



Basic information & introduction to Radiology

Lecture 1

Objectives

- Recognize, and evaluate essential information on the biologic effects of ionizing radiation and radiation safety to ensure the safe use of x-rays in diagnostic imaging.
- Know radiation quantities and units, regulatory and advisory limit for human exposure to radiation.
- Know equipment for radiation protection and measurement.
- Understand the fundamental principles of MRI safety
- Know about contrast agents reactions and safety.
- Understand how to prepare patients for radiology studies.

Color Index:

-Main text -Males slides -Female slides -Dr's notes -Important -Golden note -Extra

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Radiology



What is Radiology?

- ❖ Medical specialty that supervises, perform and interprets imaging studies.
- ❖ Reports findings to referring physicians to help in the patients management.
- ❖ Medical specialty that use medical imaging technologies to diagnose and treat patients.

Diagnostic Modalities used in radiology



Which of these modalities use ionizing radiation? • **X-Ray** • CT • Nuclear medicine

Contrast Media

Natural contrast in the body

- ❖ Air
- ❖ Fat
- ❖ Bone

Added contrast in the body

- ❖ **Barium sulfate (non water soluble)** safe for GI tract, given orally because it precipitates and cause blocking of the vessels if given IV
- ❖ **Iodine (water soluble)** can be given as IV

X-RAY

- ❖ It is a form of **Electromagnetic energy** that travel at the speed of light.
- ❖ Discovered and named by Dr. W. C. Röntgen at University of Würzburg, 1895.
- ❖ X-Rays are emitted and detected in cassette generating, either a hard copy film or a digital image.

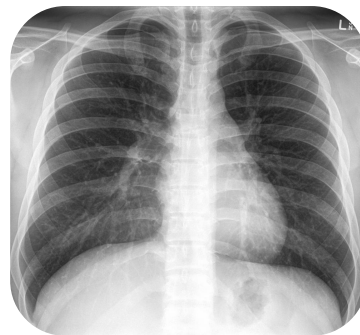
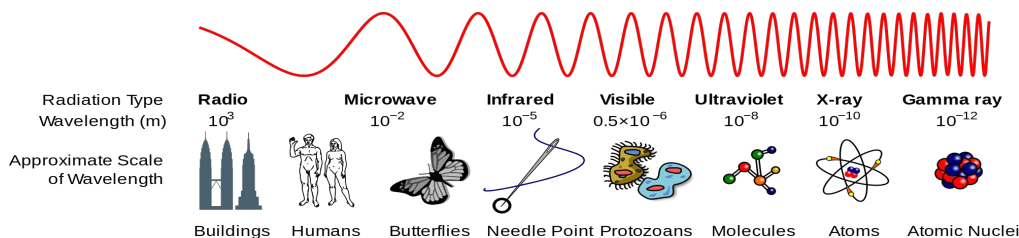


Image key = shades (Densities)

(Q:where on this image have x-rays passed through the body to the greatest degree?lungs)

Electromagnetic energy wave spectrum

- ❖ Gamma Rays
- ❖ X-rays
- ❖ Visible light
- ❖ Infrared light
- ❖ Microwaves
- ❖ Radar
- ❖ Radio waves



The higher frequency and shorter wavelength, the higher penetration ability

» The X-RAY Beam Interaction

- ❖ Projections (views) are usually described by the path of the x-ray beam.
- ❖ Thus, the term PA (poster anterior) view designates that the beam passes from the back to the front. (standard projection for a routine chest film).
- ❖ X-rays are emitted and detected in cassette which generate either a hard copy film or a digital image

1) Pass all the way through the body:

- Render the film DARK (BLACK shadow) Radio-LUCENT
- Low atomic number, eg; air
- Air has a low atomic number
 - X-rays get through → image is DARK

2) Be deflected, scattered or absorbed:

- Render the film LIGHT (WHITE shadow) Radio-OPAQUE
- high atomic number, eg; **bone** / Fat / Soft tissue/fluid /Metal / Mineral
- Bone has a high atomic number
 - X-Rays are blocked → image is LIGHT

Advantages

- Widely available
- Inexpensive
- Doesn't require advanced technologist knowledge
- Can be performed quickly
- Can be portable

Disadvantages

- **Ionizing Radiation.** can be carcinogenic / to the fetus → mutagenic or even lethal
- Relatively insensitive
- Requires patient cooperation

» FLUOROSCOPY Allow us to see the movement of body structure, e.g. : the contraction of the esophagus

- ❖ A dynamic contrast study, (dynamic) real-time imaging, utilizes image intensifier.
- ❖ It's a combination of:
 - X-Rays
 - Contrast agents

» Technique

is static image while fluoroscopy is dynamic image

Real-time imaging

- ❖ dynamic, detect the movement of the contrast fluid in certain organs
 - e.g. (to assess esophagus leakage after swallow in the GIT)

Using intensifier

- ❖ Using intensifier: to magnify the X-Rays without increasing the amount of radiations for patient's safety.

since Fluoroscopy study is continuous it has more exposure to radiation. but, using an intensifier leads to less energy intensity but still have a good image.

» Uses of FLUOROSCOPY

- ❖ GIT imaging
 - (e.g. dysphagia, peristalsis)
- ❖ Angiography
- ❖ Foreign body removal
- ❖ Musculoskeletal
- ❖ Intraoperative (during surgery)
- ❖ Genitourinary imaging
 - commonly used for recurrent UTIs, vesicoureteral reflux, Obstructions, dilatations, collecting system abnormalities

Advantages

- Widely available.
- Inexpensive
- Functional and anatomic imaging.
- No sedation required

Disadvantage

- Requires ingestion/injection of contrast medium.
- Patient cooperation.
- Radiological hazard
- Time consuming
 - It is time consuming because we are following contrast agent inside organs



COMPUTED TOMOGRAPHY (CT)

How Does CT Works?

1. Rotating an X-Ray tube with the X-Ray detector, & the patient will go through these rays
 2. cross-sectional images (like slices) is received (Axial) from the body. Each slice is an image itself
 3. Data displayed in multiple window settings (lungs parenchyma, bone, etc.)
 4. these images are reconstructed to create other images from different views (e.g. coronal) which are 3D images
 5. To show coronal (frontal) or Sagittal images, data are manipulated (reconstructed) by a computer
- ❖ Relies on X-Rays transmitted through the body that differs from conventional Radiography (plane X-Ray) in that a more sensitive X-Ray detection system is used.
 - ❖ It has the capability to measure the density by analyzing the chemical component of tissue, "Hounsfield Unit (HU)"

Density

- ❖ Density is measured by Hounsfield Unit (HU)
- ❖ CT has very small differences in X-Ray absorption values compared with conventional radiography; the range of densities recorded is increased approximately 10-fold.
- ❖ So, gradations of density within soft tissues can be recognized, e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.

Air: -1000

Fat: -150

Water: 0

Soft Tissue:
20-80

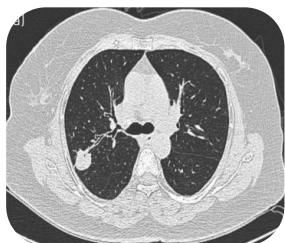
Blood:
45-75

Bone/Co:
>100->1000

» Different Windows

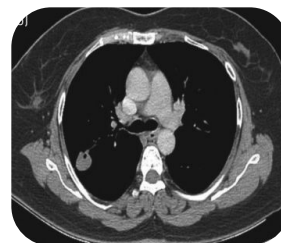
Wide window

to visualize **more** structure within a certain organ such as bronchi, vessels and alveoli in the lung (Lung window) (Bone to visualize cortex, medulla and trabeculae)



Narrow window

to visualize **certain structures** within certain region such as major vessels and heart in mediastinum "Vascular structures" (mediastinum window)

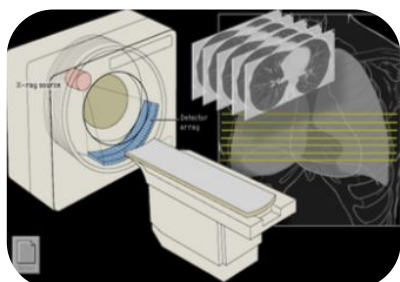


» Uses of CT

- **Neuroimaging:**
 - Emergency: Acute head trauma, acute intracranial hemorrhage.
 - Low sensitivity for:
 - Early ischemic stroke.
 - Intracranial metastatic disease.
 - White matter degenerative disease
- **Head and neck imaging:**
 - Soft tissue of neck, paranasal sinuses, temporal bone, & orbital wall imaging
- **Body imaging:**
 - Chest, Abdomen, Pelvis (with enteric and IV contrast)
 - Pulmonary nodules, **Renal calculi** (without contrast)
 - **Acute appendicitis** (with enteric and IV contrast)
- **Acute Abdomen:**
 - Decrease rate of false laparotomy
- **Trauma spine imaging:**
 - (Cervical, thoracic, lumbar) It can miss fractures.
- **Other osseous imaging:**
 - pelvis and extremities
- **Vascular imaging:**
 - CT angiography i.e. Coronary arteries.
- **Specialized protocols:**
 - Liver masses, pancreatic tissue, renal masses, and adrenal masses

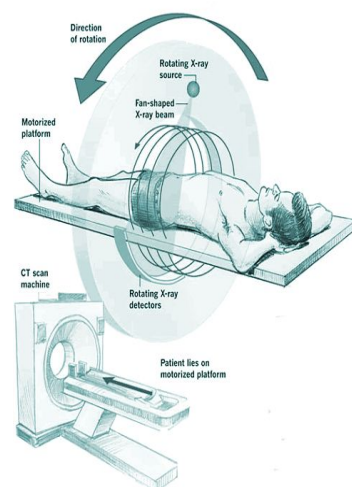
Advantages

- Can give: Cross sectional, Sagittal and Coronal Images
- More sensitive



Disadvantages

- Expensive
 - High Radiation
- So, don't request a CT scan unless needed, and we can't use it for a pregnant women unless absolutely necessary
- One brain CT scan radiation = 200 X-Ray radiation
- One pelvic CT radiation = 400 X-Ray radiation



» MRI

- T1 weighted (T1WI). (Fat → white) (Fluid → dark) (Subacute hemorrhage → white)
- T2 weighted (T2WI), (Fluid → white), (Fat less white compared to T1 weighted)
- Bone appear black on all sequences.
- Air also appear black on all sequences.
- On Flair fluid appear jet black. Very good for detection of demyelination plaques and haemorrhages
- **MRI contrast agent. Gadolinium DTPA** (Ethylene Triamine Penta acetic acid) is used as contrast agent. It is used with **T1W images only**.

» How can we produce an image by the MRI?

- ❖ it depends on the idea of that the body is full of tiny magnets which are the atoms (Ex: hydrogen atoms, markedly abundant in the body organs) then follow these 5 steps:

Hydrogen Atoms (protons) in water molecules and lipids:

1. Magnetism affects all protons causes them to line up in one direction.
2. Magnets can be switched on and off to change the direction of the magnetic field.
3. Whenever the water molecule spin around they give a light radio wave.
4. MRI machine can detect it and shows it as images.
5. Like CT, gradation of density within soft tissues can be recognized e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.

Advantages

- The best soft tissue imaging and pathology (tumors and infections), **Show better tissue characteristics**
- **Better tissue construction than CT**
- **No ionization.**
- Can be done on pregnant women.
- Images can be obtained in any plane
(unlike CT which is taken in axial position)
- Useful for soft tissue pathology (Tumor, infection) MSK
- Multisequence play with characteristic abnormal tissues
- MR angiogram can be performed without introducing contrast media

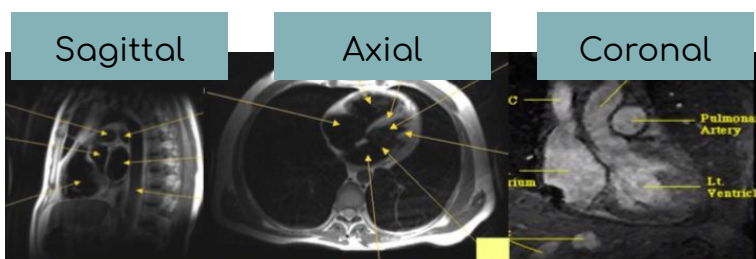
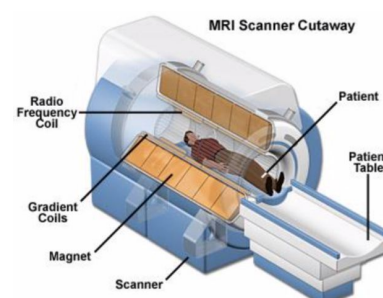


Image key = shades (Intensities)

Disadvantages

- Expensive.
- Time consuming. so we can't use it on emergency patient
- May evoke phobias Claustrophobia
- No metals allowed
- Motion.
- Patients have to keep still during the procedure



» ULTRASOUND

- Echogenicity
- Shadowing
- Doppler for flow
- Ultrasound is sound waves with frequencies which are higher than those audible to humans (>20,000 Hz).
- Ultrasonic images also known as sonograms are made by sending pulses of ultrasound into tissue using a probe.
- The sound echoes off the tissue; with different tissues reflecting varying degrees of sound.
- The echoes are recorded and displayed as an image to the operator.
- Needs a well-trained operator.
- A Doppler ultrasound is a noninvasive test that can be used to estimate the blood flow through the blood vessels, (can be used to differentiate the vessels (renal arteries) from the collecting system in the kidney.)

Advantages

1. No radiation (safest for pregnant ladies)
2. Can be portable "easily used in ICU"
3. Relatively inexpensive

White areas:

Shows echogenic structure which transmit & reflect sound waves e.g. fat, vessels, nodes soft tissue.

Black areas:

Shows anechoic areas. Fluids transmit but does not reflect sound waves

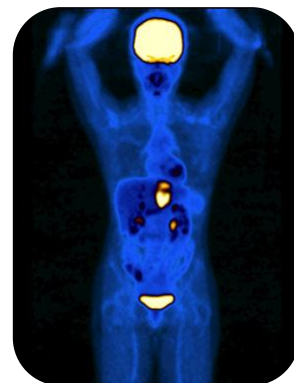
Lines:

Occur at boundary of two markedly different tissue reflectors (boundary of organs)



» NUCLEAR MEDICINE

- ❖ Uses gamma rays to produce an image (counts or activity).
- ❖ Radioactive nuclide given IV, per OS or per rectum, etc.
- ❖ Rays emitted from the patient.
- ❖ Physiological imaging (abnormal function, metabolic activity)
- ❖ Poor for anatomical information.
- ❖ Radioactivity stays with the patient until cleared or decayed
- ❖ In the nuclear medicine: the source is from patient while the detector is outside unlike the others "source were outside"



Advantages

- Evaluation of the functional and anatomical features of the structure

Disadvantages

- Sensitive but not that much specific

SUMMARY

	Advantages	Disadvantages	information
X-RAY	<ul style="list-style-type: none"> Widely available Inexpensive Doesn't require advanced technologist knowledge Can be performed quickly Can be portable 	<ul style="list-style-type: none"> Ionizing Radiation. Relatively insensitive (superimposed structures) Requires patient cooperation 	<p>The X-RAY Beam Interaction:</p> <p>1-Pass all the way through the body</p> <p>2-Be deflected, scattered or absorbed</p>
FLUOROSCOPY	<ul style="list-style-type: none"> Widely available. Inexpensive Functional and anatomic imaging. No sedation required 	<ul style="list-style-type: none"> Requires ingestion/injection of contrast medium. Patient cooperation. Time consuming 	<p>Uses:</p> <ul style="list-style-type: none"> •GIT imaging •Foreign body removal •Musculoskeletal •Intraoperative •Genitourinary imaging
COMPUTED TOMOGRAPHY (CT)	<ul style="list-style-type: none"> Can give: Cross sectional, Sagittal and Coronal Images More sensitive 	<ul style="list-style-type: none"> Expensive High Radiation 	<p>Types:</p> <ul style="list-style-type: none"> •Wide window •Narrow window <p>Uses:</p> <ul style="list-style-type: none"> •Neuroimaging •Head and neck •Body imaging
MRI	<ul style="list-style-type: none"> The best soft tissue imaging and pathology (tumors and infections). No ionization. Can be done on pregnant women. Images can be obtained in any plane 	<ul style="list-style-type: none"> Expensive. Time consuming. so we can't use it on emergency patient May evoke phobias Claustrophobia No metals allowed Motion. 	<p>MRI sees tissues based upon subatomic characteristics (magnetism).</p>
ULTRASOUND	<ul style="list-style-type: none"> No radiation Can be portable Relatively inexpensive 	<ul style="list-style-type: none"> Needs a well-trained operator. 	<p>Ultrasonic images also known as sonograms are made by sending pulses of ultrasound into tissue using a probe.</p>
NUCLEAR MEDICINE	<ul style="list-style-type: none"> •Used for Physiological imaging (abnormal function, metabolic activity) 	<ul style="list-style-type: none"> •Poor for anatomical information. •Radioactivity stays with the patient until cleared or decayed 	<p>Uses gamma rays to produce an image (counts or activity).</p>

1-Which of these modalities use ionizing radiation

- a. Plain X-Ray
- b. Ultrasound
- c. Magnetic Resonance Imaging (MRI)
- d. Nuclear Medicine (NM)

2-body imaging of chest,abdomen,pelvis using CT scan?

- a. With IV contrast only
- b. With enteric and IV contrast
- c. Without enteric
- d. Without contrast

3-Skeletal appearance on x-ray image is?

- A)Dark grey
- B) Dark
- C) Bright grey
- D) White

4--Which of the following axes will appear by direct CT scan?

- A) Axial
- B) Sagittal
- C) Coronal
- D) Oblique

5-What waves are used in fluoroscopy ?

- A)X-rays
- B) Gamma-rays
- C) CT
- D) Alpha

6-One of the specialized protocols for the uses of CT SCAN?

- a. Pancreatic tissue
- b. Pulmonary nodule
- c. Acute appendicitis
- d. Renal calculi

7-High atomic number substances will appear ...in x-ray?

- a. Light
- b. Dark

[Extra questions](#)

Answers
1) a & d
2) B
3) D
4) A
5) A
6) A
7) A