RADIOLOGY
TEAM 435

Radiological anatomy of the cardiorespiratory

[Color index: Important | Notes | Extra]

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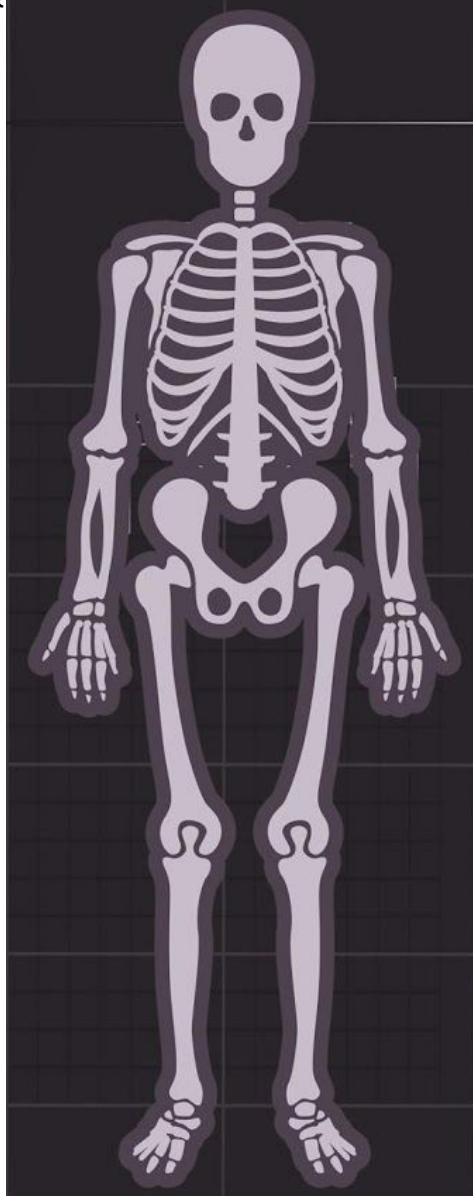
Objectives:

1. Recognize the different modalities utilized in imaging the chest & cardiovascular system
2. Recognize the basic technical factors affecting image quality
3. Recognize the radiological anatomy of chest and cardiovascular system



Resources:

- **435 Slides and notes**

Done by:

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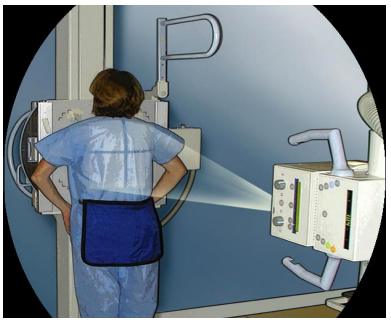
Radiological Modalities					
Plain X-Ray	**CT**	**Angiography**	**Nuclear Medicine**	**MRI**	**Ultrasound**
Ionizing Radiation			Minimal Ionizing radiation	Non-Ionizing Radiation	

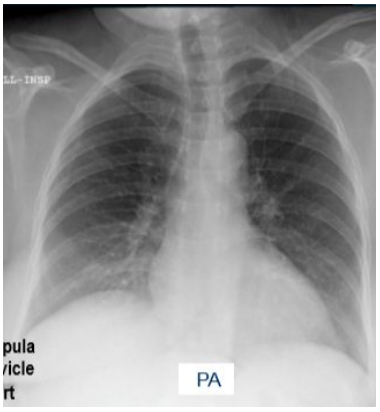
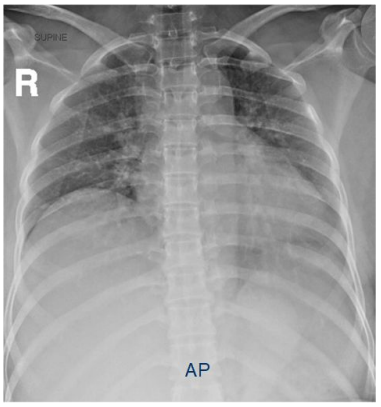
1- Plain X-Ray

- X-ray: Electromagnetic radiation
- **The image is the result of interaction of X-Ray beam and body tissue:**
  - X-Rays that pass through a structure easily are least absorbed and therefore cause blackening on the radiograph (air-lung).
  - Whereas structure that absorbs or reflects X-Ray most appear white. (bone-metallic)
  - Soft tissues lie in between -> gray, According to thickness of these the shades of gray differ.
- The image on an X-Ray film is two-dimensional. All the structures along the path of the beam are projected onto the same portion of the film (superimposed). Therefore, it is often necessary to take at least two views to gain information about the third dimension.



- Projections are usually described by the path of the X-Ray beam. Thus, the term PA (postero-anterior) view indicates that the beam passes from the back to the front, which is the the standard projection for a routine chest film.

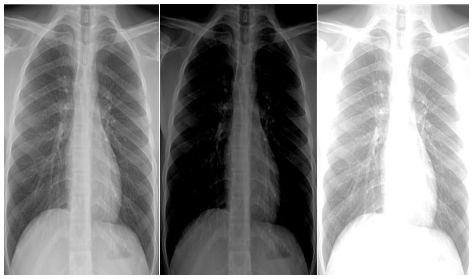
In PA, the patient is facing the chest stand while the source is behind the patient. so the sequence is : X-ray source > patient > chest stand (like the picture in the right). While In AP, the patient will be facing the source of X-ray. we usually perform PA and lateral views.

	PA	AP
why do we prefer PA over AP?		
1. Heart:	Heart length is <50% of the whole thorax The heart is in the anterior aspect of the mediastinum touching the sternum in its lower aspect, no gap between heart and chest stand (exposure to the heart is identical to its real size)	Heart shows a false cardiomegaly. (>50%) Transverse diameter of heart is larger in AP (gap -> magnification).
2. Clavicle:	Clavicles are over the lung field	Clavicles are seen almost above the lung apex. you may miss pathologies within the apex.
3. Scapula:	Scapula is seen in the periphery of the thorax more clarity to the lung fields.	Scapula is projecting inside the lung fields.

TECHNICAL FACTORS: What is a good Chest X-Ray?

1- CXR with adequate exposure

Good Exposure is assessed by visualization of the spine and lung markings and vascularity even though cardiac shadow

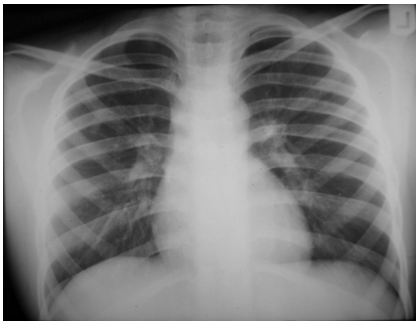


- Right: under exposure
  cardiac shadow appears wide and makes it difficult to see abnormalities behind the heart
- Middle: overexposure
  I can see the spine and vascularity within the lung, but the lung appears black and thus abnormalities within the lung can be missed.
- Left: adequate exposure

similar to the light, if you increase the kilo voltage (KV) > brighter, if you decrease KV > faint photo.

can we change the exposure factor after taking the x-ray as in CT? No, we can only adjust the window (the brightness of the screen itself).

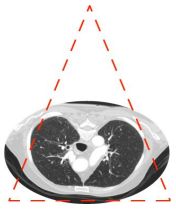
e.g. A patient came with acute respiratory distress, from first glance at X-ray it was grossly normal. however after changing the exposure factor, you can see foreign bodies at the esophagus. Picture:

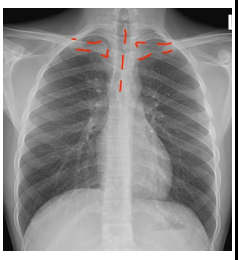


2- CXR with proper positioning

Good positioning is assessed by seeing Medial ends of clavicles are at equal distance from midline (spine).

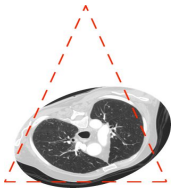
1.

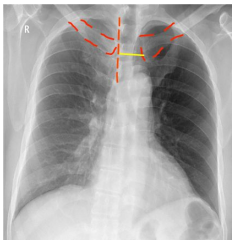




PA view: if the patient is standing parallel to the chest stand, the 2 lungs will be exposed at equal degree, and both will appear of identical density (blackening).

2.





what if the patient is rotated? There will be a gap filled with air at one side thus showing black density at one lung (you'd think of pneumothorax, COPD > emphysema)

Another technical factor is Dual energy technique:

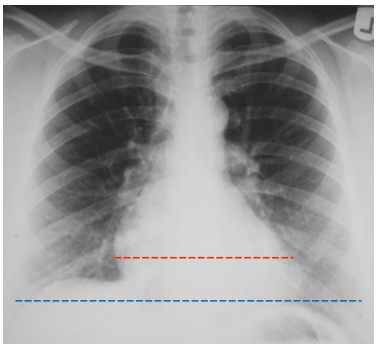
Changing energy of photons we can either eliminate the boney structures or the soft tissue. possible rib fracture? eliminate the soft tissue.

3- CXR with adequate inspiration

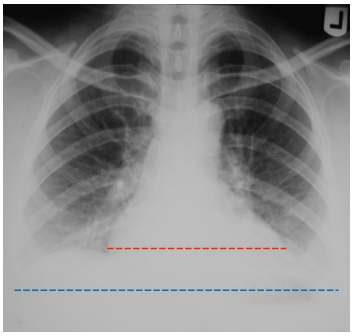
Assessed by counting 6 anterior ribs above dome of diaphragm or 9 posterior ones.

- Anterior ribs are inclined inferior medial (to the medline)
- Posterior ribs are either horizontal or inclined inferior lateral (to the periphery)

we compare the transverse diameter of the heart (in red) and compare it with the transverse diameter of the chest (in blue). The ratio shouldn't exceed 50%



Right: ratio = **46%**
Adequate inspiration



Left: ratio = **65%**
Inadequate inspiration

e.g. a patient came to the ER with dyspnea. chest X-ray with inadequate inspiratory effort showed enlarged heart and haziness over the pulmonary vasculature and bases of the lung (implicating CHF) when repeated, the heart size has reduced and the pulmonary vasculature appeared more sharp.

Applying anatomy: Chest X-Ray

1. Lungs
2. Mediastinum (cardiac shadow)
3. bony cage (ribs, sternum, spine)
4. soft tissue component lung (hemidiaphragm, breast shaddow)

1. Normal Lung

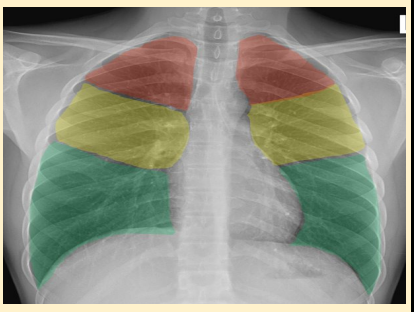
Characters of normal lungs:

- well-aerated assessed by adequate inspiration
- Symmetrical translucency:

For comparison we divide the lung in 3 zones: upper (1st 2 intercostals), middle (2nd-4th), and lower zones. These are imaging divisions, not anatomical.

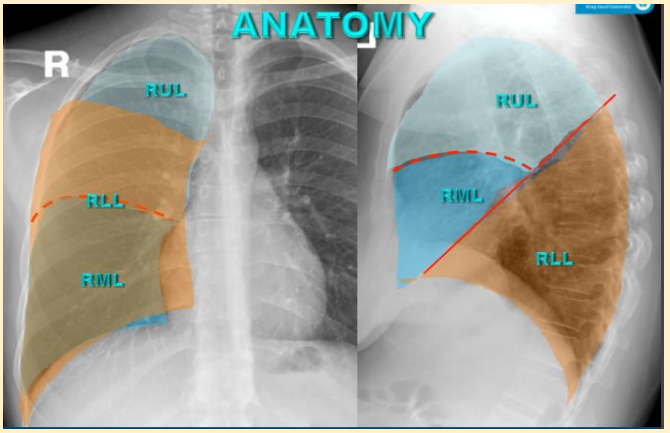
- Clear apices & costophrenic angles
- Normal vascular distribution

That is normally wider in caliber (diameter) in the centre and smaller in the periphery



Anatomical lobes of the lung:

- **RUL: right upper lobe**
- **RLL: right lower lobe**
- **RML: right middle lobe**

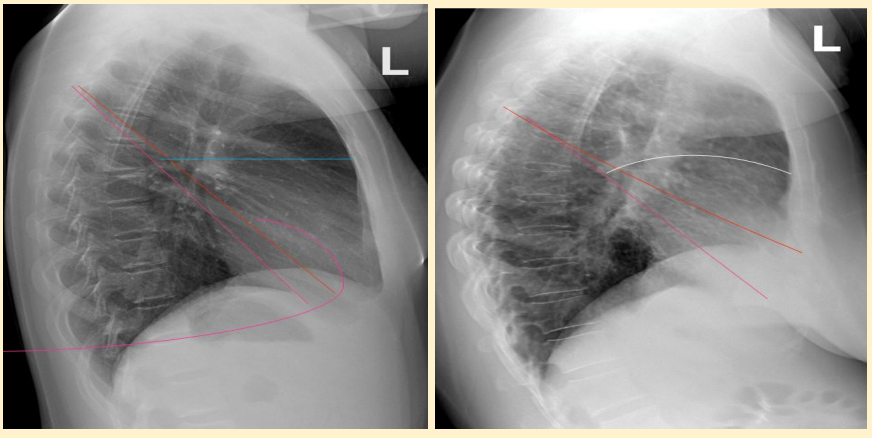


The lungs are divided anatomically by fissures (invagination of pleural membrane inside the lung) & bronchial distribution.
if you have a pathology located in the upper zone, we can't tell if it is RUL or RLL unless in lateral view, as these lobes are superimposed on each other. If pathology is in the middle zone on frontal view, it might be in the RML or RLL.
white lines: vasculature not bronchial tree, you can't see the bronchi as they contains air just like the lung and have a very thin wall

Fissures of the lung:

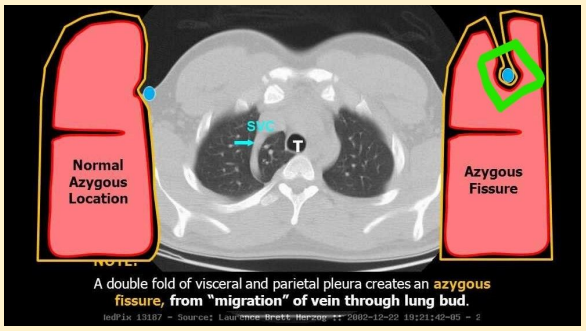
- Oblique (major) fissures: is seen best in **lateral** view (occasionally seen in PA view); **The right fissure is more anterior** and more horizontal than the left because the heart a pushes the left backward.
- Horizontal (minor) fissure: is seen in both **PA and lateral view** only in the right lung.

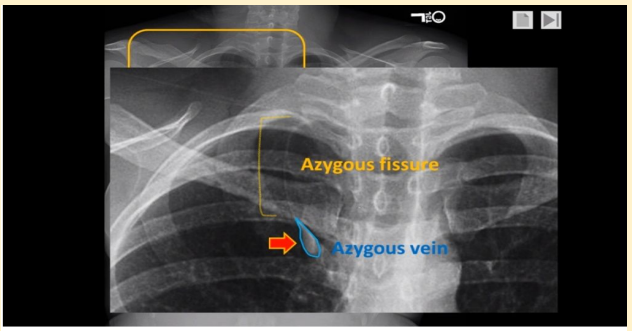
*Both are formed from 2 layers (both are visceral layers invaginating the lung, the parietal covers the lung from the outside only).



Dr.sharkawy said you can't determine whether it's the R or L side of the lateral view. This is far advanced

- The accessory fissure **e.g. Azygos fissure** has 4 layers. This fissure is seen in certain individuals due to anatomical variation during embryological development, formed because even the parietal pleura invaginates. It has no bronchus!!

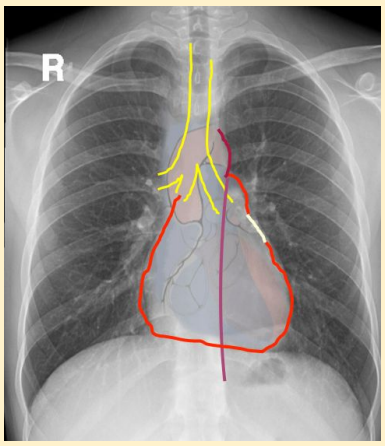


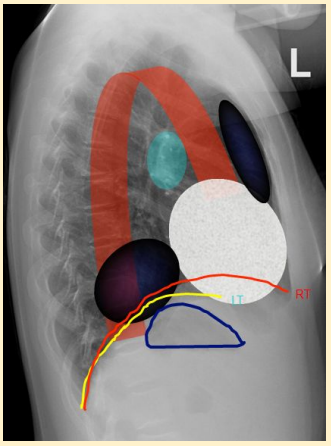


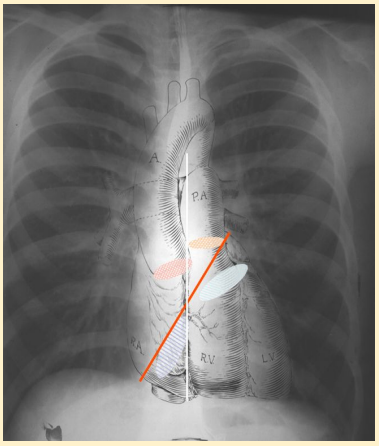
Chest Radiology: The Azygous Fissure, a normal variant

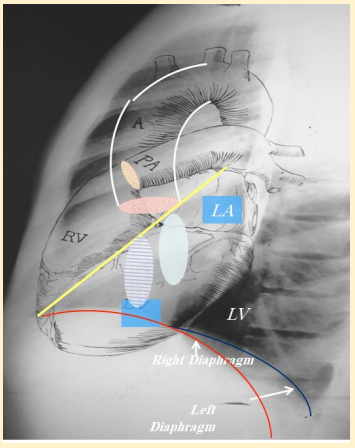
2. Mediastinum

- In the Middle (1/3 RT, 2/3 LT)
- It has 3 curves on LT (aortic arch, pulmonary trunk, Left ventricle), and 1 curve on RT (Right atrium).
- It has homogeneous density (in the normal lung, the retrosternal and retrocardiac spaces are black, not white or faint)
- It is anterior on lateral X-Ray
- The trachea is central, above the spine, bifurcates at the level of T5-6 trachea
- **The shadow of hemidiaphragm:** The right hemidiaphragm is clear anterior to posterior, while the left we can't see its anterior aspect as the the heart is setting on the diaphragm
- The most higher valve =pulmonary
- The most inferior right = tricuspid

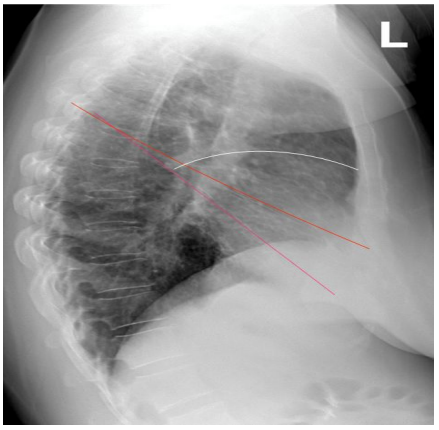








Quiz:



which of the following is true regarding the anatomical landmark related to this lateral chest X-ray?

A- The left hemidiaphragm is seen complete from anterior to posterior aspect

B- The dashed pink line refers to left oblique fissure.

C- The right oblique fissure is posterior to the left one

D- Horizontal fissure is not seen

answer: B

which of the following is true regarding the anatomical landmark related to this lateral chest X-ray?

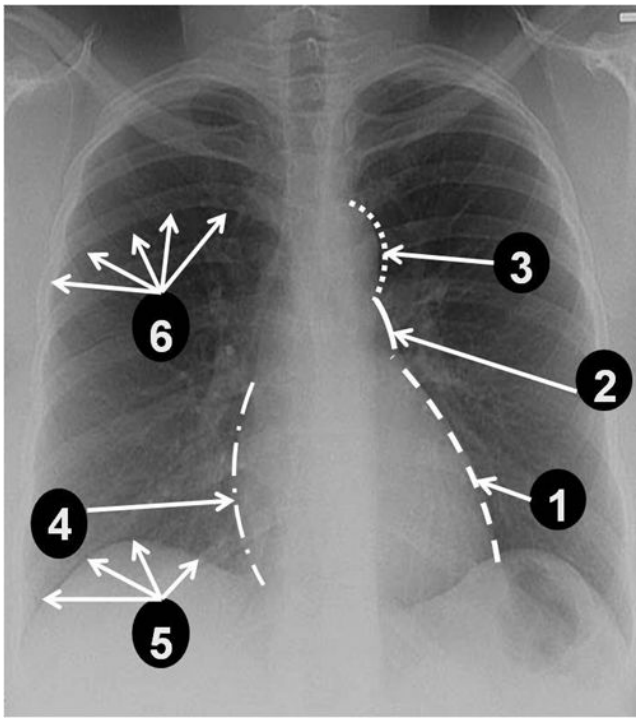
A- The heart touches the the lower third of the sternum

B- The right and left hemidiaphragm are normally superimposed

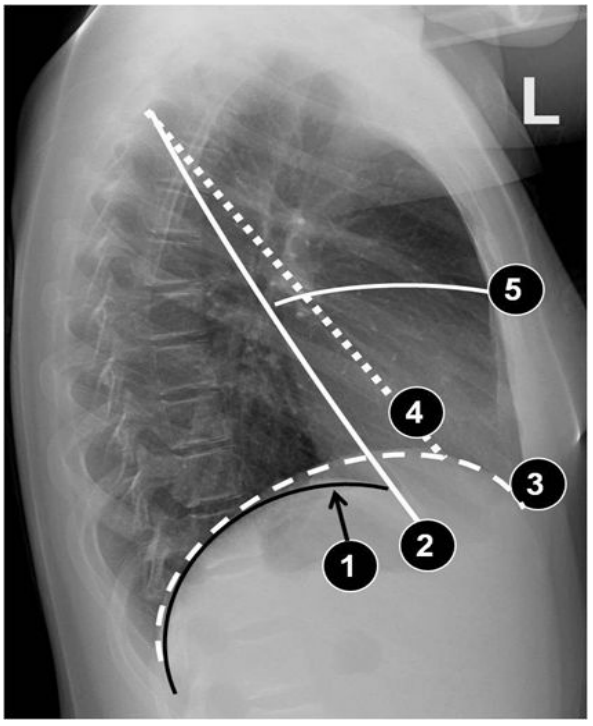
C- The oblique fissure is better seen in the frontal PA view

D- Retrocardiac area appears normally opaque.

answer: A



1. Left ventricle
2. Pulmonary trunk
3. Aortic arch
4. Right atrium
5. Right hemidiaphragm
6. Posterior right rib



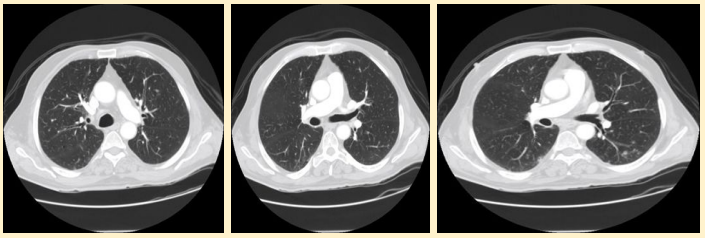
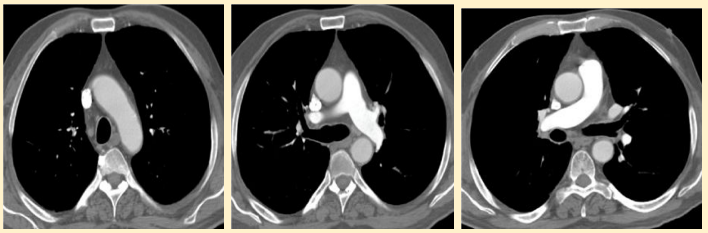
1. Left hemidiaphragm
2. Left oblique fissure
3. Right hemidiaphragm
4. Right oblique fissure
5. Horizontal fissure

2- Computed Tomography (CT)

Recall from the first lecture:

- Relies on X-Rays transmitted through the body. It differs from conventional radiography in that a more sensitive X-Ray detection system is used, the images consist of sections (slices) through the body, and the data are manipulated by a computer.
- 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.

- There is major risk behind CT scan, 1 brain CT scan radiation = 200 X-Ray radiation, pelvic CT radiation = 400 X-Ray radiation which means don't request a CT scan unless it is needed and We can't use it for a pregnant women unless it is necessary.

Lung window	Mediastinal window
is wide window to visualize lung parenchymal structures including bronchi, vessels and alveoli	is narrow window to visualize mediastinal structures including major vessels, heart .
 Window Width (WW): **wide** (1600) Window Level (WL): negative (-600)	 WW: **narrow** (450) WL: positive (35)

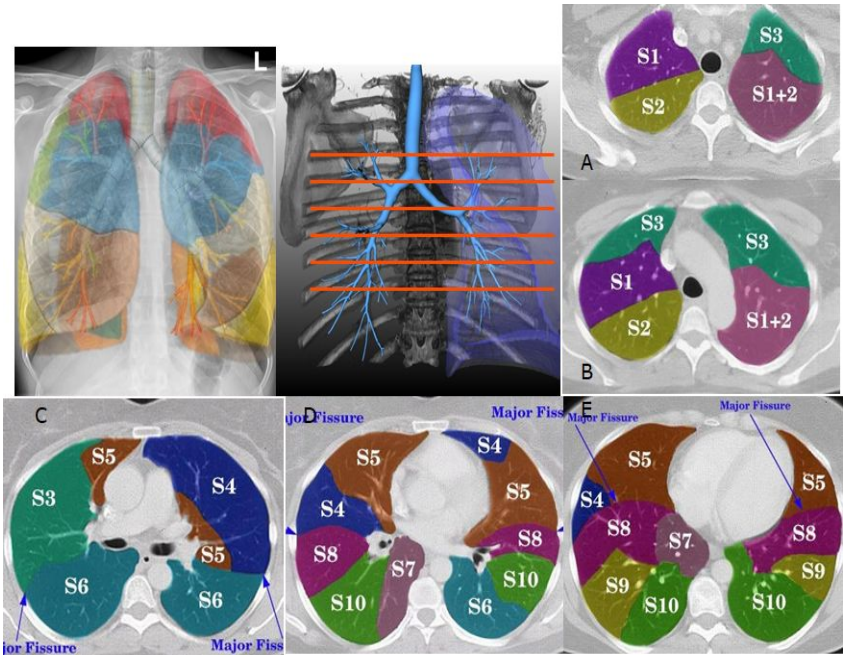
NORMAL CHEST ANATOMY: CROSS SECTIONAL CT

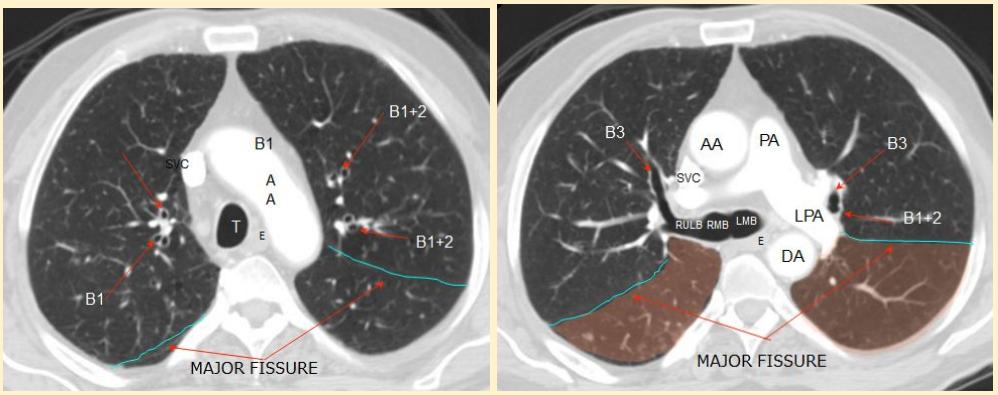
CT images are taken at different levels.

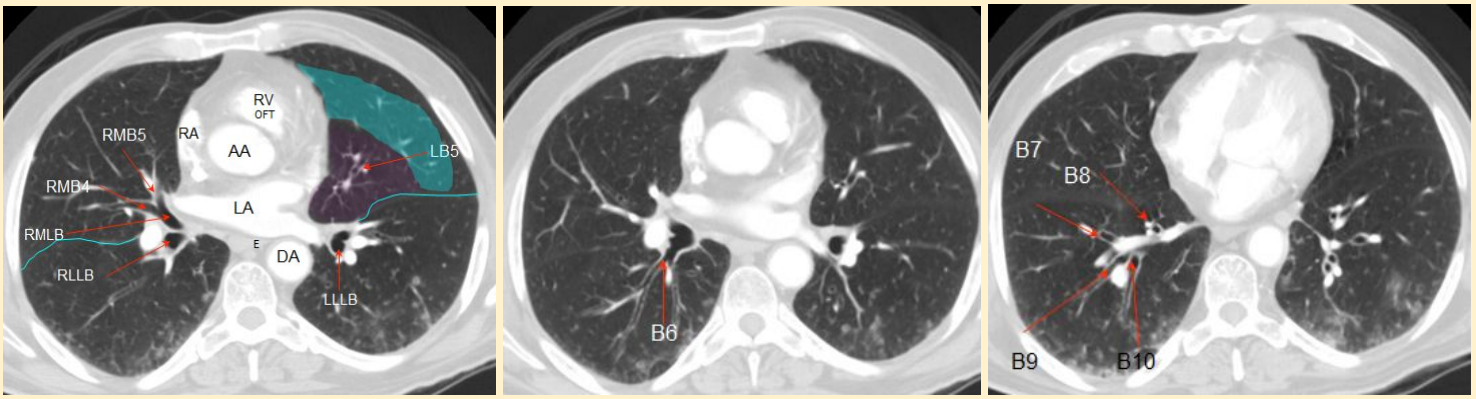
To recognise the lungs' segments we use:

1. **Major/oblique fissure** (which appears as a White hairline or Lucent/White band)
   - segments anterior to the fissure = upper lobe
   - segments posterior to the fissure = lower lobe
   - the RML bronchus is directed anteriorly & anterior to the fissure

2. The segmental anatomy (bronchial tree segmental branches)







B1= Apical Upper Lobe Bronchus **B2=**posterior Upper Lobe Bronchus
B1+2= Apicposterior Upper Lobe Bronchus **B3 =** Anterior Upper Lobe Bronchus
B6= Superior Lower Lobe Bronchus **B7=** Medial Basal Bronchus
B8= Anterior Basal Bronchus **B9=** Lateral Basal Bronchus **B10=** Posterior Basal Bronchus

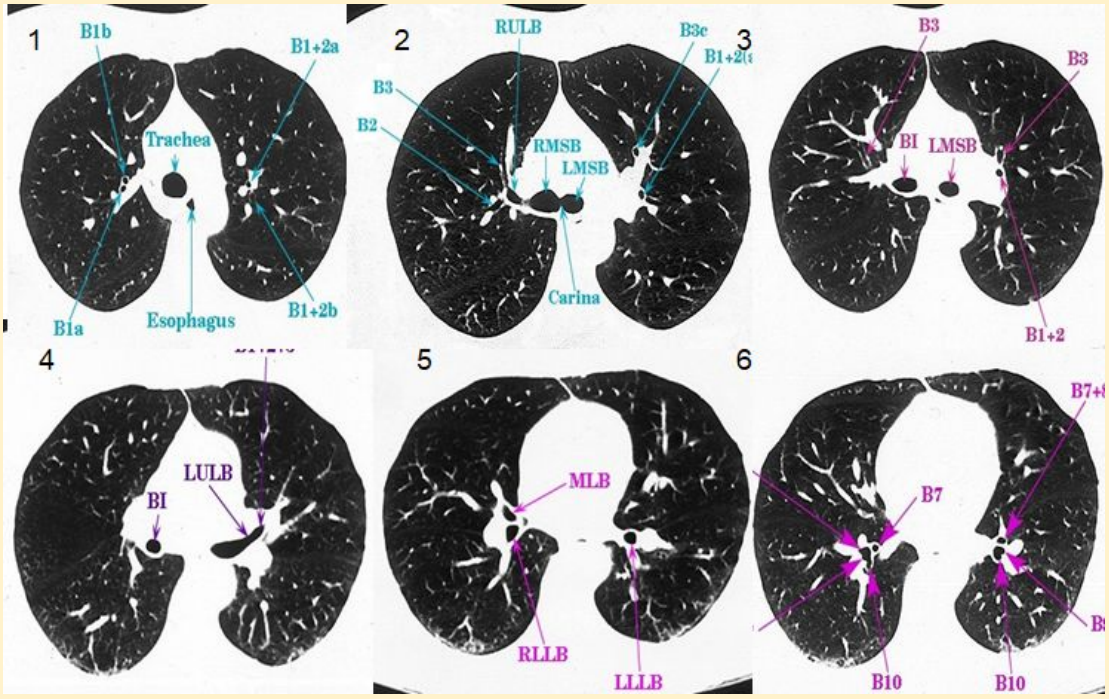
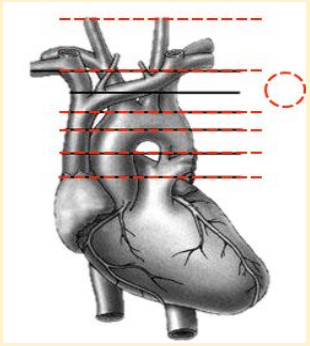
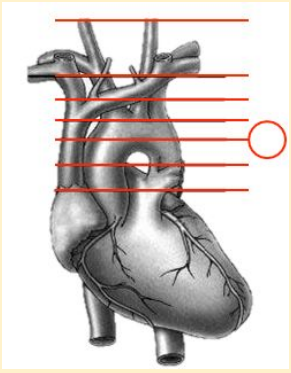
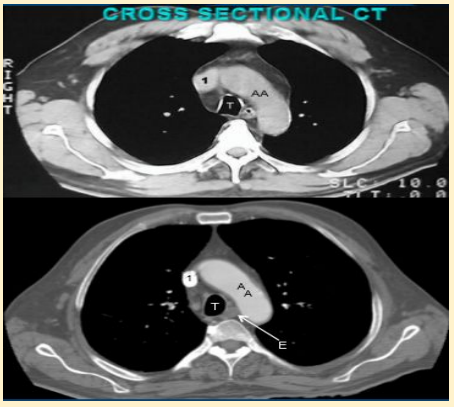
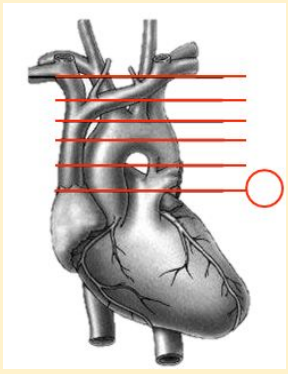
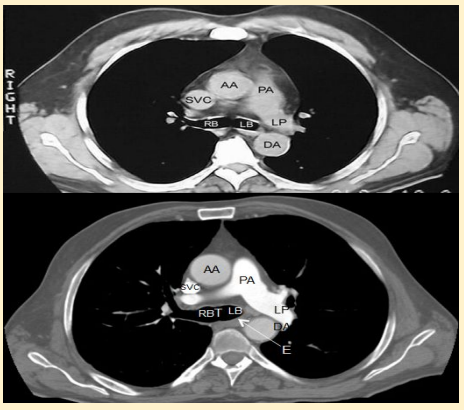
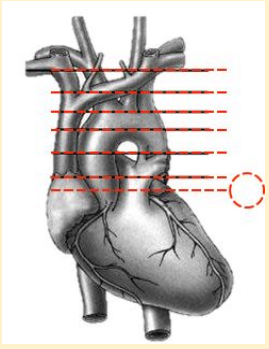
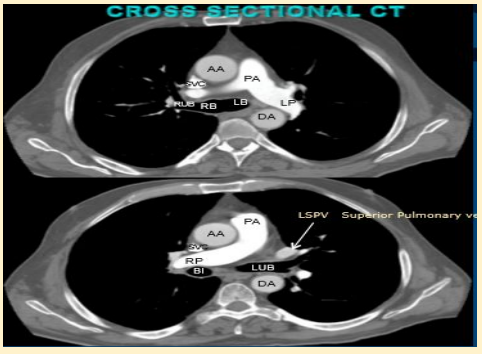
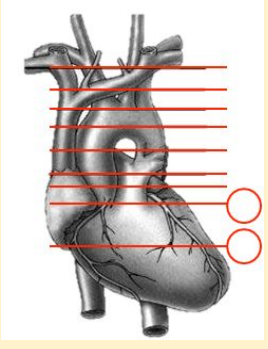
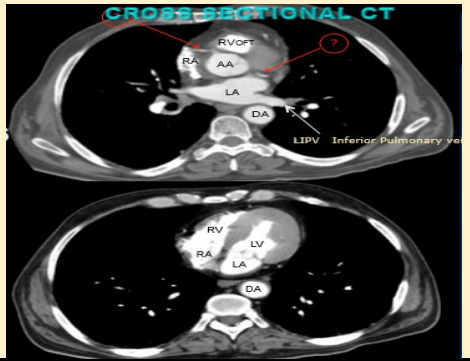
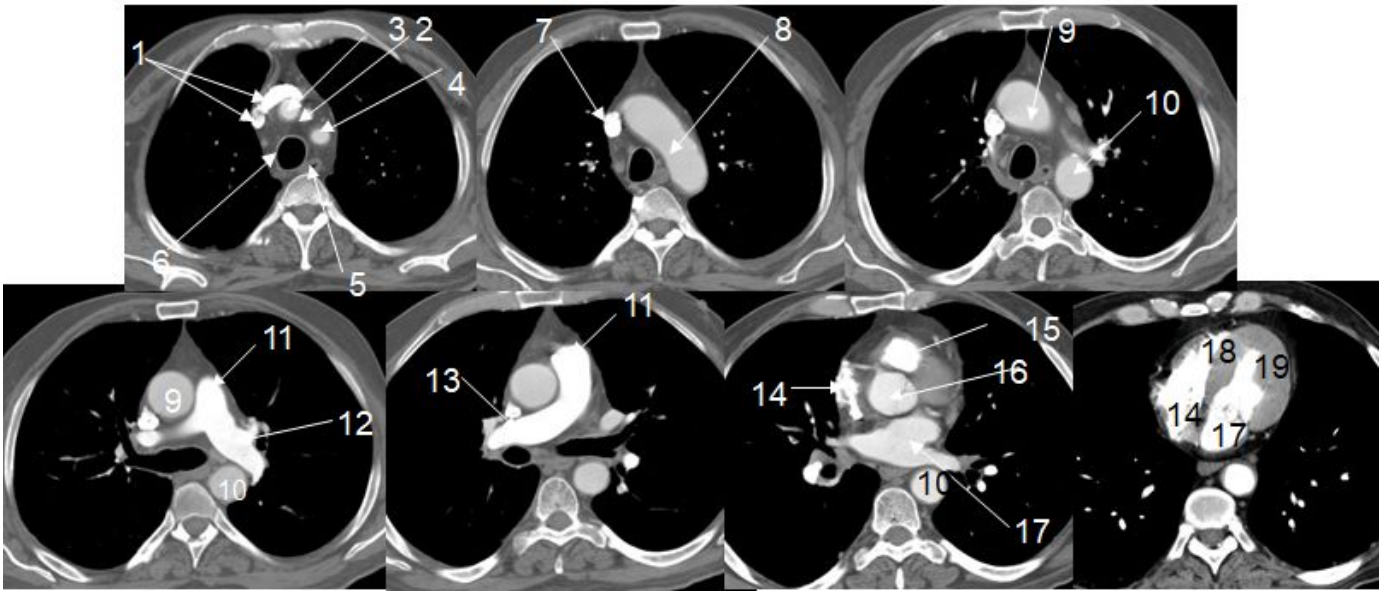


Image1: Level of trachea, we could see the upper lobe segmental bronchi
Image 2: Level of bifurcation and right upper lobe bronchus
Image 3: Lower cut at right bronchus intermedius level (BI)
Note : segments of the lung follow distribution of segmental bronchi. Fissure could be seen as either thin hairline structure or as lucent (black) density band

Level 1			• E:ESOPHAGUS • R:RIB • S:SCAPULA • T:TRACHEA • 1:Right Brachiocephalic vein • 2: Brachiocephalic artery • 3:Left common carotid artery • 4:Left subclavian artery • 5:Right Brachiocephalic vein
Level 2			• AA: Aortic Arch • T: TRACHEA • 1: Superior vena cava
LEVEL 3			• AA: Ascending Aorta • DA: Descending Aorta • LB: Left main bronchus • LP: Left pulmonary artery • PA: Pulmonary trunk • RB: Right main bronchus • SVC: Superior vena cava
LEVEL4			• AA:Ascending Aorta- • DA:Descending Aorta- • LUB:Left upper bronchus- • BI: Bronchus intermedius- • LP :Left pulmonary artery- • RP:Right pulmonary artery- • PA:Pulmonary trunk- • RB:Right main bronchus- • SVC:Superior vena cava
LEVEL 5-6			• AA:Ascending Aorta (root) • DA:Descending Aorta • LA:Left atrium • LV:Left ventricle • RA:Right atrium (auricle) • RV:Right ventricle (outflow) • LIPV:Left inferior pulmonary vein



1: Rt & Lt innominate veins (brachiocephalic veins)
2: RT brachiocephalic artery
3: LT common carotid
4: LT subclavian artery
5: esophagus
6: Trachea
7: Superior vena cava
8: Aortic arch
9: Ascending Aorta
10: Descending Aorta
11: Pulmonary trunk (artery)
12: LT Pulm artery
13: RT Pulm artery
14: RT atrium
15: Pulm artery
16: Aortic root
17: Lt atrium
18: RT ventricle
19: LT ventricle

Note: LT Pulmonary artery is seen before RT artery therefore it is higher than the right artery.
LT atrium is the most posterior chamber; RT ventricle is most anterior chamber.

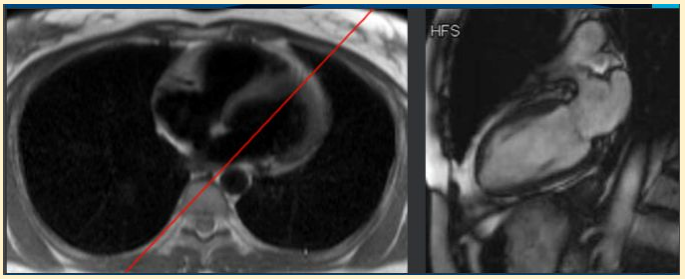
3- Magnetic Resonance Imaging (MRI)

Recall from the first lecture:

- Simply, hydrogen atoms (protons) in water molecules and lipids >> magnetism affects all protons causes them to line up in one direction >> magnets can be switched on and off to change the direction of the magnetic field >> whenever the water molecule spin around they give a light radio wave >> MRI machine can detect it >> show it as images
- So gradations of density within soft tissues can be recognized, e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.

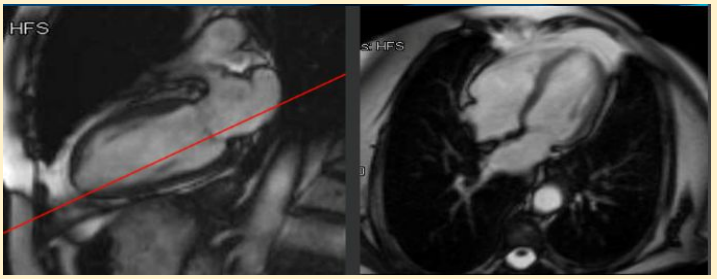
MRI advantages	MRI disadvantages
• Best for soft tissue imaging. • There is no ionization. • It can be done for pregnant women with caution. • Images can be directly in any plane	• Expensive. • Time consuming. • Patients fear it and dislike it because it is a narrow place. • Since it is magnetic no metals can be allowed. • Patient has to keep still during scanning procedure.

VERTICAL LONG AXIS VIEW



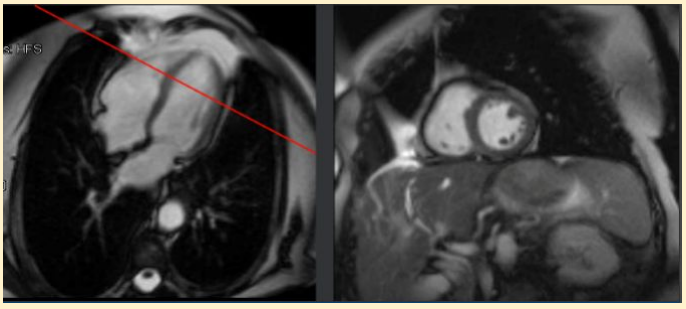
The vertical long axis is for evaluating the anterior and inferior walls and apex of the left ventricle.
An axial image through the LV and LA is chosen from the transverse localizer images, and a parasagittal plane that is perpendicular to the chosen image is prescribed that bisects the mitral valve and intersects the LV apex.

HORIZONTAL LONG AXIS VIEW



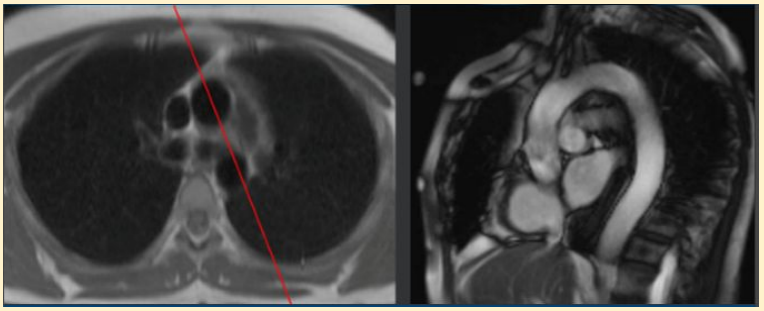
The horizontal long axis (four chamber view) is best for evaluating the septal and lateral walls and apex of the left ventricle, the right ventricular free wall, and chamber size. The mitral and tricuspid valves are also well visualized in this plane. A perpendicular plane to the vertical long axis image is chosen which intersects the lower third of the mitral valve and the LV apex.

SHORT AXIS VIEW



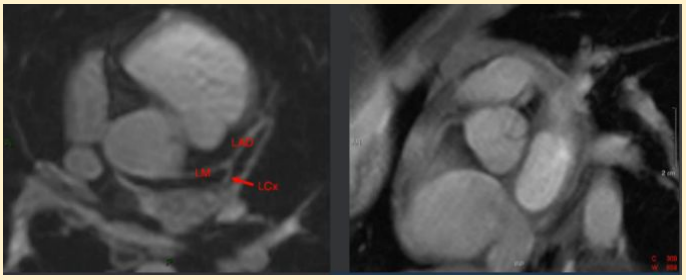
The short axis view shows cross-sections of the left and right ventricle that are useful for volumetric measurements using Simpson's rule.
The short axis view is chosen perpendicular to long axis of LT ventricle in serial cuts.

AORTIC VIEW



The Aortic view ("Candy Cane" view) shows the aorta along its entire thoracic course along with some of its branches off the aortic arch. An axial image is selected and a plane is chosen that bisects both the ascending and descending aorta.

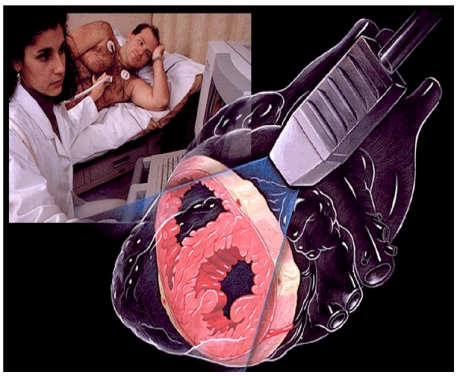
CORONARY ARTERIES VIEW

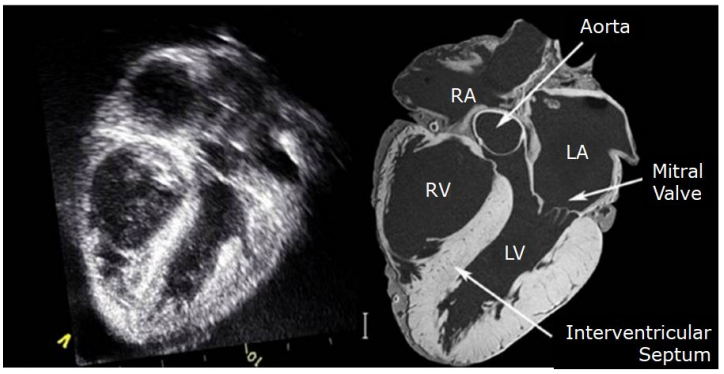


The coronary arteries originate from the proximal portion of the ascending aorta from the Sinuses of Valsalva. The two coronary arteries arising from the aorta are the right coronary artery (RCA) and the left main coronary artery (LM). The LM branches into the left anterior descending (LAD) and left circumflex (LCx) arteries.

4- ULTRASOUND

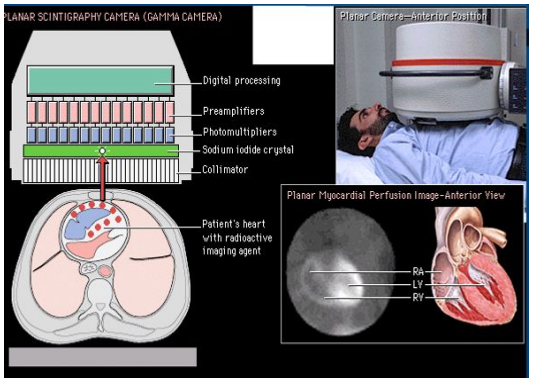
- A dynamic study of heart's contraction, valves' leaflet/reflux, and ejection of blood (EF)
- Go below the sternum and angulate the probe toward the heart in long/oblique/short view

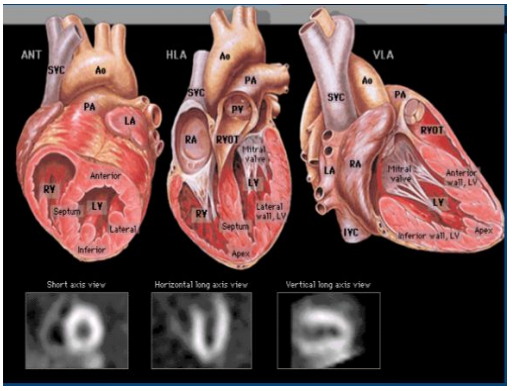


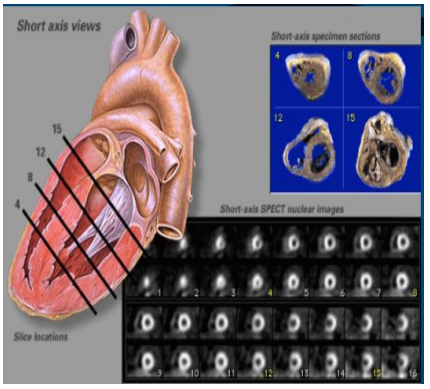


5- Nuclear Medicine

- Injected radioisotope accumulates within the structure we're interested in.
- The camera located next to the patient measures intensity of isotopes
- Decreased intensity indicates stricture/narrowing of coronary arteries. Several angles are used to know which coronaries are involved.







6- ANGIOGRAPHY

- injecting contrast material to the aorta to detect dissecting aneurysm
- cardiac catheterization to view the coronaries (sequential helical CT may be used instead to build a 3D image of vascular structures)
- viewing the pulmonary artery in case of PE