Nature and Scale of Radiation Risk

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2010 NYT Articles on Risks of Medical Imaging

- Radiation Worries for Children in Dentists' Chairs – November 23, 2010
- Radiation, Risks Are Focus of Breast Screening Studies – Aug 24, 2010
- Scientists Say F.D.A. Ignored Radiation Warnings – Mar 29, 2010
- F.D.A. to Increase Oversight of Medical Radiation – Feb 10, 2010
- They Check the Medical Equipment, but Who Is Checking Up on Them? – Jan 27, 2010

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Variable Doses of Radiation Raise Safety Concerns for CT Procedures

ScienceDaily (Dec. 15, 2009) — Radiation doses from common CT procedures vary widely and are higher than generally thought, raising concerns about increased risk for cancer, according to a new study led by UCSF imaging specialists.

THE RADIATION BOOM

After Stroke Scans, Patients Face Serious Health Risks

By WALT BOGDANICH
Published: July 31, 2010

When Alain Reyes's hair suddenly fell out in a freakish band circling his head, he was not the only one worried about his health. His co-workers at a shipping company avoided him, and his boss sent him home, fearing he had a contagious disease.

Enlarge This Image

Hair loss in patients who received radiation overdoses.

Only later would Mr. Reyes learn what had caused him so much physical and emotional grief: he had received a radiation overdose during a test for a stroke at a hospital in Glendale, Calif.

Other patients getting the procedure, called a CT brain perfusion scan, were being overdosed, too — 37 of them just up the freeway at Providence Saint Joseph Medical Center in Burbank, 269 more at the renowned Cedars-Sinai Medical Center in Los Angeles and dozens more at a hospital in Huntsville, Ala.

The overdoses, which began to emerge late last summer, set off an investigation by the Food and Drug Administration into why patients tested with this complex yet lightly regulated technology were bombarded with excessive radiation. After 10 months, the agency has yet to provide a final report on what it found.

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NY Times, July 31, 2010

15,000 will die from CT scans done in 1 year

Scans have higher levels of radiation than thought, researchers say

REUTERS
updated 5:14 p.m. ET, Mon., Dec . 14, 2009

Video

CHICAGO - Radiation from CT scans done in 2007 will cause 29,000 cancers and kill nearly 15,000 Americans, researchers said Monday.

The findings, published in the Archives of Internal Medicine, add to mounting evidence that Americans are overexposed to radiation from diagnostic tests, especially from a specialized kind of X-ray called a computed tomography, or CT, scan.

Arch Int Med, 2009

The Palm Beach Post
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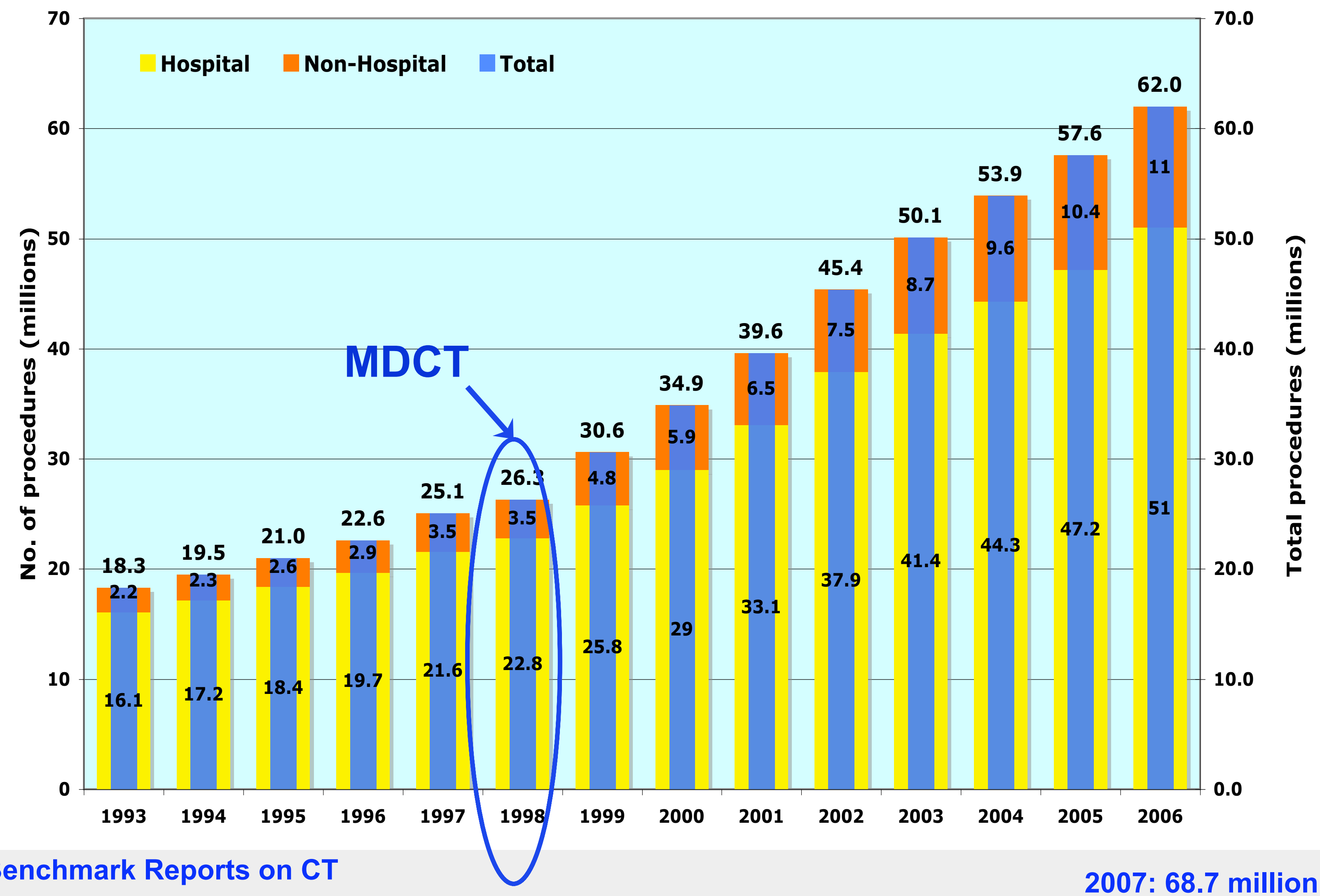
Debating the danger: Are airport scanners safe?

Palm Beach Post, Nov 23, 2010

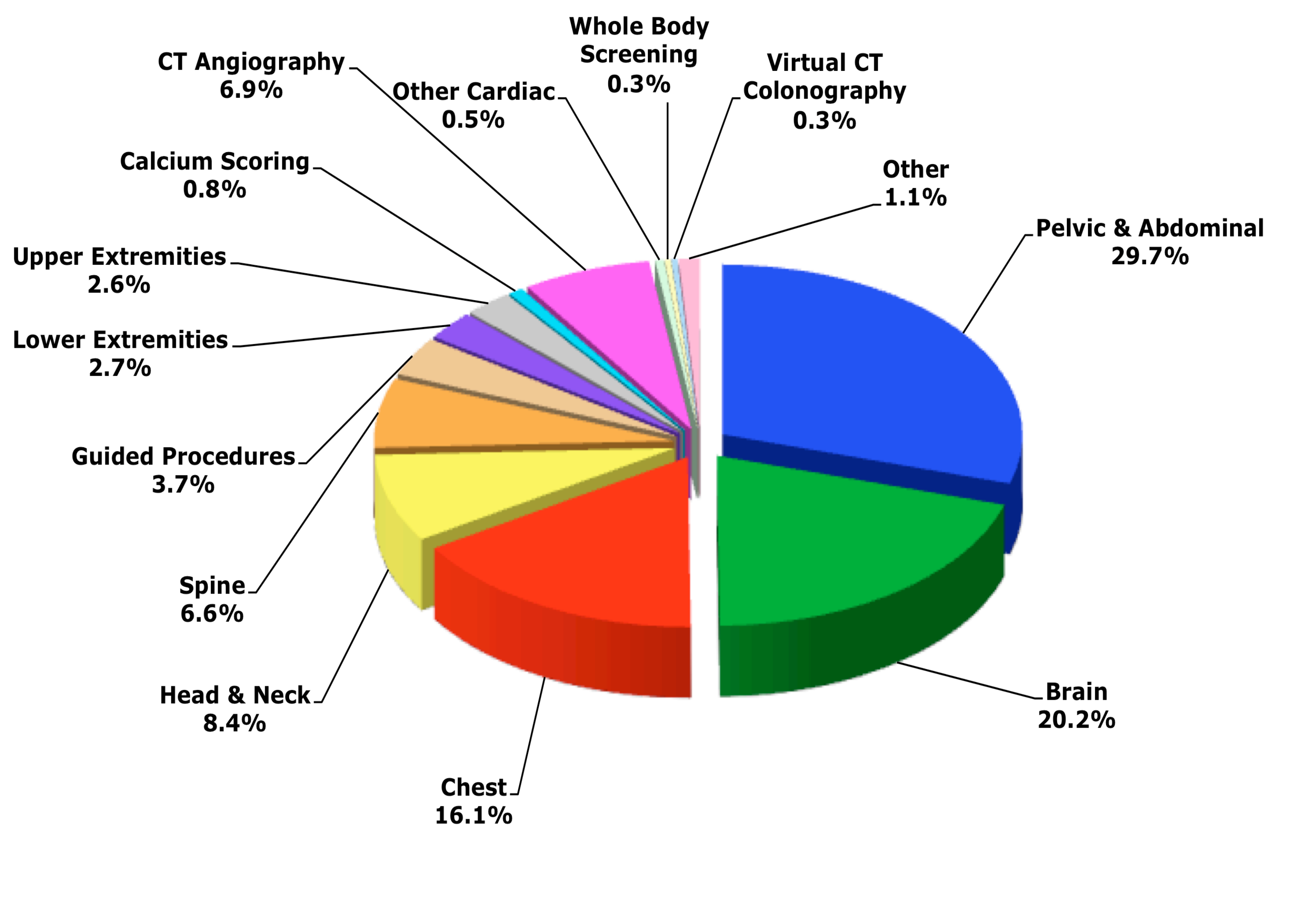
Number of CT Procedures in US



IMV Benchmark Reports on CT

2007: 68.7 million CT

Categories of CT Procedures
(62.0 million in 2006)

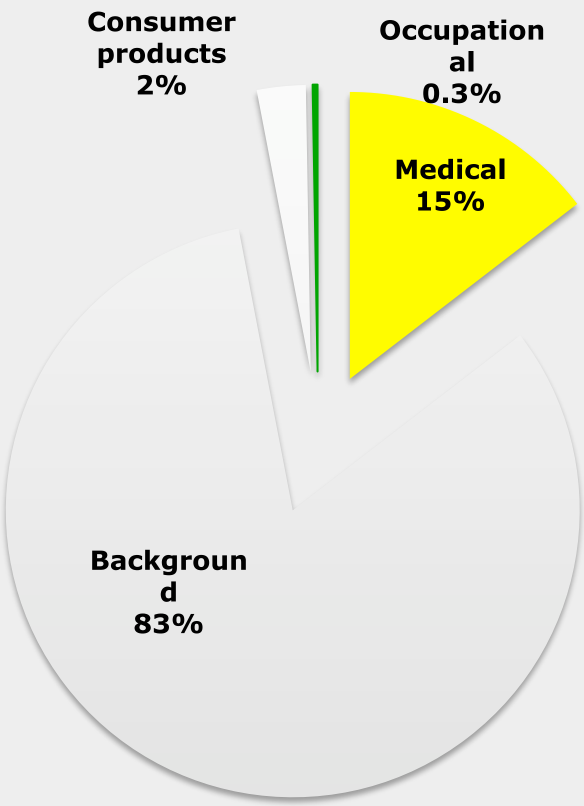


HCAP: ~80% of all CT procedures

IMV 2006

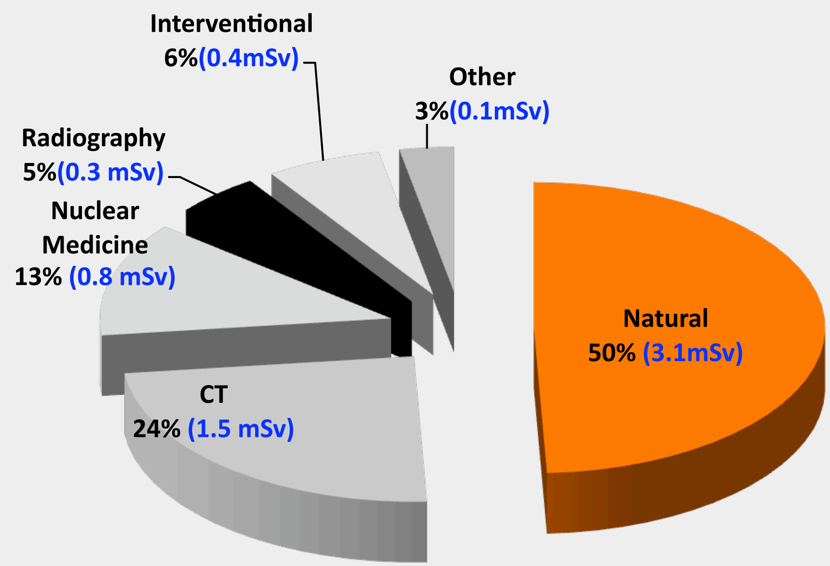
Radiation Exposure to US Population from all Sources

US 1982 (NCRP 93)



Medical 0.54 mSv per capita
Total 3.6 mSv per capita

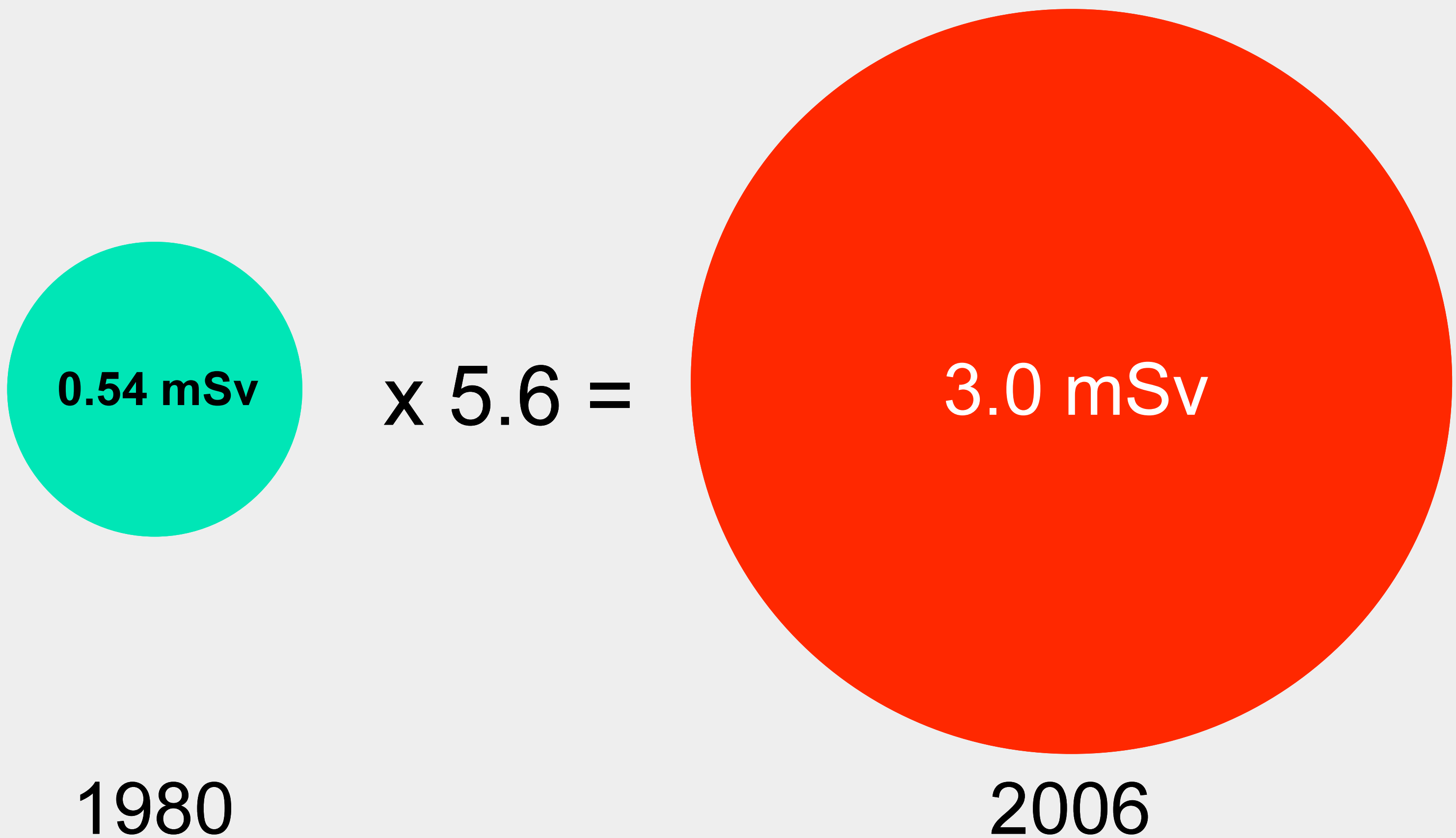
US 2006 (NCRP 160)



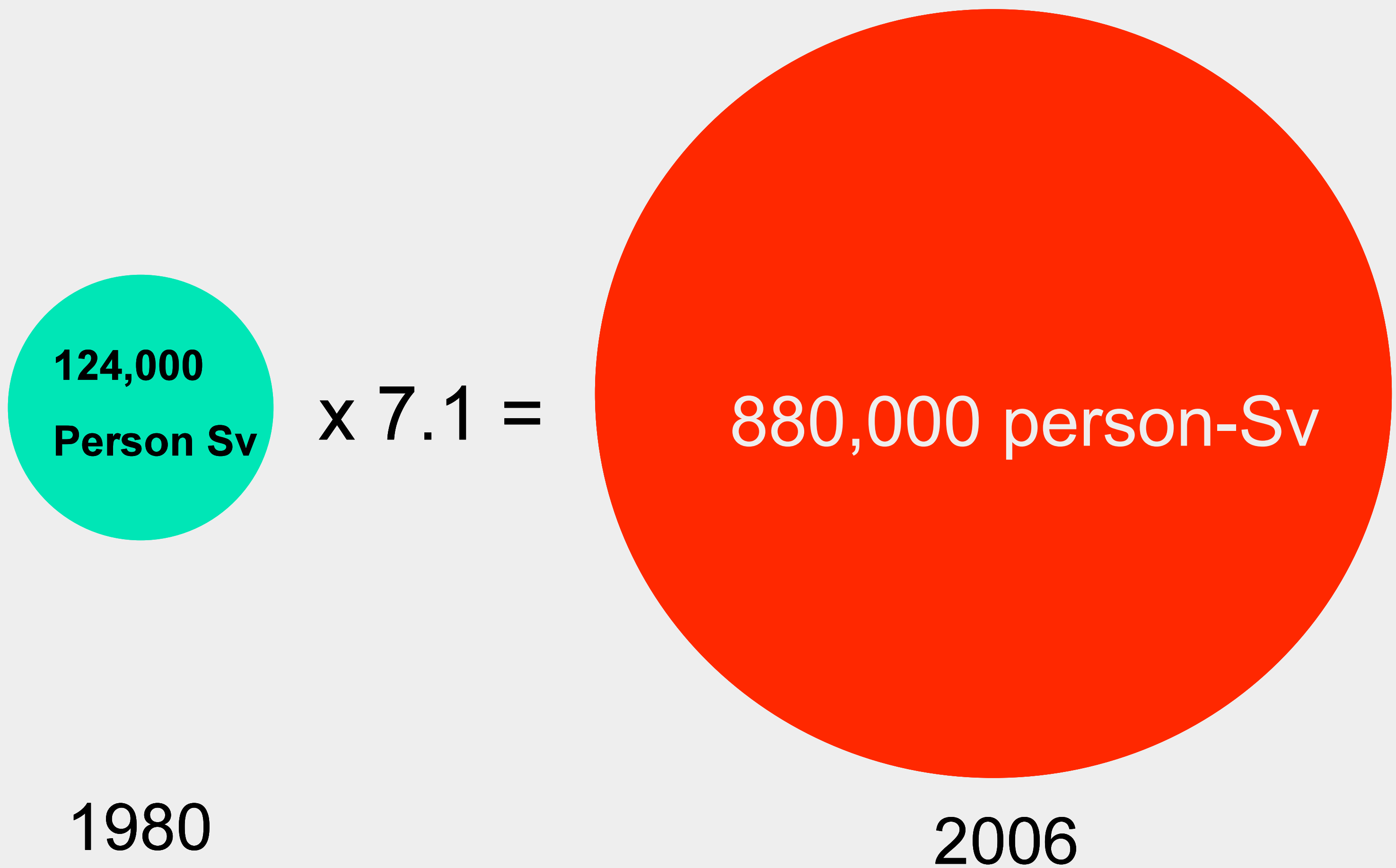
Medical 3.0 mSv per capita
Total 6.2 mSv per capita

NCRP 160 published March 2009

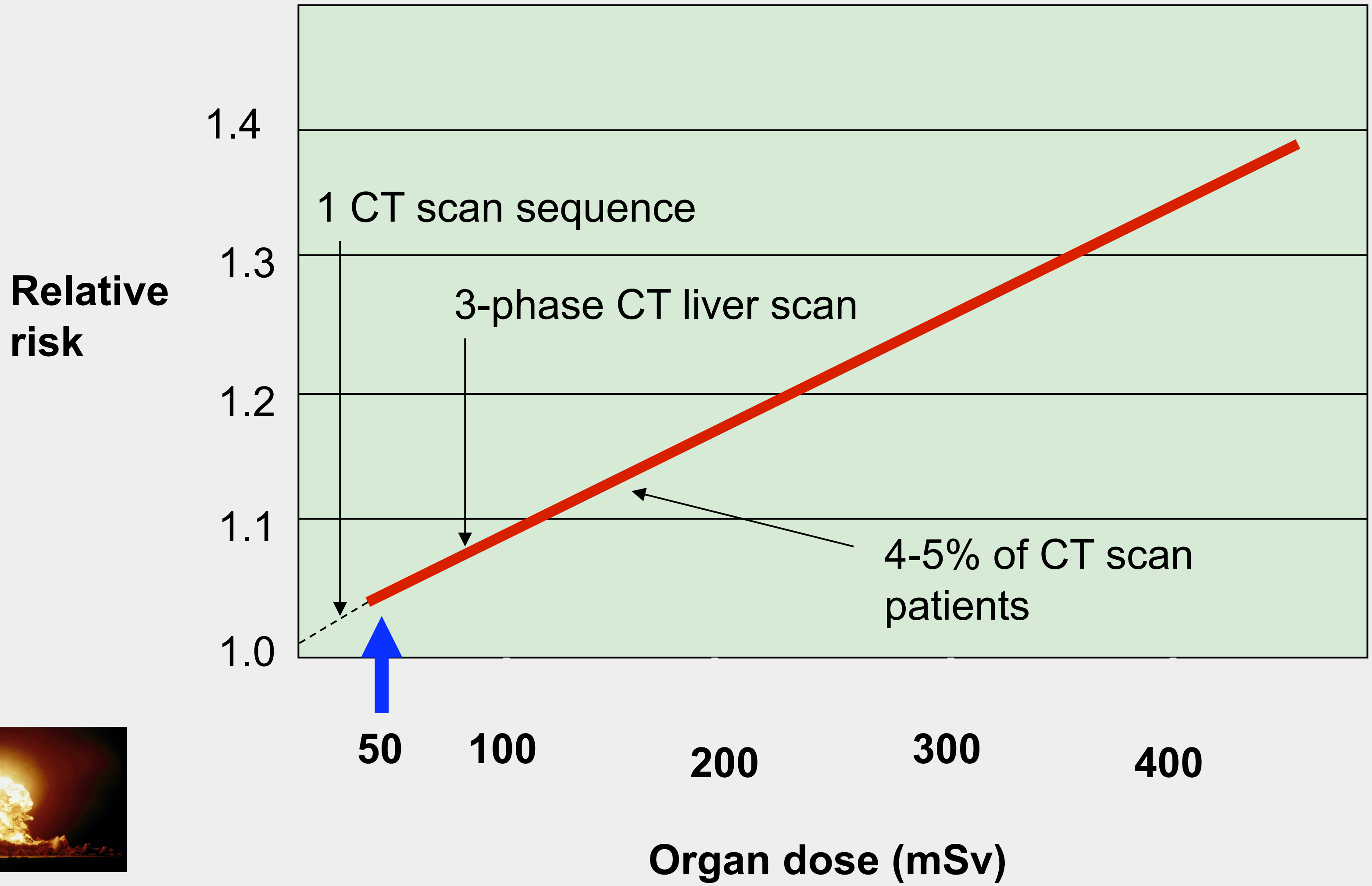
Per capita radiation dose from medicine has increased 560 percent

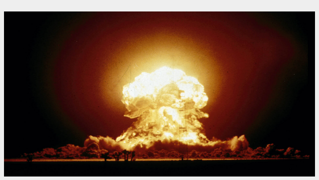


Collective annual population dose from medicine has increased over 700 percent



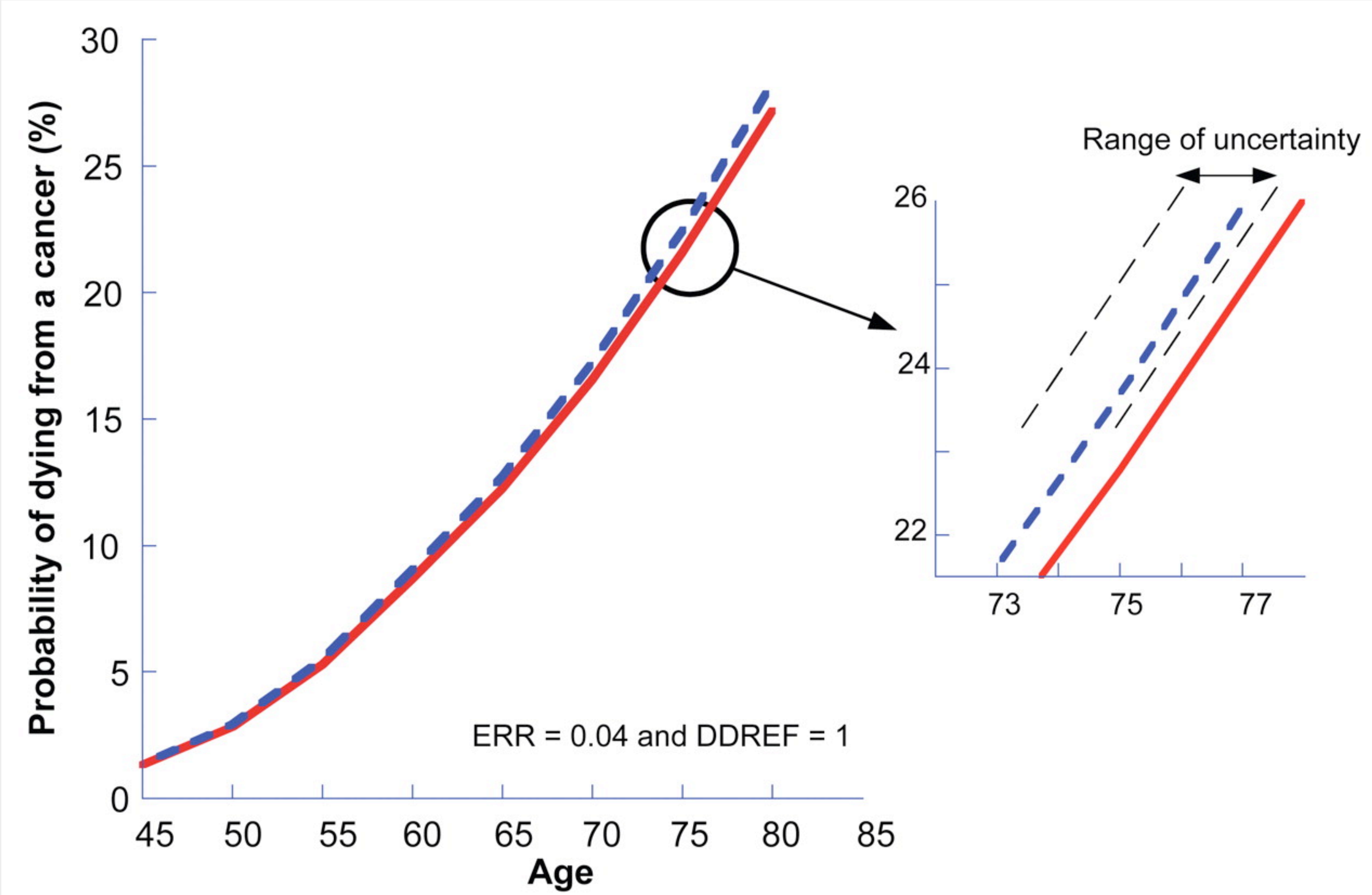
Is there a cancer risk from CT?





A-bomb data show a statistically significant increase at > 50 mSv

Graph (left) illustrates the natural risk (solid red line) of dying from cancer for a Caucasian male as a function of age.



100mSv at age 40

Verdun F R et al. Radiographics 2008;28:1807-1816

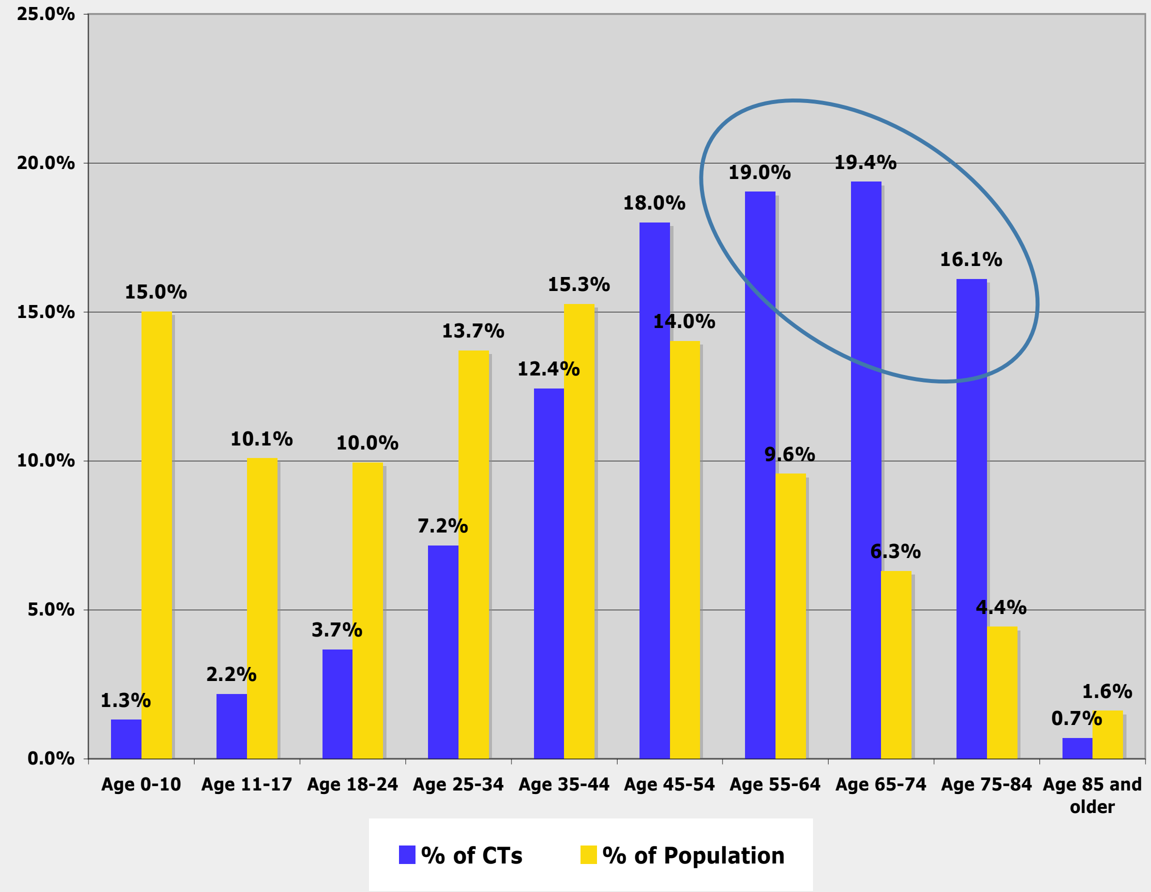
RadioGraphics

Adult Effective Doses for Various CT Procedures

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

Mettler FA, et al., Radiology, 248(1), 254-263, 2008

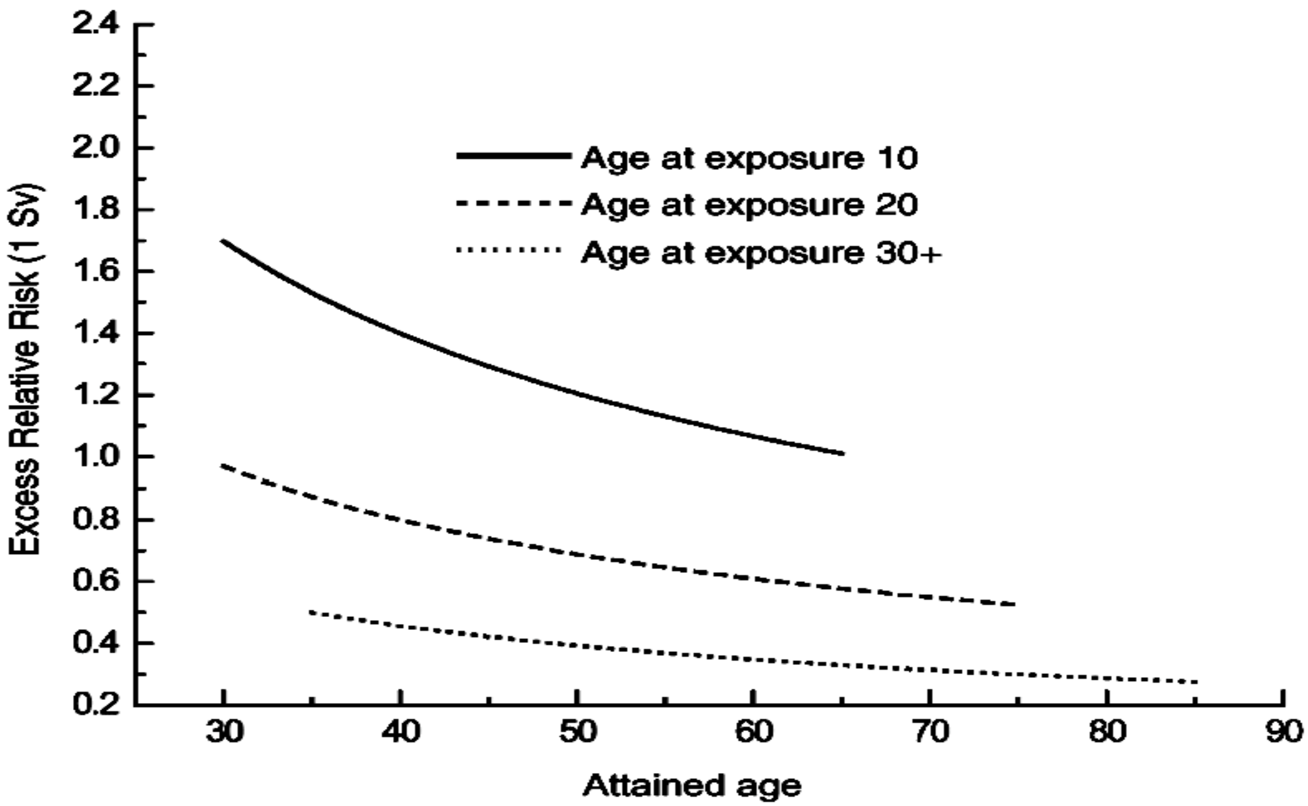
CT Scans of Abdomen and Pelvis Exam Distribution vs US Population*



~ 20% of population >55 years, receives >55% of CT scans

*** LNEP 2003**

BEIR VII ERR Model (Incidence)



NAS BEIR VII Fig 12-1 A

What might the upper estimate of risks be ?

- With assumptions of uniform population exposure and normal life expectancy etc.

  - Risk of fatal cancer from effective dose of 10 mSv from 1 CT or 1 nuclear medicine study is ~ 1/2000 or 0.05%

  - 60 million CTs <u>annually</u> in US *might* cause 30,000 fatal cancers

  - 20 million nuclear medicine exams <u>annually</u> in the US might cause 10,000 fatal cancers

U.S. FDA website

What is wrong with the analysis on the previous slide?

- Organ vs. whole-body vs. effective dose
- Linear risk estimate (solid tumors)
- Age distribution of patients
- Overestimation of dose
- Benefits not considered

Fetal Effects from Low-Level Radiation Exposure

Effect	Most Sensitive Period after Conception (d)	Threshold Dose at Which an Effect Was Observed (mGy) Animal Studies	Human Studies	Absolute Incidence*	Comments
Prenatal death	0–8		ND	ND	If the conceptus survives, it is thought to develop fully, with no radiation damage.
Preimplantation		50–100			
Postimplantation		250			
Growth retardation	8–56	10	200	ND	Atomic bomb survivors who received >200 mGy were 2–3 cm shorter and 3 kg lighter than controls and had a head circumference 1 cm smaller.
Organ malformation†	14–56	250	250	ND	None
Small head size	14–105	100	No threshold observed	0.05%–0.10%	About 25% of children with small head size were mentally retarded.
Severe mental retardation	56–105	ND	100	0.04%‡	No increase in absolute incidence was observed for exposure in the first 7 weeks or after the 25th week.
Reduction of IQ	56–105	ND	100	ND	Effects from a dose of 100 mGy or less were statistically unrecognizable. At 100 mGy or more, the IQ reduction was 0.025 points per milligray.
Childhood cancer	0–77 (first trimester)	No threshold observed	No threshold observed	0.017%§	Leukemia is the most common type of childhood cancer.

Wagner LK, Lester RG, Saldana LR. Exposure of the pregnant patient to diagnostic radiations: a guide to medical management. Madison, WI: Medical Physics Publishing, 1997.

Probability of Birth with No Malformation and No Childhood Cancer

Dose to Conceptus (mGy)	No Malformation (%)	No Childhood Cancer (%)	No Malformation and No Childhood Cancer (%)
0	96.00	99.93	95.93
0.5	95.999	99.926	95.928
1.0	95.998	99.921	95.922
2.5	95.995	99.908	95.91
5.0	95.99	99.89	95.88
10.0	95.98	99.84	95.83
50.0	95.90	99.51	95.43
100.0	95.80	99.07	94.91

Wagner LK, Hayman LA. Pregnancy and women radiologists. Radiology1982; 145: 559–562.

Estimated Conceptus Doses from Single CT Acquisition

Examination	Dose Level	Typical Conceptus Dose (mGy)
Extra-abdominal		
Head CT	Standard	0
Chest CT		
Routine	Standard	0.2
Pulmonary embolus	Standard	0.2
CT angiography of coronary arteries	Standard	0.1
Abdominal		
Abdomen, routine	Standard	4
Abdomen/pelvis, routine	Standard	25
CT angiography of aorta (chest through pelvis)	Standard	34
Abdomen/pelvis, stone protocol*	Reduced	10

McCollough CH, et al. Radiation exposure and pregnancy: When should we be concerned? Radiographics 2007; 27:909-917.

“Women should be counseled that x-ray exposure from a single diagnostic procedure does not result in harmful fetal effects. Specifically, exposure to less than 5 rad (50 mGy) has not been associated with an increase in fetal anomalies or pregnancy loss.”

American College of Obstetrics and Gynecology

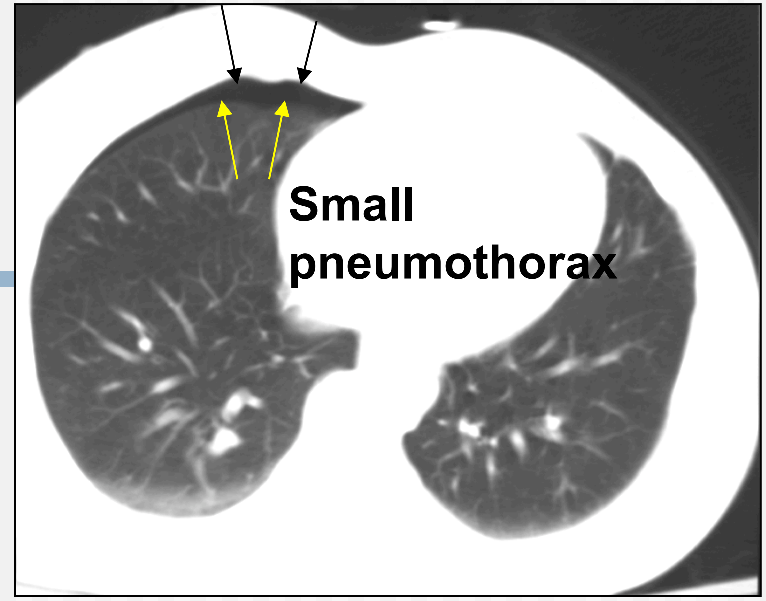
CT Use for Acute Appendicitis

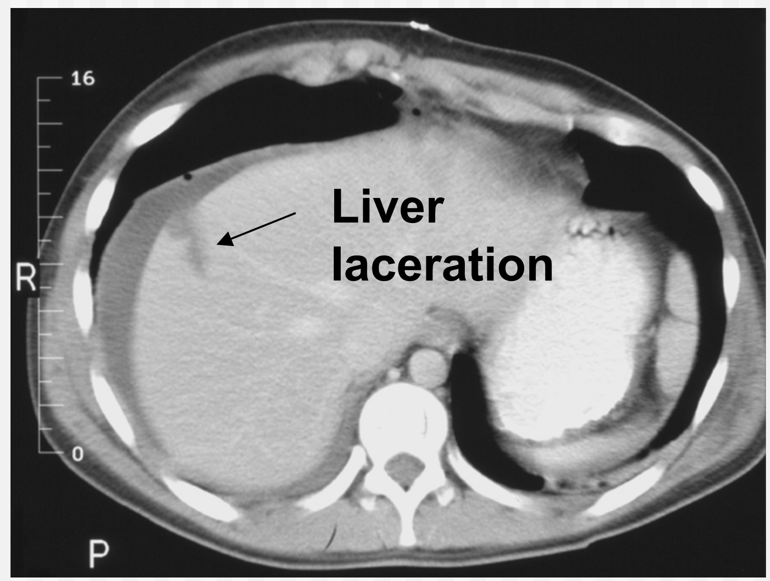
- Triad of migrating abdominal pain, RLQ abdominal pain, leukocytosis absent in 50%
- Before CT~ 15-20% of operations resulted in removal of a normal appendix
- CT accuracy 97% and now only 3% of operations yield normal appendix
- CT has a higher accuracy for alternative diagnoses

Trauma

Head, neck, chest abdomen and pelvis can be scanned in 10 seconds

Many significant findings are seen such as brain hemorrhage, small pneumothoraces and liver lacerations which are difficult or impossible to see on plain x-rays





How can we put the risk of radiation exposure into perspective?

Inappropriate Comparison of Risks

- Risk of dying from an injury over lifetime = 4.5% [NSC]
- Risk of dying from radiation-induced cancer = 5.5%/Sv
- Risks are not comparable because
  - Risk factors have different timescale (latency)
  - Medical procedures have a benefit to weigh against risk
  - Different fear factors

Comparison of adult exam dose to background radiation level	
Exam	**Reference Level (time to receive equivalent background radiation)**
Chest X-Ray PA / LAT	2.4 days / 12 days
Mammography	1 ½ months
Abdomen / Pelvis X-ray	3 months
Head CT	8 months
Thyroid scan (Tc^{99m})	1 ½ years
Abdominal CT	2 ½ years
High resolution Chest CT (e.g. pulmonary embolism, angiogram)	5 years
* Using an average background radiation level of 3 mSv/yr and Tables 8-11	

Donald Peck, PhD and Ehsan Samei, PhD

Answer True or False:

People’s perceptions of risk are often inaccurate.

Expressions of Risk Information

- Lifetime risk of 0.001
- Lifetime risk of 0.1%
- Lifetime risk of 1/1000
- In community of 1000 people, 1 expected to die

Principles of Communicating Technical Information to Patients/Public

- Tell the whole truth
- Avoid technical jargon
- Avoid absolutes
- Say only what you know
- Translate technical terms into understandable language
- Write/say simple sentences
- Ask questions for understanding

Questions Patient Should Ask

- Is this exam necessary?
- What benefits will I receive?
- Can the information be obtained without radiation?
- How much radiation will I receive?
- Can this amount be lowered?
- What is the risk from the radiation?
- Is the imaging protocol optimized? (esp. important for children)
- What is the cost of the exam?
- May I have a record of the exam and dose for my file?