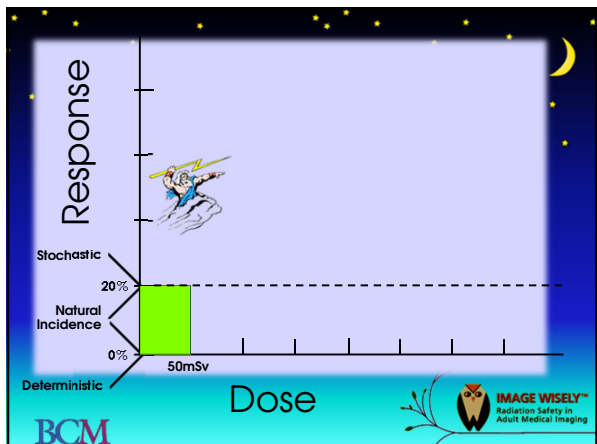
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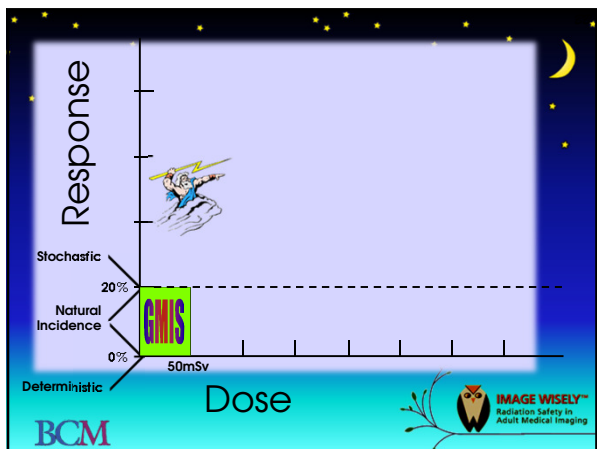
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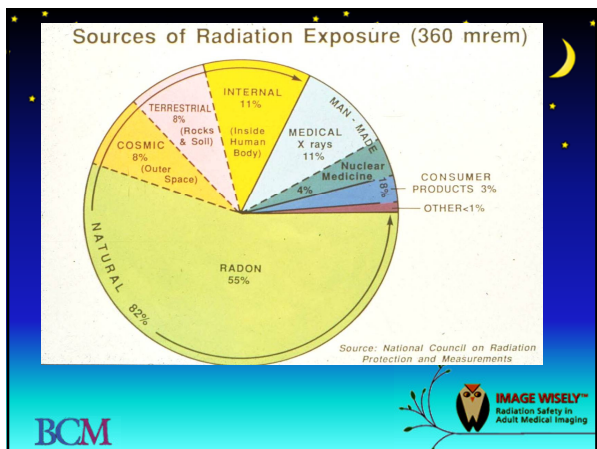
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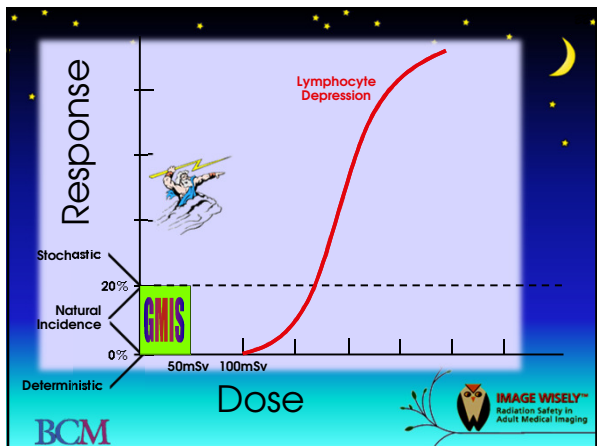
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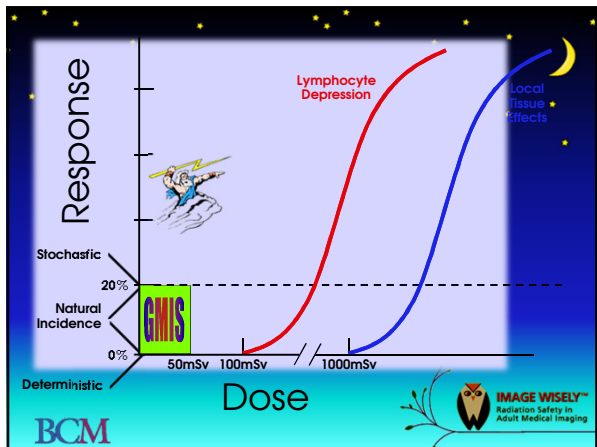
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## Deterministic

- ❖ Non-Linear
- ❖ Threshold
- ❖ Severity increases with dose



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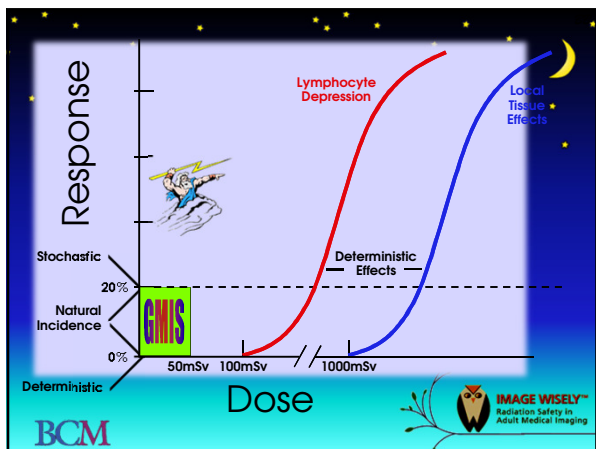
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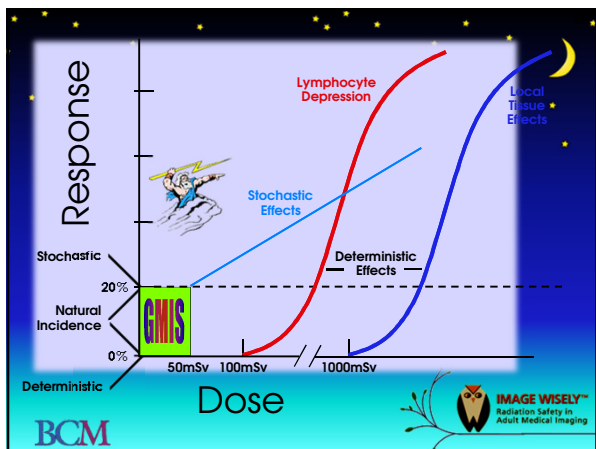
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# Stochastic

- ❖ Linear
- ❖ Non-Threshold
- ❖ Incidence increases with dose



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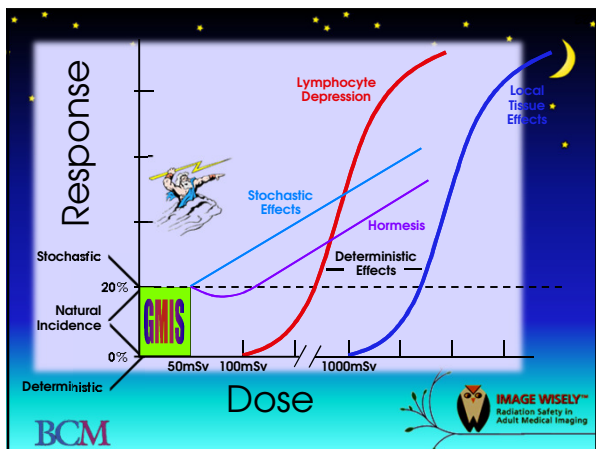
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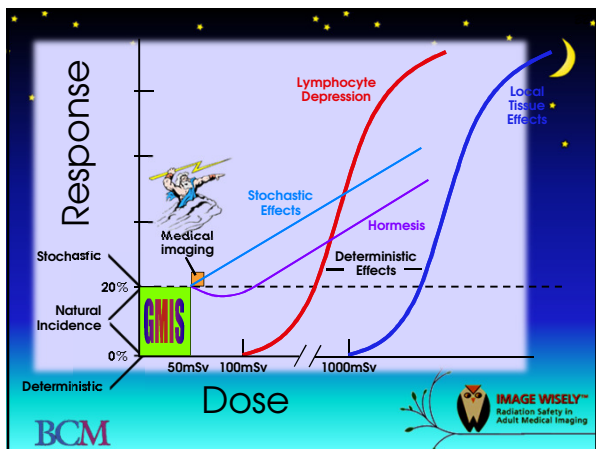
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## RADIATION SOURCES/LEVELS

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





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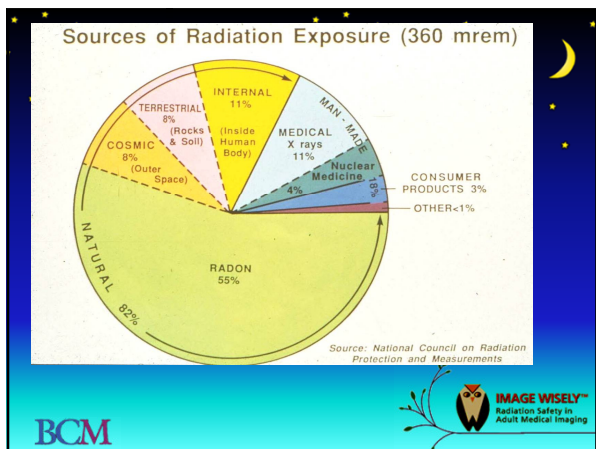
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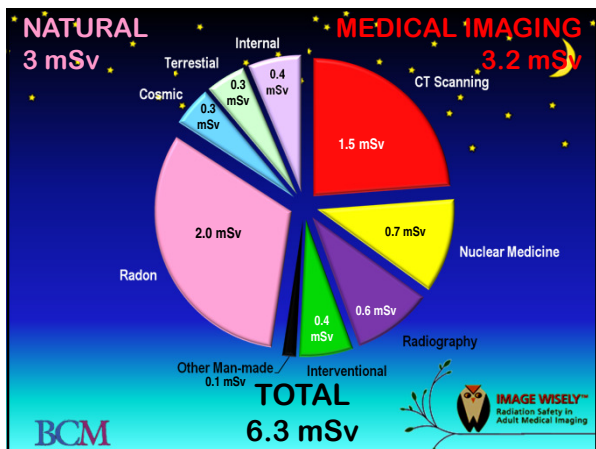
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# RADIATION SOURCES/LEVELS

- Radon
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# Radon

2.0 mSv

TOTAL 6.3 mSv

WHAT YOU DON'T KNOW CAN HURT YOU.  
**RADON**  
CALL 1-800-SOS-RADON  
EPA



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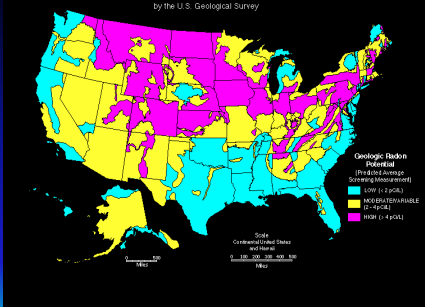
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# GENERALIZED GEOLOGIC RADON POTENTIAL OF THE UNITED STATES




by the U.S. Geological Survey



Geologic Radon Potential (Estimated Average Surface Concentration)

- LOW (1-2 pCi/L)
- MODERATE/HIGH (3-10 pCi/L)
- HIGH (> 10 pCi/L)

Scale: Continental United States and Hawaii  
0 100 200 300 400 500 Miles



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## Radon



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



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## Radon

- 21,000 lung cancer deaths attributable to radon in the US annually
- ☛ Radon is the 2<sup>nd</sup> leading cause of lung cancer, after smoking
- ☛ Radon is the 6<sup>th</sup> leading cause of cancer deaths in the US



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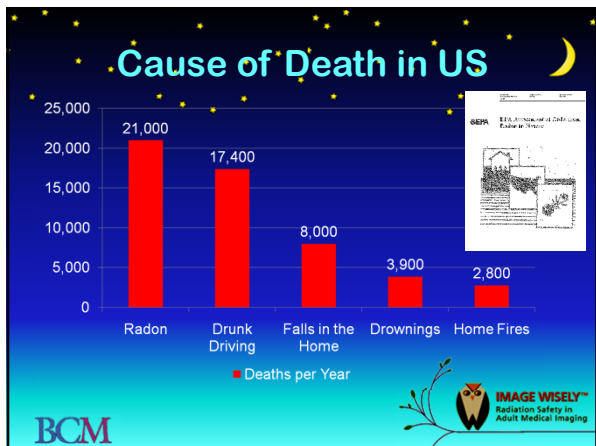
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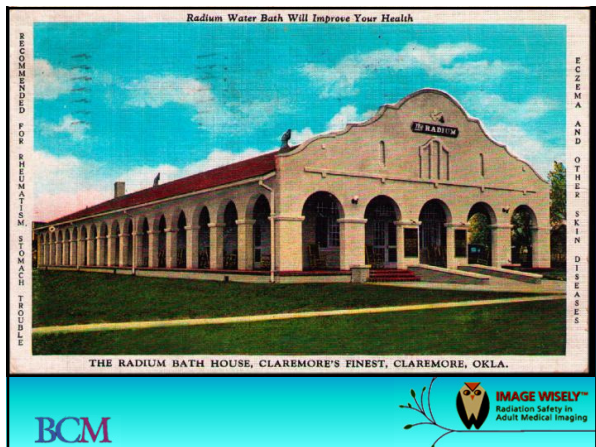
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## Invigorating Water

- 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



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**I**s your DRINKING WATER what it should be?

This Radium Viallet gives your drinking water its active

**Does it pay?**

The following statistics, furnished by that internationally known authority, Dr. Sigismund Saksman, of Berlin, Germany, on cases under careful observation will interest the thoughtful in general, and, in particular, those who are desirous of increasing their power of radium emanation. This is conclusive evidence of its restorative value.

Prepared by the National Radium Company, Inc., Chicago, Ill.

Diseases Treated	No. Treated	Cured	Benefited
Anemia	111	71	40
Ankylosis	12	30	21
Asthma (Bronchial)	17	00	11
Apoplexy	81	00	70
Arterio-Sclerosis	305	00	294
Arthritis "Gout"	125	18	63
Arthritis "Chronic"	218	189	24
Arthritis "Deformans"	691	512	52
Arthritis "Subacute"	210	137	63
Arthritis "Gonorrhoeal"	47	30	17
Bronchitis	200	104	77
Otitis, Chronic (inflammation of Middle)	21	11	00

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**NATIONAL RADIUM COMPANY, INC.**  
Chicago, Ill.

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## Radium Glass




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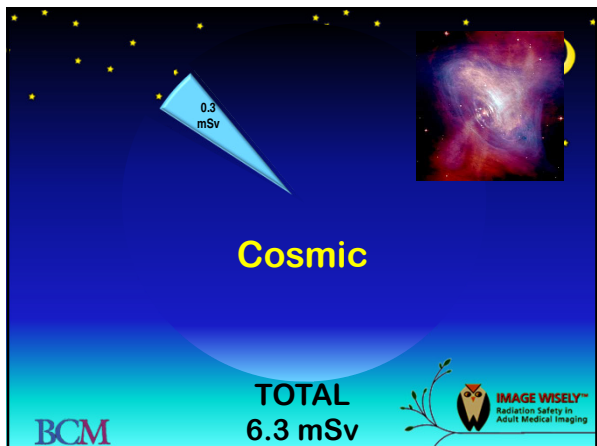
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0.3 mSv

**Cosmic**

**TOTAL**  
6.3 mSv

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This slide features a dark blue background with a starry sky. A blue wedge-shaped graphic points to the value '0.3 mSv'. An inset image shows a colorful nebula. The BCM logo is in the bottom left, and the IMAGE WISELY logo is in the bottom right.

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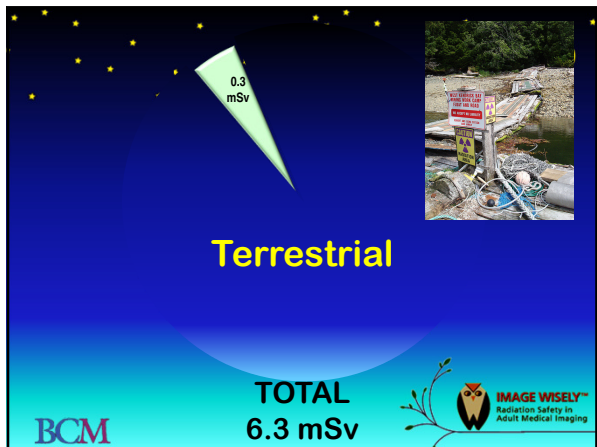
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0.3 mSv

**Terrestrial**

**TOTAL**  
6.3 mSv

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This slide features a dark blue background with a starry sky. A green wedge-shaped graphic points to the value '0.3 mSv'. An inset image shows a radiation warning sign near a body of water. The BCM logo is in the bottom left, and the IMAGE WISELY logo is in the bottom right.

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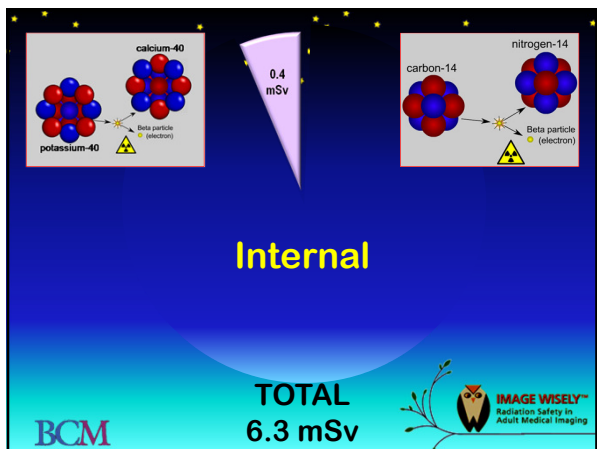
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0.4 mSv

**Internal**

**TOTAL**  
6.3 mSv

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This slide features a dark blue background with a starry sky. A purple wedge-shaped graphic points to the value '0.4 mSv'. Two diagrams show atomic nuclei: potassium-40 decaying to calcium-40 and carbon-14 decaying to nitrogen-14, both emitting a beta particle (electron). The BCM logo is in the bottom left, and the IMAGE WISELY logo is in the bottom right.

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## RADIATION SOURCES/LEVELS

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



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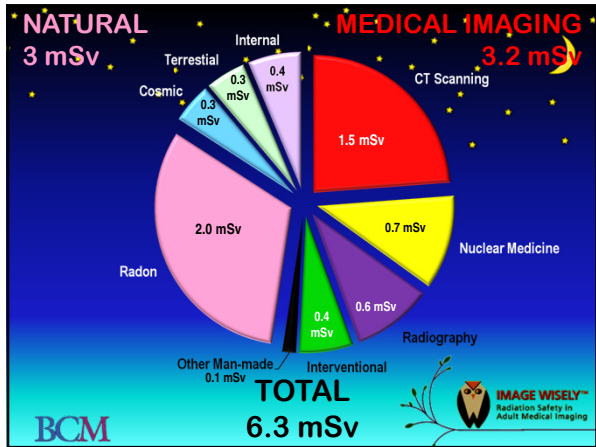
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Paper

### MEDICAL RADIATION EXPOSURE IN THE U.S. IN 2006: PRELIMINARY RESULTS

Fred A. Mettler, Jr.,<sup>a</sup> Bruce R. Thomadsen,<sup>1</sup> Mythreyi Bhargavan,<sup>1</sup> Debbie B. Gilley,<sup>1</sup>  
Joel E. Gray,<sup>2,3</sup> Jill A. Lipoff,<sup>1</sup> John McCrohan,<sup>2</sup> Terry T. Yoshizumi,<sup>1,4</sup>  
and Mahadevappa Mahesh<sup>1,5,6</sup>

<sup>a</sup>Abstract—Medical radiation exposure of the U.S. population has not been systematically evaluated for almost 25 y. In 1982, the NCRP Scientific Committee estimated the collective dose of the U.S. population to be 0.3 mSv and the per capita dose was 0.3 mSv. The preliminary estimates of the NCRP Scientific Committee in 2006, including dental and radiography, had increased almost 200% to about 1.8 mSv and the collective dose had increased almost 600% to about 900,000 person-Sv. The largest contributions and increases have come primarily from CT scanning and nuclear medicine. The 42 million CT procedures accounted for over half of the collective dose, nuclear medicine accounted for about 4% of all procedures but 26% of the total collective dose, natural background exposure is now approximately equal to Health Phys. 95(1):682-697, 2008.

Key words: National Council on Radiation Protection and Measurements; dose, population; effective dose; medical radiation.

Specific tasks of the medical subgroup included: estimating the current number and types of medical procedures using ionizing radiation and evaluating the effective annual collective effective dose as well as annual per capita effective dose; evaluating past and potential future changes in medical radiation exposure; and preparing a new report on the current status of all sources of radiation exposure in the U.S. per committee to specifically examine the changes that occurred over the last 25 y.

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### Number of Procedures (2006)

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



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### IMAGING EXAMINATIONS

- Computed Tomography
- Radiography
- Fluoroscopy
- Nuclear Medicine



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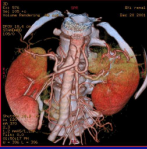
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1.5 mSv

### Computed Tomography

TOTAL  
6.3 mSv



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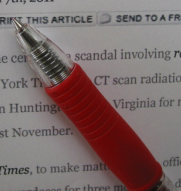
**CT Scan Radiation Overdoses Reported at Cabell Huntington Hospital in West Virginia**


Date Published: Monday, March 7th, 2011

BOOKMARK PRINT THIS ARTICLE SEND TO A FRIEND

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

According to *The New York Times*, to make matters worse, officials at Cabell Huntington Hospital did not disclose the radiation overdoses for three months.



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**The New York Times**

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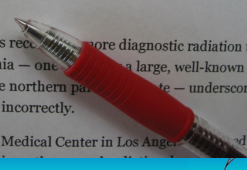
October 16, 2009


**Radiation Overdoses Point Up Dangers of CT Scans**

By **WALT BOGDANICH**

At a time when Americans receive more diagnostic radiation than ever before, a large, well-known Los Angeles hospital is under scrutiny in California — one of the largest in the country. In the same state, another tiny hospital in the northern part of the state — underscores the risks of CT scans pose when used incorrectly.

A week ago, Cedars-Sinai Medical Center in Los Angeles announced that it had administered an unusually high dose of radiation to a patient.



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**Radiation Exposure in CT: What Is the Professionally Responsible Approach?**

By any standard, the radiation exposure of the population from computed tomography (CT) is Western medicine's boldest and most controversial medical technology. The use of CT has resulted in radiation exposure that is not only significant, but also increasing.

What that there is serious variation in the exposure used for identical indications, and that these variations are not being addressed by the profession, which is a failure of the profession. The profession has a responsibility to the patient to ensure that the radiation dose is as low as reasonably achievable (ALARA). It is not enough to say that the dose is low. It is not enough to say that the dose is low because it is low. It is not enough to say that the dose is low because it is low because it is low.

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**Volume CT Dose Index and Dose-Length Product Displayed during CT: What Good Are They?**

The average medical radiation effective dose to the U.S. population in 2006 was estimated at approximately 3.0 mSv, an increase of 60% in a single year. While the increase in CT dose is not the only source of radiation exposure, it is the most important source of the medical radiation dose. The increase in CT dose will result in an increase in the radiation dose to the population. The increase in CT dose will result in an increase in the radiation dose to the population. The increase in CT dose will result in an increase in the radiation dose to the population.

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**How do Penguins stay warm?**

A cartoon illustration of a penguin wearing glasses, standing next to a small fire burning in a metal grate. The penguin is looking towards the fire, which is providing warmth. The background is a simple landscape with a few trees and a small house.

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## CT DOSIMETRY

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


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Region of body	Conversion factor from DLP to Effective Dose in [mSv/(mGy-cm)]				
	0 year old	1 year old	5 year old	10 year old	Adult
Head and neck	0.013	0.0085	0.0057	0.0042	0.0031
Head	0.011	0.0067	0.0040	0.0032	0.0021
Neck	0.017	0.012	0.011	0.0079	0.0059
Chest	0.039	0.026	0.018	0.013	0.014
Abdomen and pelvis	0.049	0.030	0.020	0.015	0.015
Trunk	0.044	0.028	0.019	0.014	0.015


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**Table 6**  
**Representative CTDI<sub>w</sub>, DLP, and ED Values for Normal-sized Adults Undergoing Specified Routine CT Examinations**

Body Region*	CTDI <sub>w</sub> (mGy) <sup>1</sup>		DLP (mGy) <sup>2</sup>		ED (mSv) <sup>3</sup>
	In 16-cm Phantom	In 32-cm Phantom	In 16-cm Phantom	In 32-cm Phantom	
Head (15 cm)	60	(30)	900	(450)	2.2
Chest (30 cm)	(30)	15	(900)	450	9.0
Abdomen (25 cm)	(40)	20	(1000)	500	8.0
Pelvis (25 cm)	(40)	20	(1000)	500	7.8
Brain (perfusion)	440	(220)	2400	(1200)	5.8

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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.

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**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

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## Diagnostic Report

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



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0.45 mSv dose



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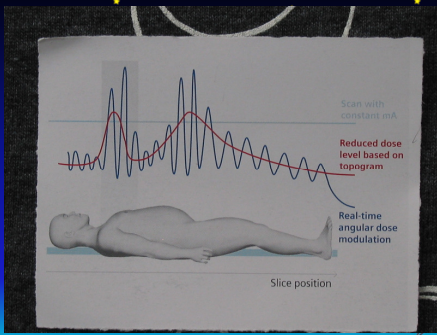
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Scan with constant mA

Reduced dose level based on topogram

Real-time angular dose modulation

Slice position



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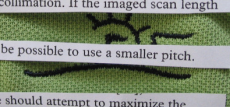
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**Discussion and Summary**  
Overranging leads to a significant level of radiation outside the planned scan region. Because scans

1. Helical scanning may not be necessary.
2. It may not be necessary to scan with a large detector collimation. If the imaged scan length
3. It may be possible to use a smaller pitch.
4. One should attempt to maximize the distance between radiosensitive organs and the imaged area, keeping in mind that overranging extends the imaged area by several centimeters.



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**Automated Extraction of Radiation Dose Information for CT Examinations**  
Tessa S. Cook, MD, PhD, Stefan Zimmerman, MD, Andrew D. A. Maidment, PhD, Woojin Kim, MD, William W. Boone, MD

... to radiation as a result of medical imaging is currently in the spotlight, receiving attention from the press as well as the lay press. Although scanner manufacturers are moving toward including effective dose information in the Digital Imaging and Communications in Medicine headers of imaging studies, there is a significant barrier to effective dose extraction. As such, it is difficult for imaging centers to participate in the ACR's Dose Index Registry. The authors designed an automated extraction system to query their PACS archive and parse CT examinations to extract and process each dose sheet and convert the information to an image-based dose sheet (ASCT) dose. Each text file is parsed, and radiation dose information is extracted from the ASCT dose sheet which can be queried using an existing web-based application. The authors are currently working on a web-based extraction pipeline, is a possible to perform dose and radiation dose information is extracted from the archive and generate dose reports for radiologists, and radiologists, and radiologists.

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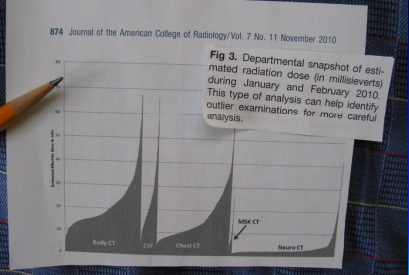
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874 Journal of the American College of Radiology/Vol. 7 No. 11 November 2010



**Fig 3. Departmental snapshot of estimated radiation dose (in millisieverts) during January and February 2010. This type of analysis can help identify outlier examinations for more careful analysis.**

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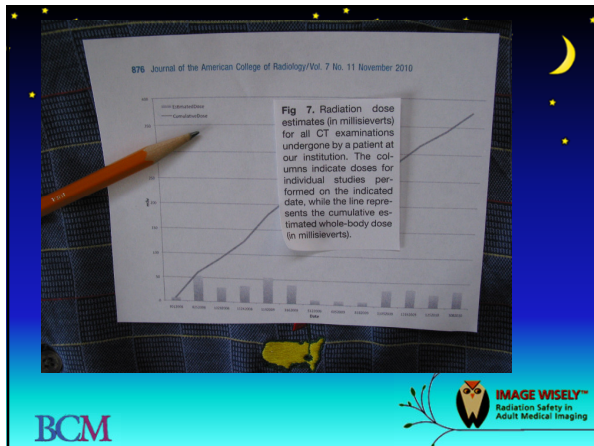
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Table 7: Average Effective Dose in CT\*

Exam	Relative Radiation Level	Range of values (mSv)
Head	☢☢☢	0.9 – 4
Chest (standard)	☢☢☢	4 – 18
Chest (high resolution, e.g., pulmonary embolism)	☢☢☢☢☢	13 – 40
Abdomen	☢☢☢	3.5 – 25
Pelvis	☢☢☢	3.3 – 10
Coronary Angiogram	☢☢☢☢☢	5 – 32
Virtual Colonoscopy	☢☢☢☢☢	4 – 13
Calcium Scoring	☢☢☢	1 - 12

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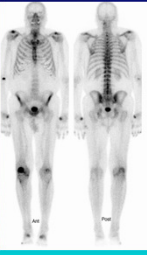
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## Nuclear Medicine.



0.7 mSv

**TOTAL**  
**6.3 mSv**

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- Administered Radiopharmaceutical Dose
- Critical Organ Radiation Dose
- Whole Body Radiation Dose
- Effective Dose

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**Whole-Body PET/CT Scanning: Estimation of Radiation Dose and Cancer Risk<sup>1</sup>**

**Purpose:** To estimate the radiation dose from whole-body fluorine 18 (<sup>18</sup>F) fluorodeoxyglucose (FDG) positron emission tomography (PET)/computed tomography (CT) studies and to evaluate the induced cancer risk to U.S. and Hong Kong populations.

**Materials and Methods:** Fluorine 18-FDG PET/CT studies obtained by using a 64-detector CT unit and one of three CT protocols were evaluated. CT protocol A consisted of 120 kV, rotation time, 0.5 second; pitch, 0.984; 100–200 mAs; and noise level, 20. CT protocol B was the same as A, except for a fixed tube current of 250 mAs. CT protocol C consisted of 140 kV; rotation time, 0.5 second; pitch, 0.984; 120–350 mAs; and noise level, 3.5. CT doses were measured in a phantom abdomen equipped with thermoluminescent detectors.

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**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 13.45, 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.

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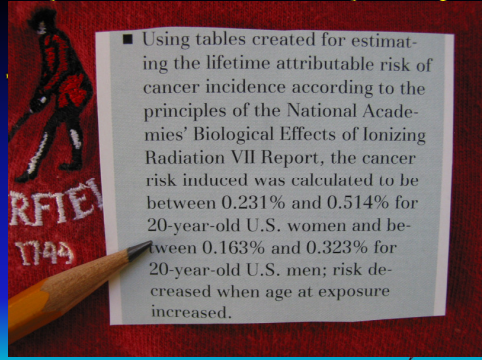
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■ Using tables created for estimating the lifetime attributable risk of cancer incidence according to the principles of the National Academies' Biological Effects of Ionizing Radiation VII Report, the cancer risk induced was calculated to be between 0.231% and 0.514% for 20-year-old U.S. women and between 0.163% and 0.323% for 20-year-old U.S. men; risk decreased when age at exposure increased.

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### 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

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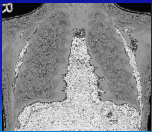
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### Radiography



0.6 mSv

**TOTAL**  
6.3 mSv

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Exam	Relative Radiation Level	Range of values (mSv)
Extremity	☢	0.0002 - 0.1
Chest X-ray PA / LAT	☢☢	0.007 - 0.24
Mammography	☢☢☢	0.1 - 0.6
Abdomen / Pelvis	☢☢☢☢	0.04 - 1.2
Thoracic / Lumbar Spine	☢☢☢☢☢	0.5 - 1.8
IVU	☢☢☢☢☢☢	0.7 - 3.7
Upper GI w/fluoroscopy	☢☢☢☢☢☢☢	1.5 - 12
Barium enema w/fluoroscopy	☢☢☢☢☢☢☢☢	2 - 18

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**Abstracts**  
549  
radiographics.rsn.org  
March-April 2010  
**Optimizing Parameters for Flat-Panel Detector Digital Tomosynthesis<sup>1</sup>**  
Haruhiko Machida, MD, PhD • Toshiyuki Yuhara, RT • Takako Mori, RT  
Eiko Ueno, MD • Yoshio Moribe • John M. Sabol, PhD

Digital tomosynthesis is a novel technique that allows easy and swift volume data acquisition in selected regions of the body. However, many radiologists and technologists are unfamiliar with this technique and the potential artifacts related to data acquisition. Digital tomosynthesis requires a single linear sweep of the large-area flat-panel detector through the patient. Standard acquisition parameters include synthesis corresponding tomographic data. Standard acquisition parameters include the corresponding tomographic data. Standard acquisition parameters include the corresponding tomographic data. Standard acquisition parameters include the corresponding tomographic data.

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**Figure 2.** Drawings illustrate the basic principle of digital tomosynthesis performed with a flat-panel detector.  $\theta$  = sweep angle, which is the total arc about the center of the detector as defined by the focal spot position from the first to the final projection in the sweep.

(a) In wall stand acquisition, the x-ray tube moves vertically, with multiple projections obtained from different angles during a single linear sweep relative to the stationary detector (arrow) behind the patient barrier (a).

(b) Table acquisition is similar, except the x-ray tube moves in a straight line above the table, on which the stationary detector (arrow) is positioned.

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...approves Hologic's 3D digital breast tomosynthesis system  
If you have trouble viewing this e-mail, please click here

**AuntMinnie.com**  
**BREAKING NEWS**

February 11, 2011      A breaking news service from AuntMinnie.com

**FDA approves Hologic's 3D digital breast tomosynthesis system**

After years of development, women's healthcare vendor Hologic today received approval from the U.S. Food and Drug Administration for its Selenia Dimensions 3D system, the first x-ray mammography device that provides 3D digital breast tomosynthesis images for breast cancer screening and diagnosis.

[Click here to read the rest of the article.](#)

AuntMinnie.com Breaking News      February 11, 2011

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What are a group of Penguins on land called?

"OK...now try it again but this time try not to waddle, this is called a waltz."

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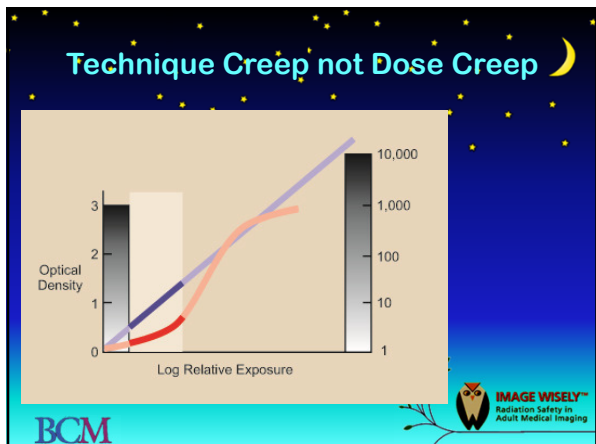
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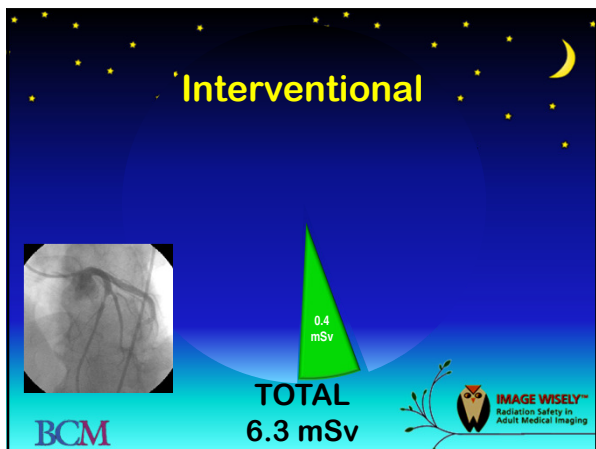
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### Table 8: Average Effective Dose in Interventional Radiology\*

Exam	Relative Radiation Level	Range of values (mSv)
Head/Neck angiography	☆☆☆☆	0.8 – 19.6
Coronary angiography (diagnostic)	☆☆☆☆	2 – 15.8
Coronary angioplasty, stent placement, RF ablation	☆☆☆☆	6.9 – 57
TIPPS	☆☆☆☆	20 – 180

Saints

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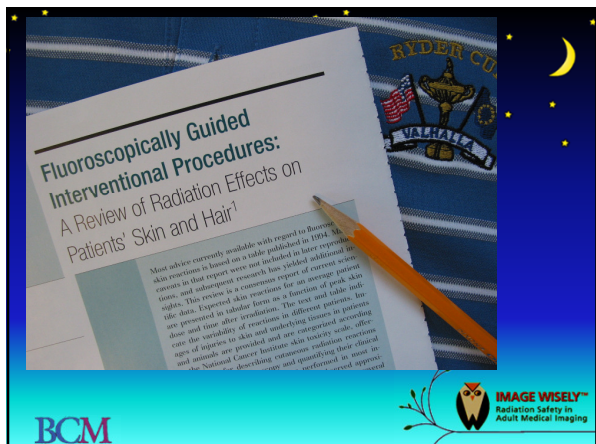
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### Fluoroscopically Guided Interventional Procedures: A Review of Radiation Effects on Patients' Skin and Hair<sup>1</sup>

Most advice currently available with regard to fluoroscopic procedures is based on a table published in 1974. Most of the data in that report were not included in later reports on skin reactions, and additional research has yielded additional information. This review is a consensus report of current scientific data. Expected skin reactions for an average patient are presented in tabular form as a function of peak skin dose and time after radiation. The new and tabular data offer the variability of reactions in different patients, offering age of patients to skin and underlying tissue, offering age of patients to skin and underlying tissue, offering age of patients to skin and underlying tissue, offering age of patients to skin and underlying tissue, offering age of patients to skin and underlying tissue.

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**Figure 1**



**Figure 1:** Radiation injury in a 60-year-old woman subsequent to successful retrograde interventional procedure for the treatment of acute stroke. Estimated fluoroscopy time was more than 70 minutes; 43 imaging views were performed during course of the procedure. The head was not shielded. Acute focal epilation on scalp and skin injury on neck but not on scalp. No dose estimates were available for this patient.

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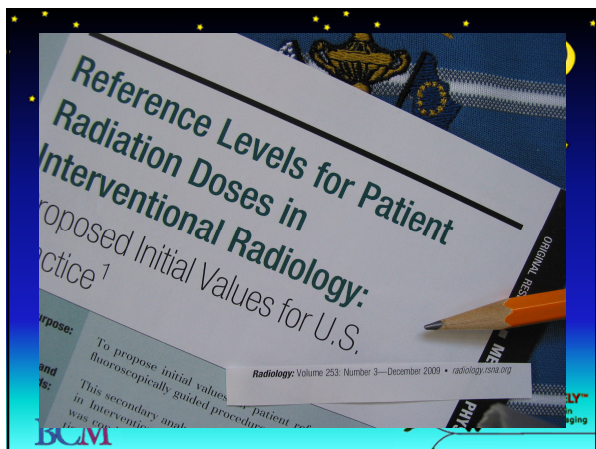
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### Reference Levels for Patient Radiation Doses in Interventional Radiology: Proposed Initial Values for U.S. Practice<sup>1</sup>

**Purpose:** To propose initial values for patient radiation doses in interventional radiology.

**and To:** This secondary guided procedure was developed to provide a starting point for the development of local or institutional policies.

*Radiology: Volume 253, Number 3—December 2009 • radiology.rsna.org*

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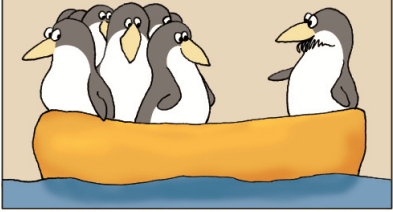
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What do you call a group of Penguins in the water?



"Really... it wasn't me... really... come on now..."

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**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

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**ORGANIZATIONS**  
**PROGRAM INTRODUCTION**  
**RADIATION SOURCES/LEVELS**  
**IMAGING EXAMINATIONS**  
**APPROPRIATENESS**  
**OVERUTILIZATION**

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**Appropriating Imaging**  
 What is Radiology's Role in Controlling Utilization?  
 By Seth M. Greenman

CPQE, appropriateness criteria, ethical prediction rules, and other types of decision support can reduce the sheer number of unnecessary exams. What role should radiology have in achieving that objective?

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**Table 5: Relative Radiation Level Scale**

Relative Radiation Level	Effective dose range
None	0
Minimal	Less than 0.1 mSv
Low	0.1 – 1.0 mSv
Medium	1.0 – 10 mSv
High	10 – 100 mSv

\* Adapted from ACR Appropriateness Criteria, Radiation Dose Assessment Introduction 2008

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### Increasing the Appropriateness of Outpatient Imaging: Effects of a Barrier to Ordering Low-Yield Examinations\*

**Abstract:** To determine the effect of a registration-inhibitor on the appropriateness of outpatient imaging, we conducted a retrospective analysis of 1,000 outpatient CT scans ordered before and after the implementation of a registration barrier. The mean appropriateness score increased from 92.5 (before) to 94.5 (after), and the mean number of low-yield examinations decreased from 1.5 (before) to 1.2 (after). Our findings suggest that a barrier to ordering low-yield examinations may be an effective strategy to increase the appropriateness of outpatient imaging.

**Keywords:** Outpatient imaging, registration barrier, appropriateness, low-yield examinations.

**Background:** The inappropriate ordering of imaging studies is a common problem in outpatient settings. The implementation of a registration barrier to ordering low-yield examinations may be an effective strategy to increase the appropriateness of outpatient imaging. We conducted a retrospective analysis of 1,000 outpatient CT scans ordered before and after the implementation of a registration barrier to determine the effect of this barrier on the appropriateness of outpatient imaging and the number of low-yield examinations ordered.

**Methods:** We reviewed 1,000 outpatient CT scans ordered before and after the implementation of a registration barrier. The appropriateness of each scan was determined using a validated scoring system. The number of low-yield examinations ordered before and after the implementation of the barrier was also determined.

**Results:** The mean appropriateness score increased from 92.5 (before) to 94.5 (after), and the mean number of low-yield examinations ordered decreased from 1.5 (before) to 1.2 (after). Our findings suggest that a barrier to ordering low-yield examinations may be an effective strategy to increase the appropriateness of outpatient imaging.

**Conclusion:** The implementation of a registration barrier to ordering low-yield examinations may be an effective strategy to increase the appropriateness of outpatient imaging and reduce the number of low-yield examinations ordered.

**Keywords:** Outpatient imaging, registration barrier, appropriateness, low-yield examinations.

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## ACR Reference Values

- Head CT – 80 mSv
- Adult Abdomen CT – 25 mSv
- Pediatric Abdomen CT – 20 mSv

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**TABLE 7.1—NCRP recommended diagnostic reference levels and achievable doses (in milligray, unless noted) from NCRP Report to be published soon**

Exam	Ref Level	Achievable Dose	BT CT 1	BT CT 2	BT CT 3
Adult head CT (CTDIvol)	80	80			
Adult chest CT (CTDIvol)	22	14	19.4	74.5	48.2
Adult abdomen-pelvis CT (CTDIvol)	22	17	19.4	14.5	14.5
Pediatric head (5 y old) (CTDIvol)	43	32			
Pediatric abdomen-pelvis (5 y old) (CTDIvol)	22	15	13.2	13.0	14.0

Exam	Ref Level	Achievable Dose	2/7/2011		2/24/2011	
			TX Limit	Typical Dose	BTCH	BTCH
Adult PA chest, with grid (23 cm)	0.15	0.11				
Pediatric chest, without grid	0.08	0.04				
AP abdomen (23 cm)	0.12	0.07				
AP lumbosacral spine (23 cm)	3.4	2.4				
Upper GI fluoroscopy, without contrast	4.2	2.8				working on data
Upper GI fluoroscopy, with contrast	66 mGy/min	40 mGy/min				now with techs
Fluorographic image	81 mGy/min	72 mGy/min				for PT exposures
Dental posterior bitewing	20	9				
Dental panoramic	1.6	1.2				

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reference levels and achievable doses (in milligray, unless noted)

Level	Achievable Dose	BT CT 1	BT CT 2	BT CT 3
66		78.7	74.5	48.2
14		19.4	18.0	14.5
17		19.4	18.0	14.5
32				
15		13.2	13.0	14.0
		2/7/2011	2/7/2011	2/24/2011
Level	Achievable Dose	TX Limit	Typical Dose BTGH	
0.11		0.30		
0.04			working on data	
0.07			now with techs	
			for PT exposures	

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**ORGANIZATIONS**  
**PROGRAM INTRODUCTION**  
**RADIATION SOURCES/LEVELS**  
**IMAGING EXAMINATIONS**  
**APPROPRIATENESS**  
**OVERUTILIZATION**

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Monday, March 2, 2009

### Medical imaging draws scrutiny from industry

■ Experts point to unnecessary scans and a largely unregulated field as reasons for concern

**BY GINA ROLATA**

When Cal Kislavitz had an MRI scan of her knee, it came back blurry. "Unacceptable," her orthopedic told her.

Her insurer refused to pay for another scan, but she had to pay out of pocket. She had to pay the full cost of the machine she was using, she says. "I was told to get another opinion," she says.

The industry is under fire for unnecessary scans and a largely unregulated field, experts say. "Unnecessary scans and a largely unregulated field are reasons for concern," says Kislavitz, who is a board member of the American College of Radiology. "The requirements for a scan are not standardized, and there are no certification standards for the scanning physicians," he says. "The industry is under fire for unnecessary scans and a largely unregulated field, experts say."

The radiology department at Thomas Jefferson University Hospital in Philadelphia shows whether the cartridge in Kislavitz's knee was clearly visible. The requirements for a scan are not standardized, and there are no certification standards for the scanning physicians, he says.

Many factors contribute to the problem, though. In the past, scans were done on a 10-year-old machine, but now they are done on a newer machine.

Many factors contribute to the problem, though. In the past, scans were done on a 10-year-old machine, but now they are done on a newer machine.

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MONDAY, MAY 2, 2005 © 2005 Dow Jones

*Own Image*  
**MRI and CT Centers Offer Doctors Way to Profit on Scans**

Physicians Pay a Flat Fee For Procedures, Then Bill Insurers—at Higher Rate


Navigating Legal Landscape  
 By DAVID ARMSTRONG

Medical imaging such as MRI and CT scanning is one of health care's fastest-growing sectors. Last October, an owner of imaging centers told doctors how they could get in on the boom.


At a meeting of cardiologists, neuro-

It's a federal crime for health-care providers to compensate doctors for referrals, or for doctors to receive such compensation, when Medicare or Medicaid patients are involved. Such a ban, called an anti-kickback law, extends to all other types of patients, too, under 36 state statutes, including one in California. Some lawyers say the doctors' almost

**Health**  
 Some doctor groups have been using imaging facilities. Labeled as "referral facilities," the deals allow doctors to send MRI or CT scans done in their own offices and permit the doctors themselves to bill insurers.



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GA · THURSDAY, SEPTEMBER 10, 2009 · USA TODAY

File photo by Ron Edmunds, AP

**Outlining his plan:** President Clinton holds up a proposed health security card during his 1993 health care speech before Congress.

**Health care: Then and now**

Aside from annual State of the Union messages, presidents rarely speak to joint sessions of Congress. On Sept. 22, 1993, President Clinton spoke on the topic of health care.



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**Obama:** Everyone in his room knows what will happen if we do nothing. Our deficit will get so big that banks will go bankrupt, businesses will close, and we will lose our jobs. More people will die because we can't afford to care for them. These things are happening now. We can't count on the government to take care of us. We have to take care of ourselves.

**health care**

■ 1993 ■ 2009<sup>1</sup>

Total U.S. spending on health care

\$912.5 billion (1993) vs \$2.5 trillion (2009)

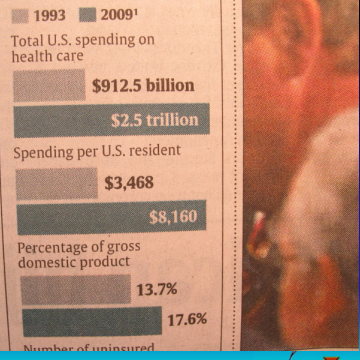
Spending per U.S. resident

\$3,468 (1993) vs \$8,160 (2009)


Percentage of gross domestic product

13.7% (1993) vs 17.6% (2009)

Number of uninsured



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❖ Inflation.....3%/yr

❖ Healthcare.....9%/yr

❖ Medical Imaging.....18%/yr

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CT, MRI, and PET has  
balloned to \$100 billion/year

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National Trends in CT Use in the  
Emergency Department:  
1995-2007<sup>1</sup>

**Purpose:** To identify nationwide trends and factors associated with the use of computed tomography (CT) in the emergency department (ED).

**Materials and Methods:** This study was a review of national data based on data from the 1995-2007 National Hospital Ambulatory Medical Care Survey which were used to evaluate the numbers and percentages of ED visits associated with CT. A total of 20,000 visits were sampled over 12 years. Data were also categorized according to multiple patient and hospital characteristics. The frequency of use was compared to determine whether CT use was similar across subpopulations. Data were analyzed according to descriptive and logistic growth models.

**Results:** The number of ED visits that included CT increased from 2.2 million in 1995 to 10.2 million in 2007, an increase of 460%. The percentage of ED visits that included CT increased from 1.2% to 2.2% over the same period.

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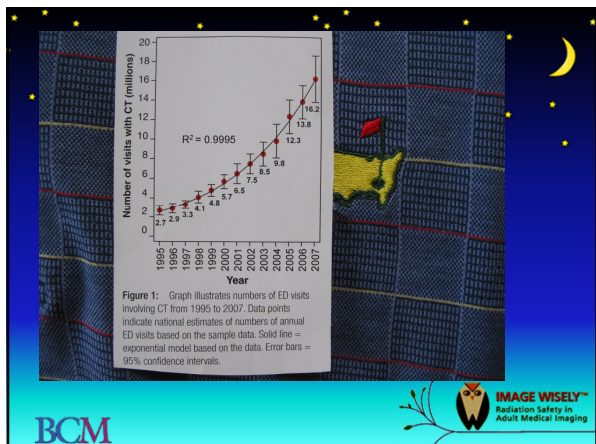
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### Ownership or Leasing of CT Scanners by Nonradiologist Physicians: A Rapidly Growing Trend That Raises Concern About Self-Referral

David C. Levin, MD<sup>a,b</sup>, Vijay M. Rao, MD<sup>a</sup>, Lawrence Parker, PhD<sup>a</sup>,  
 Andrea J. Frangos, MS<sup>a</sup>, Jonathan H. Lubliner, PhD<sup>a</sup>

**Purpose:** The aim of this study was to examine recent nationwide trends in the ownership or leasing of computed tomographic (CT) scanners in private offices by nonradiologist physicians.

**Methods and Materials:** The Medicare Part B fee-for-service data sets for 2001 through 2006 were analyzed to identify all CT scans performed in nonhospital, private-office settings. Ownership or leasing of CT scanners was determined by tabulating all global and technical-component-only claims. Professional-component-only claims were excluded. The specialty of the owner or lessee was determined using Medicare's physician specialty code. Individual specialty volume trends and growth rates among all nonradiologist physicians as a group were compared with radiologists. Individual specialty volume trends and growth rates were also studied.

**Results:** From 2001 to 2006, Medicare private-office CT scan volume in facilities owned by radiologists increased 104%, while volume in facilities owned or leased by nonradiologist physicians as a group increased 263%. Nonradiologist physicians performed 192,255 scans in 2006, compared with 184,091 scans performed in independent facilities owned or leased by radiologists. The volume of scans performed in independent facilities owned or leased by radiologists increased 10% from 2001 to 2006, while the volume of scans performed in independent facilities owned or leased by nonradiologist physicians increased 28%.

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(106,729 scans) and medical oncology (61,976 scans). This study was performed in independent diagnostic imaging facilities (for which physician ownership cannot be determined), nonradiologists' private-office CT market share rose from 16% in 2001 to 28% in 2006.

**Conclusions:** The majority of Medicare private-office CT scans are done in facilities owned by radiologists. However, nonradiologist physicians are acquiring or leasing CT scanners in increasing numbers, and the growth trend is much more rapid among them than it is among radiologists (85% among radiologists from 2001 to 2006, compared with 263% among nonradiologists). As a result, nonradiologists' market share has increased considerably. At a time when both cost containment and reduction in radiation exposure are urgent priorities, the self-referral opportunities resulting from this trend should be of concern to payers and policymakers.

**Key Words:** Computed tomography, utilization of imaging, self-referral, medical economics, radiology, radiologists, socioeconomic issues

*J Am Coll Radiol* 2008;5:1206-1210. Copyright © 2008 American College of Radiology

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 Health Policy Institute, Houston, Texas.  
 American College of Radiology, Reston, Virginia.  
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 This study was supported in part by a grant from the American College of Radiology, Reston, Virginia.

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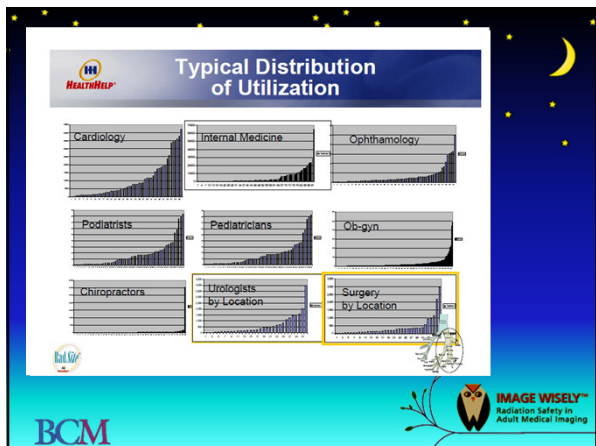
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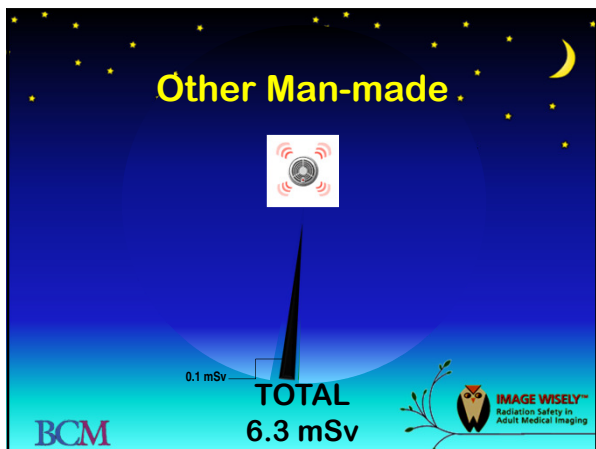
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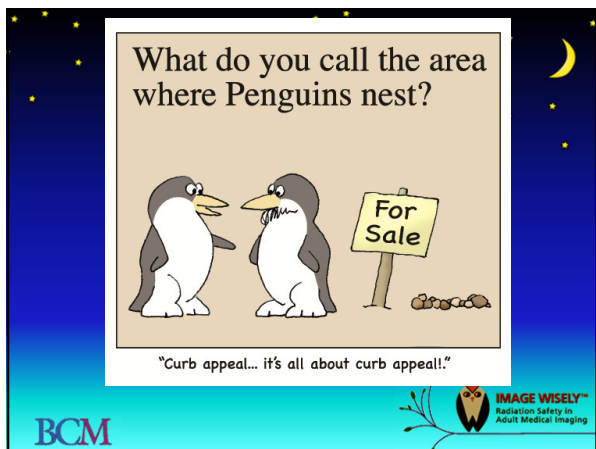
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### CONSUMER RADIATION SOURCES

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



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### CONSUMER RADIATION SOURCES

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

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How do you know your microwave oven isn't functioning properly? Maybe your microwave oven leak detector isn't functioning properly.

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### CONSUMER RADIATION SOURCES

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



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### AIRPORT SCANNERS

- Hall Effect Metal Detectors (0 uSv)
- Millimeter Wave Scanners (0 uSv)
- Backscatter x-ray scanners (0.1 uSv)



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DATE 1/27/11 NATION 3A


### TSA defends safety of scanners

#### Radiation expert outlines differences in machines

By David L. Byerman, Ph.D., DOE

A radiation expert says that the different scanners used at airports have different safety profiles, and that the most common type of scanner, the backscatter X-ray, is the safest. The expert says that the most common type of scanner is the backscatter X-ray, which uses a low dose of X-rays to create an image of a person's body. He says that this type of scanner is the safest because it uses a very low dose of radiation, and that the other types of scanners, such as the CT scanners and the dual-energy X-ray scanners, use much higher doses of radiation. He says that the TSA has a responsibility to ensure that the scanners it uses are safe, and that it should be transparent about the safety of the scanners it uses.

The article also mentions that the TSA has a responsibility to ensure that the scanners it uses are safe, and that it should be transparent about the safety of the scanners it uses. It also mentions that the TSA has a responsibility to ensure that the scanners it uses are safe, and that it should be transparent about the safety of the scanners it uses.

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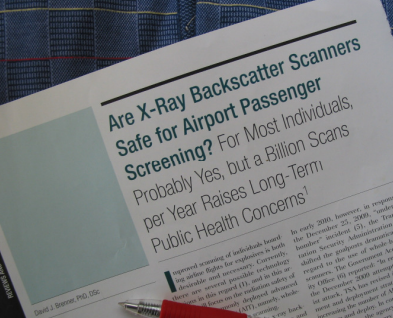
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DATE 1/27/11


### Are X-Ray Backscatter Scanners Safe for Airport Passenger Screening?

#### Probably Yes, but a Billion Scans Per Year Raises Long-Term Public Health Concerns!

By David L. Byerman, Ph.D., DOE

In early 2009, however, in response to the Transportation Security Administration's (TSA) decision to use backscatter X-ray scanners for airport passenger screening, the American Nuclear Society (ANS) issued a statement expressing concern about the safety of these scanners. The ANS stated that the use of backscatter X-ray scanners for airport passenger screening is not safe because it involves a billion scans per year, which raises long-term public health concerns. The ANS also stated that the TSA should be transparent about the safety of the scanners it uses, and that it should ensure that the scanners it uses are safe.

The article also mentions that the TSA has a responsibility to ensure that the scanners it uses are safe, and that it should be transparent about the safety of the scanners it uses. It also mentions that the TSA has a responsibility to ensure that the scanners it uses are safe, and that it should be transparent about the safety of the scanners it uses.

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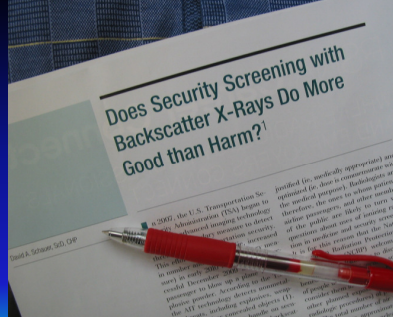
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DATE 1/27/11

### Does Security Screening with Backscatter X-Rays Do More Good than Harm?

By David L. Byerman, Ph.D., DOE

In early 2009, however, in response to the Transportation Security Administration's (TSA) decision to use backscatter X-ray scanners for airport passenger screening, the American Nuclear Society (ANS) issued a statement expressing concern about the safety of these scanners. The ANS stated that the use of backscatter X-ray scanners for airport passenger screening is not safe because it involves a billion scans per year, which raises long-term public health concerns. The ANS also stated that the TSA should be transparent about the safety of the scanners it uses, and that it should ensure that the scanners it uses are safe.

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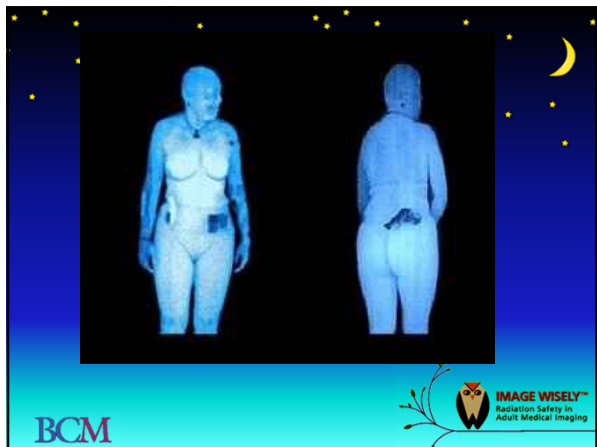
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- 10 backscatter scans = 1 day GMIS
- 50 backscatter scans = one way air travel
- 100 backscatter scans = 1 CXR
- 500 backscatter scans = 1 ABD




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**'Inexcusable' delay on TSA body-scanner safety reports**

Agency: No ill effects for the 'IMX' process

**USA TODAY** WASHINGTON, February 8 (UPI)—The U.S. Transportation Security Administration says it will not allow passengers to fly without a full-body scanner at airport checkpoints because of a "significant delay" in releasing safety reports for the technology. The agency says it will continue to use the technology until the reports are released. The reports are expected to be released by the end of the month. The agency says it will continue to use the technology until the reports are released. The reports are expected to be released by the end of the month.




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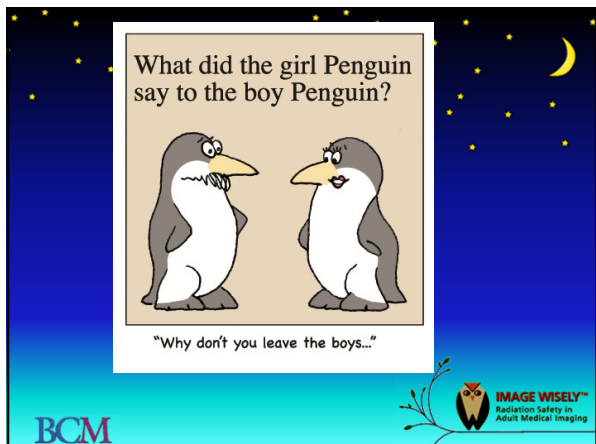
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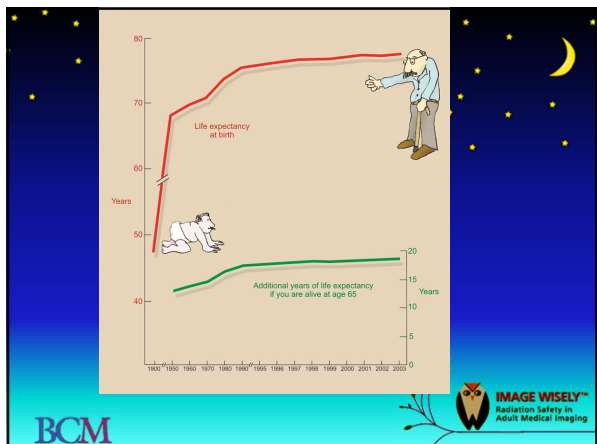
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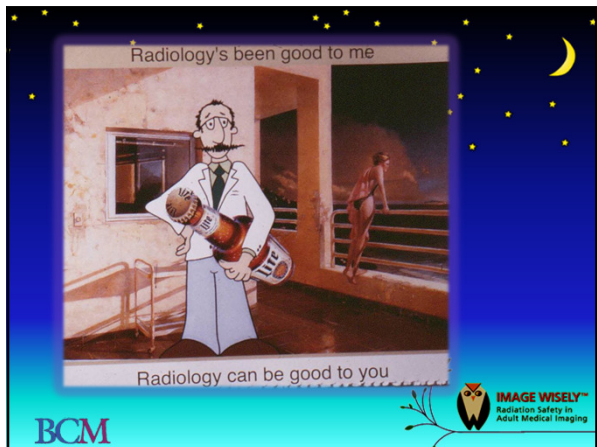
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