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.

Done By

Team Leaders:

Khalid Alshehri

Hanin Bashaikh

Team Members:

Nawwaf AlHarbi

Reem Alshathri

Laila Mathkour

Revised by:

Abdulaziz Alangari

Maha Alghamdi

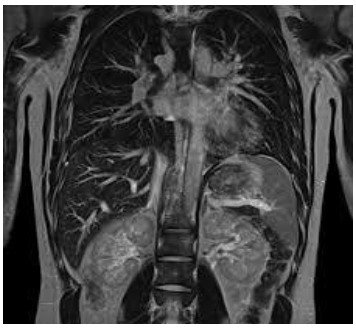
Color Coding

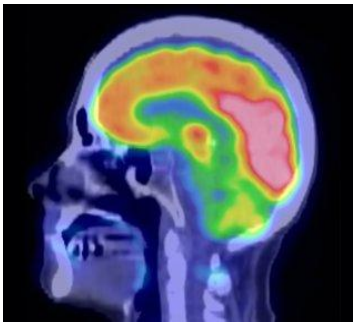
Important | Notes | Extra

Editing File

Introduction





What is Radiology?

A Medical specialty that supervises & performs then interprets the images and reports the findings to the physicians to help patient's management.

Radiological Modalities					
Plain X-Ray	CT	Angiography	Nuclear Medicine	MRI	Ultrasound
Ionizing Radiation			Minimal Ionizing radiation	Non-Ionizing Radiation	

Contrast media

- **Natural contrast in the body:**

1. Air.
2. Fat.
3. Bone.

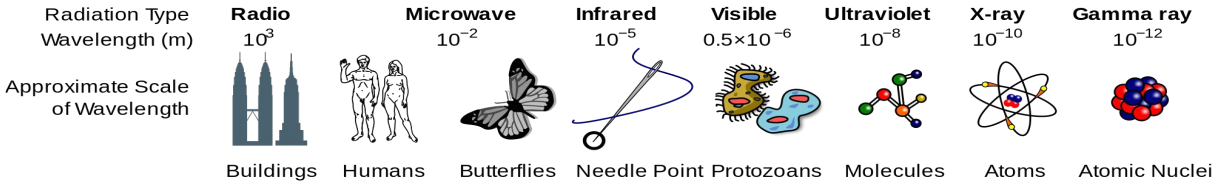
- **Added contrast in the body:**

1. Barium sulfate: only orally. It is a powder which doesn't dissolve in water and it forms a suspension when you add it to the water, so we can't give it through IV.
2. Iodine (Water Soluble): IV , orally, rectally. It is water soluble so it means we can give it through IV and orally.

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.
- Electromagnetic energy wave spectrum:

Gamma rays has the highest frequency level



X-Rays are emitted (produced) and detected in cassette generating, either a hard copy film or a digital image. The X-Ray beam (Emission of electromagnetic radiation or particles from the X-Ray tube) interaction with body tissue can:

1. Pass all the way through the body

- Render (make) the film **DARK, BLACK shadow, Radio-LUCENT.**
- Air has a low atomic number ⟶ X-rays get through ⟶ image is **DARK.**

2. Be deflected, scattered or absorbed

- Render (make) the film **LIGHT, WHITE shadow, Radio-OPAQUE.**
- Bone has a high atomic number (higher density) ⟶ X-Rays are blocked ⟶ image is **light.**

In conclusion, the

darkness of the image depends on the thickness of the tissue.

The X-Ray has 3 components:

1- the source. 2- the X-Ray bulb. 3- the film where you could produce the image.

Advantages	Disadvantages
- Widely available. - Inexpensive. - Doesn't require advanced technologist knowledge. - Can be performed quickly. - Can be portable.	- Ionizing Radiation. - Relatively insensitive (superimposed structures)[1]. - Requires patient cooperation.

[1] Structures relay on top of each other, so you can't see anatomical or pathological structures clearly.

Fluoroscopy

- Dynamic contrast studies.

The only difference between Fluoroscopy and X-Ray is that in fluoroscopy we take the picture in dynamic states rather than static

Combination of:

1. X-Rays.
2. Contrast agents.

Technique:

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

Used in:

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

Advantages	Disadvantages
- Widely available. - Inexpensive. - Functional + Anatomical imaging. - No sedation required.	- Requires ingestion/injection of contrast medium. - Requires patient cooperation. - Time consuming. - Higher radiation than X-Ray.

Computed Tomography

How does CT work?

By rotating an X-Ray tube with the X-Ray detector, and the patient will go through these rays. Then, we will receive cross-sectional images (axial) (like slices). Each slice is an image by itself. We reconstruct these images to create other images from different views (coronal for example), which are 3D images.

Relies on X-Rays transmitted through the body.

- Images consist of sections (slices) through the body, and are taken horizontally.
- To show coronal (frontal) or Sagittal images, data are manipulated (reconstructed) by a computer.
- Differs from conventional radiography (traditional 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.

Computed Tomography

It has two windows: Important (Checkout the pictures in slide 8)

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 (mediastinum window).

- CT often requires a contrast. however, an example that doesn't require a contrast is stone imaging.
- Density is measured by Hounsfield Unit (HU). Read more about it here.
- Has very small differences in X-Ray absorption values compared with conventional radiography; the range of densities recorded is increased approximately 10-fold.

Ex: If we put the computer pointer on the liver to read the density it will show around 60 HU. And if I see an area within the liver that measures around 1000 that means its calcification.

Densities					
Air	Fat	Water	Soft Tissue	Blood	Bone / Ca
-1000	-150	0	20-80	45-75	>100->1000

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

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.

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 mases, pancreatic tissue, renal mases, and adrenal masses.

Uses of CT

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 structures:
Pelvis and extremities.

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

So, gradations of density within soft tissues can be recognized, e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.

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.

Magnetic Resonance Imagining:

In CT Scan the bones are **WHITE** but in MRI it appears **GREY**.

- MRI sees tissues based upon sub-atomic 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 (tumors and infections). - No ionization. - Can be done on pregnant women. - Images can be obtained in any plane (unlike CT which is taken in axial position).	- Expensive. - Time consuming. so we can't use it on emergency patient - May evoke phobias Claustrophobia (phobia of narrow places). - No metals allowed. - Motion.

Ultrasound aka Ecography/sonography

- 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 your blood vessels.

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:**

1. No radiation. 2. Can be portable. 3.Relatively inexpensive.

Nuclear Medicine

- We use an isoton which is an excited atom.
- Uses gamma rays to produce an image (Counts or Activity).
- Radioactive nuclide given IV, per os, per rectum etc.
- Rays emitted from the patient. (unlike the other modalities)
- Physiologic imaging (Abnormal function, metabolic activity).
- Poor for anatomical information.
- Radioactivity stays with the patient until cleared or decayed.
- The most important difference in the nuclear medicine: the source is from within the patient while the detector is outside.
- One of the important advantages of nuclear medicine is that it shows you the function and the structure.

What is nuclear medicine? An illustrated introduction

For better understanding

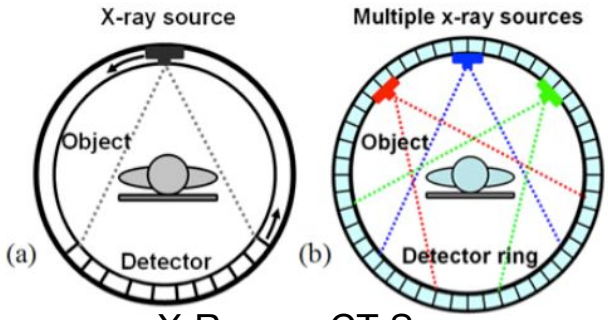
a. X-Ray:

What is the difference between the X-Ray and the light?
Is the energy that could allow the X-Ray to penetrate the body while the light couldn't.

When we X-Ray a patient chest what are we expected to see?
A two dark fields which are the right and the left lungs.

What would be the expected relatively white structures within the central part of these two black fields?
The heart because it is soft tissue component.

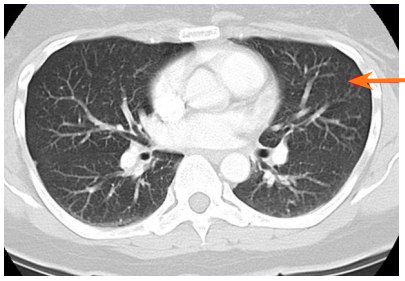
b. CT Scan:



X-Ray vs. CT Scan

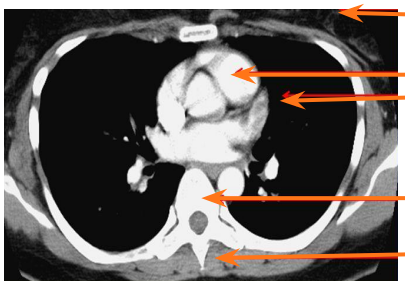
Wide VS Narrow windows:

Lung Window



Wide range of visible grays

Mediastinal Window



Narrow range of visible grays

If you want to order CT scan would you use a wide or a narrow window to look at the structures of the bone ?
Wide window, because we have several components in the bone such as cortex, medulla, nutrient vessels.

A patients comes to the ER with shortness of breath (dyspnea) and the ER physician suspected that this patient has pulmonary embolism so he requested a CT scan of the chest to evaluate the pulmonary artery, will he use a wide window or narrow window ?
Narrow window, because I'm only looking at the vessels of the pulmonary artery.

Summary

X-Ray

•It is a form of Electromagnetic energy that travel at the speed of light.

Two interactions :
1- Dark, black, radio-lucent.
2- Light, white, radio-opaque.

Advantages:
- Inexpensive.
- Doesn't require advanced technologist knowledge

Disadvantages
- Ionizing Radiation.
- Requires patient cooperation.

Fluoroscopy

Technique:
- **Real-time imaging:** dynamic.
- **Using intensifier**

Advantages:
- Functional + Anatomical imaging

Disadvantages:
- Time consuming.
- Higher radiation than X-Ray.

CT

It has two windows:
- Wide window: to visualize more structure within a certain organ (Lung window).
- Narrow window: to visualize certain structures within certain region (mediastinum window).

- Density is measured by Hounsfield Unit (HU).

Advantages:
- Gives: Cross sectional, Sagittal and Coronal Images.

Disadvantages:
- High Radiation.

MRI

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

Advantages:
- No ionization.
- Images can be obtained in any plane.

Disadvantages:
- Expensive.
- Time consuming.
- May evoke Phobias Claustrophobia.

Nuclear Medicine

- Rays emitted from the patient.
- Physiologic imaging.

Ultrasound

Advantages:
- No radiation.
- Can be portable.
- Relatively inexpensive.

Questions

Q1: Which one of these X-ray disadvantages is responsible for making it contraindicated in pregnancy?
a. Relatively insensitive
b. Requires cooperation
c. Ionizing radiation
d. Unavailability

Q2: A CT scan of a patient in the ER with history of trauma showed black area around the liver with the density of 45-75 what is it?
a. Fat
b. Blood
c. Soft tissue
d. Air

Q3: Which one of these modalities can assess the function and the shape of an organ at the same time (dynamic and static)?
a. Nuclear medicine
b. CT
c. X-ray
d. MRI

Q4: To reduce the the amount of radiation needed in fluoroscopy we use:
a. Intensifier
b. Real time imaging
c. Stone imaging
d. Contrast

Q5: The technique we use to detect the movement of the contrast in fluoroscopy is called:
a. Intensifier
b. Real time imaging
c. Stone imaging
d. Angiography

Answers:
1- c.
2- b.
3- a.
4- a.
5- b.