Essential Imaging in Radiology

Understanding Radiation Dose

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Goals:

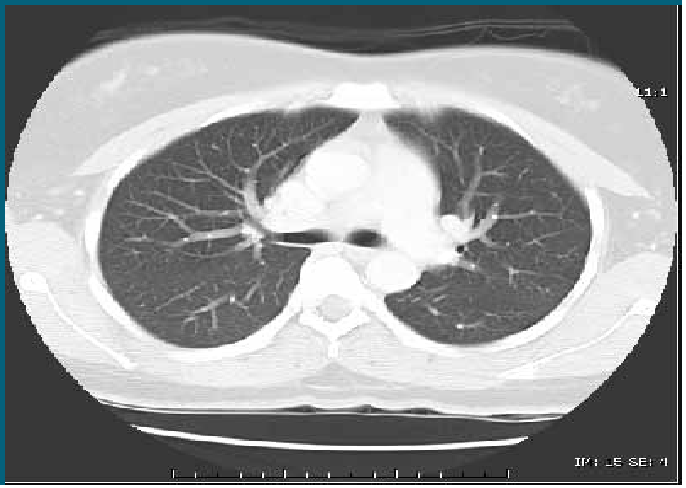
- Improved patient care with imaging
- Associated radiation doses with technology
- Upcoming and new imaging techniques

Growth of Radiation Imaging

- Growth of computed tomography (CT) and nuclear medicine examinations in the United States (approx)
- CT:
  - 1980: 3,000,000 2005: 60,000,000

- Nuclear medicine

  1980: 7,000,000 2005: 20,000,000



Wilhelm Röntgen (1845–1923),

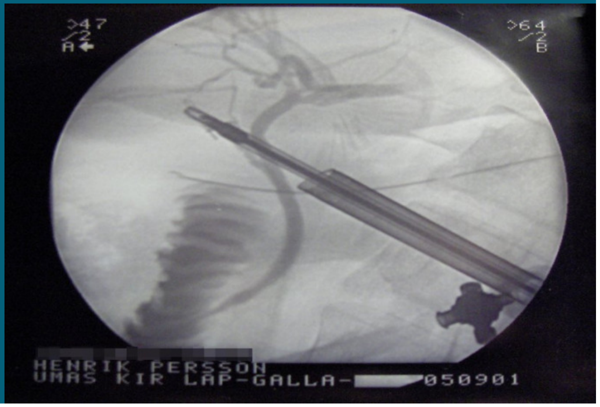
- German physicist, discoverer of XRay November 1895
- Roentgen was awarded the first Nobel Prize in Physics in 1901 in recognition of his incredible discovery of the Xray. Published 3rd and final paper on Xrays in 1897. Preferred "Xray" to "Roentgen Ray".
- Nearly two weeks after his discovery, he took the very first picture using X-rays of his wife Anna Bertha's hand. When she saw her skeleton she exlaimed   "I have seen my death!"[
- Röntgen died on 10 February 1923 from carcinoma of the intestine. It is not believed his carcinoma was a result of his work with ionizing radiation because of the brief time he spent on those investigations, and because he was one of the few pioneers in the field who used protective lead shields routinely.   (Landwehr, 1997)
- ^{111}Roentgenium

Growing Effects

- Ionizing radiation used for diagnostic purposes for over 100 years
- Remarkable equipment has increased utilization of Xray and nuclear imaging studies like multidetector row computed tomography
- International and federal interest in radiation dose from imaging: radiation safety
- Accreditation, Practice Guidelines, Appropriateness Criteria, Dose Registry, ACR Imaging Network (ACRIN@)

Why? Radiation effects

- Benefits of diagnostic imaging have revolutionized the practice of medicine
- Increased sophistication and efficacy have resulted in dramatic growth in past 25 years
- Data suggest that expanding imaging modalities using ionizing radiation may result in increased incidence of cancer in exposed population



Really? Radiation Effects

- 1987: medical XR and nuclear medicine were <15% average yearly radiation exposure in US
- Most radiation attributed to radon and other natural sources
- 2007: current annual collective dose estimate in US = total worldwide collective dose generated by Chernobyl (Mettler, 2007)
- United States has about 4.6% of the world's population, it accounts for approx 12% of all radiologic procedures and about half of all nuclear medicine procedures performed in the world (Mettler, 2009)

Growing Effects of Radiation

- Myocardial perfusion imaging contributed to 22% of total effective dose from medical imaging studies, while CT of the abdomen, pelvis, chest accounted for 38%, (Fazel, 2009).

- 2009 National Council on Radiation Protection and Measurements reported a 7-fold increase in radiation exposure to the population of the United States from medical radiation since the early 1980s (IMV, 2005).

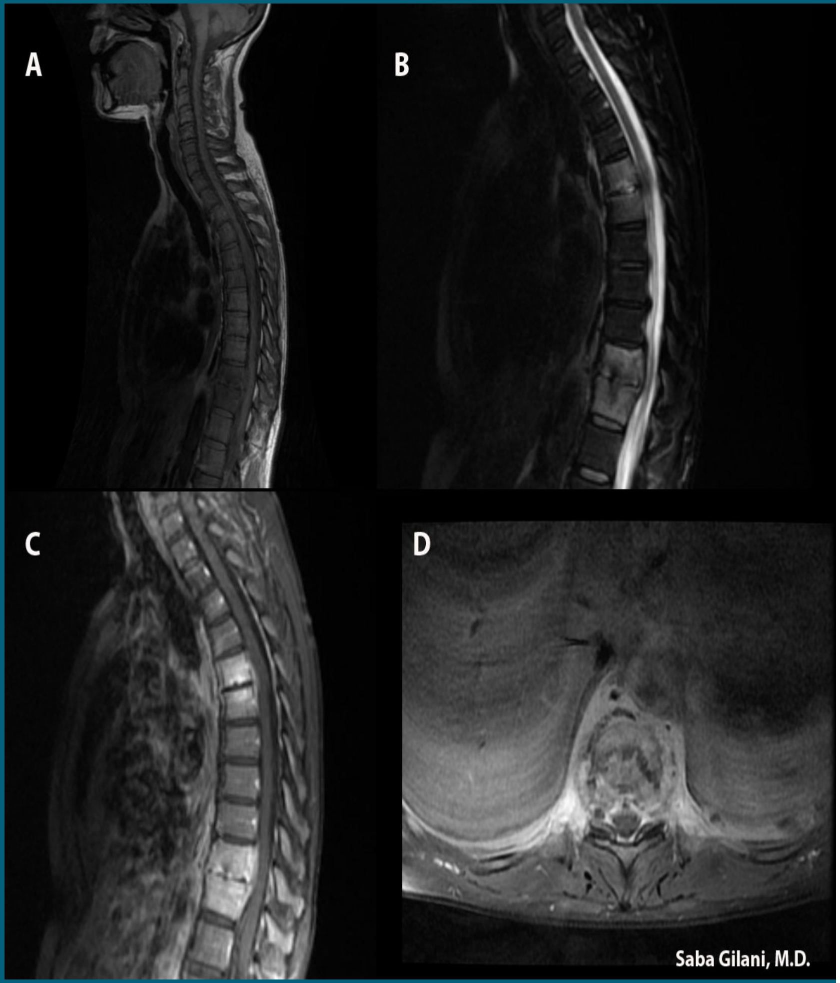
- The contribution that medical radiation makes to the US per capita average annual exposure grew from 15% in the early 1980s to 48% in 2006. *(IMV, Ionizing Radiation Exposure of the Population of the United States,* 2005).

How much is it?

- Data from comprehensive studies from atomic bomb survivors in Japan show statistically significant increase in cancer at dose estimates in excess of 50 mSv.
- CT and NM studies have effective dose estimates in range of 10-25 mSv for single workup (Regulla, 2005, Stabin, 1998)
- International Commission on Radiological Protection has reported that CT doses and nuclear medicine in patients with multiple diagnostic studies can approach or exceed levels that have been shown to result in an increase in cancer (ICRP Pub 87, 2000)

Problem solving

- Problem can be minimized by preventing inappropriate use
- Optimize studies performed to obtain best image quality and lowest radiation dose



What can we do?

- Awareness of radiation exposure for training physicians
- Physicians are an effective ally to accomplish the goal to lower medical imaging radiation exposure for all
- Most physicians lack the training in curriculum specific to radiation safety issues when considering imaging preferences, learn more
- Hoping more appropriate utilization of imaging will reduce overall radiation exposure

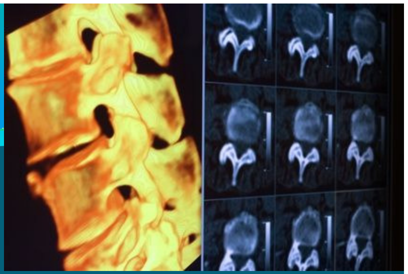
Radiologists' Challenge: we can help each other

- Clinical Acumen:
  - we need physical exam and patient history information >>>>>→ crap in = crap out

- Mastery of technology:
  - radiologists should be a wealth of information to aid in best imaging for symptoms

- Dedication to safety and quality:
  - best imaging option

Trends for Measurement



- "Dose" has been replaced with "Dose Estimate"
- Dose Estimate = Radiation measurement x Factors
- Factors include mathematical representations of human body: Abdomen accumulates more radiation dose than an ankle
- Feasibility of database entered by technologist to include age, gender, size for more accurate dose estimate per patient

Examination Reference Levels

- Average US background radiation exposure
  - 5 mSv per year
  - The National Academies of Science and the International Commission on Radiation Protection estimates an increase in cancer incidence of one new cancer in 1,000 people exposed to 10 mSv.
  - As an example, a patient has a CT and is exposed to 10 mSv. That person's lifetime risk of cancer attributed to the scan would be 1 in 1,000 or 0.1%.
  - In comparison, his or her lifetime risk of developing ANY cancer is 1 in 2.5 or 40%. (http://EzineArticles.com/4459837)

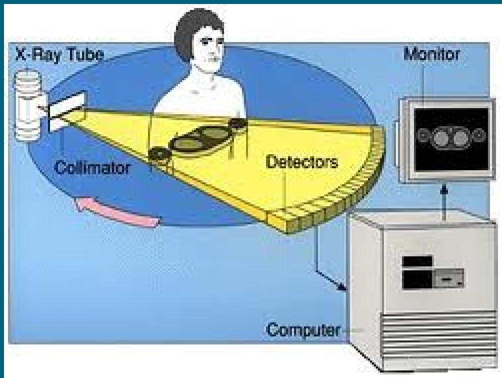
Examination Reference Levels

- CT head 2 mSv (effective dose 100 CXR)
- CT adult abdomen 10 mSv (500 CXR)
- Abdomen XR .7 mSv (35 CXR)
- VQ scan 1.3 mSv (65 CXR)
- CT chest 8 mSv (400 CXR)
- PA CXR .02 mSv (1 CXR)
- L-spine XR 1 mSv (50 CXR)
- L-spine CT 19 mSv (950 CXR)
- CT T-spine 18 mSv (900 CXR)
- BE 7.2 mSv (360 CXR)
- Dynamic cardiac CT 6 mSv (300)
- Thyroid (Tc99m) 1 mSv (50 CXR)
- Bone scan 4 mSv (200 CXR)
- Digital Mammo 0.4mSv (15 CXR)
- Coronary angio or cath 15 mSV (750 CXR)
- PET Imaging 5 mSv (250 CXR)

(Weinberg, 2010)

Well established lower dose controls:

- automatic exposure control
- automatic prefilter exchange
- adjustable pulse frequency down to 0.5 frames per second,
- radiation-free adjustment of the primary and semitransparent collimators,
- object positioning without radiation
- measurement and display of the active area dose product and the accumulated skin dose
- removable grids, and the
- option to store fluoro images



Advanced exposure controls in New Technologies

- To further reduce patient radiation dose by varying detector doses.
- Short pulse widths prevent motion blurring for small and fast-moving objects.
- New algorithms can distinguish between noise and signal, enabling them to amplify the signal and reduce the noise.
- Super-resolution technique can improve the image resolution beyond the pixel resolution.

ACR, RSNA: Joint Task Force on Adult Radiation Protection

- Image Wisely:
  - A Campaign to Increase Awareness about Adult Radiation Protection

- The task force's mission:
  - to raise awareness of opportunities to eliminate unnecessary imaging examinations
  - to lower the amount of radiation used in necessary imaging examinations
  - only that needed to acquire appropriate medical images

One size does not fit all…

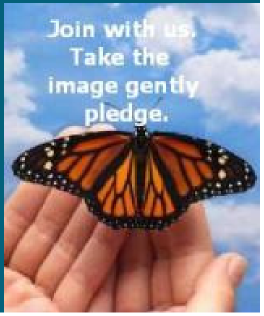
There's no question: X-rays help us save kids' lives. But when we image, radiation matters!   Children are more sensitive to radiation. What we do now lasts their lifetimes. So, when we image, let's image gently.

Initially focused on CT imaging , now covers CT, NM, XR, fluoroscopy, IR

The Alliance for Radiation Safety in Pediatric Imaging

Formed in 2007 as a coalition of health care organizations dedicated to promoting safe, high-quality pediatric imaging nationwide

The *Image Gently* Campaign is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The campaign goal is to change practice by increasing awareness of the opportunities to promote radiation protection in the imaging of children.



One size does not fit all…

Image gently: More is often not better.

When CT is the right thing to do:

Child size the kVp and mA

One scan (single phase) is often enough

Scan only the indicated area

More is often not better.

When X-ray is the right thing to do:

Measure patient thickness for "child-size" technique

Avoid using grids for body parts less than 10 - 12 cm thick

X-ray only the indicated area with proper collimation and shielding

Check exposure indicators and image quality

Image kids with care:
Pause and child-size the technique
use the lowest *Pulse* rate possible.
Consider ultrasound or MRI when possible.

Treat kids with care:

Interventional Radiology

Step lightly on the fluoroscopy pedal.

Stop and child-size the technique.

Consider ultrasound or, when applicable, MRI guidance

Guidelines!

Follow the new North American Guidelines for Pediatric Nuclear Medicine for high quality images at low radiation dose.

Use Ultrasound when possible.

No radiation is used for Ultrasound exams.

Using Ultrasound is a real opportunity to lower radiation dose in the imaging of children.

Review:

- Very fortunate to have such great technology at our fingertips
- Knowledge is power
- Not only should we seek information in imaging, but we should team up to image effectively for patients health and safety
- Image Wisely@, Image Gently@

Thank you !!

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