1st Lecture

MED437
King Saud University

RADIOLOGY TEAM

Color Index:

- ✓ Important
- ✓ Notes
- ✓ Extra

Editting File

Introduction to Radiology

objectives:

- ➔ Introduce the various Medical Imaging Modalities.
- ➔ Understand the basics of image generation.
- ➔ Relate imaging to gross anatomy.
- ➔ Appreciate constraints and limitations.
- ➔ Develop imaging vocabulary in the interpretation.

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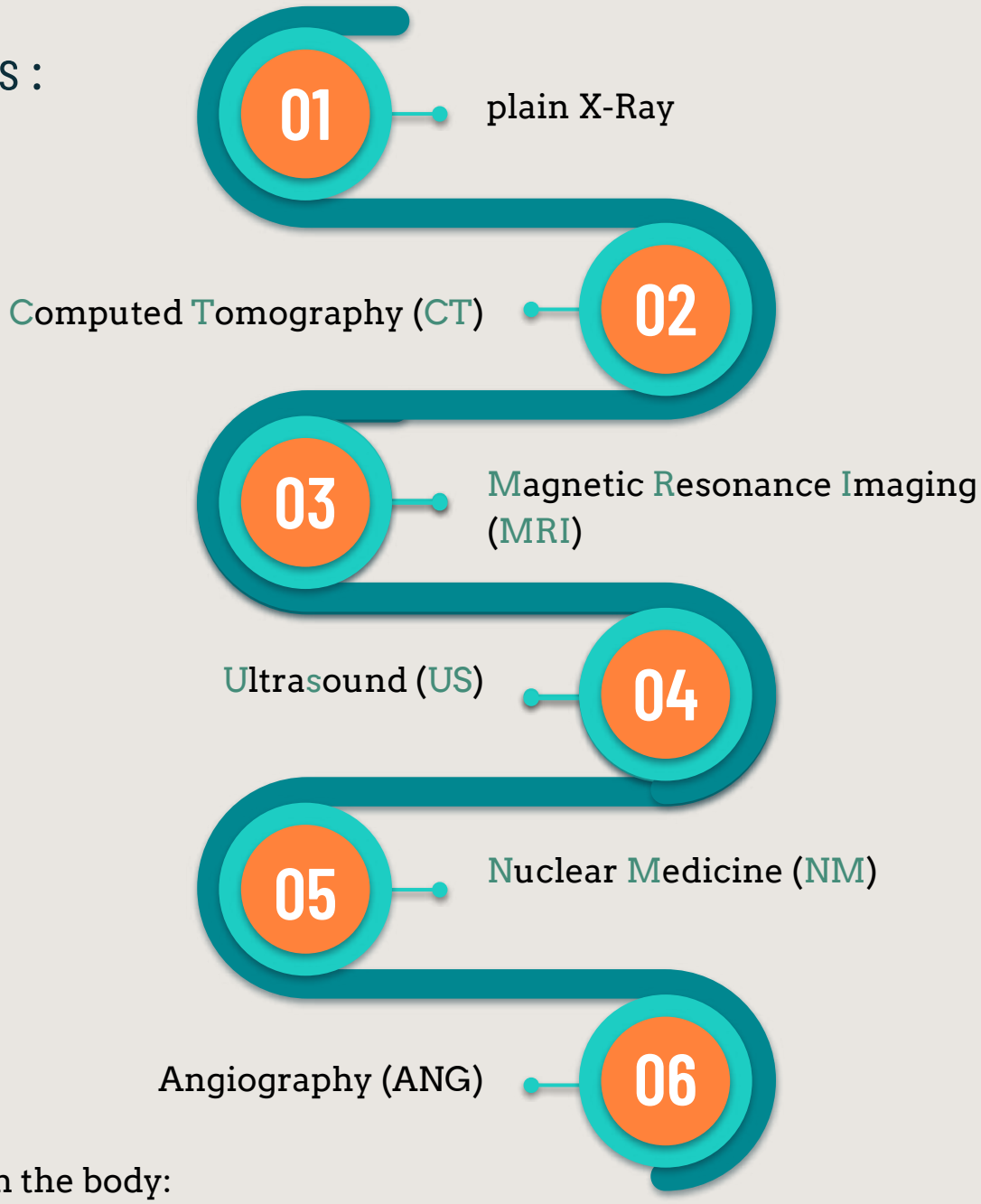
What is Radiology?

- ✓ Medical specialty that supervises, perform and interprets imaging studies.
- ✓ Reports findings to referring physicians to help in the patients management.

Diagnostic Modalities :

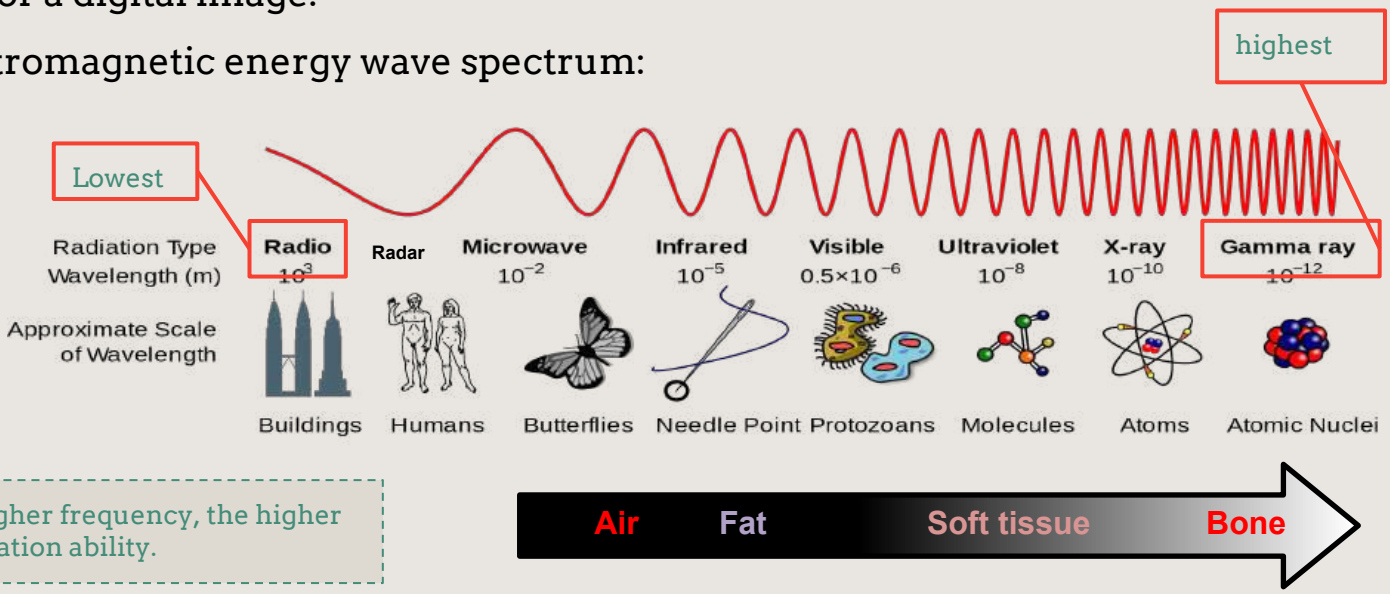


Contrast Media:

- Natural contrast in the body:
  1. Air
  2. Fat
  3. Bone
- Added contrast in the body:
  1. Barium sulfate (non water soluble). safe for GI tract, given orally because it precipitates and cause blocking of the vessels if given IV
  2. 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. Röentgen at University of Würzburg, 1895.
- X-Rays are emitted and detected in cassette generating, either a hard copy film or a digital image.
- Electromagnetic energy wave spectrum:



The higher frequency, the higher penetration ability.

The X-RAY Beam Interaction

1. **Pass all the way through the body:**
   - Render the film <u>DARK</u> (BLACK shadow), **Radio-LUCENT.**
   - Air has a low atomic number → X-rays get through → image is <u>DARK</u>.

2. **Be deflected, scattered or absorbed:**
   - Render the film <u>LIGHT</u> (WHITE shadow), **Radio-OPAQUE.**
   - Bone has a high atomic number→ X-Rays are blocked → image is <u>LIGHT</u>.

Advantages

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

Disadvantages

- x Ionizing Radiation.
- x Relatively insensitive (superimposed structures).
- x Requires patient cooperation.

FLUOROSCOPY

What is fluoroscopy?

- A dynamic contrast study.
- It's a combination of:
  1. X-Rays.
  2. Contrast agents.

Fluoroscopy is used to asses function and anatomy, unlike X-RAY which only asses anatomy.

Technique:

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1. **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).

2. **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.

Used In:

1. GIT imaging (e.g. dysphagia, peristalsis).
2. Genitourinary imaging (commonly used for UTIs, Obstructions, dilatations, collecting system abnormalities).
3. Angiography (vascular system) (assess the blood flow in the vessels).
4. Intraoperative (during surgery).
5. Foreign body removal.
6. Musculoskeletal.

Advantages

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

Disadvantages

- × Requires ingestion/injection of contrast medium.
- × Patient cooperation.
- × Time consuming.

  It is time consuming because we are following contrast agent inside organs.

COMPUTED TOMOGRAPHY

How Does CT Works?

01 — Rotating an X-Ray tube with the X-Ray detector, and the patient will go through these rays.

02 — cross-sectional images (like slices) is received from the body. Each slice is an image itself.

03 — these images are reconstructed to create other images from different views (e.g. coronal) which are 3D images

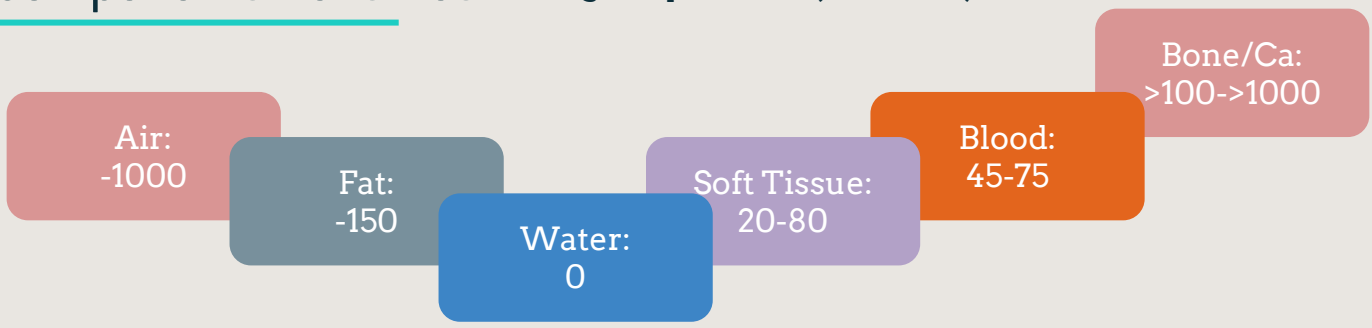
04 — To show coronal (frontal) or Sagittal images, data are manipulated (reconstructed) by a computer.

- Relies on X-Rays transmitted through the body.
- 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:

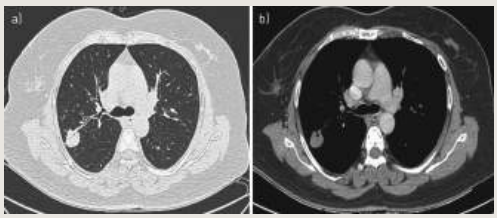
- Density is measured by Hounsfield Unit (HU). Read more about it here.
- CT has very small differences in X-Ray absorption values compared with conventional radiography; the range of densities recorded is increased approximately 10-fold.
- So, gradations of density within soft tissues can be recognized,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

Components Densities: image key: shades (densities)



COMPUTED TOMOGRAPHY

lung window | Mediastinal window



Different Windows: (IMPORTANT)

it has **two windows:**

1. **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)

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

Uses of CT:

1. **Neuroimaging:**
   - Acute head trauma, acute intracranial hemorrhage.
   - We can use CT on patient that presents with headache to diagnose brain tumor.
   - Low sensitivity for:
     a. Early ischemic stroke.
     b. Intracranial metastatic disease.
     c. White matter degenerative disease.

2. **Head and neck imaging:**
   Soft tissue of neck, paranasal sinuses, temporal bone, and orbital wall imaging.

3. **Body imaging:**
   - Chest, Abdomen, Pelvis (with enteric and IV contrast).
   - Pulmonary nodules, Renal calculi (without contrast).
   - Acute appendicitis (with enteric and IV contrast).

4. **Specialized protocols:**
   Liver masses, pancreatic tissue, renal masses, and adrenal masses.

5. **Acute Abdomen:**
   Decrease rate of false laparotomy (a surgical incision into the abdominal cavity, for diagnosis or in preparation for surgery).

6. **Trauma spine imaging:**
   (Cervical, thoracic, lumbar) It can miss fractures.

7. **Other osseous imaging:**
   pelvis and extremities

8. **Vascular imaging:**
   CT angiography I.e. Coronary arteries.

Radiation Risks

There is a major risk behind CT scan:

- One brain CT scan radiation = 200 X-Ray radiation.
- One pelvic CT radiation = 400 X-Ray radiation.

So, don't request a CT scan unless needed, and we can't use it for a pregnant women unless absolutely necessary.

Advantages	Team436	Disadvantages
✓ Can give: Cross sectional, Sagittal and Coronal Images.		× High Radiation.
✓ More sensitive.		× Expensive.

MAGNETIC RESONANCE IMAGING

image key: shades (intensities)

- MRI sees tissues based upon subatomic characteristics (magnetism).
- Proton nucleus of Hydrogen has small magnetic field that can be used to detect tissues containing hydrogen.

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:

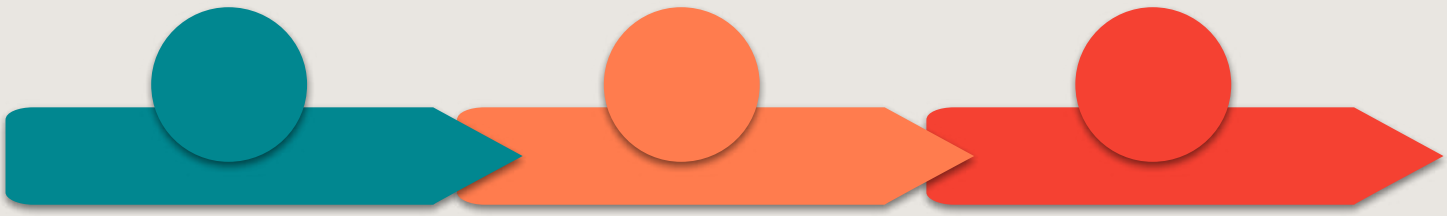
1. Magnetism affects all protons causes them to line up in one direction.
2. Magnets can be switched on and off to change the direction of the magnetic field.
3. Whenever the water molecule spin around they give a light radio wave.
4. MRI machine can detect it and shows it as images.
5. Like CT, gradation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

Advantages	Disadvantages
✓ The best soft tissue imaging and pathology (tumors and infections).	× Expensive.
✓ No ionization.	× Time consuming. so we can't use it on emergency patient
✓ Can be done on pregnant women.	× May evoke phobias Claustrophobia (phobia of narrow places).
✓ Images can be obtained in any plane (unlike CT which is taken in axial position).	× No metals allowed.
	× Motion. (patient movement)

ULTRASOUND

- 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.

EXTRA



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).

Advantages

- ✓ No radiation.
- ✓ Can be portable. "easily used in ICU"
- ✓ Relatively inexpensive.

NUCLEAR MEDICINE

In the nuclear medicine: the source is from patient while the detector is outside unlike the others "source were outside"

- 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.

What is nuclear medicine? An illustrated introduction

these notes will help with explaining the lecture

NOTES!

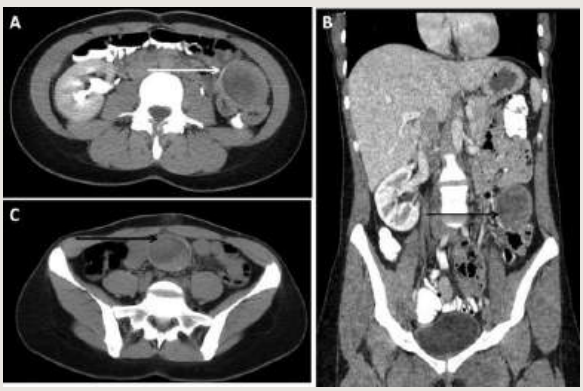
1. X-Ray is an Electromagnetic energy same as light.
2. what is the difference between light and X-Ray?
    - the intensity of the energy, X-Ray has higher energy thus can penetrate the structures.
3. gamma rays has the highest intensity, radio has the lowest.
4. X-Rays are conserved in a leaded glass, except for a small window directed to the patient that allows x-rays to go through.
5. the densities is graded as shadows (dark and light) according to the X-Ray waves that penetrate the body. the more penetration the more black such as air, BUT the rays can't penetrate bone thus it reflects with light shadows.
6. the higher the atomic number the less x-rays get through (penetrate)
7. example for black shadows is lungs (because it's filled with air)
8. dense structures such as bones appear white (light)
9. but, the soft tissue and muscles appear in grades of grey (from light to dark grey according to the thickness and composition of soft tissue.
10. example for patient cooperation importance in X-Rays: when taking lungs x-rays the patient must hold breath for a certain time (may cause a problem with patients).
11. CT is a CROSS-SECTIONAL imaging, meaning it can only take axial images (slices)..
12. but, to have different planes (coronal, sagittal) these slices are manipulated with by the computer to make an approximal image of different planes.
13. SO! CT can ONLY make axial images.
14. in liver CT you can see the vascular structures and the portal vein.
15. the most proximal structure to the vertebra to see in abdominal CT is abdominal artery and it's seen as a round structure.
16. two important parameters in CT windows; the width (narrow,wide) and the level (depends on the density of the structure).
    - to evaluate the bone; put density at the level of bone (100-1000 HU) density, with wide angle window.
    - to evaluate the lungs; level at the air (-1000 HU) density with wide window
    - to evaluate a vascular structure of abdominal; relatively narrow window w/ soft tissue (20-80 HU) density level.
17. How does Ultrasound produce an image?
    - first when the probe is on it produce sound waves (felt as vibration) into the certain area where it's placed, second the probe is turned off to collect the reflecting sound waves from the body (known as echos)
18. the sound waves are collected at the interface between tissues
19. ultrasound allows to see the movement of fluids within tubular structures by applying the doppler technique
20. tubular structures are black in US
21. doppler technique is valuable to differentiate between bile ducts and hepatic and portal veins within the liver
22. nuclear medicine is inserting radioactive nuclide, thus exciting the nucleus and collect the gamma rays by an outside detector
23. nuclear medicine is considered sensitive but not specific

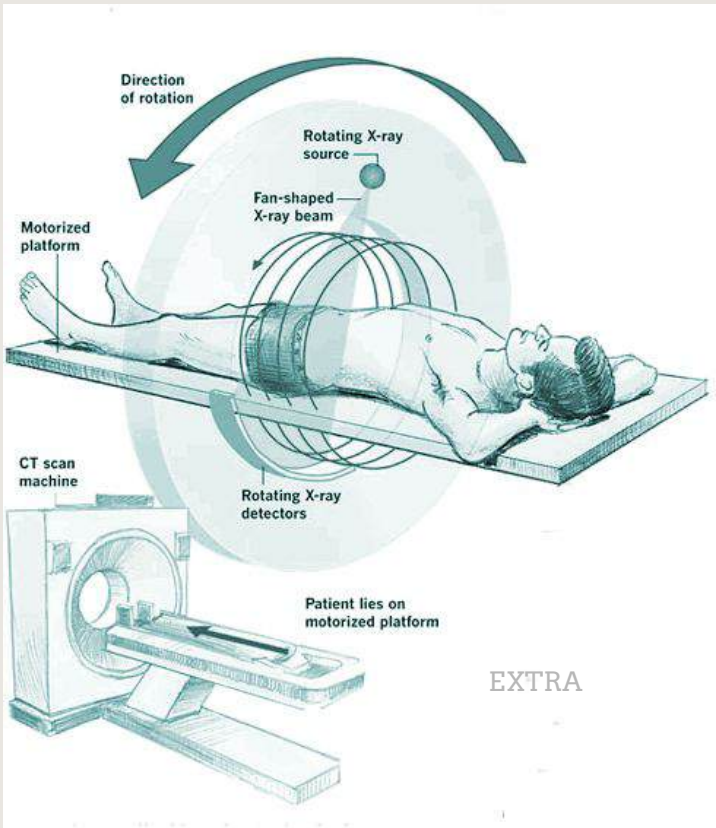
PICTURES

Fluoroscopy

CT

EXTRA





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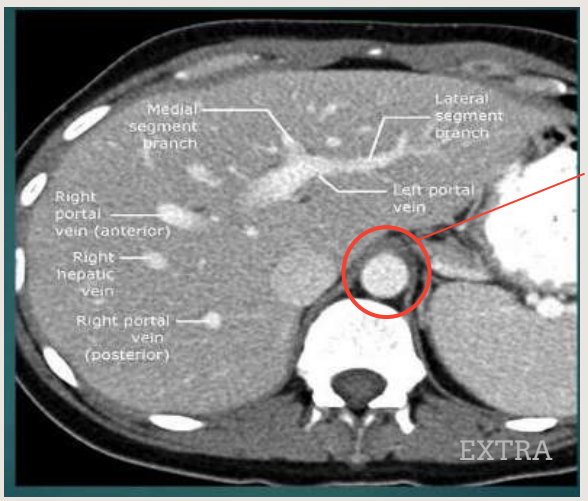

abdominal aorta

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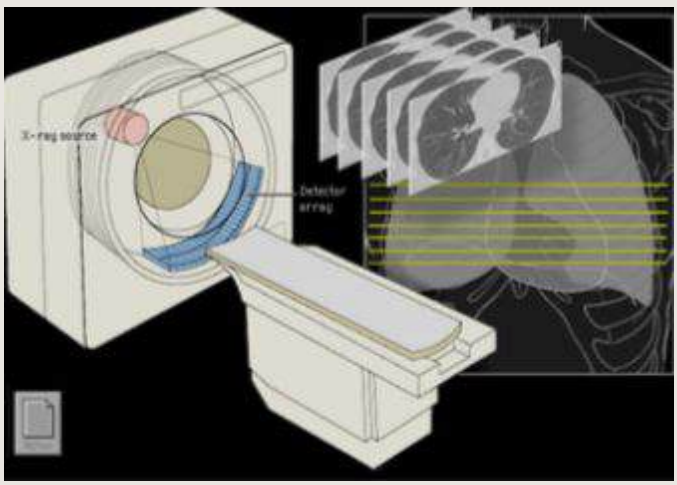
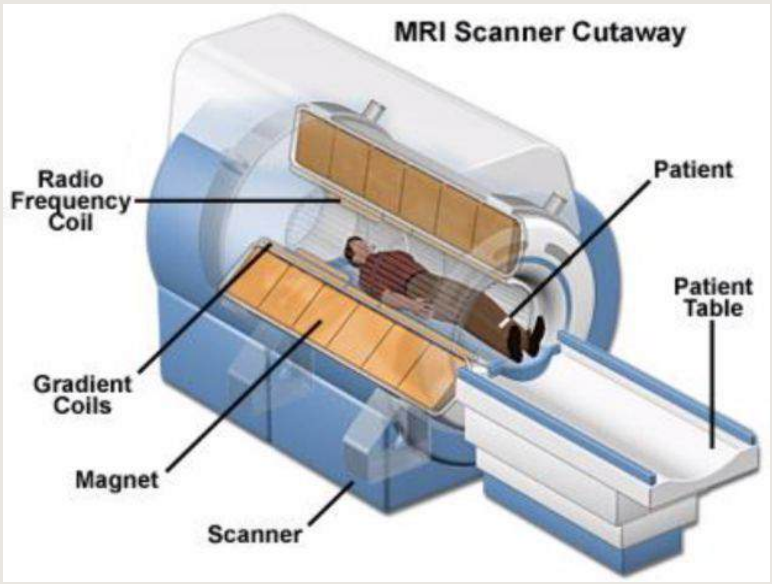


PICTURES

MRI



Sagittal Axial Coronal

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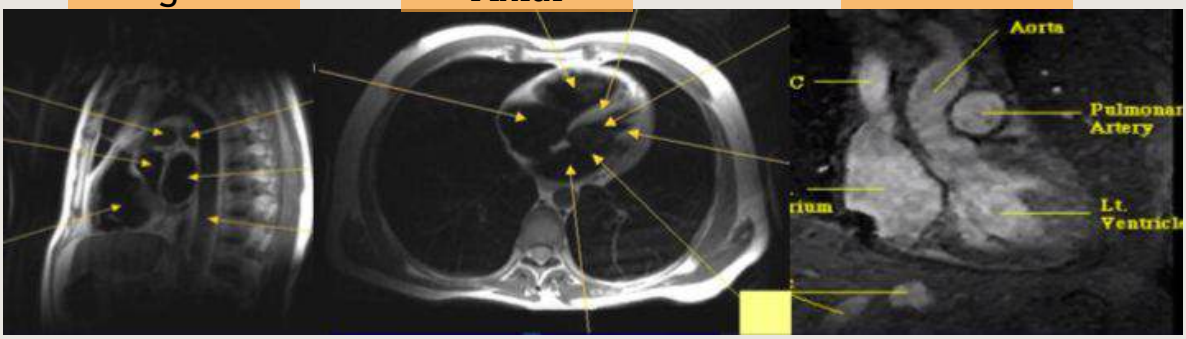
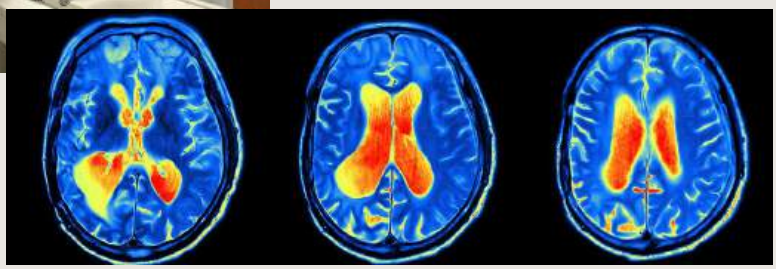


Ultrasound

Nuclear Medicine



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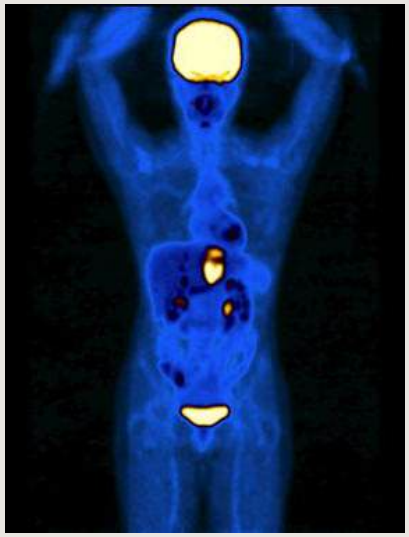

SUMMARY

Anatomical structure

	definition	pros	cons	indications
X-Ray	a form of electromagnetic energy that travel at the speed of light	• Widely available. • Inexpensive • Can be performed quickly.	• Ionizing Radiation. • Relatively insensitive	
MRI scan	The MRI machine generates an extremely strong magnetic field and pulses of radiofrequency energy, which align hydrogen nuclei in tissues and body water. The subsequent loss of alignment with time produces the MRI signal.	• The best soft tissue imaging • No ionization. • Images can be obtained in any plane	• Expensive. • Time consuming. • May evoke phobias Claustrophobia	
CT scan	refers to a computerized x-ray imaging procedure in which a narrow beam of x-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed by the machine's computer to generate cross-sectional images—or “slices”.	• measure the density by analyzing the chemical component of tissue • The Cross sectional slices are manipulated By a computer to produce Sagittal and coronal plane views.	• not recommended For pregnant women • high radiation • expensive	• Neuroimaging • Head and neck imaging • Specialized protocols • Acute Abdomen • Trauma spine imaging • Other osseous imaging • Vascular imaging

CT scan **types**	Wide window	Narrow window
	to visualize more **structure within certain organ** such as bronchi, vessels and alveoli in the lung (Lung window).to visualize cortex, medulla and trabeculae (bone)	to visualize certain **structures within certain region** such as major vessels and heart in mediastinum (Mediastinal window)

physiology/ function

	definition	pros	cons	indications
Fluoroscopy	During fluoroscopy, x-ray beams are continually emitted and captured on a screen, producing a real-time, dynamic image. This allows for dynamic assessment of anatomy and function.	• Functional and anatomic imaging.	• Requires ingestion/injection of contrast medium. • Time consuming.	• GIT imaging • Genitourinary imaging • Angiography • Intraoperative Foreign body removal. • MSK.
Ultrasound	In medical ultrasound the Doppler effect is used to measure the velocity of blood in blood vessels, especially arteries to determine if a stenosis is present	• No radiation • Can be portable • Relatively inexpensive		
Nuclear medicine	Nuclear medicine imaging uses small amounts of radioactive material to diagnose, evaluate or treat a variety of diseases.	• Uses gamma rays to produce image • Physiologic imaging (abnormal function, metabolic activity).	Poor for anatomical function	

x-ray imaging interpretation	dark	light
	air (low atomic number substances)	bone (high atomic number substances)

SUMMARY

Modality	Terminology	Contrast medium	Radiation	Prep	Contraindications/Problems
X-ray	Opacity vs Lucency	Iodine (e.g. IV pyelogram)	Yes	-	Pregnancy (relative)
CT	Attenuation/Density	Iodine	Yes	Hydration (low eGFR)	Renal impairment, Pregnancy (relative)
MRI	Signal intensity	Gadolinium	No	Remove piercings	Metals, Electronics, Claustrophobia
Ultrasound	Echogenicity	Air ('microbubbles')	No	Full bladder (gynae scans)	Body habitus, Operator skill
Nuclear	Uptake	Radioactive labelled 'tracer'	Yes	-	Pregnancy, Breastfeeding
Fluoroscopy	Filling defect	Barium/Air/Gastrografin	Yes	NBM/Bowel prep	Poor mobility

source:
https://www.radiologycafe.com/medical-students/radiology-basics/imaging-modalities

QUESTIONS

1. Which of the following uses ionizing radiation:

a) MRI
c) Nuclear medicine
b) US
d) CT scan

2. which of the following is true regarding natural contrast media in the body :

a)hair
c) blood
b) fat
d) cartilage

3. high atomic number substances will appear ...in x-ray?

a) light
b) dark

4. which of the following modalities is contraindicated in case of implanted pacemaker?

a) US
c) x-ray
b) Nuclear medicine
d)MRI

5. the best modality to confirm the diagnosis of pituitary adenoma?

a) US
c) x-ray
b) Nuclear medicine
d)MRI

6.the window of choice to confirm the diagnosis of bronchiolitis ?

a) wide window
b) narrow window

7. Which modality is best used to assess for motility disorders of the gastrointestinal tract?

a) fluoroscopy
c) MRI
b) x-ray
d) CT scan

8. the modality of choice to detects differences between cancer and normal cells in the consumption of glucose?

a) fluoroscopy
c) MRI
b) Nuclear medicine
d) CT scan

9. the modality that uses doppler effect to asses the velocity of blood in blood vessels is?

a) fluoroscopy
c) MRI
b) x-ray
d) US

Answers

1) d
2) b
3) a
4) d
5) d
6) a
7) a
8) b
9) d

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References

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