Evolution of Radiology: For Non-Radiologists

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  - ✓5 Fellows
- Chief Bone CT

www.radiology.wisc.edu

Nov 8th, 1895: The Birth of Radiology

- 11/8/95 Wilhelm Conrad Röntgen produces "X-rays"
- 12/28/95 Röntgen presents: "On a New Kind of Rays"
- 2/11/96 Jones publishes: "The Discovery of a Bullet Lost in the Wrist by Means of the Roentgen Rays"

First Radiograph
Röntgen's wife

1901:Röntgen wins 1st Nobel prize in physics

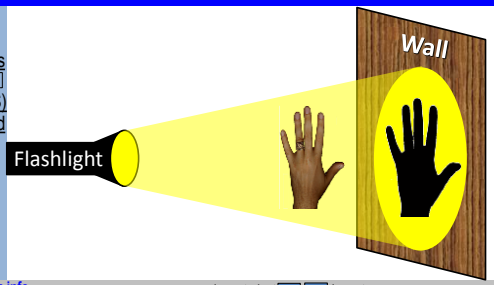
How We Make Photographs

Light rays bounce off my hand and into my camera.

We call the image:

- ~~"Light-Ray"~~
- "Photograph"
  - ✓Image of the light photons that bounce off my hand and into my image capture device.

How We Make Shadows



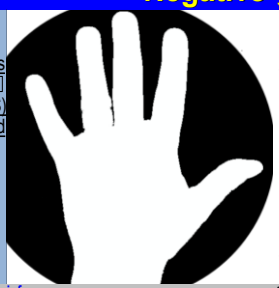
"Shadow-graph"

Everywhere hand blocks the light is dark…

Everywhere hand doesn't block the light is illuminated.

Now, if we hang photographic film on wall we get…

"Negative-graph"



Everywhere hand blocks light the film is *not* exposed and stays white...

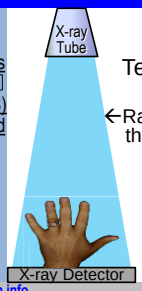
Everywhere hand doesn't block the light the film *gets* exposed and turns dark.

Evolution of Radiology: For Non-Radiologists

Evolution of Radiology An Introduction for Non-Radiologists

How We Make Radiographs

TOPICS
- Radiographs
- CT
- X-rays(EMS)
- Nuclear Med
- Ultrasound
- MRI
- Physics
- Coils
- Magnets
- Safety
- WOW



Terminology:
"X-rays":
←Rays that pass thru the patient.
The image→ is called a "radiograph"

Evolution of Radiology An Introduction for Non-Radiologists

20th Century: Images = Film

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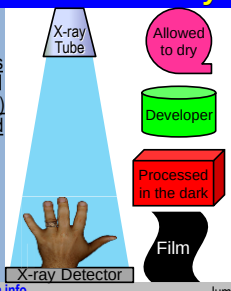

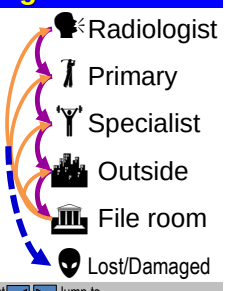

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21st Century: Images = Film

TOPICS
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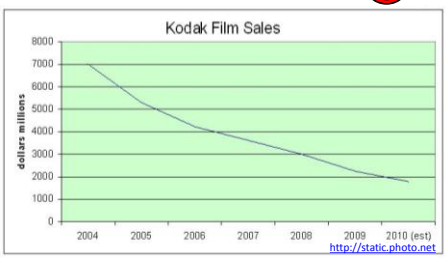

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21st Century: Digital Imaging

TOPICS
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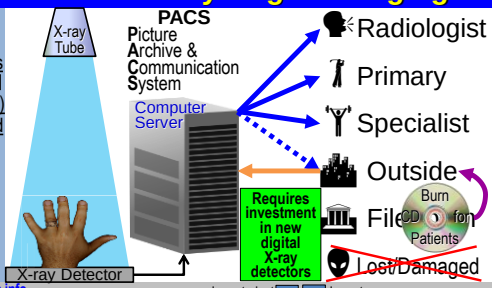

Evolution of Radiology An Introduction for Non-Radiologists

Old Terms Still Used

TOPICS
- Radiographs
- CT
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"Film": What I tend to call radiographs
"Wet read": Look at the film STAT
➢Refers to when we would look at films right out of the developing solution, before they had time to dry.
"Dial a telephone"
"Ring tones"

Evolution of Radiology An Introduction for Non-Radiologists

Radiographs are Limited

TOPICS
- Radiographs
- CT
- X-rays(EMS)
- Nuclear Med
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- Magnets
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- WOW

Radiographs can detect only four densities of tissue:
Metal (white)
Bones (light gray)
Soft Tissues (dark gray)
All soft tissues look the same on radiographs:
✓Muscles/Tendons
✓Vessels/Nerves
✓Organs/Blood
Air (black)

X-rays as Diagnostic Tool

Can see:

- Bones
  - ✓Fractures
- Joint width, surfaces
  - ✓Arthritis
    - ❖Osteophytes
    - ❖Erosions

Can't see:

- Inside skull
  - ✓Can't see the brain
- Inside joints
  - ✓Can't see tears
    - ❖Ligaments, Tendons
    - ❖Menisci, Cartilage

Radiographs: 2D projection of 3D patient

- Radiographs flatten everything
  - ✓Can't tell what's in front, what's behind
- With radiographs: NEED MULTIPLE VIEWS!

"One view = No views"

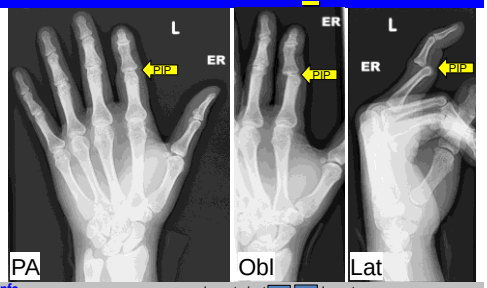
"One view = No views"

Need Multiple Views

Small finger

- Not a subtle fracture
- Fragment overlap each other so perfectly on PA view, are undetectable

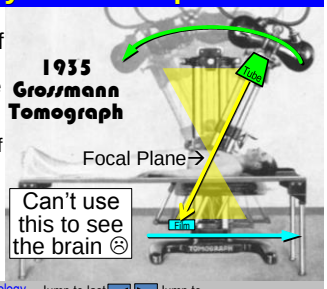
For Joints: Need 3 Views!



Tomography: Small Step Forward

To overcome flat 2D nature of radiographs…

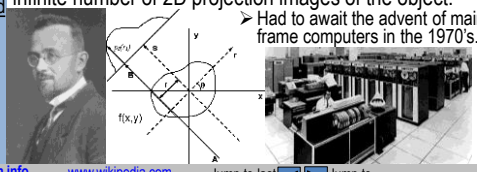
- Structures in the Focal Plane → are in focus.
- Structures out of focal plane are blurred out.
- At best, we got blurry pictures.
- Long exposures = high radiation.



CT: Giant Leap Forward

CT: Computed Tomography (*Tomo* [Gr]: part, slice)
CAT: Computed Axial Tomography
1917 Johann Radon, Austrian mathematician, proved image of a 3D object could be reconstructed from an infinite number of 2D projection images of the object.

- Had to await the advent of main-frame computers in the 1970's.

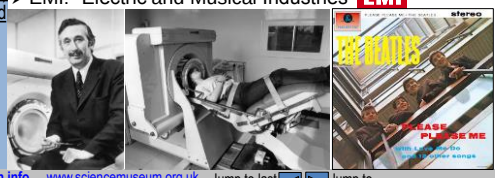


Evolution of Radiology: For Non-Radiologists

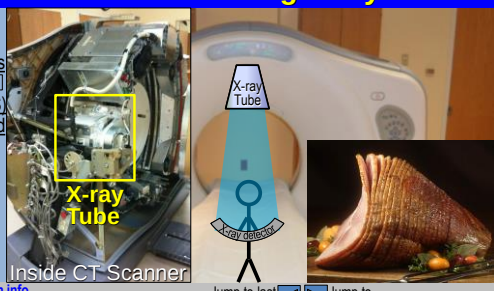
Hounsfield & EMI Brain Scanner

1972: Godfrey Hounsfield, a British electrical engineer at EMI Laboratories, developed EMI Brain Scanner.

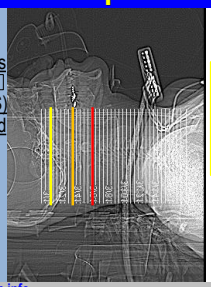
- **Finally, could see through the skull into the brain!**
  - ✓Awarded Nobel Prize for Medicine 1979; Knighted 1981.
  - ✓"Hounsfield Units" is the scale we use to measure CT density.
- EMI: "Electric and Musical Industries"



CT = Rotating X-rays

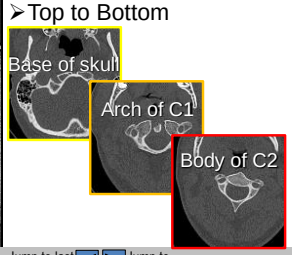


Computed AXIAL Tomography

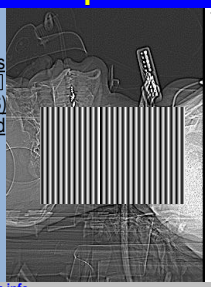


Axial Plane:

- Top to Bottom



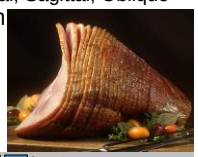
Computed VOLUME Tomography



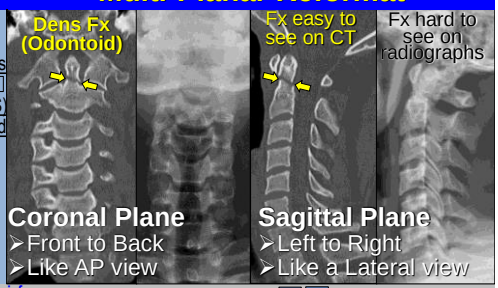
Thin, continuous slices= Solid volume of data

Can reformat data:

- Any 2-D plane
  - ✓Coronal, Sagittal, Oblique
- Even in 3-D!



Multi-Planar Reformat



Why CT is So Great

Can see fractures otherwise missed

- ➢Cervical spine, pelvis

Can see the brain!

- ➢Strokes, bleeds, tumors

Can see organs (lungs, liver, bowel)

- ➢Tumors, trauma, acute/chronic diseases

And now with ultra-fast, multi-slice…

- ➢Can scan the heart in a single beat!
  - ✓Can see coronary arteries, pulmonary emboli

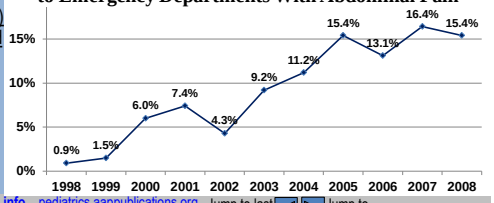
Hospitals have CT scanners in the ER

Evolution of Radiology: For Non-Radiologists

CT Usage Increasing in ERs

Pediatrics Nov 2012 Vol 130, # 5, p 1–7 PEDIATRICS Published online October 8, 2012

Computed Tomography Use Among Children Presenting to Emergency Departments With Abdominal Pain



Problems with CT

Usually requires IV contrast
- 1% patients are allergic to CT contrast
- Can affect renal function

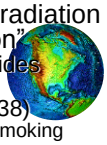
Costs more than radiographs
- Knee radiographs (4 views): $154
- Knee CT (no contrast): $1,200

Can't see structures inside joints
- Knee: Menisci, Ligaments, Cartilage
- Shoulder: Rotator Cuff, Labrum
- Spine: Disks, Spinal Cord

☢ Biggest Problem with CT ☢

High radiation dose

We are exposed to low levels of radiation every day, "Background Radiation"



- Earth: naturally occurring radionuclides
  - ✓Uranium-238, potassium-40
- Atmosphere: Radon-222 (from U-238)
  - ✓2nd leading cause of lung cancer after smoking
- Space: cosmic rays
  - ✓Airline crews are more exposed to cosmic rays, doubling their background exposure.

Ave background dose ≈ 2.4mSv/year

☢ Radiation from Diagnostic Imaging ☢

Ave background dose ≈ 2.4mSv/year

Chest Radiograph ≈ 0.06mSv
- ≈1 week of background radiation

Chest CT ≈ 7.0mSv
- ***≈3 YEARS of background radiation***

How much radiation is too much?

The American Association of Physicists in Medicine

*"Risks of medical imaging at effective doses below **50 mSv** for single procedures or **100 mSv** for multiple procedures over short time periods are too low to be detectable and may be nonexistent."*

What are X-rays?

X-rays are not naturally occurring
- Produced by X-ray tubes
- Used for diagnostic imaging
  - ✓Radiographs
  - ✓Tomography
  - ✓CT
  - ✓Fluoroscopy (radiographs in real-time)
- Used for radiation therapy
  - ✓Treating tumors
  - ✓Orders of magnitude higher radiation dose than in diagnostic imaging

X-rays part of Electromagnetic Spectrum

Electromagnetic Spectrum

Evolution of Radiology: For Non-Radiologists

Electromagnetic Spectrum

Iguaçu (Iguazú) Falls
Brazil-Argentina Border

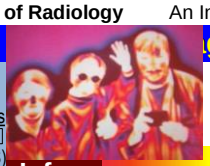
Electromagnetic Spectrum

R O Y G B I V

Visible Light

This is the part of the EMS we can see.
But there's much more…

Electromagnetic Spectrum



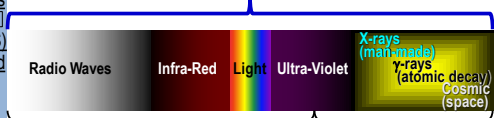
Infra-Red Visible Light Ultra-Violet

Infrared (below red)
- IR: Heat Vision
  - ✓Nocturnal animals

Ultraviolet (above violet)
- UV: Sun Tans/Burns
  - ✓Bees see in UV

Electromagnetic Spectrum

The Way Energy Moves Throughout the Universe



Non-Ionizing Radiation
- No Free Radicals
- Doesn't Damage DNA
- May cause Heat Damage

Ionizing Radiation
- Detach Electrons
  - ✓Atoms ionized
  - ✓"Free Radicals"
- Damage DNA

Electromagnetic Spectrum

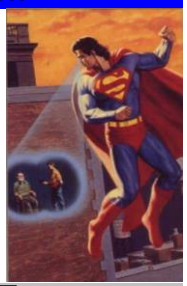
To Perceive Energy
- Detector sensitive to energy frequency
  - ✓Human retina sensitive to visible light
- Energy able to reach the detector

"X-ray Vision Specs" even if they *could* detect X-rays they still wouldn't work…

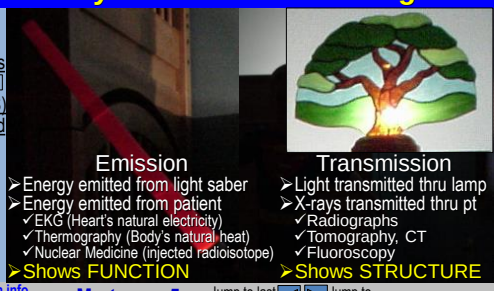
There are no naturally occurring X-rays out there to detect!

X-ray Vision

"SUPERMAN IS ABLE TO FOCUS ON OBJECTS FAR BEYOND THE RANGE OF NORMAL HUMAN SIGHT. HIS EYES CAN PERCEIVE *VIRTUALLY THE ENTIRE ELECTROMAGNETIC SPECTRUM*, ENABLING HIM TO SEE THROUGH MOST SOLID OBJECTS."



Ways we can Perceive Light



Emission
- ➢Energy emitted from light saber
- ➢Energy emitted from patient
  - ✓EKG (Heart's natural electricity)
  - ✓Thermography (Body's natural heat)
  - ✓Nuclear Medicine (injected radioisotope)
- ➢Shows FUNCTION

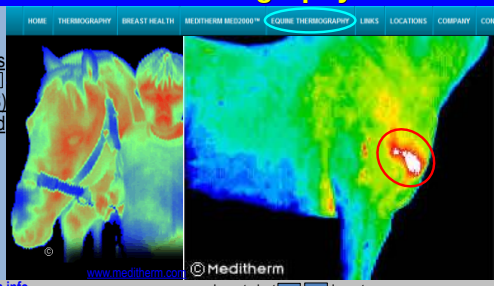
Transmission
- ➢Light transmitted thru lamp
- ➢X-rays transmitted thru pt
  - ✓Radiographs
  - ✓Tomography, CT
  - ✓Fluoroscopy
- ➢Shows STRUCTURE

Marty age 5

Thermography

Images patient's naturally emitted heat energy.
Widely agreed to be of NO diagnostic value.

Thermography



Nuclear Medicine

Developed after World War II
Research on nuclear bomb byproducts
- ➢Fission Uranium-235 → Iodine-131

Iodine

Naturally occurring element
- ➢Rare on Earth (47th abundant)
- ➢Rare in Humans (<0.05%)
  - ✓Taken up by Thyroid Gland
  - ❖Made into Thyroid Hormone

Used in X-ray contrast dye

Nuclear Medicine

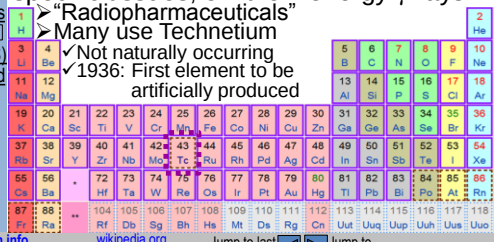
Developed after World War II
Research on nuclear bomb byproducts
- ➢Fission Uranium-235 → Iodine-131

Naturally occurring Iodine not radioactive
Iodine-131 is HIGHLY radioactive
- ➢Emits β-particles
  - ✓Much more damaging than γ-rays
- ➢Accumulate in and destroys Thyroid tissue
- ☹ Nuclear Reactor Fallout → Hypothyroid
  - ✓Take Iodine pills to block I-131 from Thyroid
- ☺ Useful for treating Thyroid Cancer

Nuclear Medicine

Developed more agents to accumulate in specific tissues, emit low-energy γ-rays.

- ➢"Radiopharmaceuticals"
- ➢Many use Technetium
  - ✓Not naturally occurring
  - ✓1936: First element to be artificially produced



Nuclear Medicine

Technetium-99m: Ideal Imaging Agent

- ➢Short half-life (6 hours)
  - ✓After 24 hours 94% gone
- ➢Emits γ-rays
  - ✓γ-rays pass out of the patient without accumulating
- ➢Good energy for gamma-camera detection
  - ✓Dual-head cameras: Image γ-rays emitted front & back

Nuclear Medicine: Bone Scan

Was used a lot before CT & MR

- ➢Shows bone pathology earlier than radiographs

Nowadays, seldom used for *focal* lesions

We use MR for:

- ➢Focal bone pain not seen on radiographs
- ➢Infections (osteomyelitis)
- ➢Imaging primary bone tumors

We *still* use Nuc Med Bone Scans for:

- ➢Looking for bone metastases in *entire body*
  - ✓Breast Cancer
  - ✓Prostate Cancer

Nuclear Medicine: PET/CT

Most recent innovation in Nuc Med

PET: Positron Emission Tomography

- ➢Uses agents with *very* short half-lives
  - ✓Flourine-18 (100 min)
  - ✓Oxygen-15 (2 minutes)
  - ✓Made onsite with cyclotron
- ➢Agents taken up by tumors, metastases
- ➢**Well shows abnormal FUNCTION**

Combined with CT (Computed Tomography)

- ➢**Well shows underlying ANATOMY**

Used for staging cancer patients

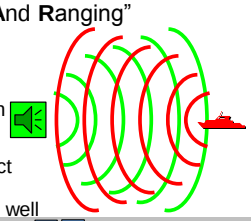
Ways we can Perceive Light

Ultrasound

Developed after World War II

Based upon **SONAR**

- ➢"**SO**und **N**avigation **A**nd **R**anging"
  - ✓Sound wave sent out
  - ✓If sound hits an object get reflected back
  - ✓Measure time for the reflected echo to return
  - ✓Multiplying the time by speed of sound (÷2) = distance from the object
- ➢Works best in water
  - ✓Water transmits sound well



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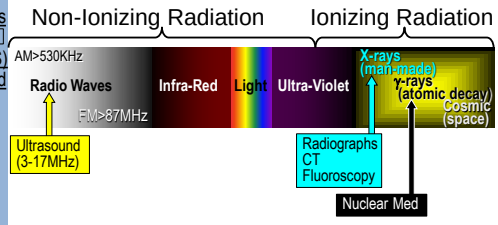
Sonography

Uses radio waves (Not X-rays, γ-rays)



Sonography Useful for…

Tissues that contain/surrounded by water
- ➢Abdominal organs
  - ✓Gall bladder (Gall Stones)
  - ✓Kidneys (Kidney Stones)
- ➢Blood vessels
  - ✓Blood clots (DVT: Deep Venous Thrombosis)

Imaging without Ionizing Radiation
- ➢Pelvic organs
  - ✓Uterus, Ovaries
  - ✓Testes
- ➢Babies (Newborn)
- ➢Babies… before birth

Obstetric Ultrasound

Marty age -5 months

Next… MRI

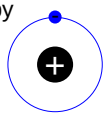
MRI: Giant Leap Sideways

MRI doesn't rely on X-rays to see projected shadows of patients
- ➢Unlike radiographs, CT, fluoroscopy

MRI sees tissues based upon sub-atomic characteristics
- ➢Proton nucleus of Hydrogen

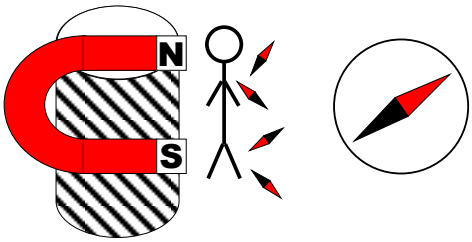
"NMR"
- ➢"~~Nuclear~~ Magnetic Resonance"
- ➢*"No More Radiologists"*

MRI
- ➢"Magnetic Resonance Imaging"



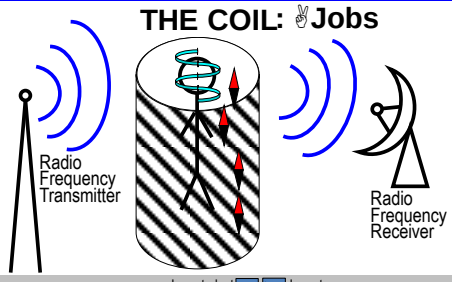
MRI Scanner: 2 Components

THE MAGNET



MRI Scanner: 2 Components

THE COIL: ✌Jobs



How MR Scanner Works

Magnet

- ➢Aligns spins of protons in hydrogen nuclei
  - ✓Align in direction of magnetic field, B_0

Coil

1) Sends RF pulse to flip spinning protons
   - ✓After RF pulse is off, protons realign to B_0
   - ✓As protons realign, resonate RF energy
2) Measures strength of resonant RF echo
   - ✓**At a specific time, T_E, "Echo Time"**

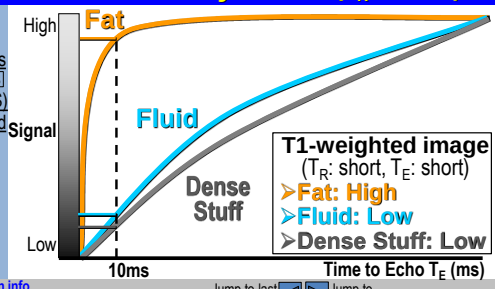
Steps 1&2 repeated many times / image slice
- ✓**At a specific "Repetition Time", T_R**

🗝 Key to MRI

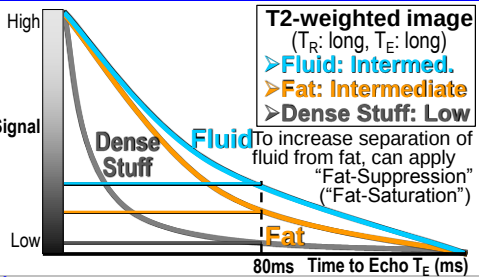
Specific tissue types have specific resonant echoes (T1, T2) depending upon specified T_R & T_E

- ➢**Fluid (Hydrogen protons in H_2O)**
  - ✓Cysts
  - ✓Joint effusions
  - ✓Edema (in soft tissues, in bone marrow)
- ➢**Fat (Hydrogen protons in fat)**
  - ✓Sub-cutaneous fat
  - ✓Fatty yellow bone marrow
- ➢**Dense Stuff (with few Hydrogen protons)**
  - ✓Cortical bone
  - ✓Ligaments, tendons
  - ✓Menisci

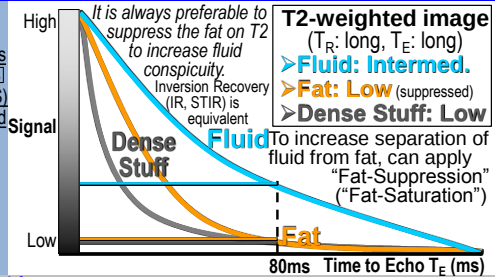
T1 Recovery Curve (T_R~500ms)



T2 Decay Curve (T_R~2,000ms)

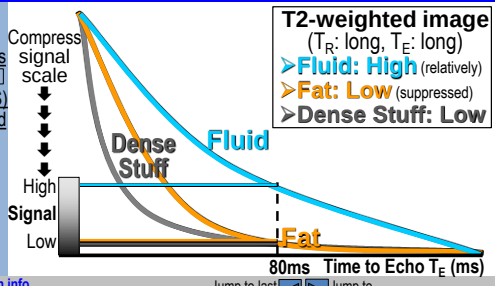


Fat-Sat T2 Decay Curve (T_R~2,000ms)



Evolution of Radiology: For Non-Radiologists

Fat-Sat T2 Decay Curve (T_R~2,000ms)



How We Make MR Images

Magnetic field divides body into slices

Each slice is subdivided into "voxels"

- voxel: 3D pixel
- voxel size = 2D pixel size X slice thickness

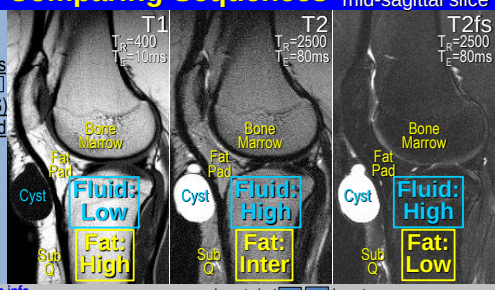
Coil measures signal in each voxel

Computer maps this onto 2D slices

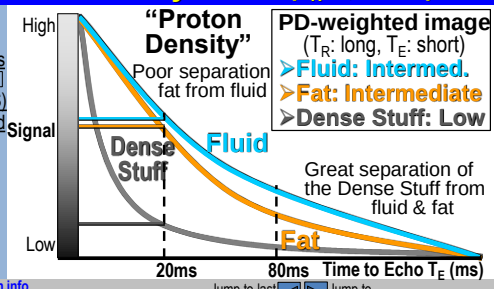
- **High signal: White ("Bright")**
- **Intermediate signal: Gray ("Iso-intense")**
- **Low signal: Black ("Dark")**

Comparing Sequences

Knee, same mid-sagittal slice

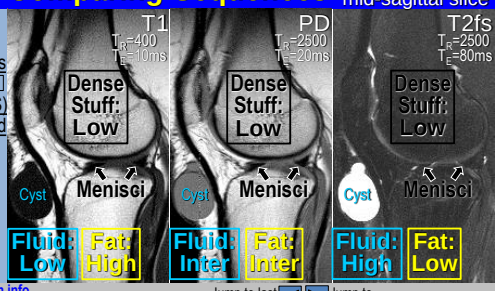


T2 Decay Curve (T_R~2,000ms)



Comparing Sequences

Knee, same mid-sagittal slice



MRI: Need Multiple Sequences

T1 shows Fat best

- Most normal anatomy surrounded by fat
- In essence, T1 shows anatomy best

T2 shows Fluid best

- Most pathology contains fluid (edema)
- In essence, T2 shows pathology best
  - ✓Fat-suppression makes fluid more conspicuous

PD shows Dense Stuff best

- Good for meniscal and tendon tears
- Used mostly for MRI of joint pain

Evolution of Radiology: For Non-Radiologists

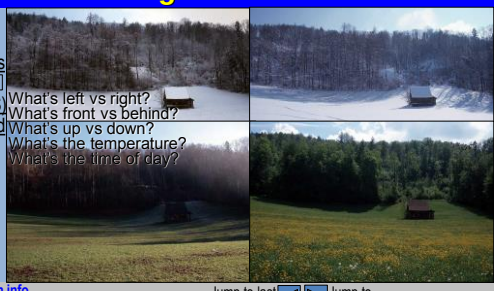
Seeing in 4-Dimensions

Radiographs are flat projections
- Only give information in 2-D
- Need 2+ projections to fully see patient

CT is a stack of slices
- Images the patient in 3-D

MR is a stack of slices… and more
- Not only shows tissues in 3-D
- It shows the composition of the tissues
  - ✓T1: How Fatty, T2: How Wet
- MR shows *more than* just 3-D

Seeing in 5-Dimensions!



Seeing in 5-Dimensions!

Limitations of MRI

Limited Field of View (FOV)

Image resolution related to voxel size
- Smaller FOV = smaller voxels
- Smaller voxels = higher resolution
- To maximize resolution, try to limit FOV

Can only image inside the coil
- Requires an assortment of different coils for different body parts

Knee Coil

Knee Coil for the Ankle

Evolution of Radiology An Introduction for Non-Radiologists

Foot Coil

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
Ultrasound
MRI
Physics
Coils
Magnets
Safety
WOW

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Elbow Coil

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
Ultrasound
MRI
Physics
Coils
Magnets
Safety
WOW

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Wrist Coil

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
Ultrasound
MRI
Physics
Coils
Magnets
Safety
WOW

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2 Part Torso Coil

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
Ultrasound
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Safety
WOW

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Many Coils are Needed

TOPICS
Radiographs
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WOW

Evolution of Radiology An Introduction for Non-Radiologists

MRI Scans are Expensive

- Coils are expensive: >$25,000 EACH!
- Scanners are expensive: >$2,000,000
- Specialty trained technologists are expensive
- **MR scans take 30-60 minutes**
  - ✓Run several sequences in several planes
  - ✓Can scan only a limited number of patients per day
  - ✓Have to charge a lot per scan

Knee Radiographs (4 views): $154
Knee CT (no contrast): $1,200
Knee MR (no contrast): $2,400

Don't order MSK MR before getting Radiographs!

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Evolution of Radiology: For Non-Radiologists

MR Scans are Long

MR scans take 30-60 min

- Patient's need to lie still… like a statue… for the entire time.
- If the patient is ill the day of the scan and can't stop coughing or sneezing, should reschedule.
- Patients who can't lie flat, severe heart failure (CHF), can't get MRI.

Marty age 6

Scanners

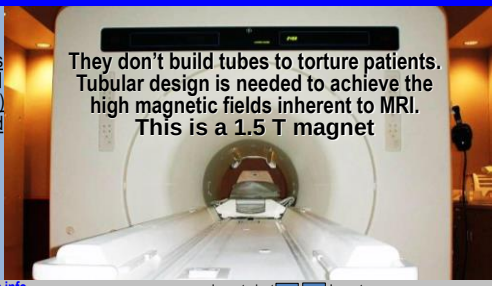
A CT scanner… is a doughnut

Scanners

A CT scanner… is a doughnut

An MR scanner… is a cannoli

MR Scanner is a Tube



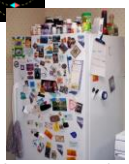
Tesla: Measure Magnetic Field Strength

Earth's magnetic field:

- 30 μT (3×10^{-5} T)

Typical refrigerator magnet:

- 3 mT (3×10^{-3} T)



High Field MRI scanner:

- 1.5 – 3 T
- 1,000 times the strength refrigerator magnet
- 100,000 times the Earth's magnetic field

"Open" MRI = Low Field

Favored by commercial stand-alone MRI sites

"Our MRI scanner is open on all four sides; that's a major advantage for large people who find a tunnel too confining, for children who might become frightened inside a tunnel, and for anyone with a touch of claustrophobia."

open-mri-inc.com

Evolution of Radiology: For Non-Radiologists

"Open" MRI = Low Field

Favored by commercial stand-alone MRI sites

- Typical open MR: 0.1-0.3T
- 1/10th strength of a high field scanner…

- 1/10th image resolution of a high field scanner.
- Costs 1/10th the price to buy low field scanner…
- They charge the same price as a high field scan.

Diagnostic value of low field MR is inferior to that of high field MR.

UW Experience with Open MR

0.7 T "Mid Field"

- This is highest field open scanner made

Our accuracy: Knee

- In 1.5 T MR: ≈ 95% ☺
- In this scanner: 75% ☹
  - ✓Same UW radiologists
  - ✓Same UW protocols

Diagnostic value of low field MR is inferior to that of high field MR.

UW Experience with Open MR

Our surgeons refused to schedule patients in our open scanner.

- Ran it only 2 days/week
- Primarily:Obese patients
- As bad as this scanner was, it did a particularly poor job with… obese patients.
- Got rid of it for a 3 T ☺!

My Recommendations

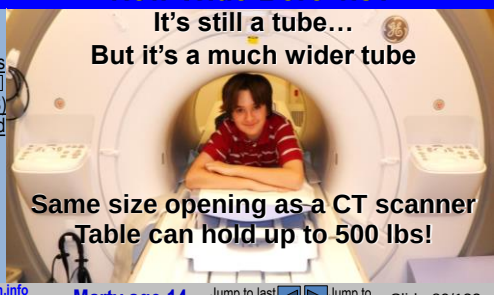
For yourself or your patients:

- Don't use open low field scanners
- Always want to use at least a 1.5 T scanner
- **Go to a 3 T if available!**

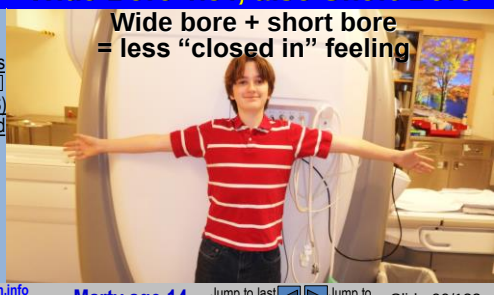
What about obese patients?

- Patients who don't fit in the standard 1.5 T?
- **We now have an alternative to low field open scanners for the "Wisconsin-sized" patient…**

New Wide Bore 1.5T



Wide Bore 1.5T, also Short Bore



MR scanner is a tube

Claustrophobia

Don't make patients claustrophobic

- Things I've seen clinicians write:
  - ✓*I told my patient how traumatic an MR scan is*
  - ✓*I told my patient it's like laying inside a* ***COFFIN***
  - ✓*I told my patient it's like laying in a* ***SEWER PIPE***

MR scanner is just a tube

Nothing happens inside the tube

- Nothing moves
- Nothing crushes
- Open at both ends
- Plenty of air
- No radiation
- No X-rays
- No flashing lights

If it didn't make any noise you wouldn't even know anything was happening.

MR scanners make lots of noise

We protect the patient's ears

- Ear plugs
- Headphones
  - ✓Can play radio station
  - ✓or CD
  - ✓or patient's iPod

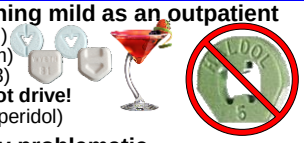
Our goal is to make patient relaxed

- We get our best pictures of people sleeping

If your patient is still anxious

Can take something mild as an outpatient

- Valium (Diazepam)
- Ativan (Lorazepam)
- Cocktail? (not all 3)
- **Patient should not drive!**
- *NOT Haldol* (Haloperidol)



If patient is really problematic

- We can provide conscience sedation at hospital
  - ✓Not at outpatient facility

If patient is *really really* problematic

- General anesthesia can be arranged
  (It rarely comes to that)

The Big Problem with MRI

It's a Big Magnet
It's Always On

Why is it Always On?

Isn't it an electromagnet?

- Can't we just flick a switch and turn it off?
- It's not that simple…
- Yes, it's an electromagnet.
- Yes, it works by passing current through wire

To achieve 1.5T, need to pass A LOT of current through wire

- Requires low resistance wire…
- …super-conducting wire
- Super-conducting materials operate at CRYOGENIC TEMPERATURES!
- Can't turn off magnet with venting cryogens.

Occasionally Replenish Cryogens

MRI Safety

Everyone in the entire medical center needs to respect MRI safety

Can't bring into the scanner room anything that is:

- Ferromagnetic
- Electronic

that is not certified MRI compatible.

Safety Videos

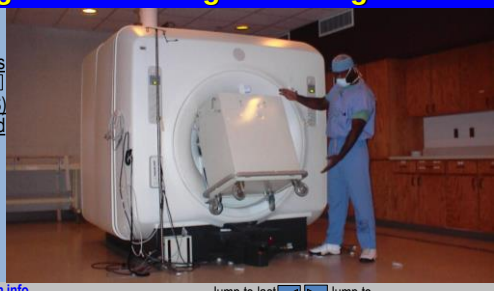
Things Stuck in Magnets: Floor Buffer

Things Stuck in Magnets: Gas Tank

Things Stuck in Magnets: ICU Bed

Things Stuck in Magnets: Chair

Things Stuck in Magnets: Drug Cart



Warning Signs

Warning Signs

Metal Objects May Become Airborne

MRI Safety in China

MRI Safety in China

Limit Access to MR Suite

A True Tragedy

New York Daily News Online **Tuesday, July 31, 2001**

Freak MRI Accident Kills Westchester Boy

Magnet send canister flying into him

6-year-old boy undergoing an MRI exam at a Westchester hospital died after the machine's powerful 10-ton magnet turned an oxygen canister into a missile that smashed his skull, officials said yesterday.

Michael Colombini

MRI Safety

Everyone in the entire medical center needs to respect MRI safety

Can't bring into the scanner room anything that is:

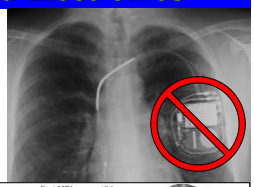
- ➢Ferromagnetic
- ➢Electronic

that is not certified MRI compatible.

No Implanted Electronics

No pacemakers

- ➢Magnet won't suck pacer out of chest
- ➢But magnet may…
  - ✓Drain the battery
  - ✓Make pacer fire erratically
  - ✓Scramble electronics
  - ✓May even *reprogram* pacer

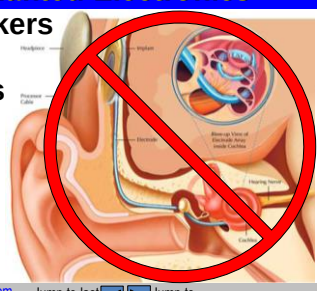


FDA approves first MRI-compatible pacemaker
February 09, 2011
by Sruthi Valluri, DOTmed News
The U.S. Food and Drug Administration Tuesday approved a pacemaker compatible with magnetic resonance imaging. The device is the first of its kind in the United States, and will allow patients with pacemakers to safely undergo the exam.

No Implanted Electronics

No pacemakers

No cochlea implants



Evolution of Radiology: For Non-Radiologists

No Implanted Electronics

No pacemakers

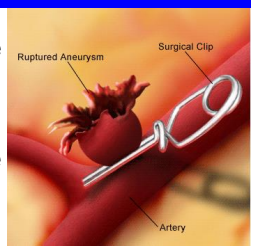
No cochlea implants

No neuro-stimulators

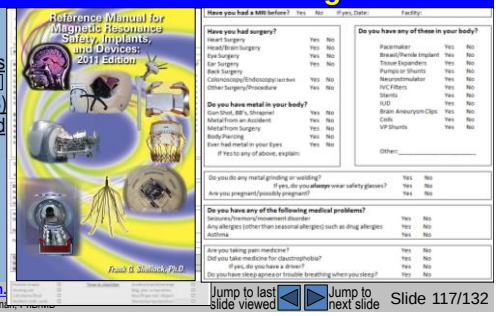
Metal Inside Patients

Safety Issues

- Metal that can't move is not a safety issue
  - ✓Fillings in the teeth
  - ✓Orthopedic hardware
- Need to worry about metal that CAN move
  - ✓**Metal in/around eyes**
    - ❖Welding equipment
    - ❖Grinding equipment
    - ❖Fire guns w/o protection
    - ❖*People who've been shot*
  - ✓Old aneurysm clips



New UW Screening Sheet



An actual case…

We're screening the patient to see if he's MR compatible.

We ask the patient if he has any metal in his body.

He replies, "… yeah… I think I was shot in the head once."

Is this patient MR compatible?

Maybe yes, maybe no.

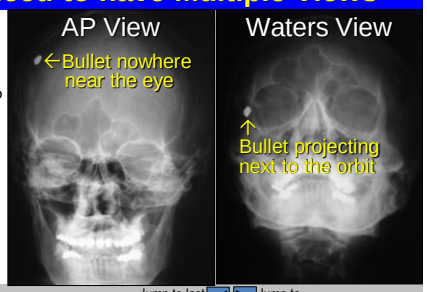
We get a skull radiograph…

What do you say now?

"*One view = no views*"

Need to have Multiple Views

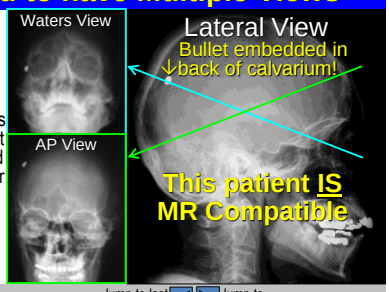
What's the answer?



Need to have Multiple Views

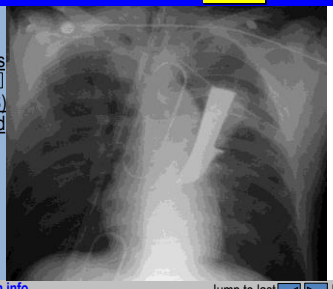
Here's the answer on the lateral view!

On the Waters view the bullet just happened to project over the eye.



Evolution of Radiology: For Non-Radiologists

This Patient is NOT MR Compatible

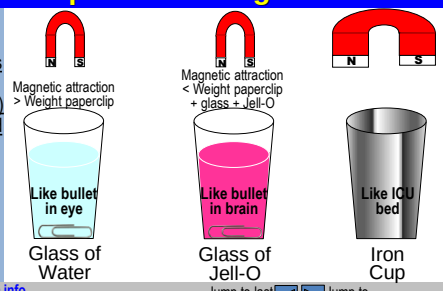


Don't want this knife blade to move from its current position.

History?

"Stabbing Chest Pain"

Thought Experiment: Magnetic Attraction



Metal Inside Patients

Safety Issues

- No implanted electronics
- No metal that can move
- OK: Orthopedic hardware
- OK: Modern aneurysm clips
- OK: Modern heart valves
- OK: Vascular stents
- OK: IVC filters

Imaging Issues

- Metal can affect the magnetic field
  - ✓"Susceptibility artifact"
- May limit diagnostic value of the scan…
- But often the scans come out just fine.
  - ✓As long as the patient is MR safe, we're willing to try.
  - ✓If we can't get useful images, cancel all charges

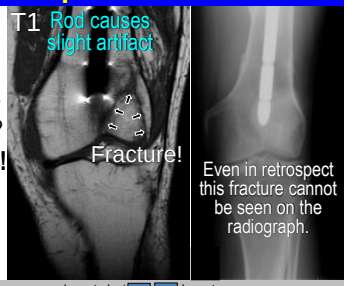
Metal Example: Femoral Rod

Patient with lots of metal

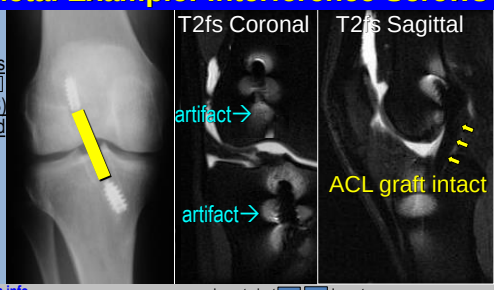
Is it unsafe to put this patient in the magnet?

Of course not!

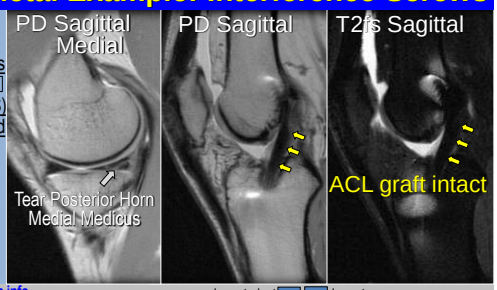
Patient has unexplained knee pain.



Metal Example: Interference Screws



Metal Example: Interference Screws



Evolution of Radiology: For Non-Radiologists

What to Order When (WOW): MSK

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
Ultrasound
MRI
Physics
Coils
Magnets
Safety
WOW

Should always start with radiographs
- Least expensive study
- May show the answer
- Needed for planning other studies

CT
- In ER for fracture detection (spine)
- For surgical planning of known fractures
- To assess degree of surgical fusion

MRI
- Joints: Tears, internal derangement
- Spine: Disk bulges, cord compression
- Bones: Occult fractures, infection, tumors,…

Putting it all together: Case example

TOPICS
Radiographs
CT S
X-rays(EMS)
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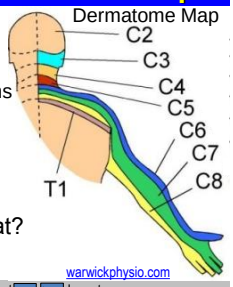
WOW

41 yo F
- Neck pain
- Numbness/tingling
  - ✓Radiating down both arms
  - ✓Down to the fingers
  - ✓Spares the thumbs
- Radiculopathy
  - ✓C7, C8

What to order first?
- **Radiographs**… of what?
- Cervical spine



warwickphysio.com

Putting it all together: Case example

TOPICS
Radiographs
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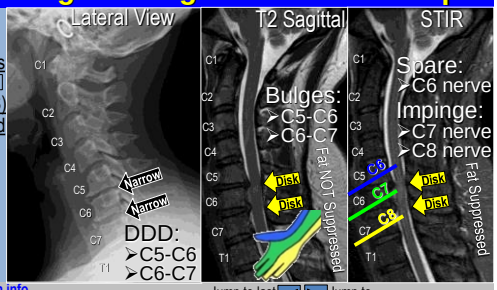

Putting it all together: Case example

TOPICS
Radiographs
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Safety
WOW

Surgery
- Remove bulging C5-C6 & C6-C7 disks
- Fuse vertebral bodies of C5 to C6 & C6 to C7

Did well for nearly two years…

Putting it all together: Case example

TOPICS
Radiographs
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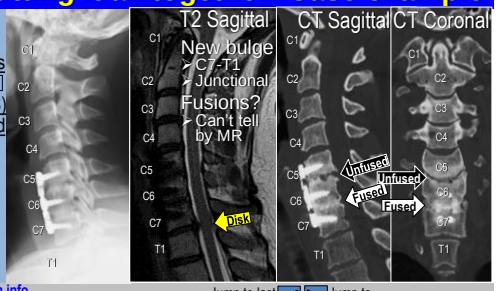
WOW



WOW: Practical Considerations

TOPICS
Radiographs
CT S
X-rays(EMS)
Nuclear Med
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Safety
WOW

	Charge	Time	Radiation
Radiographs	$154	< 1 sec	~0.06 mSv (1 week background)
CT	$1,200	~ 5 min	~7.0 mSv (3 years background)
MR	$2,400	30-60 min	NONE
US (abdomen) (extremity)	$1,200 $700	~30 min	NONE
Bone Scan SPECT	$1,500 $2,500	~30 min 4hr post inject	~3.5 mSv (1.5 years background)
PET/CT	$7,400	30-60 min 1hr post inject	PET: 7 mSv CT (whole body): 18mSv **Total: 10 years background**

www.wikipedia.com
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