Radiology
Team 438

New Slides

Introduction to diagnostic imaging (part one)

Lecture 1

Radiology
Team442

Revised by
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Objectives

- Introduce meaning of Radiology.
- Introduce various medical imaging modalities.
- Appreciate constraints and limitations.
- Appreciate importance of imaging relation to gross anatomy.

Color Index: Main text | Males slides | Female slides | Dr's notes | Important | Golden note | Extra

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Radiology

Medical specialty that uses imaging technology to diagnose and treat patient illnesses, it is the Medical specialty that deals with:

What is Radiology?

- Supervises, perform and interprets imaging studies of different body parts, tissues or organs.
- Medical imaging technology in the clinical diagnose, management and disease monitoring.
- Reports findings to referring physicians.

Divided into 2 broad areas

- Diagnostic radiology
- Interventional radiology (focuses on patient management utilizing minimally invasive intervention techniques "non-surgical procedures")

- Neuroradiology
- Pediatric radiology
- Cardiovascular radiology
- Chest radiology
- Gastrointestinal radiology
- Genitourinary radiology
- Emergency radiology
- Nuclear radiology

- Angiography & Angioplasty (imaging & treatment of blood vessels)
- Biopsy procedures
- Cardiac Catheterization
- Stents
- Fluid & Abscess drainage
- Laser treatment of varicose veins

Diagnostic Modalities used in radiology

Conventional/plain X-Ray → Computed Tomography (CT) → Magnetic Resonance Imaging (MRI) → Ultrasound (US) → Nuclear Medicine (NM) → Angiography (ANG)

- Single-photon emission computed tomography (SPECT)
- Positron emission tomography (PET)

Ionizing radiation can be carcinogenic / to the fetus mutagenic or even lethal (x-ray)

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

X-Ray

X-RAY

- It is a form of Electromagnetic energy **wave spectrum** 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.
- Generated via interactions of the accelerated electrons with electrons of tungsten nuclei within the tube anode Kinetic energy of the electron is converted in to electromagnetic energy by atomic interaction
- X-Rays has restricted distribution of light to prevent its spread, as it is considered harmful.

Image key = shades (Densities)

- 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).

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

The X-RAY Beam Interaction

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

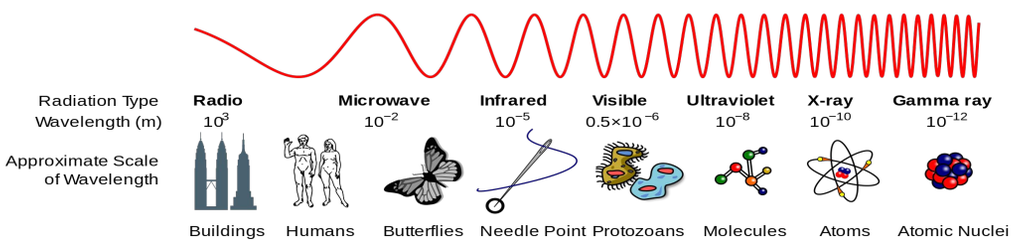
(Best modality to visualize air under diaphragm)

Disadvantages

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

Electromagnetic energy wave spectrum

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



Include all of these, with gamma rays being the one with highest energy

Air → Fat → Soft tissue → Bone

The higher frequency and shorter wavelength, the higher penetration ability

Fluoroscopy

FLUOROSCOPY

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

Type of medical imaging utilizing continuous x-ray with images displayed on a monitor (like x-ray movie). During a fluoroscopy procedure, an x-ray beam passes through the body and image is transmitted to a monitor so the movement of a body part or of an instrument or contrast agent through the body can be seen in detail.

- A dynamic contrast study, (dynamic) real-time imaging, utilizes X-ray with image intensifier.
- It's a combination of:
  - X-Rays — is static image while fluoroscopy is dynamic image
  - Contrast agents

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.

Utilization of FLUOROSCOPY

- Imaging different body parts (GI, GU, Vascular,...) commonly used for recurrent UTIs, vesicoureteral reflux, Obstructions, dilatations, collecting system abnormalitie
- Management procedures (interventional radiology)
- Monitoring during surgery (Ortho, Neuro...)

COMPUTED TOMOGRAPHY (CT)

- Mobile X-ray tube rotating around a patient. (Cross Sectional imaging modality).
- More sensitive x-ray detection system is used.
- Images consist of sections (slices) through the body, and the data are manipulated by a computer.
- Data displayed in multiple window settings (lungs parenchyma, bone, etc.)
- The source of beam rotates around patients to create cross- sectional pictures (unlike X-Ray which is 2 dimensions only)
- Key advantage of CT is that anatomy is more detailed
- creates coronal and sagittal images indirectly, but it creates axial directly

Density

- Density is measured by **Hounsfield Unit (HU)** every structure has its own density measured in HU
- 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/Ca: >100->1000

Applications of TOMOGRAPHY (CT)

(White area represents bone in CT)

- Neuro-imaging
- Head and neck imaging
- Body imaging (chest, abdomen and pelvis)
- Specialized protocols
- Other osseous structures (extremities)
- Vascular imaging

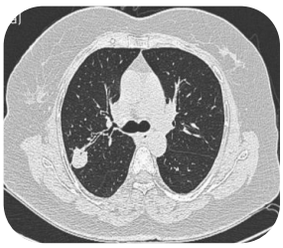
Different Windows

Wide window

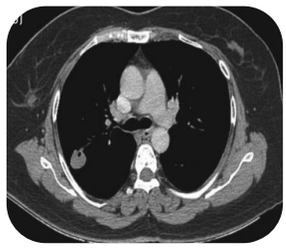
to visualize more (detailed) structures within a certain organ such as bronchi, vessels and alveoli in the lung (Lung window) (Bone to visualize cortex, medulla and trabeculae)

Narrow window

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

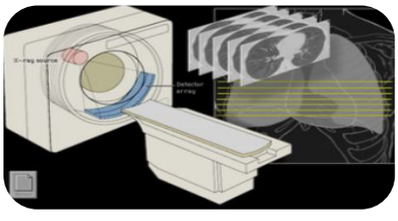


(Focus on the pictures)



Advantages

- Available everywhere, consistent quality, best option for whole-body evaluation (trauma)
- Fast



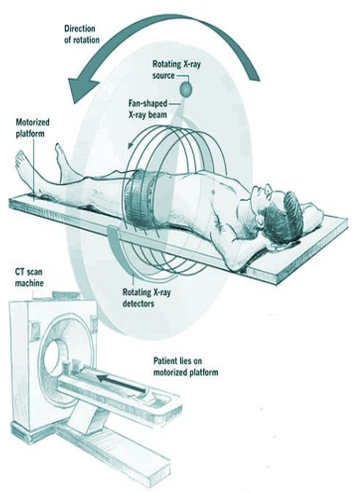
Disadvantages

- Less sensitive for small liver metastases than MRI
- High Radiation even more than X-Ray

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 →whit) (Fluid → dark) (Subacute hemorrhage → white)
- T2 weighted (T2WI), (Fluid →whit),(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.

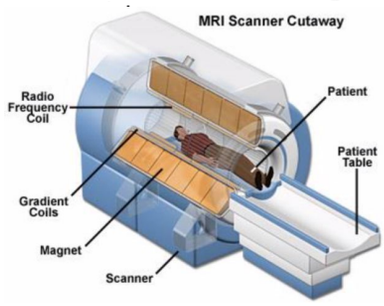
Advantages

- The best soft tissue imaging and pathology (tumors and infections), Show better tissue characteristics
- Better tissue construction then 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 perform without introducing contrast media

Disadvantages

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

Image key = shades (Intensities)



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.
- 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.)

- High-frequency sound waves are used to visualize soft tissue structures in the body in real time.
- No ionizing radiation.
- Image quality obtained is highly dependent on the person skills.
- Safe can be useful in imaging of children and pregnant women.

Advantages

1. No radiation (safest for pregnant ladies)
2. Can be portable "easily used in ICU"
3. Relatively inexpensive
4. Good to evaluate fetus within amniotic fluid

Disadvantages

1. Gas filled and bony structures can't be visualized (absorbs ultrasound beam)
2. Operator dependent (require skills)

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).
- Isotopes injected into patient that emits gamma-rays
- 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

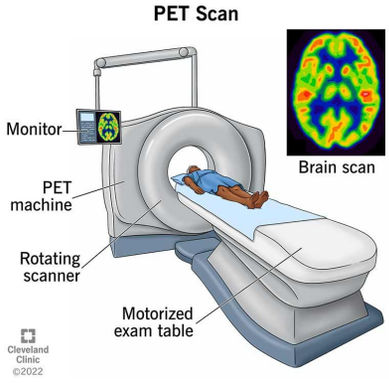
- Sensitive but not that much specific

PET - POSITRON EMISSION TOMOGRAPHY

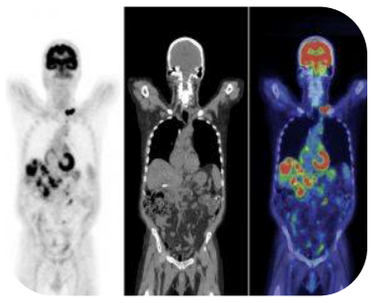
- PET is Nuclear medicine functional imaging technique for metabolic processes/ functions in the human body.
- Positron emitting tracer is injected into the body which emits positrons causing annihilation that results two gamma rays.
- They detectors are detected by opposing detectors.
- Then these signals are transferred to amplifier and other electronic circuit.
- Tracer may be injected, swallowed or inhaled depending on which organ or tissue is being studied by the PET scan. Tracer is
- collected in certain areas of the body that have higher levels of chemical activity, which often correspond to areas of disease. On PET scan, these areas show up as bright spots.
- measures metabolic activity of the cells of body tissues.

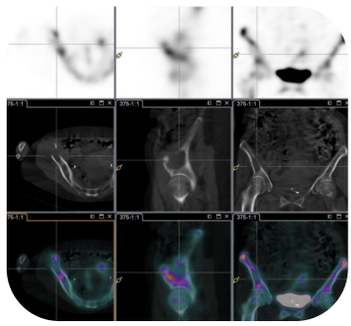
What is the primary function of PET

- Detect and stage a cancer (Earlier than CT / MRI).
- Determine spread of a cancer throughout the body.
- Detect the primary site of the cancer.
- Decide whether the cancer can be resected surgically.
- Help in treatment plan.
- Assess effectiveness of a treatment plan (chemotherapy).
- Differentiates between scar and active cancer tissue.
- Determines recurrence of a cancer.



SPECT - SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY





- It is Nuclear medicine tomographic imaging technique using gamma rays (very similar to conventional nuclear medicine planar imaging using gamma camera "scintigraphy"; however it is ale to provide true 3D information) which is presented as cross-sectional images.
- Detect single photons emitted by radionuclide tracers
- Determine the origin and direction of emitted gamma
- Reconstruct 3D images of the source or anatomy
- Used as diagnostic tool to image tumors, disease and perform bone scan
- Images reflect functional information similar to PET
- Adding CT to SPECT and PET

SPECT	PET
SPECT imaging is inferior to PET less resolution and sensitivity	Superior to SPECT "Better because it could highlight the high metabolic activity"
Lower cost	Very expensive
Uses gamma emitting radioisotope (tracer) - half life around 6h	Uses postiron emitting radioisotope (tracer) - half life 75 seconds
SPECT radio tracers are cheaper	SPECT radio tracers are expensive

Picture archive and communication system(PACS) Radiology information system (RIS)

- Within the radiology department there are two key elements that form the information infrastructure. The first is the radiology information system (RIS) and the second is imaging network most often called picture archiving and communication system (PACS)

ADVANTAGES of PACS & RIS

- It consists of
  - The imaging modalities.
  - A secured network for transmission of information
  - Workstations for interpreting and reviewing images.
  - Archives for the storage and retrieval of images and reports
- Is a medical imaging technology that provides secure storage of an convenient access to images from multiple medical imaging modalities and digitally transmit electronic images and clinically-relevant reports.
- It eliminates the needs to manually file, retrieve, or transport film jackets.

Artificial intelligence and radiology

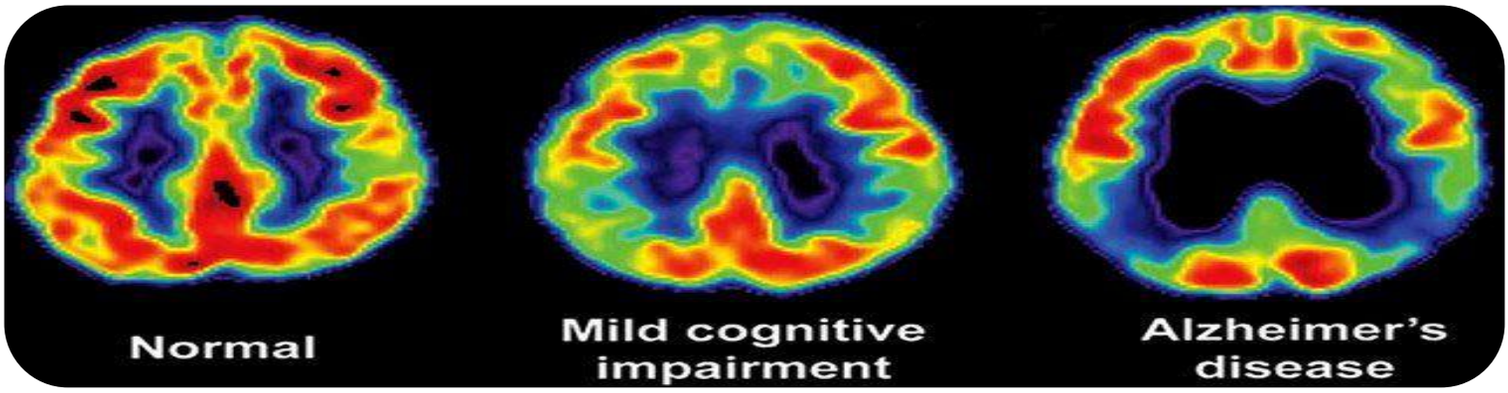
- Branch of computer science devoted to creating systems to perform tasks that ordinarily require human intelligence.
- Creation of intelligent machines that work and react like humans reasoning, planning, learning, language processing, perception and the ability to move and manipulate objects.
- Creating a self-learning computer software that can help radiology practice in, for example, spotting anomalies and detecting tumors.
- Creating systems that can act to be more accurate than human radiologists in detecting and diagnosing diseases

Top three benefits of AI in Radiology

- Greater profitability: Radiology AI can pre-sort and review scans for radiologists, enabling them to do more work in less time.
- Radiologist support: Radiology Artificial Intelligence is evolving into highly supportive role in which the AI assumes routine tasks that slow radiologist efficiency.
- Improved patient care: Radiology Artificial Intelligence promises to help deliver a high quality medical experience that will provide better patient care.

Artificial intelligence & Radiology - Examples

Detecting Alzheimer's disease
Researchers developed an algorithm that can detect Alzheimer's based on FDG-(PET) scan (such as changes in glucose uptake), which cannot be observed with the naked eye and therefore boost radiologists' confidence in diagnosing



INTERVENTION RADIOLOGY

- Is a subspecialty which provides minimally invasive diagnosis (angiogram) and /or treatment
- (angioplasty)using imaging to target the intervention and show the results of the intervention
- It is an image-guided surgery
- Can be used in
  - Diagnose & Treat vascular problems
  - Biopsy
  - Drainage of fluid or collections (abscesses)
  - Embolization
  - Treat infertility
  - Treat liver tumors
- It uses local anesthesia
- Usually no need for hospital admission
- Safe and effective

SUMMARY

	Advantages	Disadvantages	information
X-RAY	• Widely available • Inexpensive • Doesn't require advanced technologist knowledge • Can be performed quickly • Can be portable	• Ionizing Radiation. • Relatively insensitive (superimposed structures) • Requires patient cooperation	**The X-RAY Beam Interaction:** 1-Pass all the way through the body 2-Be deflected, scattered or absorbed
FLUOROSCOPY	• Widely available. • Inexpensive • Functional and anatomic imaging. • No sedation required	• Requires ingestion/injection of contrast medium. • Patient cooperation. • Time consuming	**Uses:** ⬥GIT imaging ⬥Foreign body removal ⬥Musculoskeletal ⬥Intraoperative ⬥Genitourinary imaging
COMPUTED TOMOGRAPHY (CT)	• Can give: Cross sectional, Sagittal and Coronal Images • More sensitive	• Expensive • High Radiation	**Types:** ⬥Wide window ⬥Narrow window **Uses:** ⬥Neuroimaging ⬥Head and neck ⬥Body imaging
MRI	• 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	• Expensive. • Time consuming. so we can't use it on emergency patient • May evoke phobias Claustrophobia • No metals allowed • Motion.	MRI sees tissues based upon subatomic characteristics (magnetism).
ULTRASOUND	• No radiation • Can be portable • Relatively inexpensive	• Needs a well-trained operator.	Ultrasonic images also known as sonograms are made by sending pulses of ultrasound into tissue using a probe.
NUCLEAR MEDICINE	⬥Used for Physiological imaging (abnormal function, metabolic activity)	⬥Poor for anatomical information. ⬥Radioactivity stays with the patient until cleared or decayed	Uses gamma rays to produce an image (counts or activity).

quiz

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 axises 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