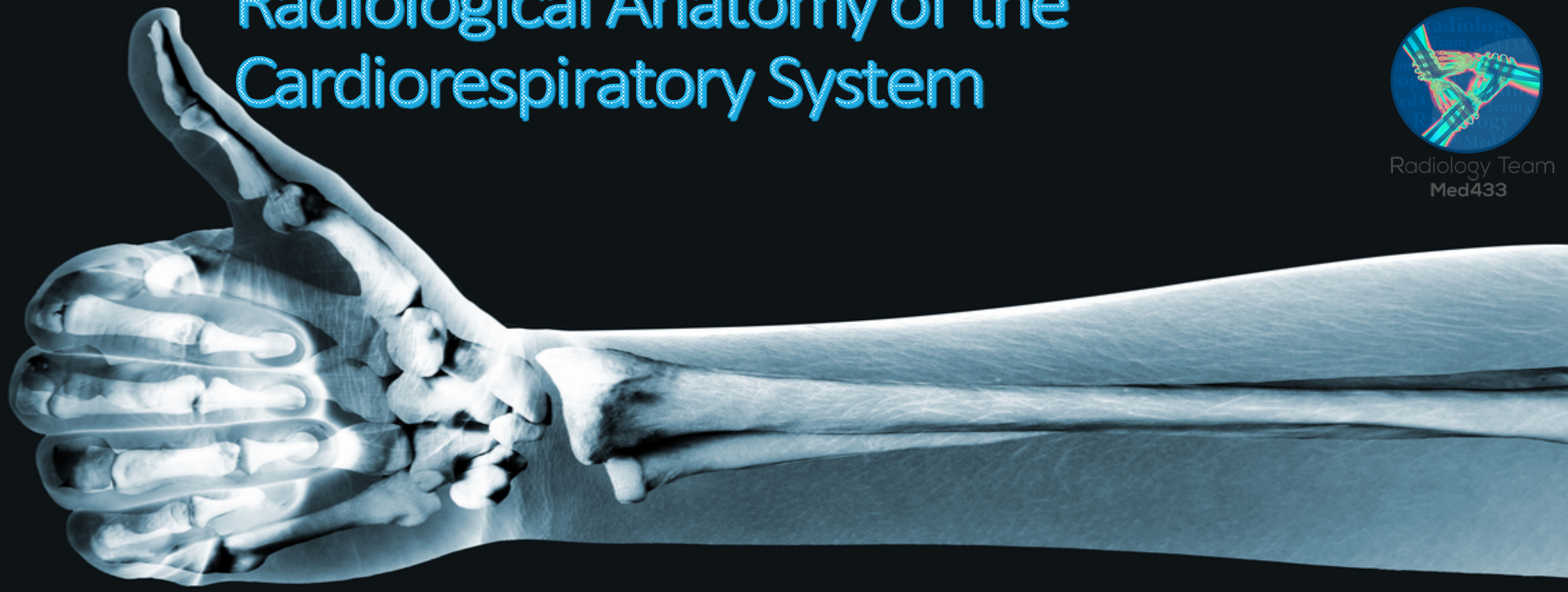
Lectures 3 & 4 & 5:

Radiological Anatomy of the Cardiorespiratory System



Radiology Team
Med433

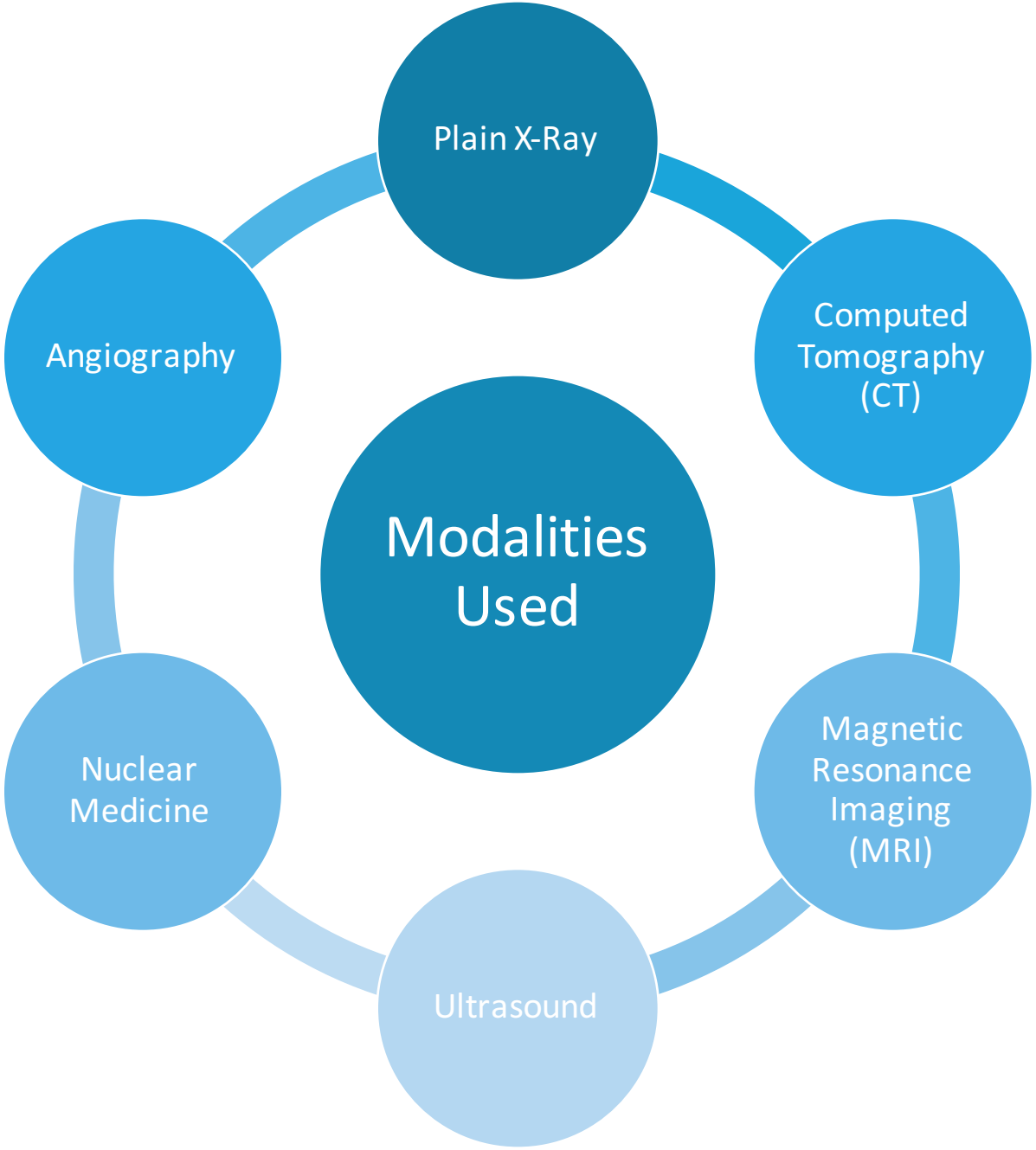
● Slides ● Explanation ● Notes ● Additions ● Important

Objectives

Lectures 3 & 4:

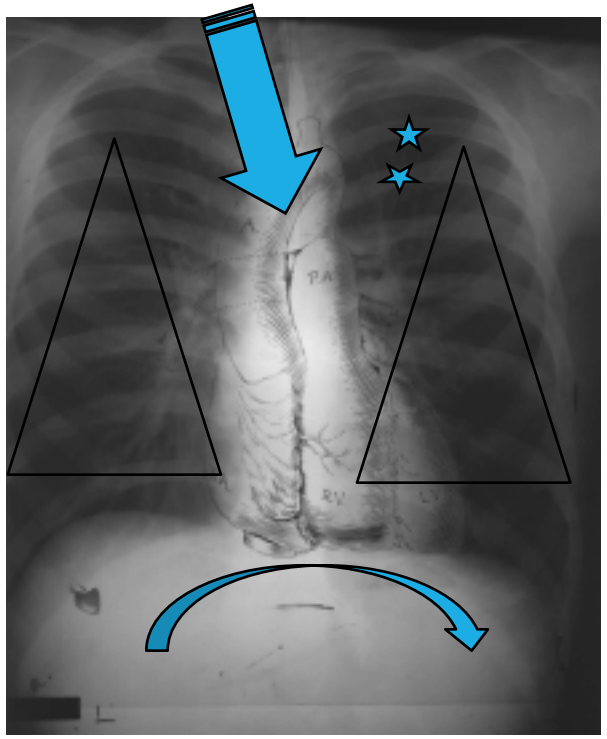
- ✓Recognize the different modalities utilized in imaging the chest & cardiovascular system
- ✓Recognize the radiological anatomy of chest and cardiovascular system
- ✓Develop Interpretation Skills “Where to look & What to look for”
- ✓Recognize the chest pattern of abnormality seen on the CXR
- ✓Recognize the imaging vocabulary utilized in chest & cardiovascular

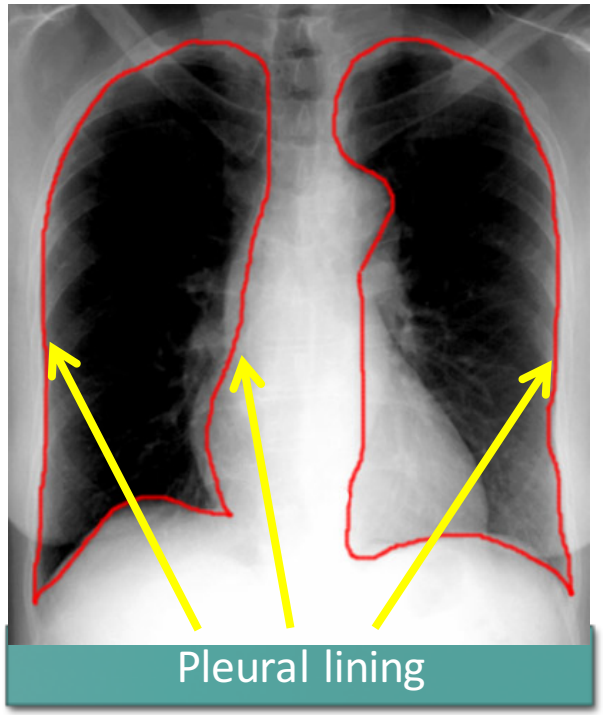
Lecture 5: not given


Plain X-Ray
Computed Tomography (CT)
Magnetic Resonance Imaging (MRI)
Ultrasound
Nuclear Medicine
Angiography
Modalities Used

What Do We Mean By Chest?

We mean study of thoracic cage contents.
(lungs, mediastinum, ribs and diaphragm)



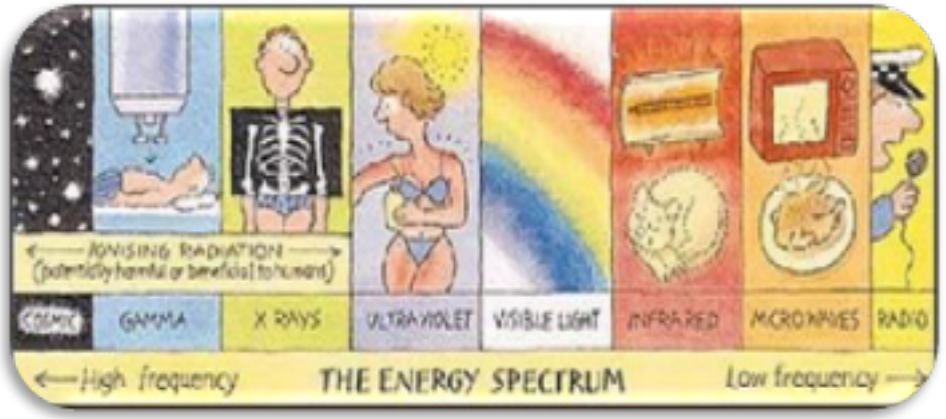


Outline of the lung; we don't see pleura but we know its place

Basic Chest Exams

- Plain Films (Chest X-ray)
  always start with it (gold standard)
- Computed Tomography
  - CT lungs & mediastinum
  - CT Angiography (CTA)
    particularly for PE
  - High Resolution CT of the chest (HRCT)
    specific for lungs only, without IV fluid
- Angiography
  - Not used any more due to its complication (mortality 30%)
  - used as therapeutic not diagnostic
- MRI
  not used

Plain X-Ray



What are x-rays?

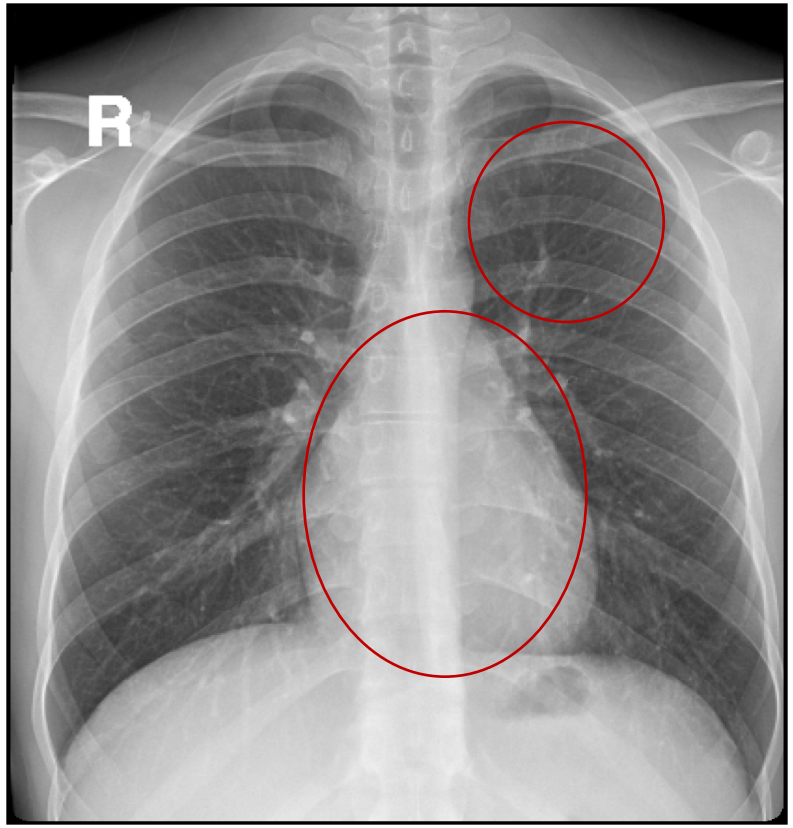
Electromagnetic radiation.

There are three main kinds of ionizing radiation: alpha particles, which include two protons and two neutrons. beta particles, which are essentially high-speed electrons. gamma rays and x-rays, which are pure energy (photons)

An electromagnetic wave of high energy and very short wavelength, which is able to pass through many materials opaque to light

The image is the result of interaction of X-ray beam and body tissue.

- X-rays pass through a structure: **blackening** on the radiograph (air-lung).
- X-rays absorbed or reflected: **white** on radiograph (bone-metallic).
- Soft tissues lie in between: **gray**. (According to thickness of these the shades of gray differ.)



Projections are usually described by the path of the x-ray beam.

PA (poster anterior) view designates that the beam passes from the back to the front, is the **standard projection** for a routine chest film.

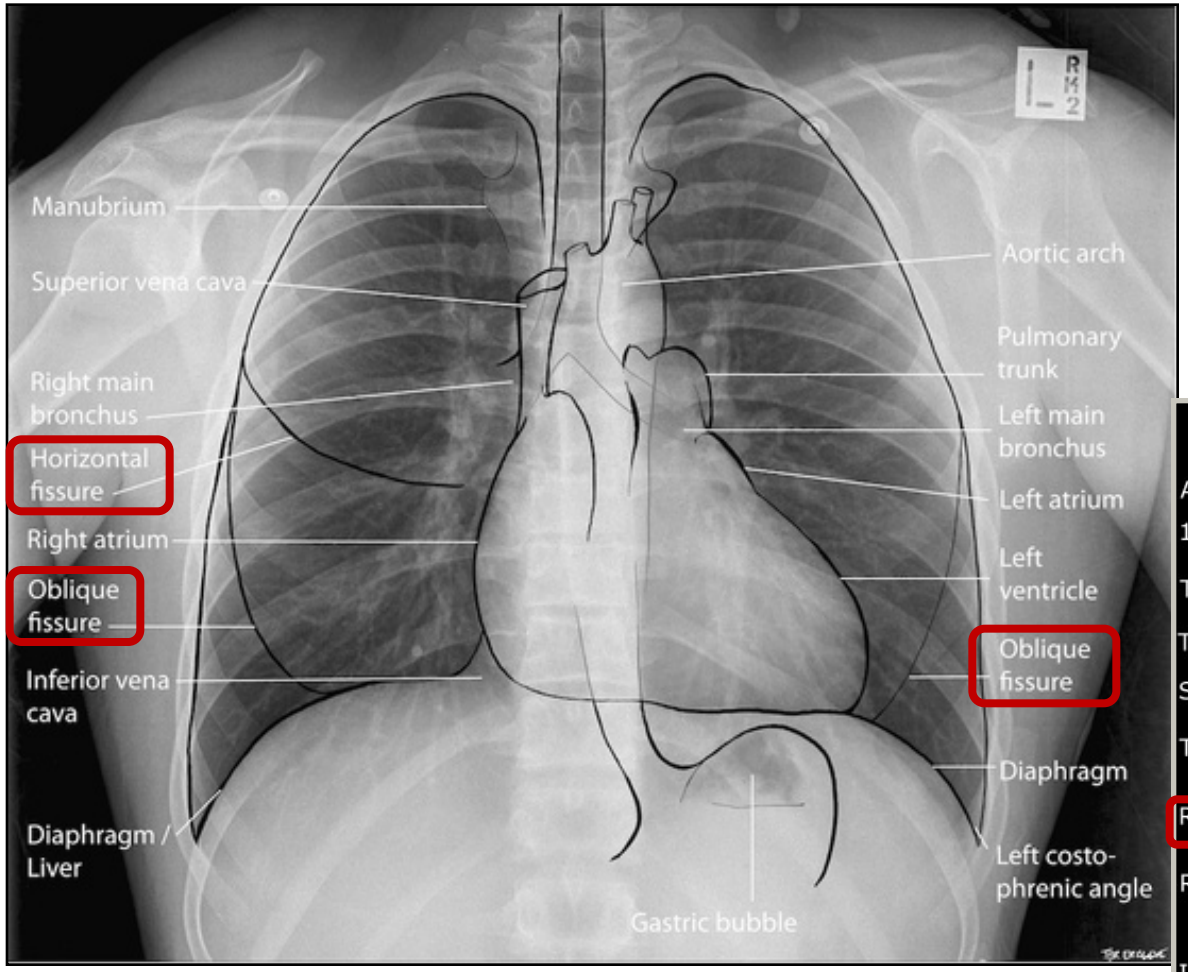
The image on an x-ray film is **two-dimensional**. All the structures along the path of the beam are projected on to the same portion of the film (superimposed). Therefore, it is often **necessary to take at least two views** to gain information about the third dimension.

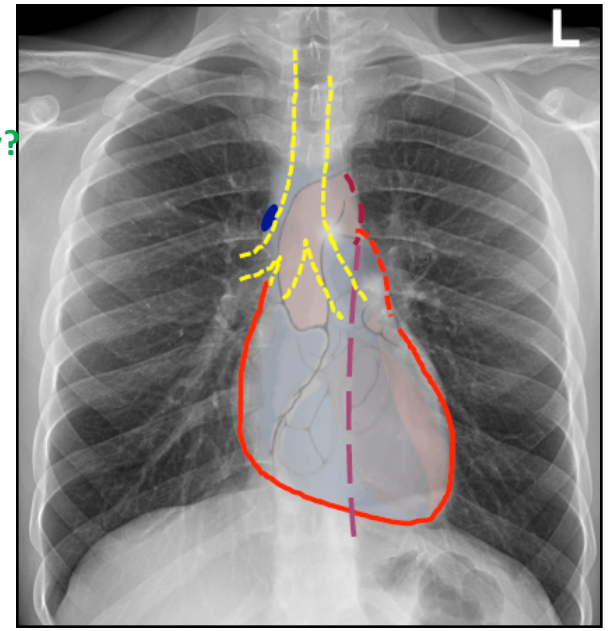
Review of Chest Anatomy

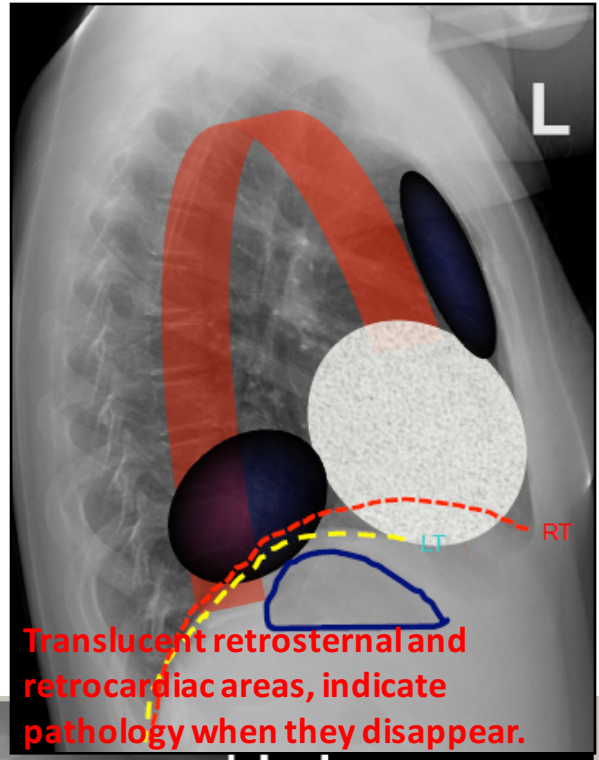
Usually the white structures are vascular structures (not related to the bronchi). Justify?

They contain blood so they'd appear as grey scale.

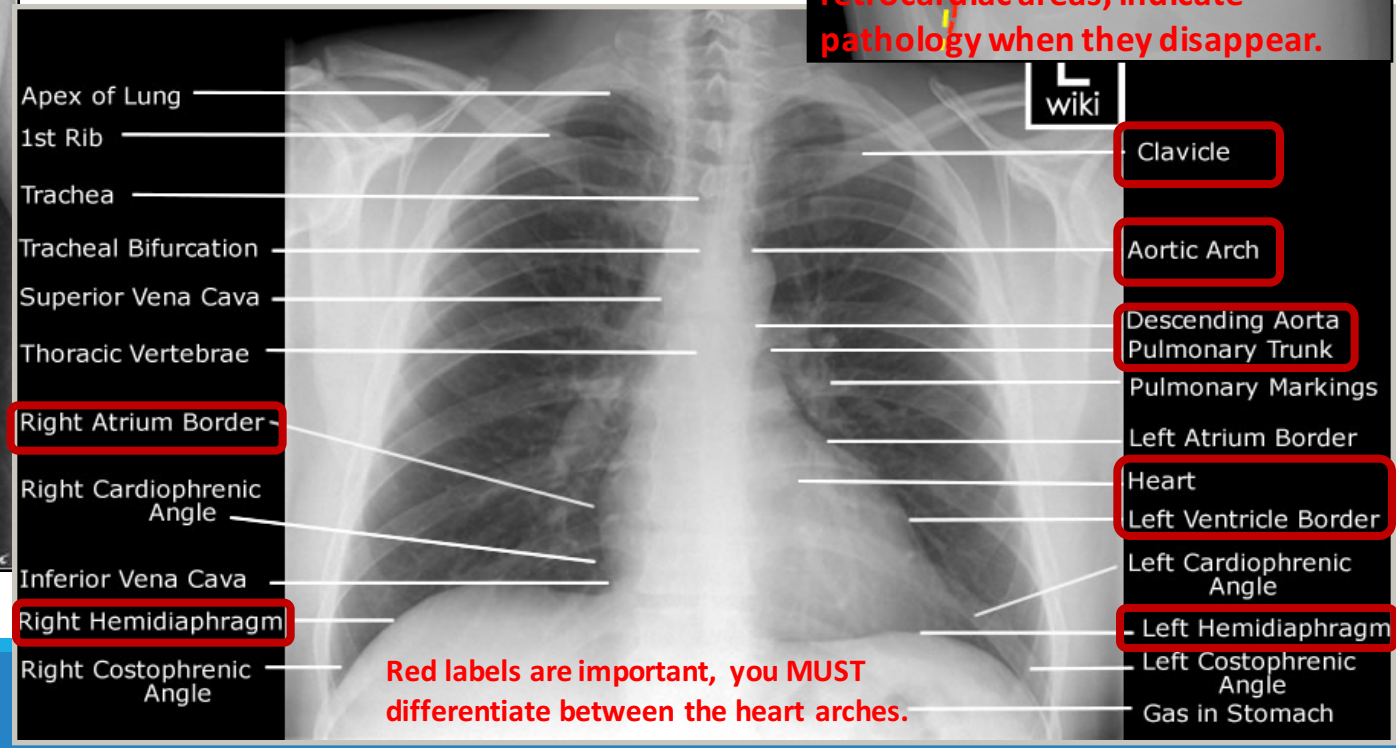
If it was filled with air (i.e. bronchi) it would've appeared black.







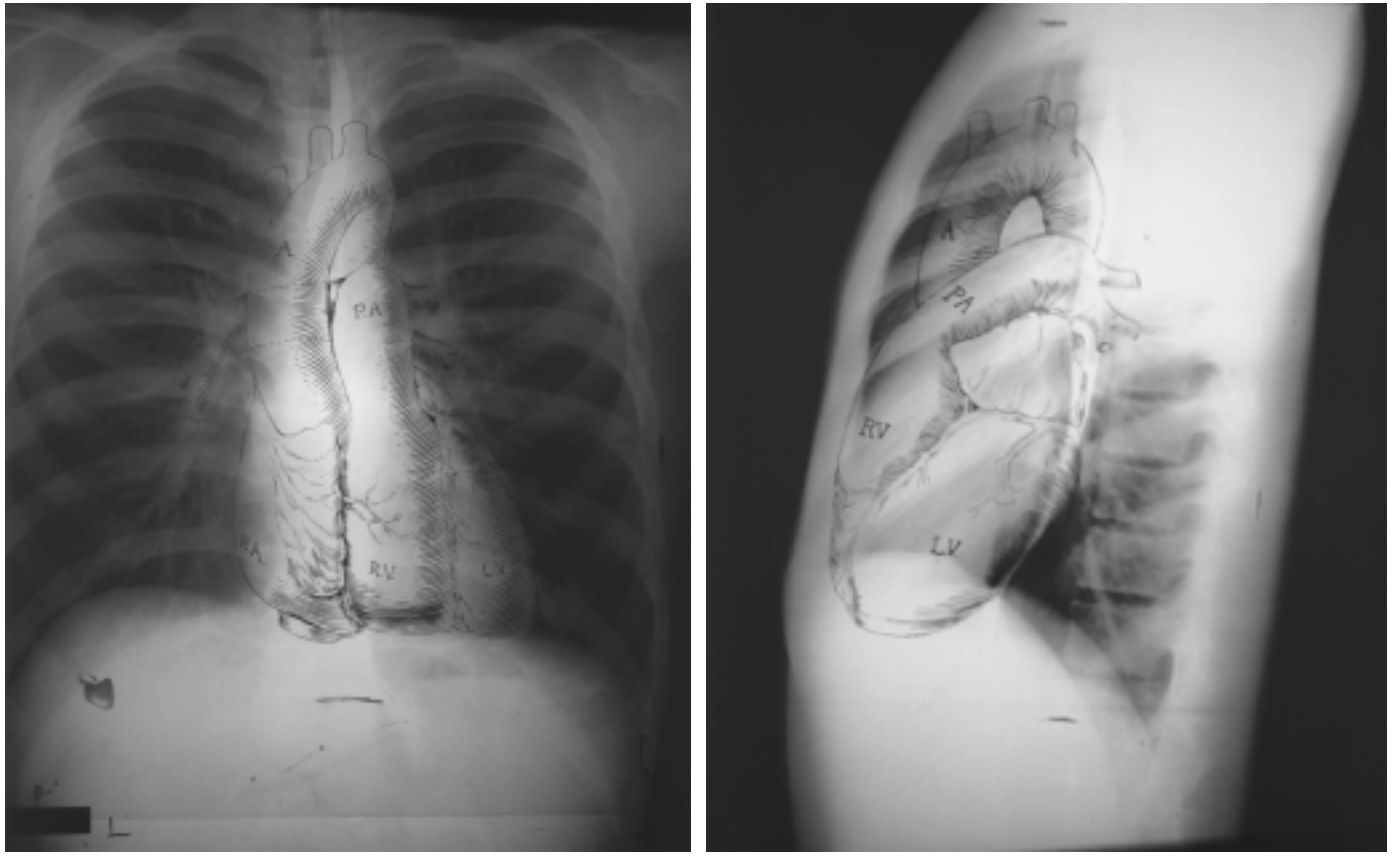
Translucent retrosternal and retrocardiac areas, indicate pathology when they disappear.



Red labels are important, you MUST differentiate between the heart arches.

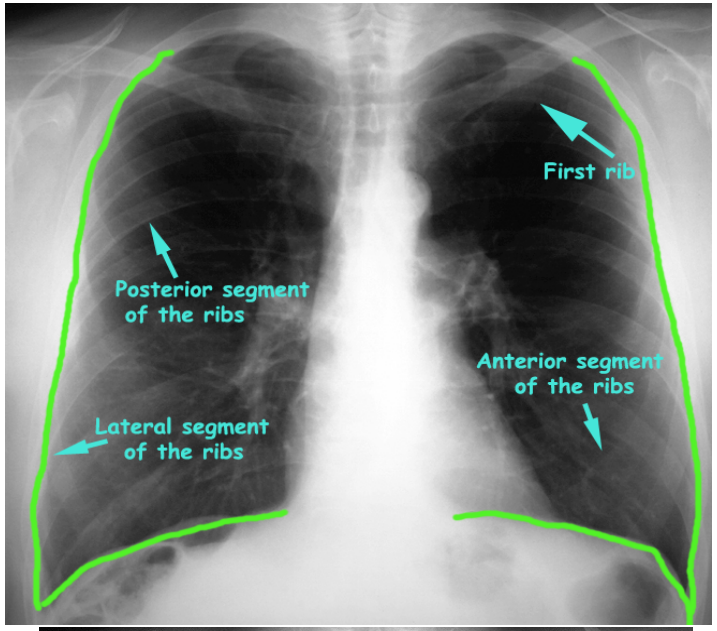
Note: the left hemidiaphragm appears noncontinuous unlike the right hemidiaphragm because the heart is sitting on it.

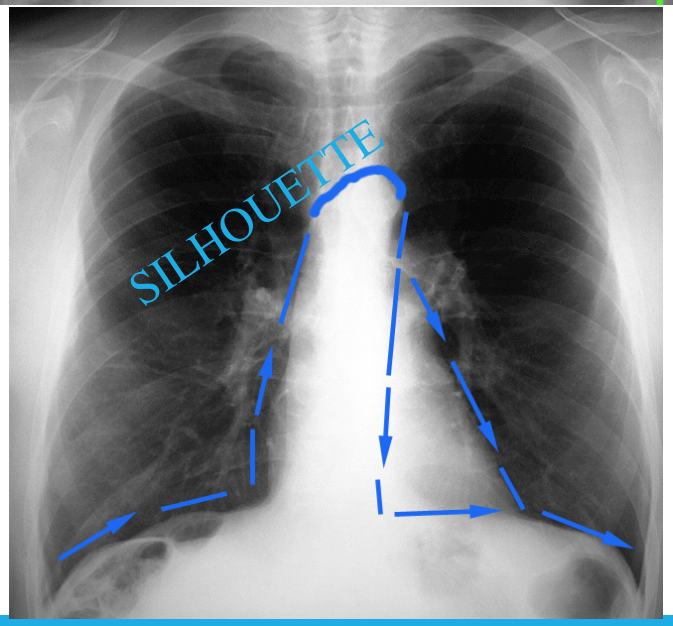
Review of Chest Anatomy



Heart borders and chambers of the heart on PA and lateral views.

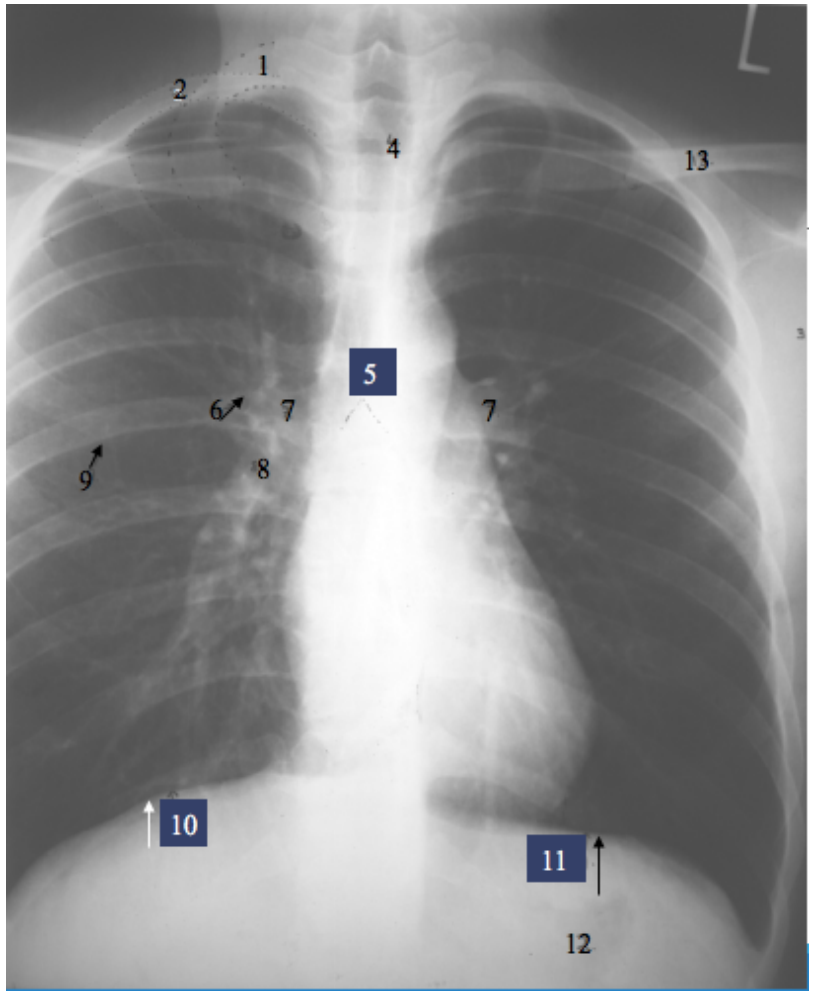
Frontal Chest X-ray:





See section on the Silhouette sign

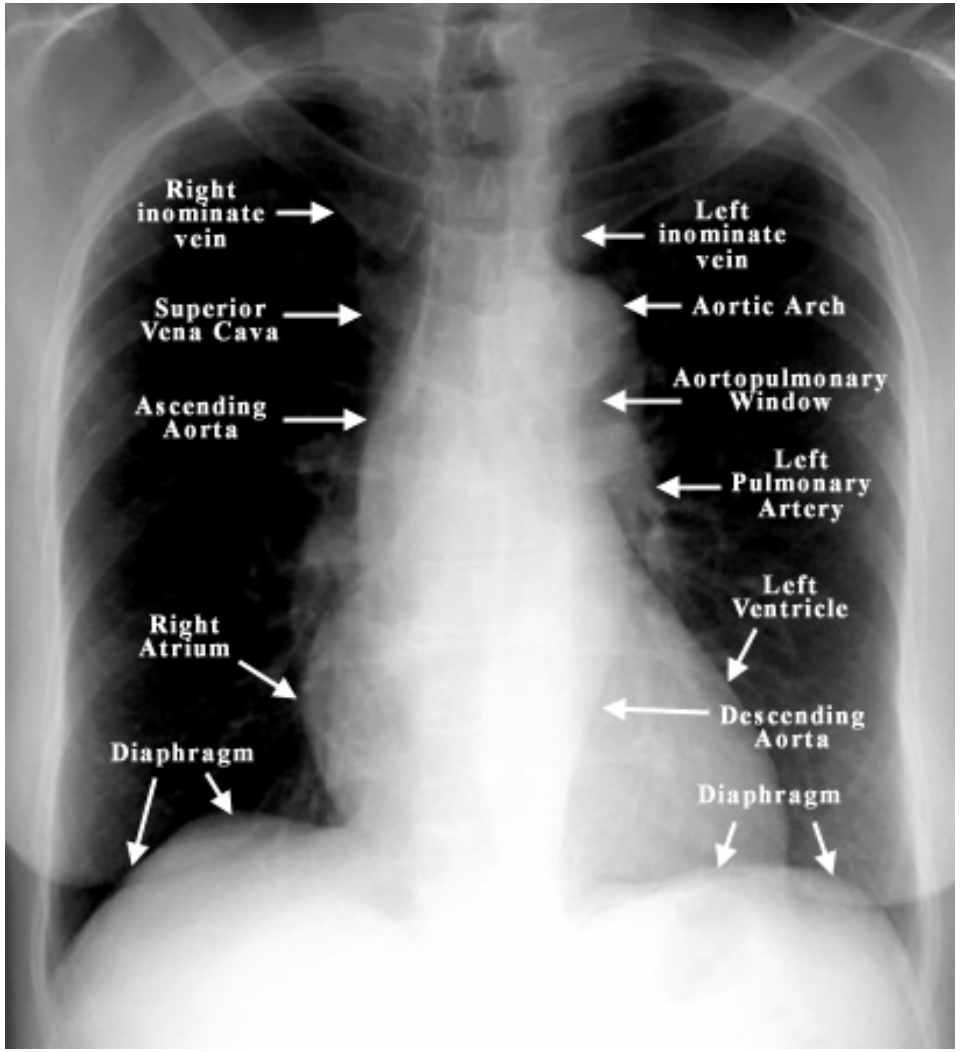
Review of Chest Anatomy



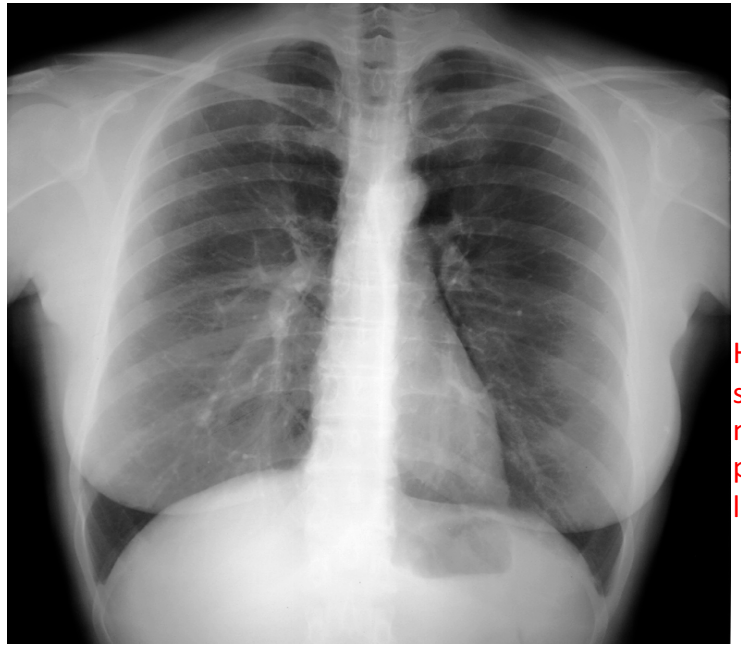
Key:

1. Right 1st rib
2. Right 2nd rib
3. Scapula
4. Trachea
5. Carina
6. Bronchus seen end on
7. Bilateral hila
8. Branch of right main descending pulmonary artery
9. Right minor (horizontal fissure)
10. Right hemi diaphragm
11. Left hemi diaphragm
12. Gastric air bubble
13. Left clavicle

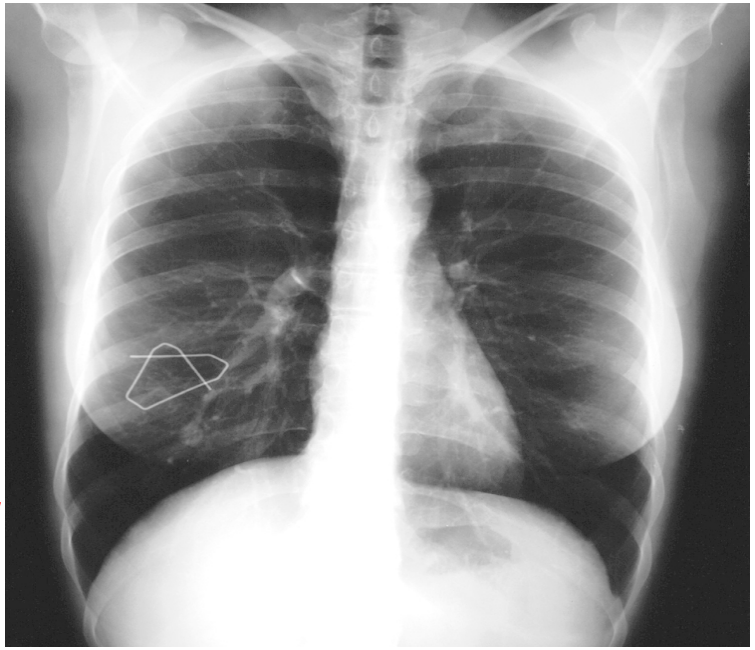
PA view:



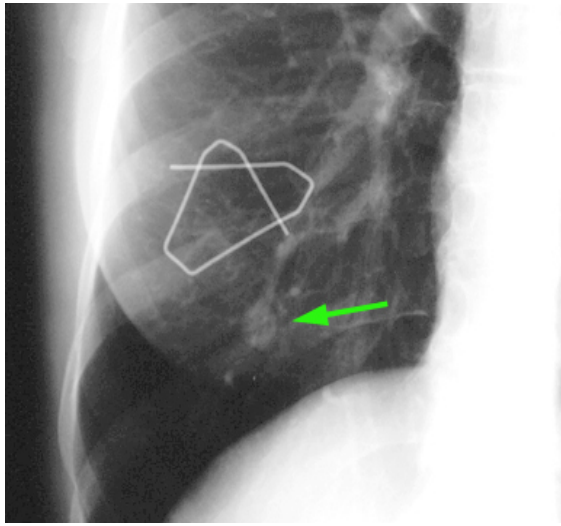
Frontal Chest X-ray

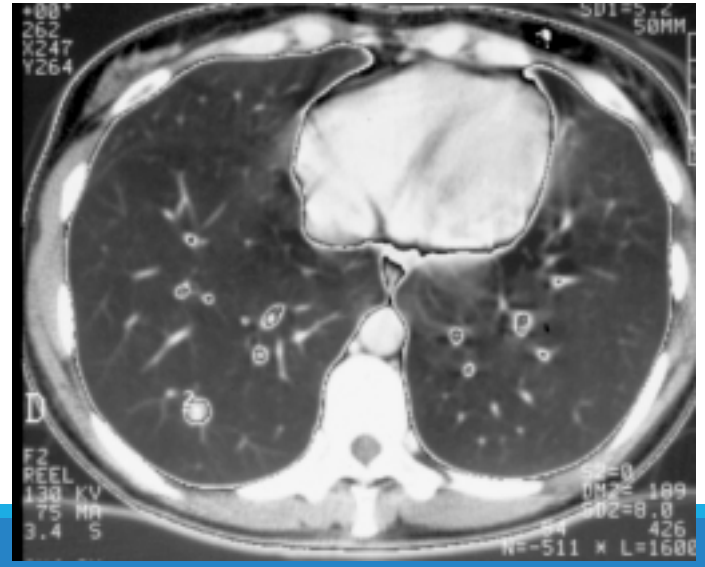


Here we surrounded the nipple with a paperclip to locate it's shadow

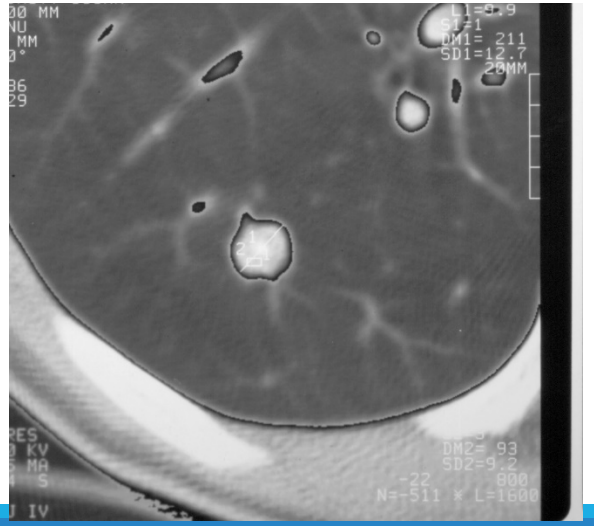


Zoom





Zoom

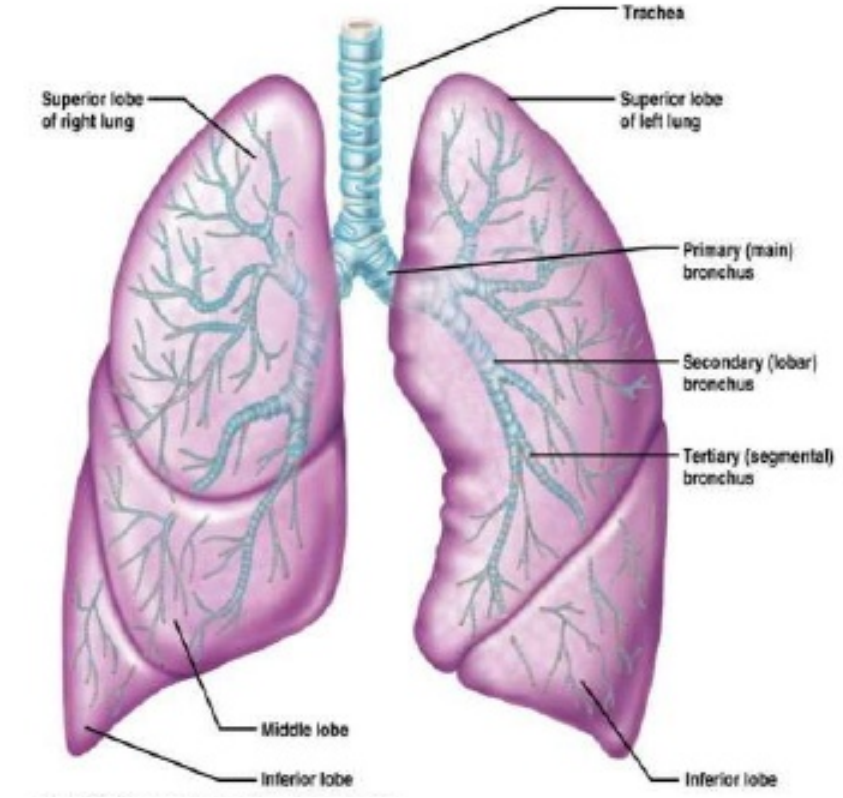


Nodule or right nipple? (green arrow)
Intrapulmonary nodule: hamartoma

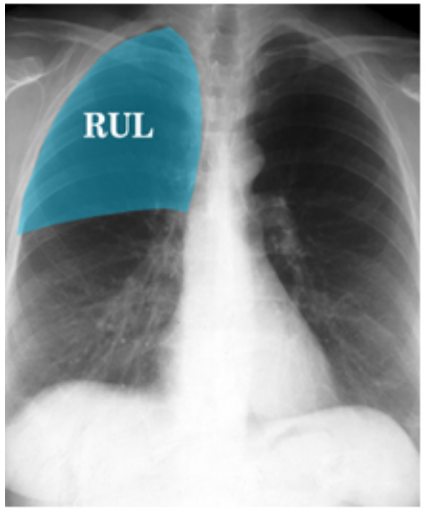
Remember:
It's chest x-ray
Not lung x-ray

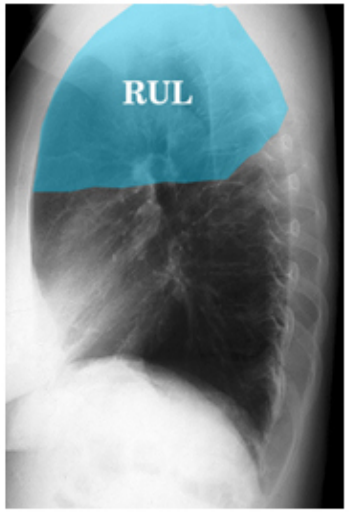
Lung Fissures

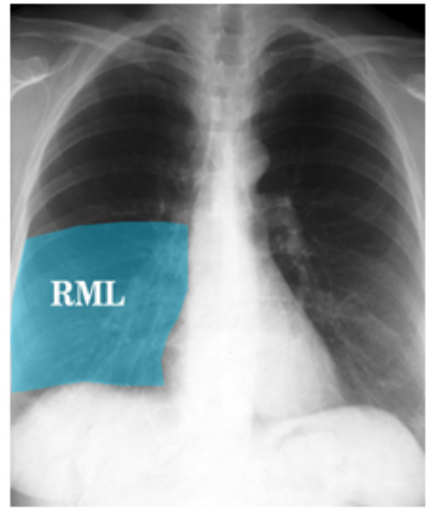
- Fissures are invaginations of plural reflection from the surface of the lung inside the lung. They divide the lung into lobes.
- The right lung is divided into **upper**, **middle** and **lower** lobes by **oblique** and **horizontal fissures**.
- The left lung has two lobes, **upper** and **lower**. They are separated by the **oblique fissure**.

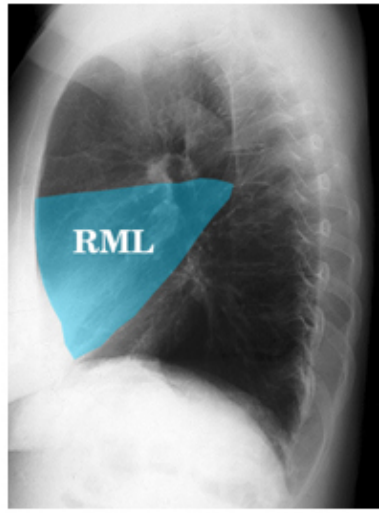


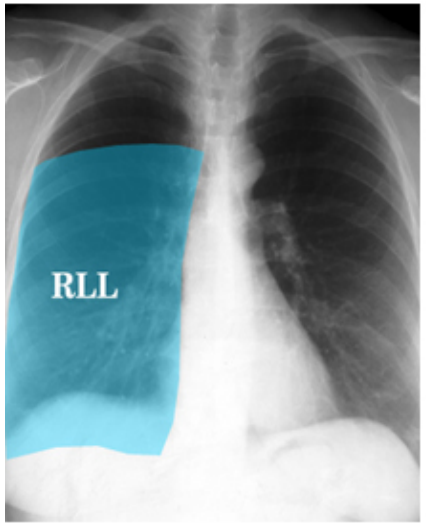
Fissures of the Right Lung

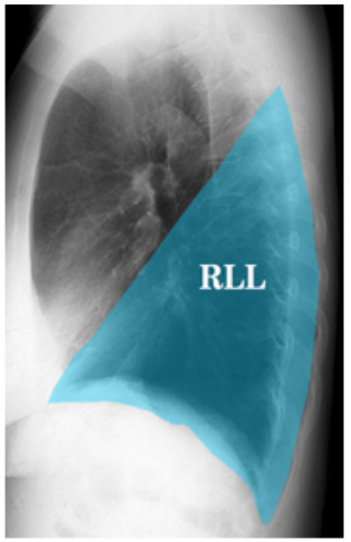


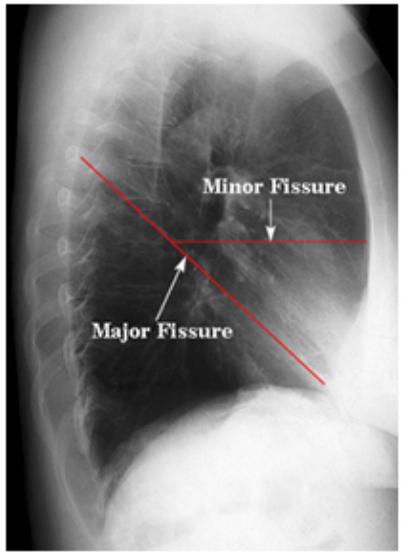


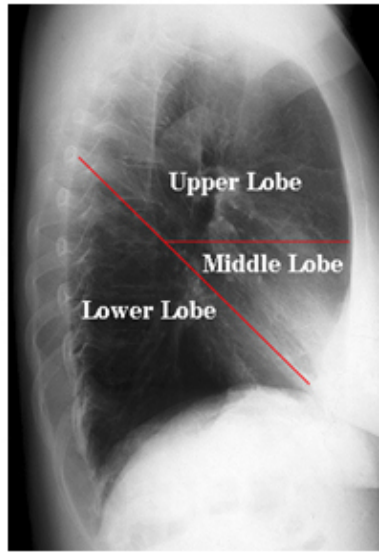




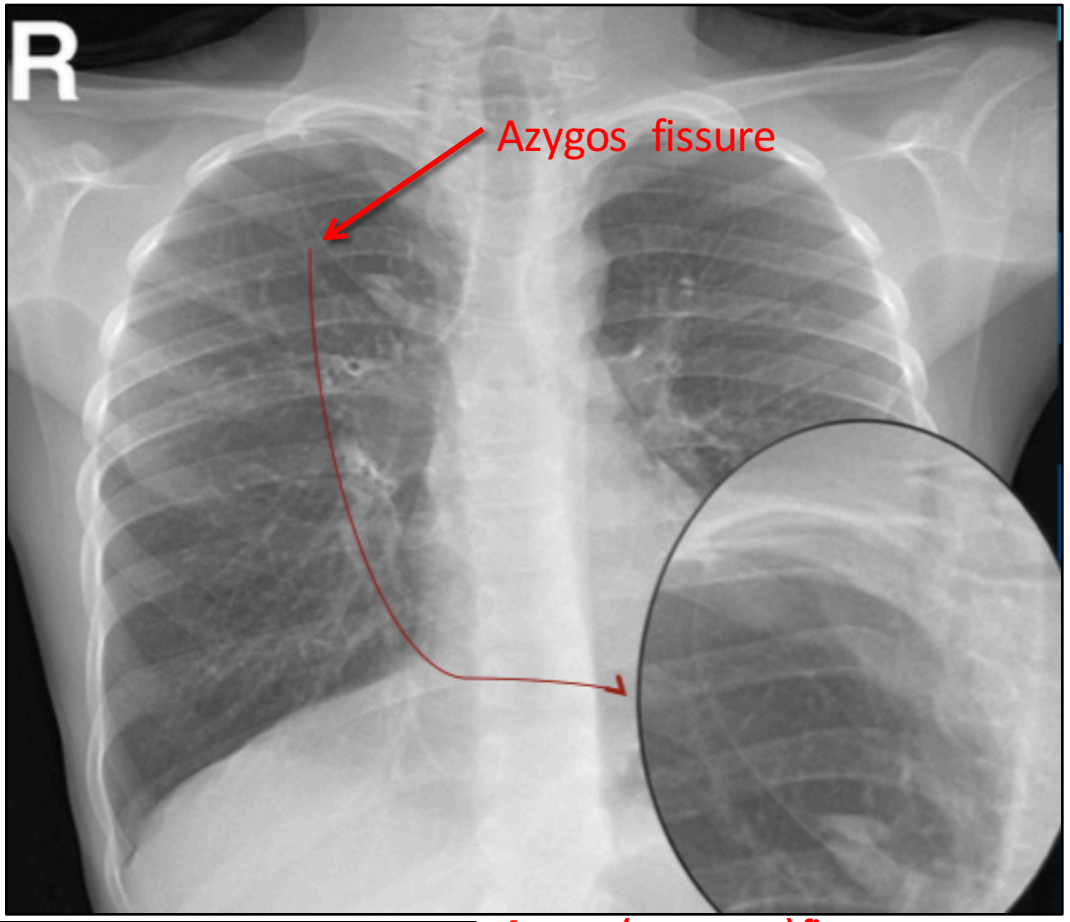






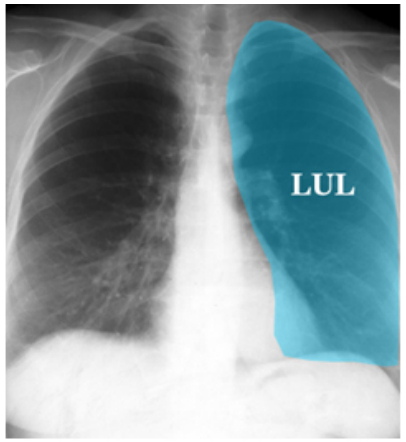


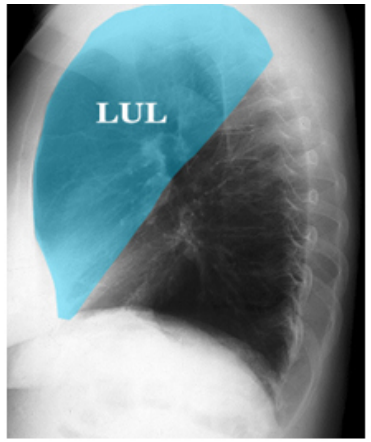
Lung Fissures (CONT.)

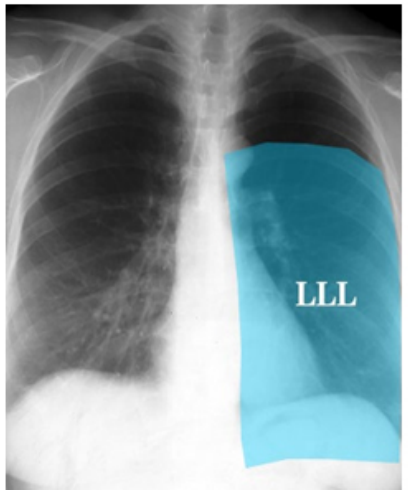


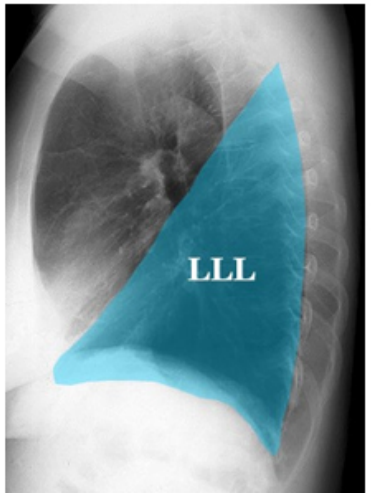
Azygos (accessory) fissure: Invagination of one layer of the pleura in the lung due to delayed migration of the azygos vain from the apex of the neck to the tracheobronchial angel of the lung.

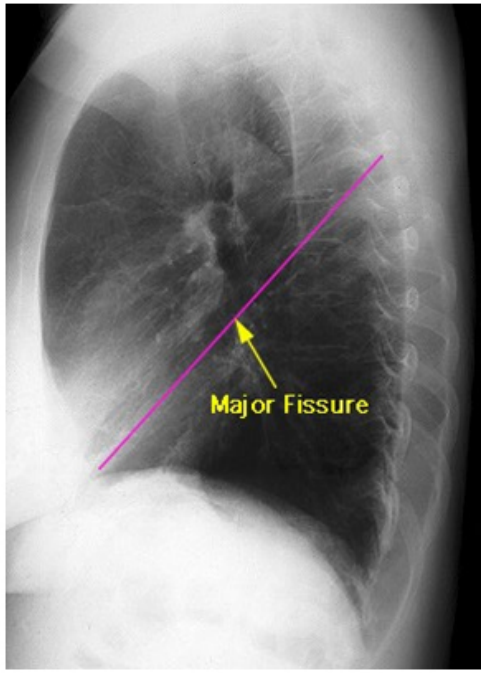
Fissures of the Left Lung





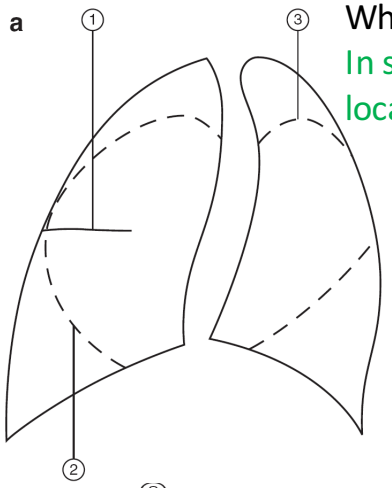






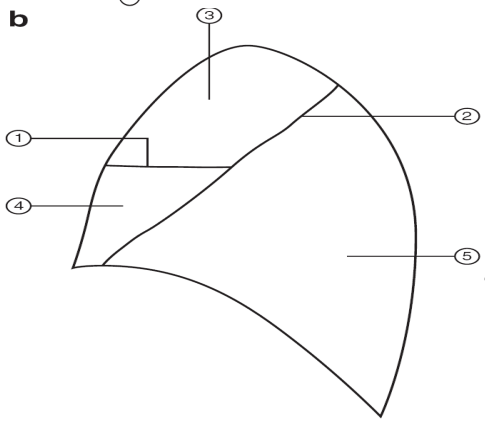
Compared to the right lung, the major fissure lies more posteriorly in the left lung. Due to the fact that the heart is sitting on it.

Lung Fissures (CONT.)

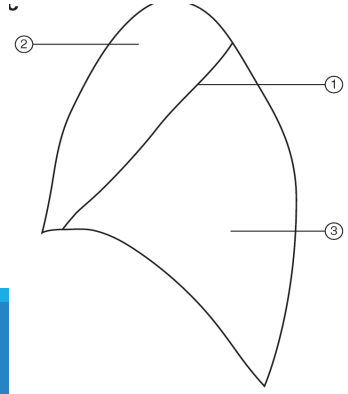


Why these lines are important?
In some diseases they help in localizing the disease.

1. Horizontal fissure
2. Right oblique fissure
3. Left oblique fissure

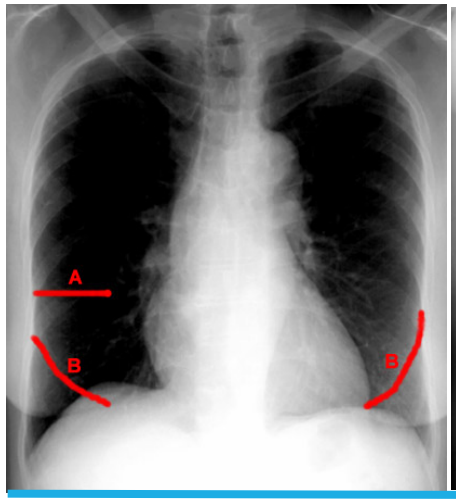


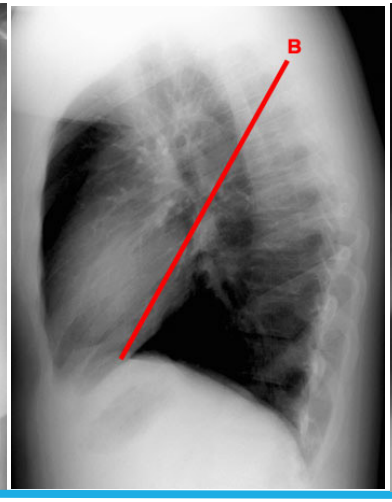
1. Horizontal fissure
2. Right oblique fissure
3. Right upper lobe
4. Right middle lobe
5. Right lower lobe

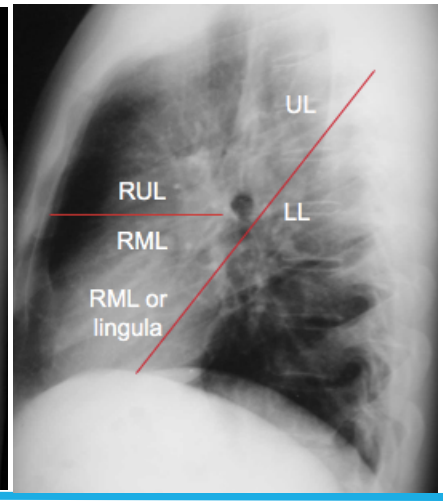


1. Left oblique fissure
2. Left upper lobe
3. Left lower lobe

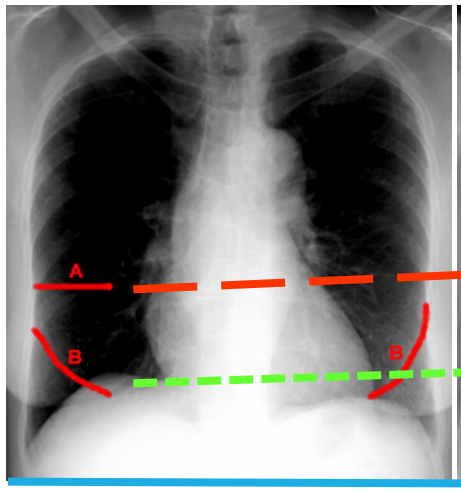
*They're only visible in 30% of the people but in some disease they appear clearly.

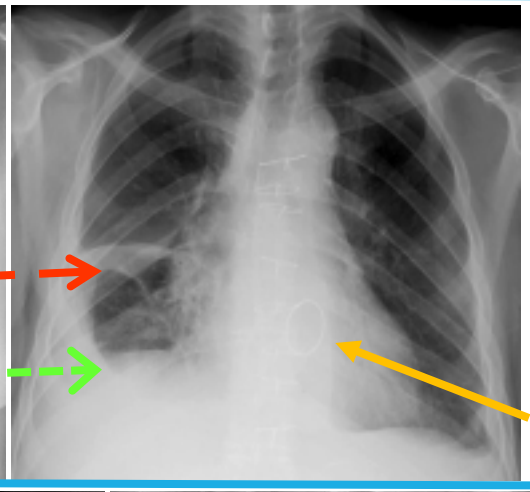




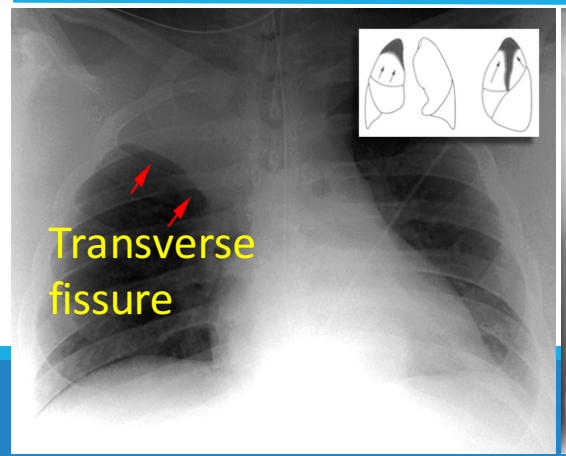


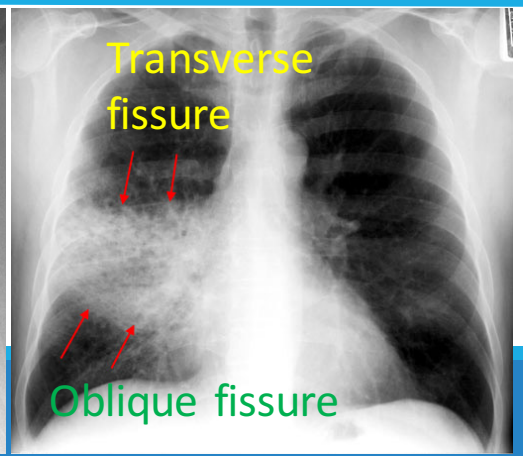
Line B: from the hilum on the right side to the cardiophrenic angle.
Above the line: calcification of the aorta
Below the line: calcification of pulmonary or tricuspid valve





Here the fissures appear clearly due to fluid accumulation between the segments.
Left picture : Normal *Fissures are mostly not seen in normal condition, but we know their places*
Right picture : Pleural effusion extending into the right fissures
Notice the replaced mitral valve appear as a loop

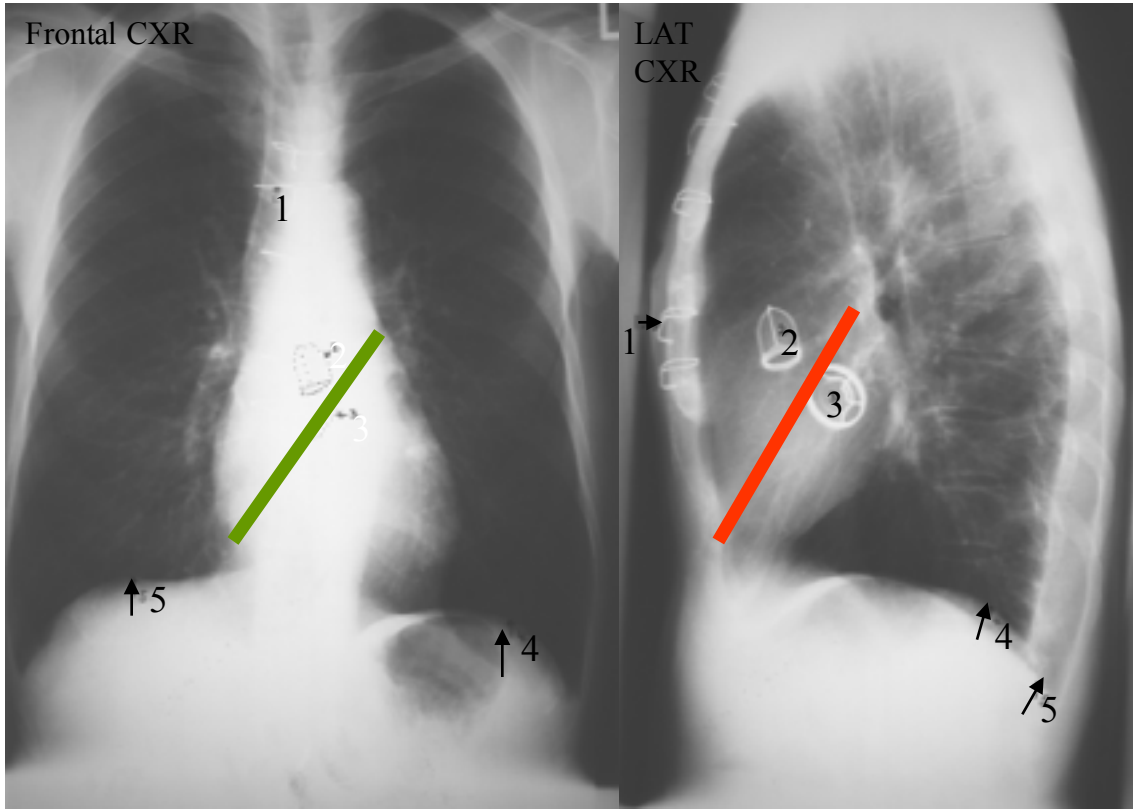




Left picture: atelectasis
Transverse fissure moves because of lose of volume (lung collapse)

Right picture: Middle lobe **pneumonia** with non-displaced fissure

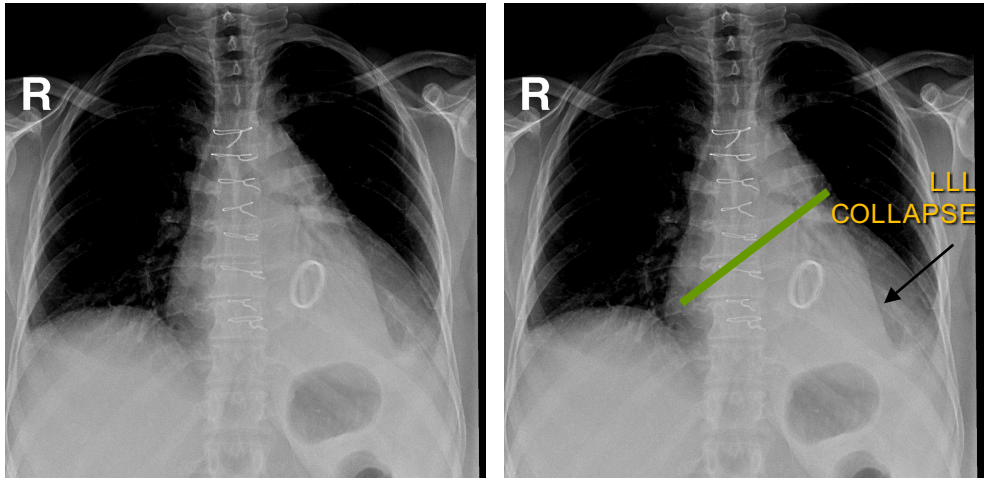
Cardiac Valves



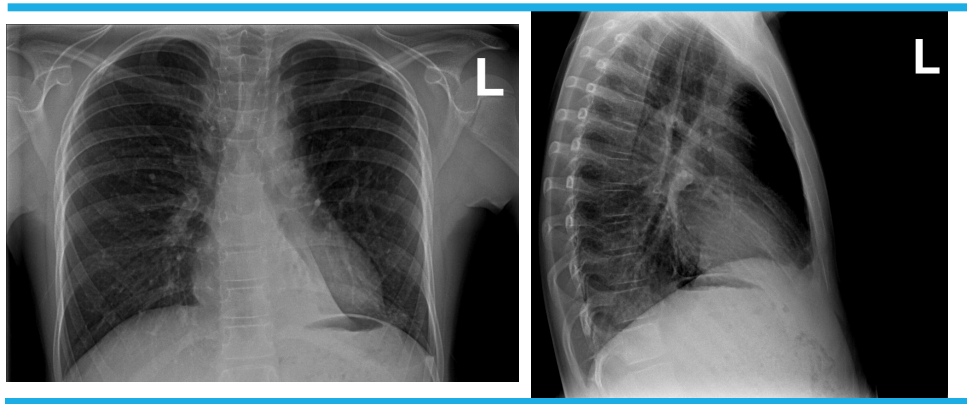
Key:

1. Suture material used for repair of vertical incision thru sternum (median sternotomy)
2. Aortic valve prosthesis
3. Mitral valve prosthesis
4. Left hemi diaphragm
5. Right hemi diaphragm

This patient had a malfunctioning mitral valve (between left atrium and left ventricle) and aortic valve (between left ventricle and aorta) and prosthetic valves were inserted (better seen on lateral)



Draw line from right cardiophrenic angle to left hilum; above this line is **aortic** and under it is **mitral**.



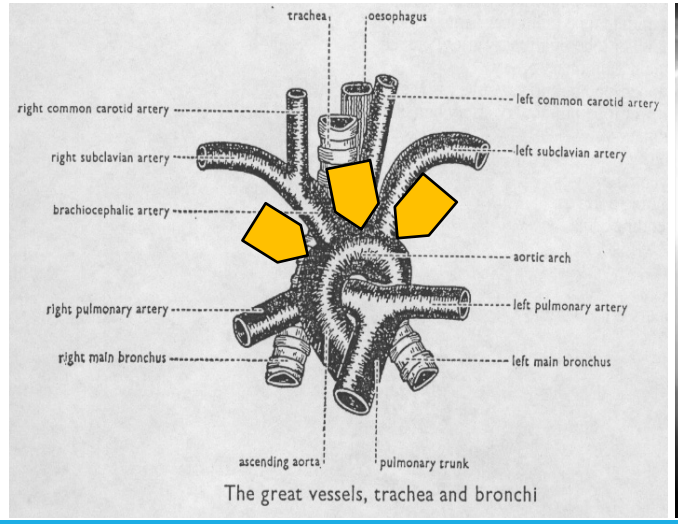
LLL COLLAPSE

Breast shadow on routine x-ray

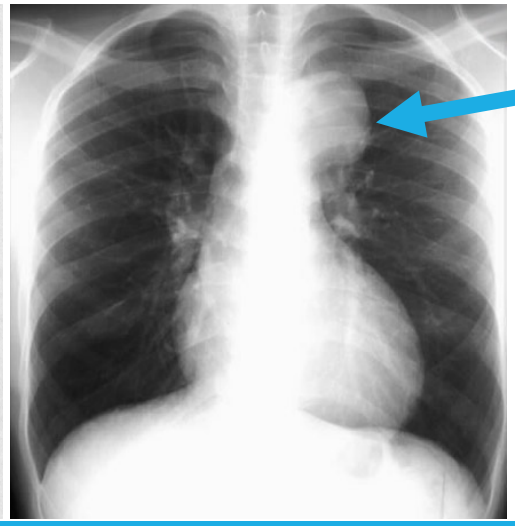
How to read frontal chest x-ray?

Always dived and compare.

Aortic Aneurysm:



The great vessels, trachea and bronchi



Aortic knob/knuckle

What Is a Good (CXR) Chest X-ray?

WHAT TO LOOK FOR IN CHEST X-RAY?

1. Lungs
2. Mediastinum (heart)
3. Bony cage (ribs)
4. Soft tissue component

   * Soft tissue includes tendons, ligaments, fascia, skin, fibrous tissues, fat, and synovial membranes (which are connective tissue), and muscles, nerves and blood vessels (which are not connective tissue).

WHAT IS A GOOD (CXR) CHEST X-RAY? **(Will be detailed in the next slides)**

A. Adequate exposure
B. Proper positioning
C. Adequate inspiration

Using X-ray TECHNIQUEs **(Will be detailed in the next slides)**

1. AP Vs PA technique
2. Dual energy technique

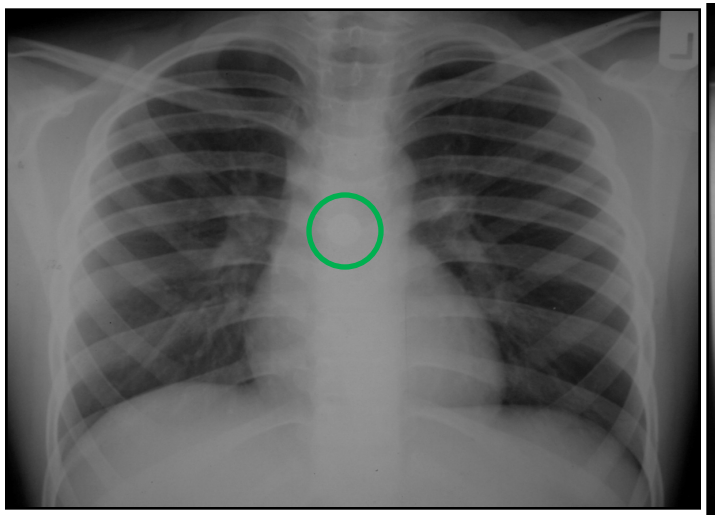
A. Adequate Exposure

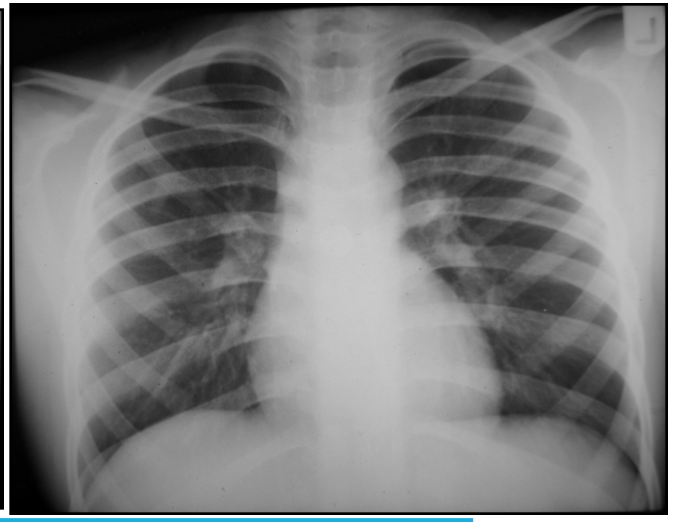
Why adequate exposure ?
so we don't miss anything i.e. we don't miss a lesion or foreign body.

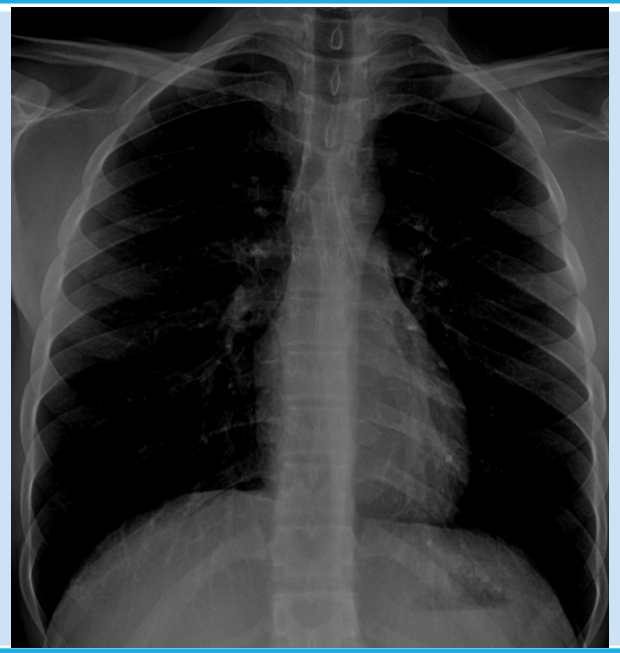
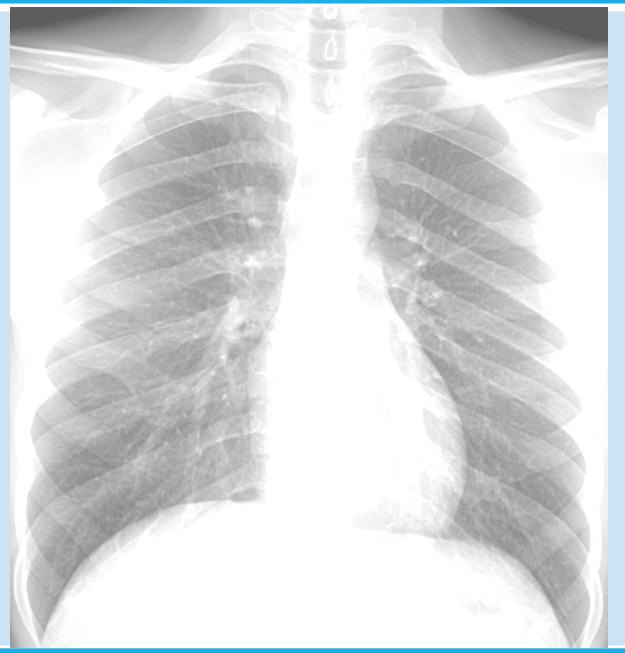
Exposure factors:
Could be from the camera setting e.g. taking photo at sunlight differ from at night.

Type of exposure:

A foreign body (green circle) was missed in the initial x-ray due to inadequate exposure.





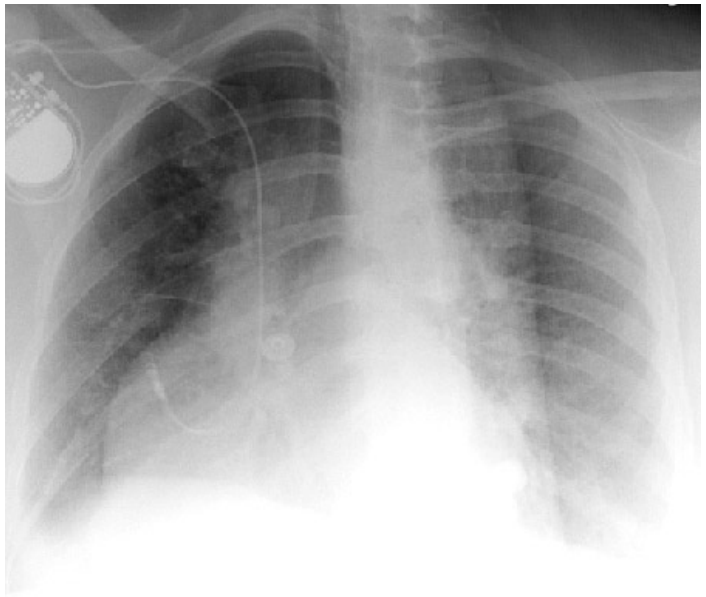
ADEQUATE	OVER	UNDER
		

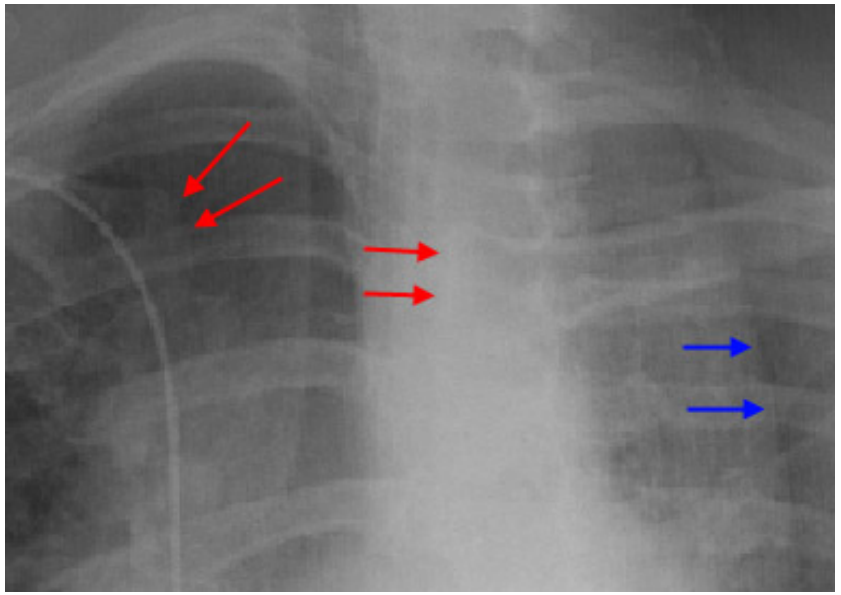
The most important factor that effect the intensity and amount of x-ray is the kilovoltage (kV) and milliampere.

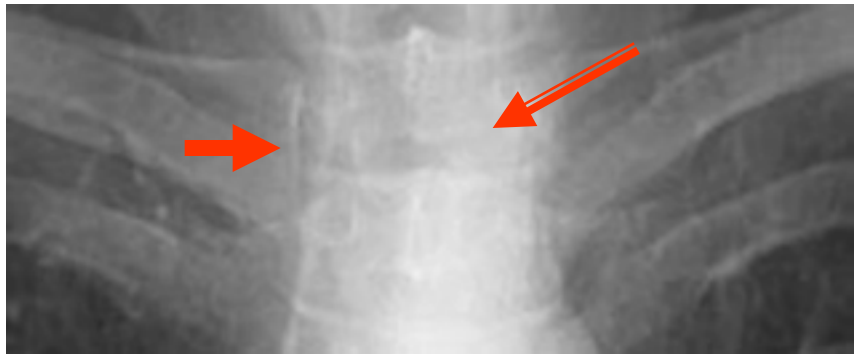
B. Proper Positioning

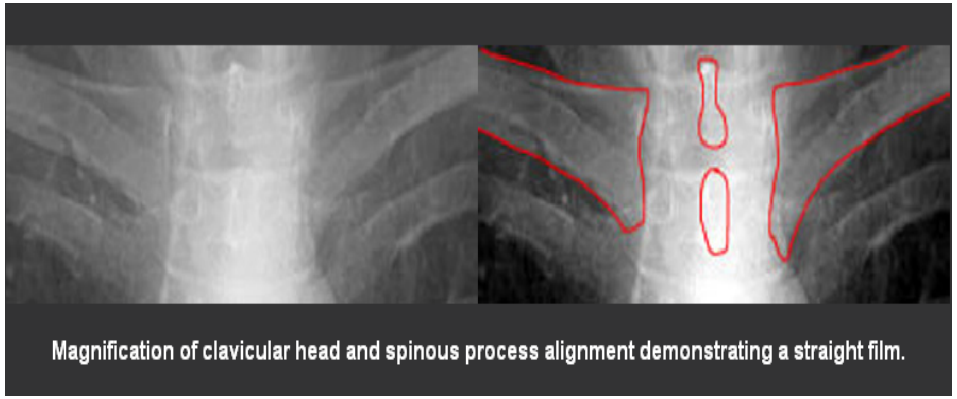
The technologists are usually very careful to x-ray the patient flat against the cassette. If there is **rotation** of the patient, the mediastinum may look very unusual.

In this rotated film, **skin folds can be mistaken for a tension pneumothorax** (blue arrows).
Notice the skewed positioning of the heads of the clavicles (red arrows) and the spinous processes.









Magnification of clavicular head and spinous process alignment demonstrating a straight film.

B. Proper Positioning (CONT.)

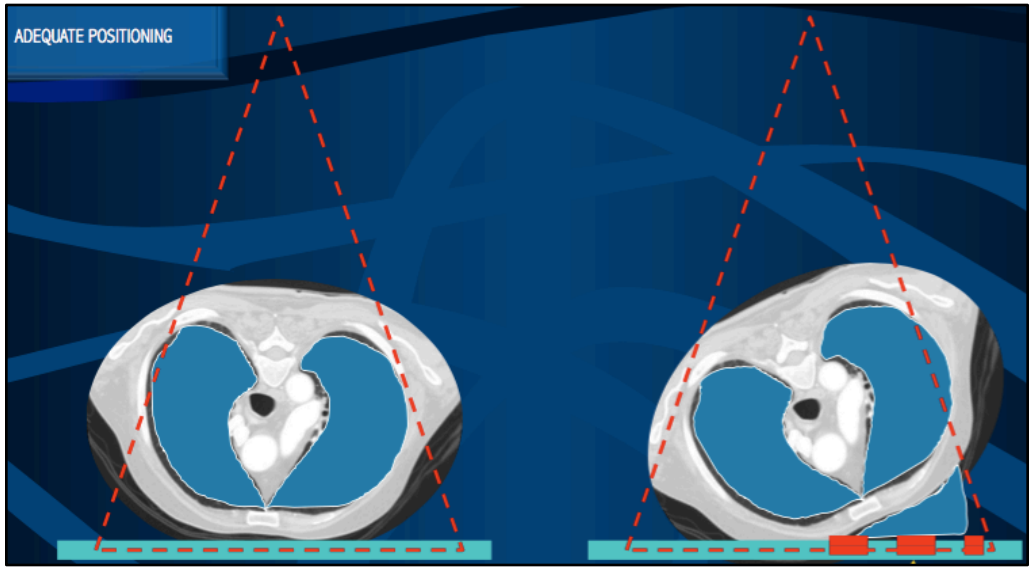
Who to asses proper or adequate positioning?

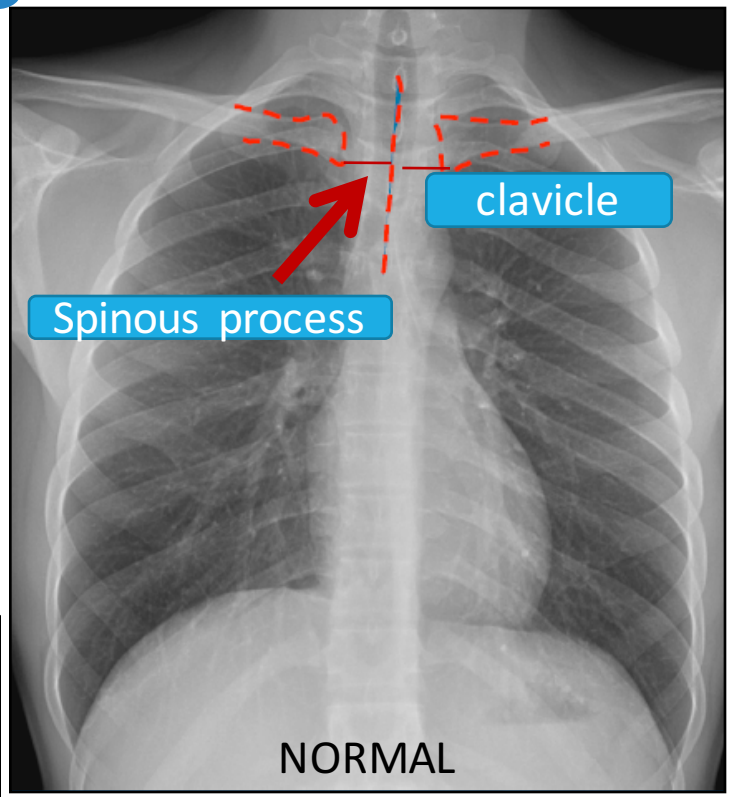
By looking at the distance between **medial ends of the clavicles** and the midline which represent the **spinous process**.

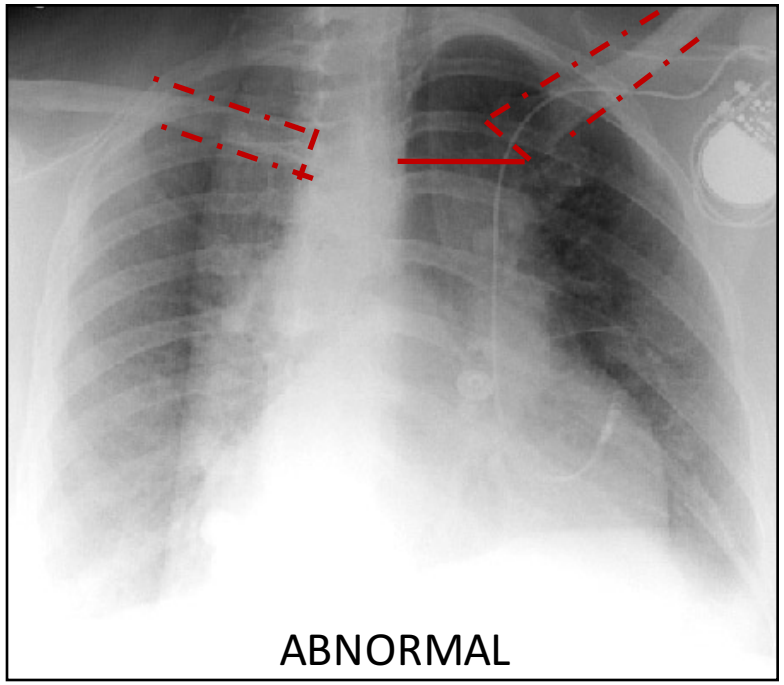
- **Same distance:** proper or adequate positioning
- Different distance: not the above.

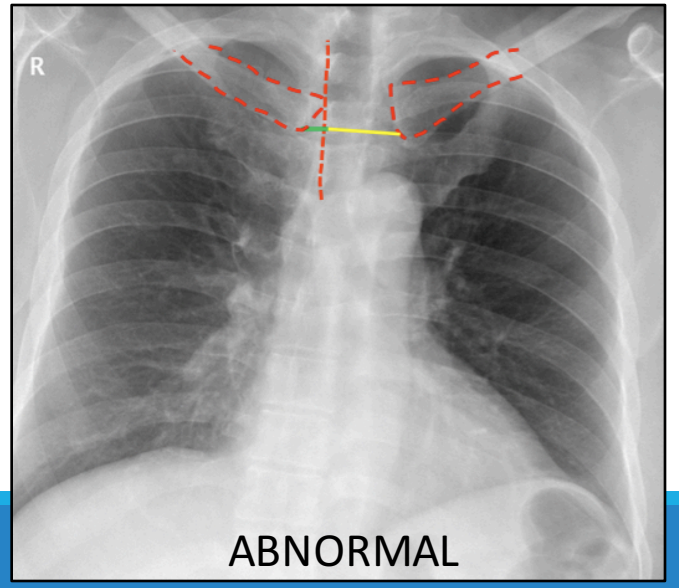
Different blackening of the lung would appear if:

1. **Physiologic:** The patient is in rotated position.
2. **Pathologic:** Normal position with increased air in lungs e.g. emphysema and pneumothorax.







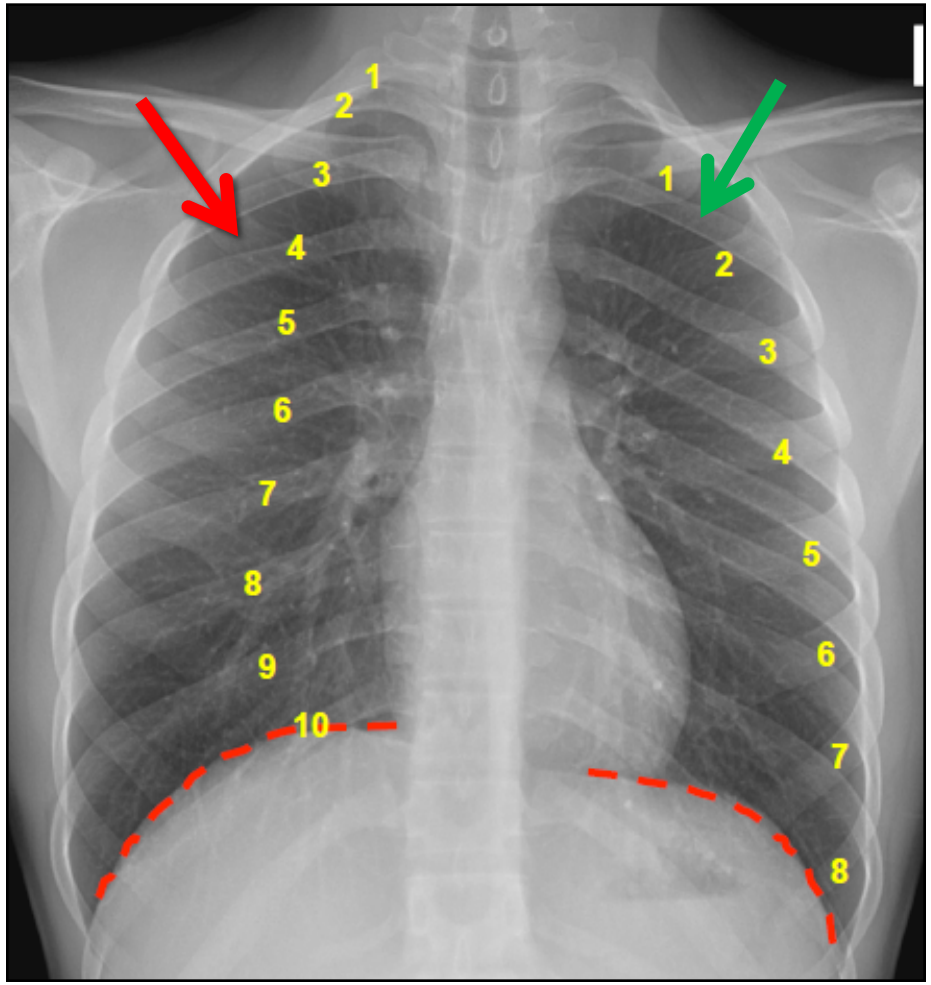


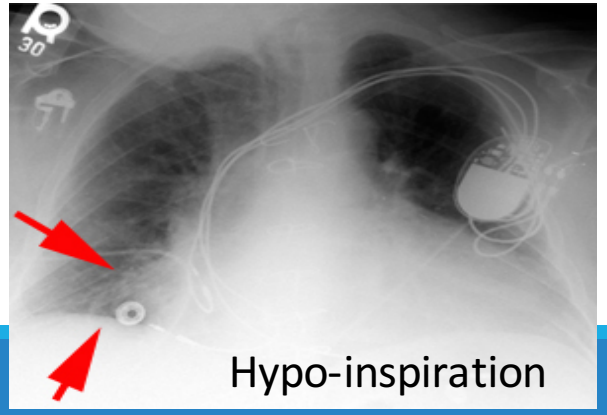
C. Adequate Inspiration

It is always important to have a proper inspiration effort.
It greatly helps the radiologist to determine if there are **intrapulmonary abnormalities**.
After inspiration we measure the diameter of the heart i.e. asses the size of the heart.
*Inadequate inspiration could give a false sign of CHF (congestive heart failure)
The normal is 46% of total chest.

Counting the ribs: to see if adequate inspiration
we compare it to the upper most aspect of the diaphragm.
Anterior ribs: usually inclined inferiorly toward the Medline
We count to **5-6 ribs**, they should be above diaphragm if it's an adequate inspiration. (green shadow)

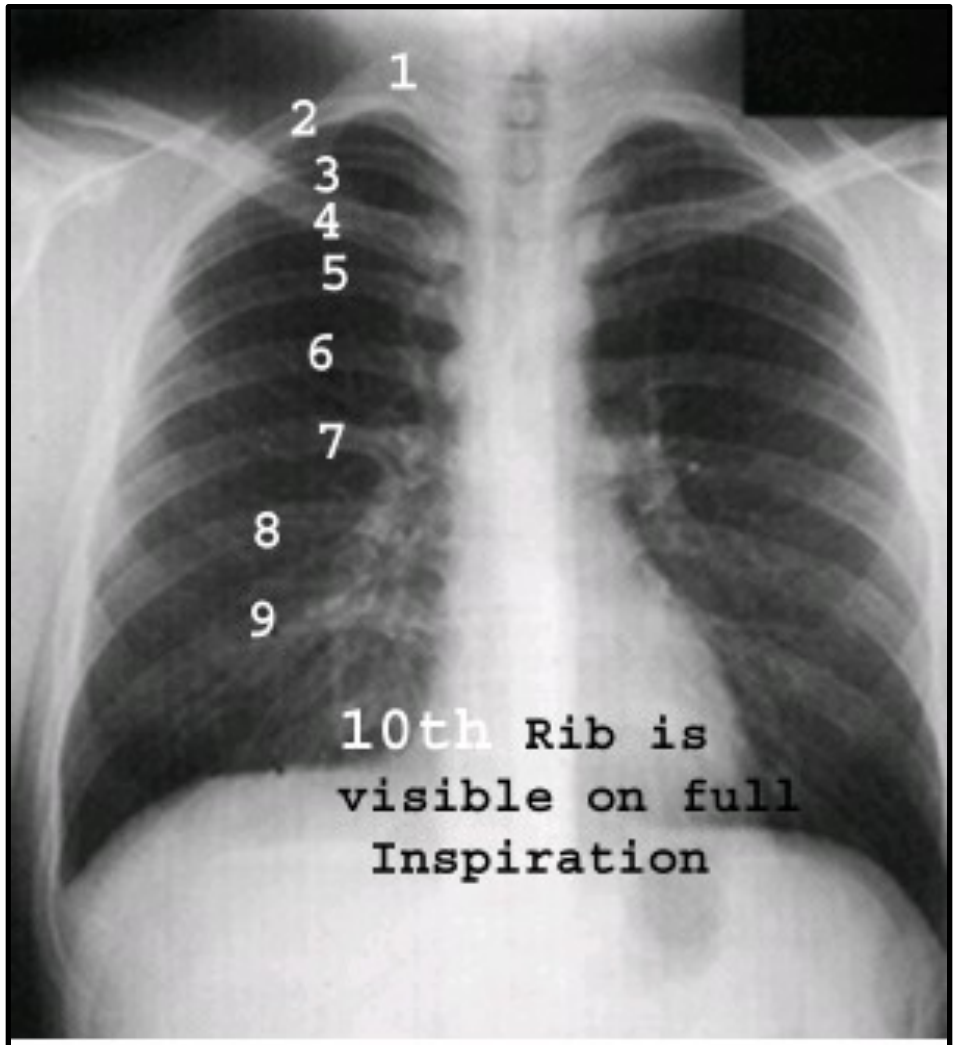
Posterior ribs: horizontal or slight inclination laterally
We count to **8-10 ribs**, they should be above diaphragm if it's an adequate inspiration. (red shadow)



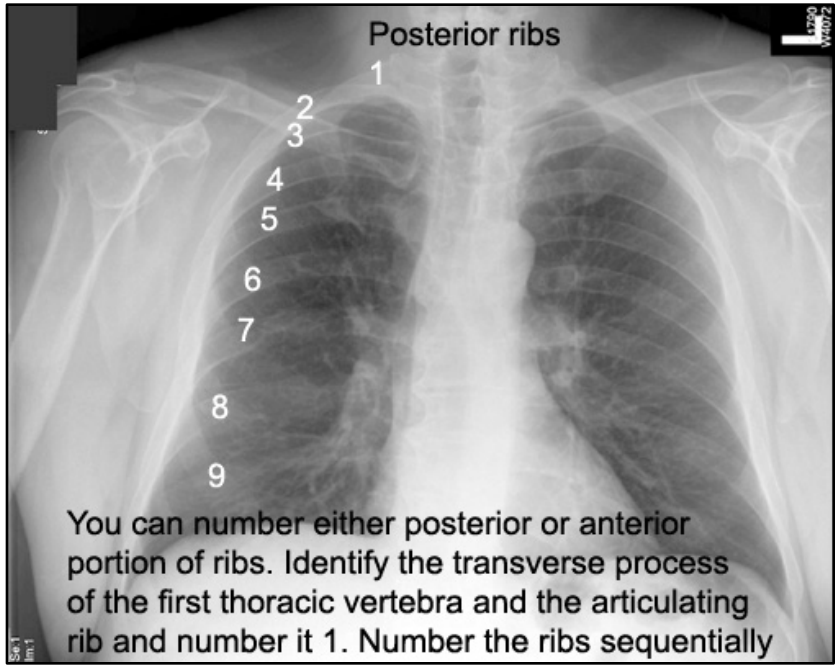

Hypo-inspiration

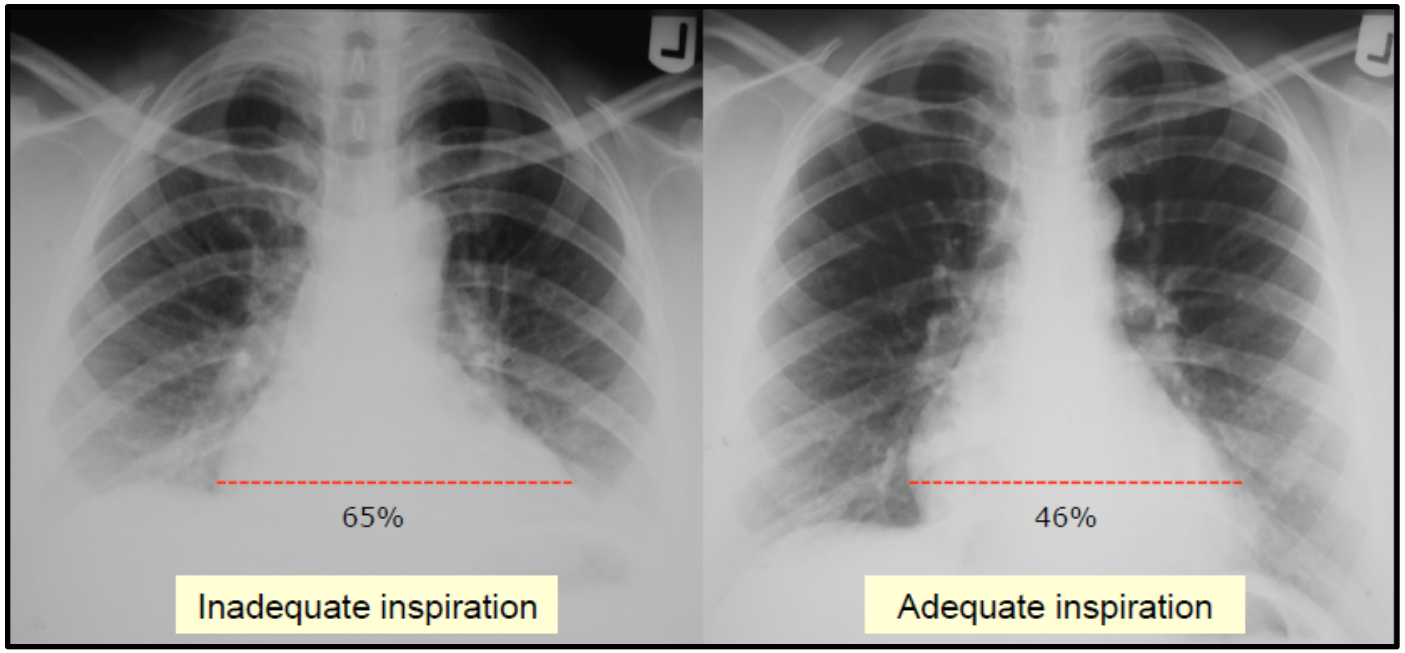

inspiration

C. Adequate Inspiration



PA view on full inspiration. Image courtesy of Dr. Naveed Ahmad.





The heart looks big, lung ends appear hazy.
False impression of Congestive Heart Failure.

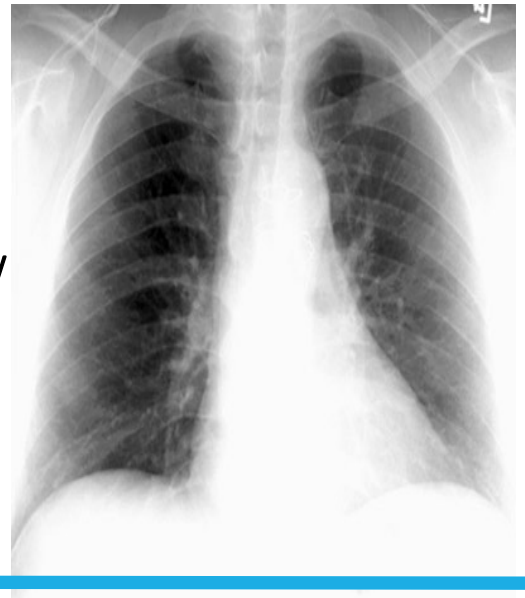
1. AP Vs PA Technique

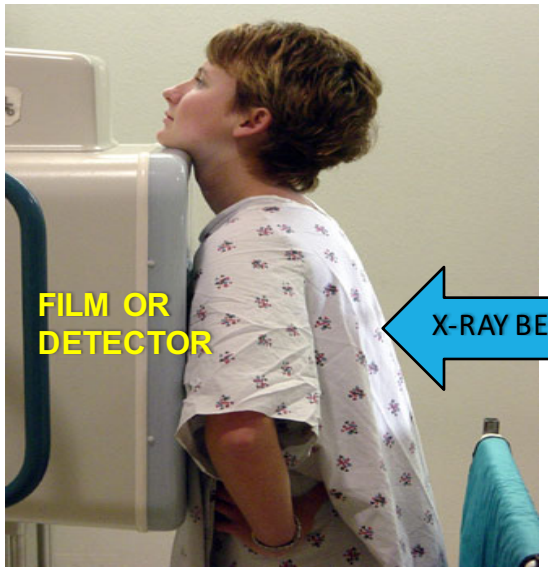
Why do we prefer PA?

- ✓ More clear
- ✓ Avoid the enlargement of the heart
- ✓ Clear ribs
- ✓ Level of the lungs is clear
- ✓ Clear border of the diaphragm

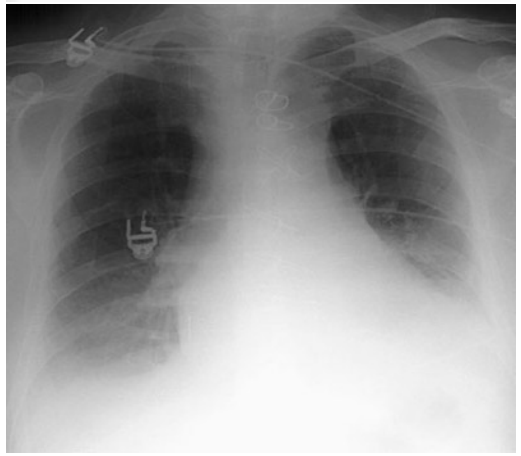
Gold standard: 2 views (PA & lateral)

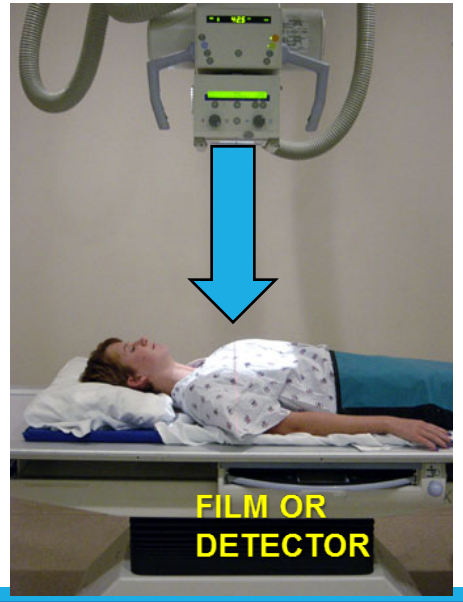
PA view:
also called PA erect view





AP view:
Patient is lying down, used especially in children (3 months of age or so) or in ER when the patient can't stand up.

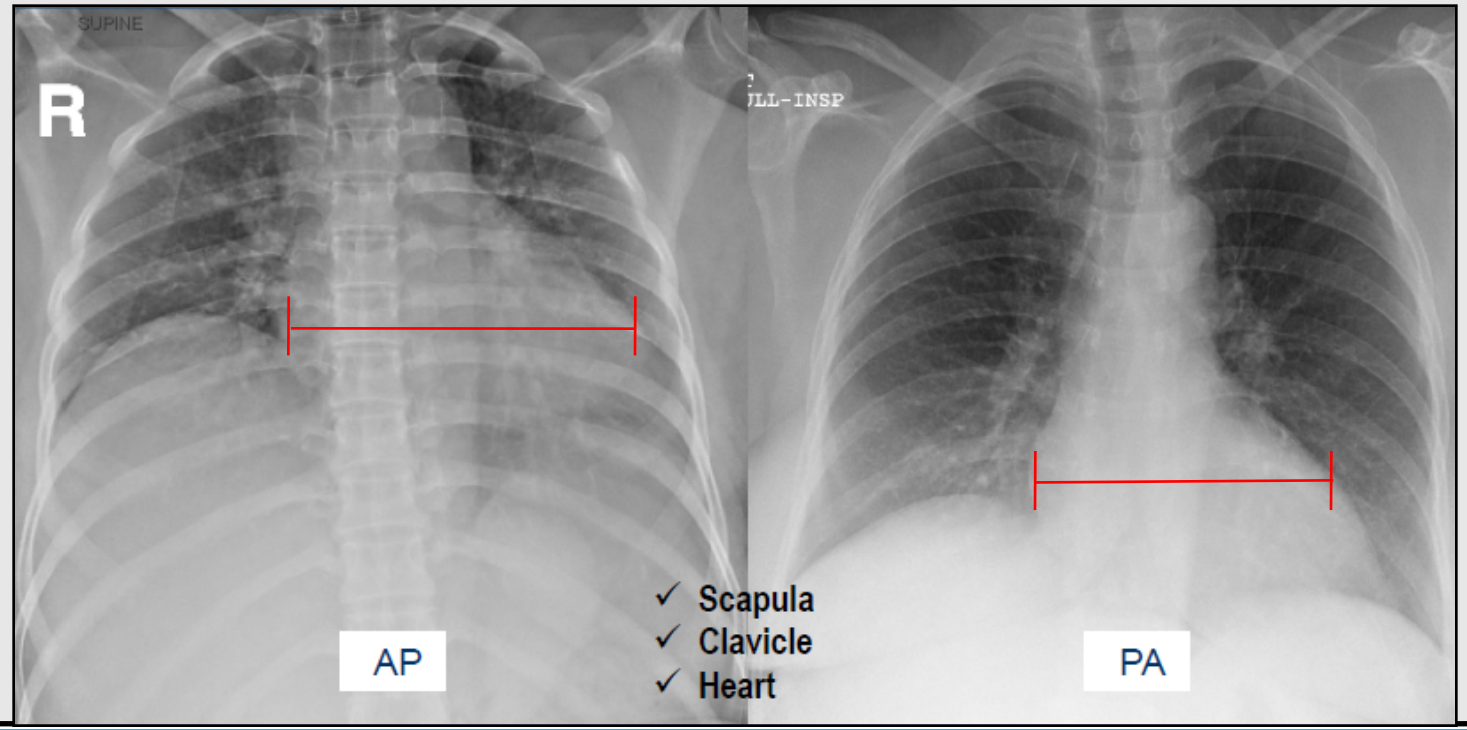




Lateral view:

1. AP Vs PA Technique (CONT.)

Anteriorposterior (AP):	Posterioanterior (PA):
• **False enlargement of the heart.**	• **Heart outline is well defined and normal sized.**
• Costo-phrenic angle is not clear.	• Costo-phrenic angle is visible and clear.
• **Ribs and clavicles are not as clear as PA**	• **Ribs and clavicle are clearer.**
• Patient is usually bed ridden so he can't take full inspiration because bowl can't retract down by the gravity as the supine position (that will shorten the lung field)	• Patient can take full inspiration because gravity pull bowel down as the patient standing (allowing us to see more of the lung field)
• **Scapula are over the lung field**	• **Scapula is seen in periphery of thorax**
	• **Commonly used in clinical practice (standard).**



In normal individual These branches are blood vessel not bronchi which appear black (air-filled)

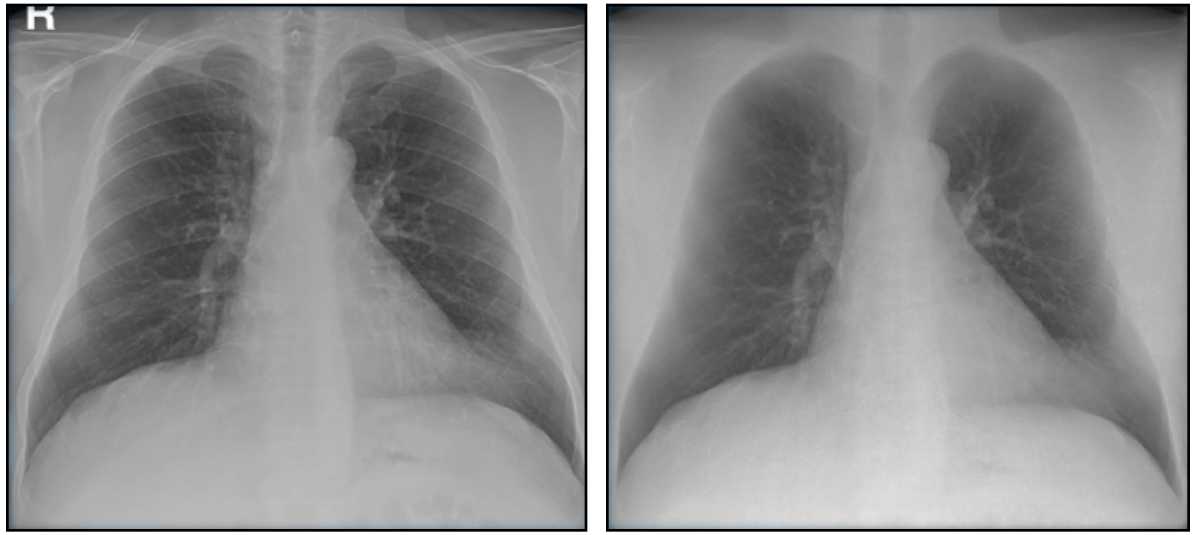
*The most important thing to look at is the cardiac shadow

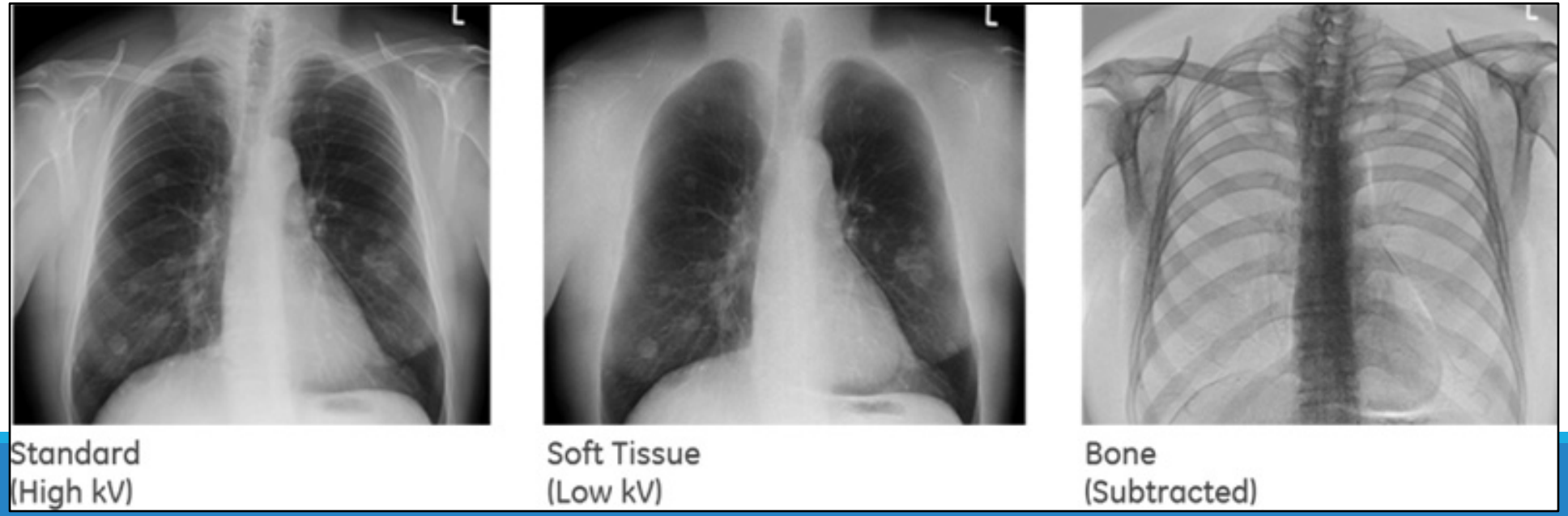
2. Dual Energy Technique

A test which allow to see soft tissue or bone alone instead of combine both as in plain x-ray.

Example: in case of there was a shadow at the base of the lung and we're not sure weather it's related to the lung itself or to the bone.

- We expose the patient to low kV, to omit the bone so the lung would appear clear.
- If we're worried about rib fracture, we could omit the lung and evaluate the bone easily.





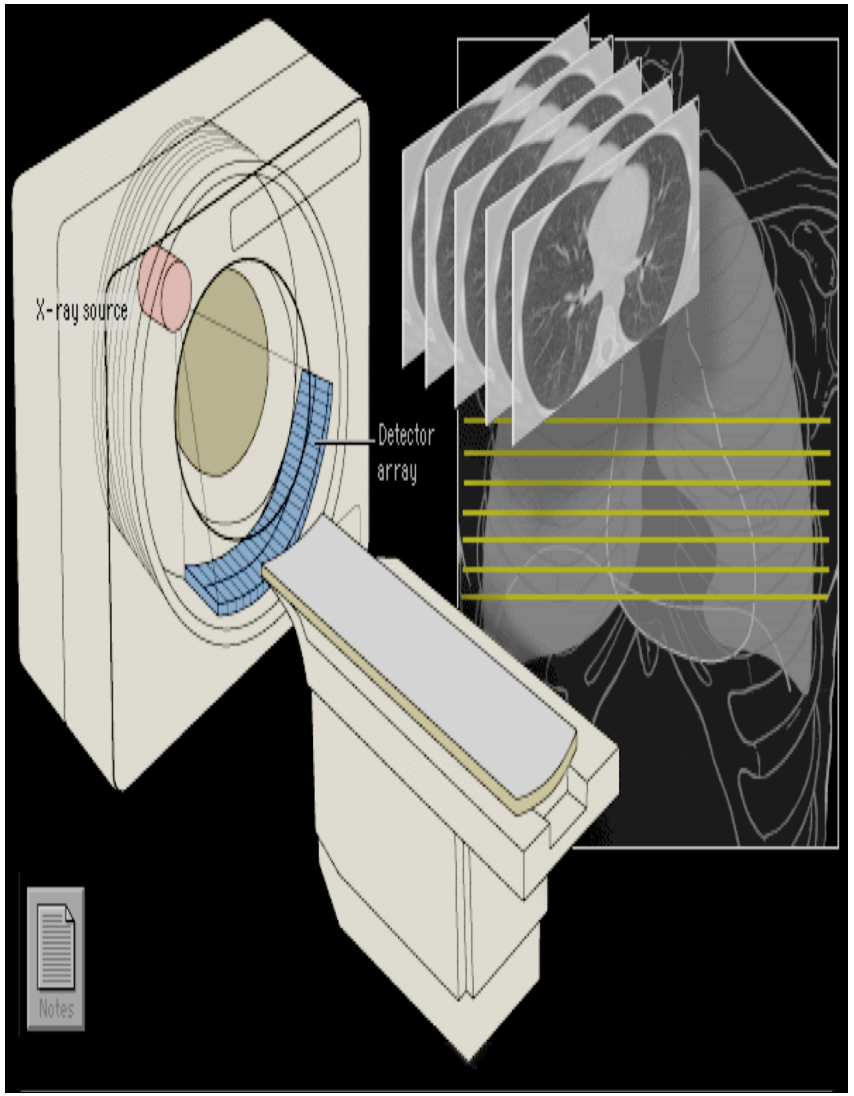
Computed Tomography (CT)

- 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, 1barin CT scan radiation = 200 x-ray radiation , pelvic CT radiation = 400 xray 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.**



High Resolution CT Scan:

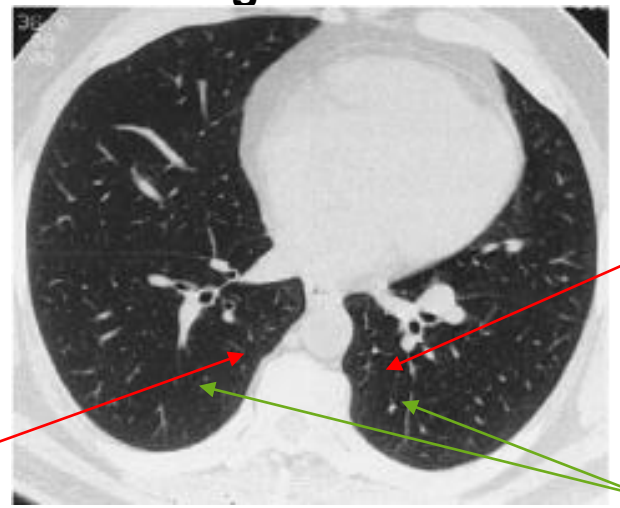
- HRCT uses very **thin slices** (1mm) to achieve better spatial resolution & precision.
- HRCT is indicated **after normal CXR in a symptomatic patient** - the setting of high clinical suspicion of disease.

Advantages:

- High sensitivity for adenopathy, infiltrates, and architectural distortion.
- HRCT can identify areas of reversible vs. irreversible lung damage.

Normal Lung Anatomy in HRCT

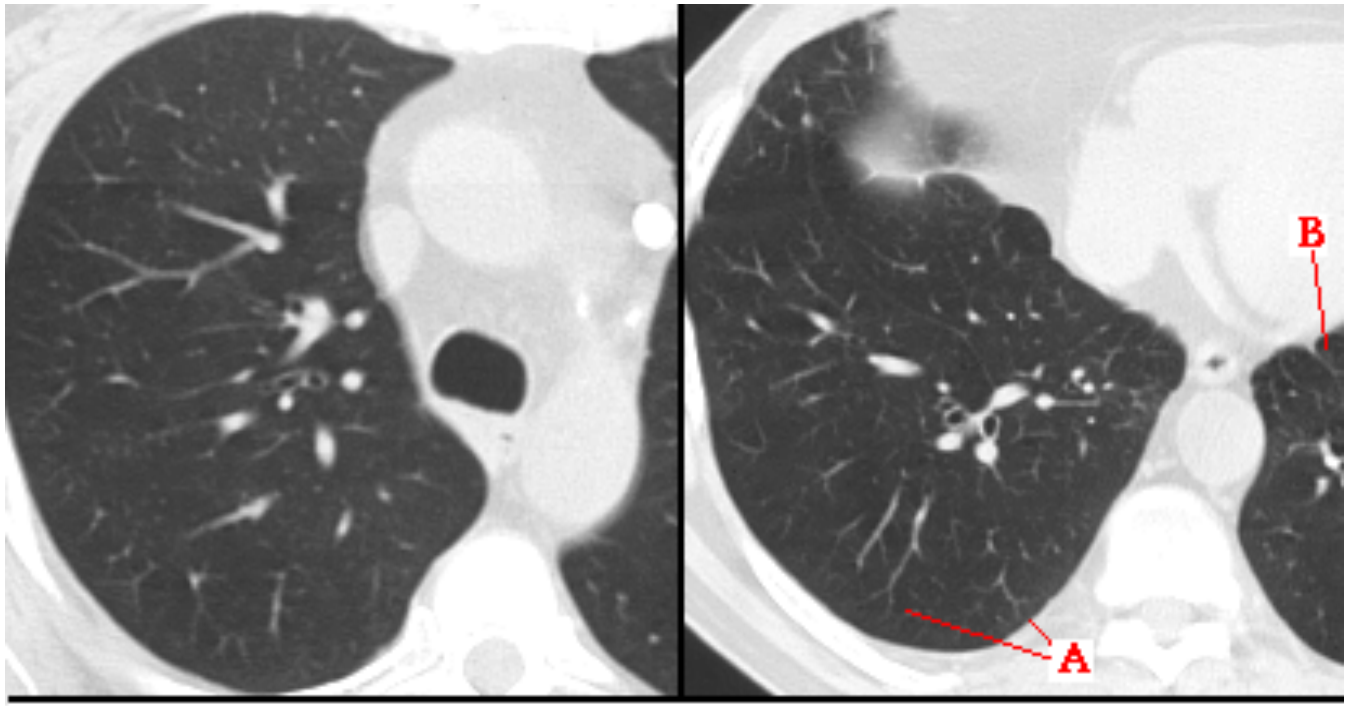
Normal lung at level inferior



L inferior pulmonary vein

R inferior pulmonary vein

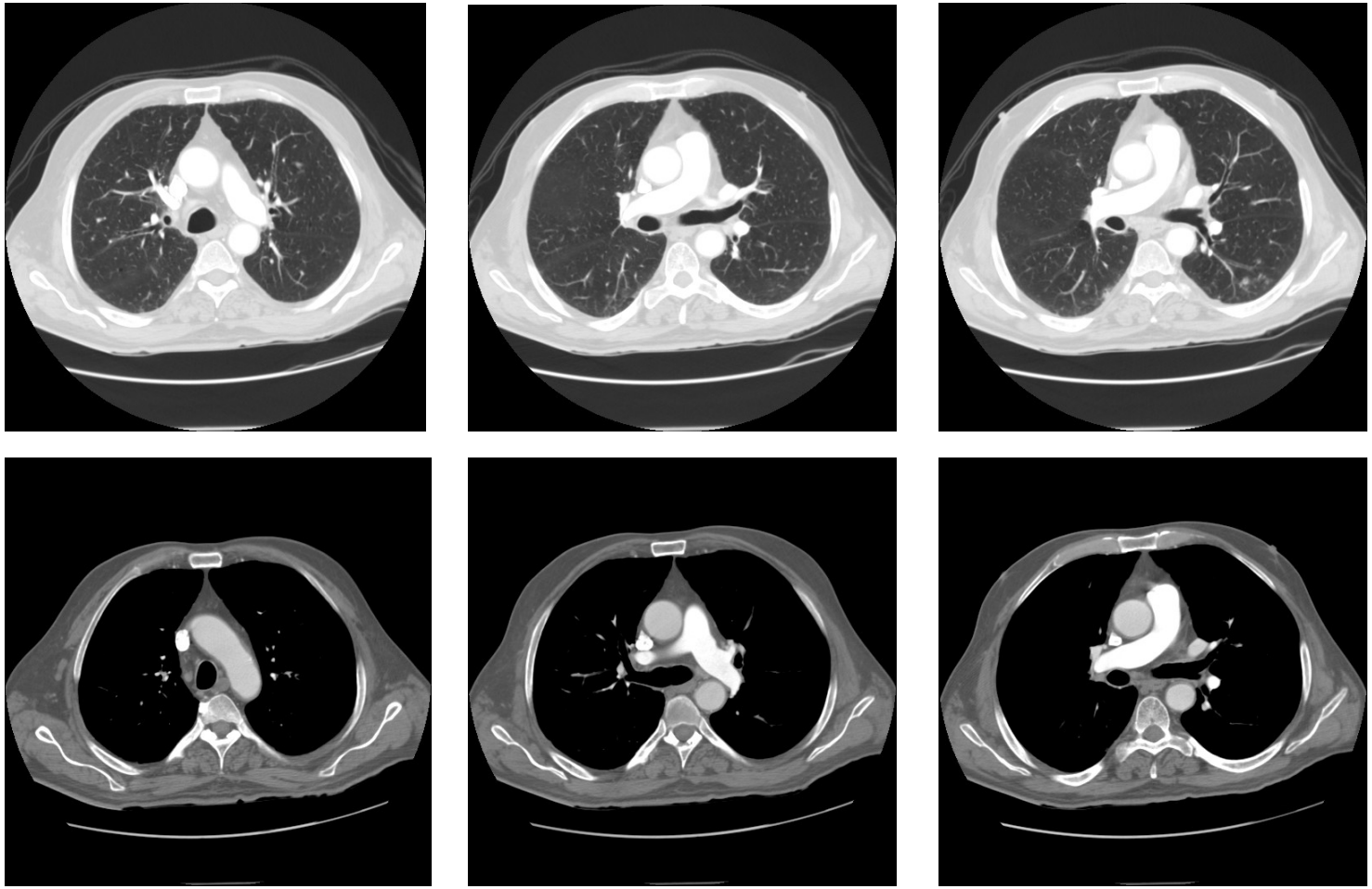
Lower lobe bronchi



Normal upper (left) and lower (right) HRCT scans obtained in the prone position. The center of a pulmonary lobule is defined by the presence of a distal pulmonary artery (A). The faint outline of a distal interlobular septum is noted in the lower lobes (B). A subpleural clear space is normally present in the nondependent lung.

Computed Tomography (CT)

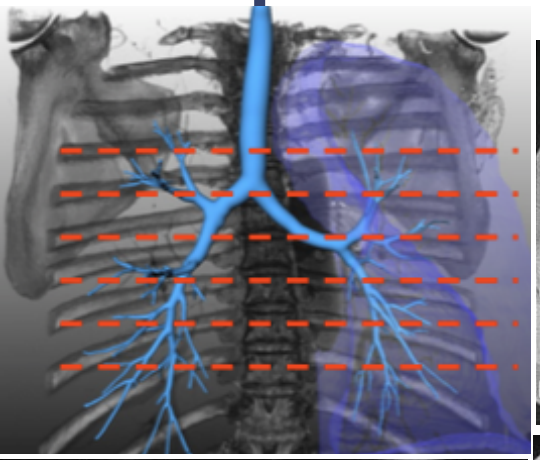
- **Lung window** is wide window to visualize lung parenchymal structures including bronchi, vessels and alveoli.
- **Mediastinal window** is narrow window to visualize mediastinal structures including major vessels, heart….

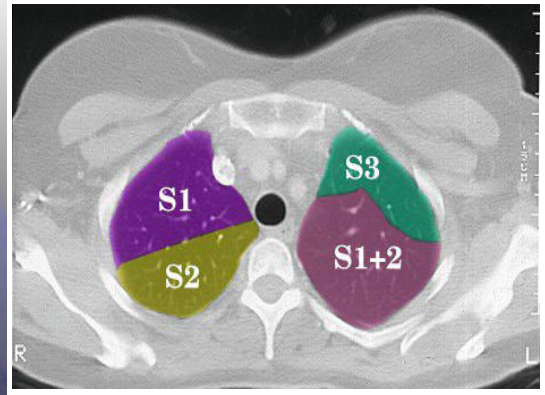


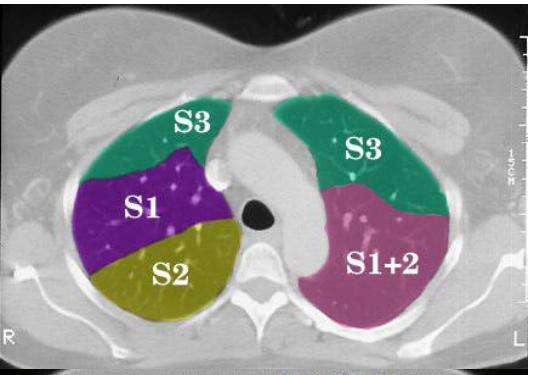
LUNG WINDOW
WW: wide & WL: negative
1600 : -600

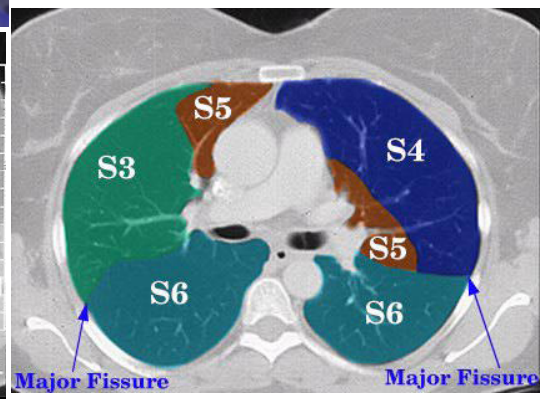
MEDIASTINA WINDOW
WW: narrow & WL: positive
1600 : 600

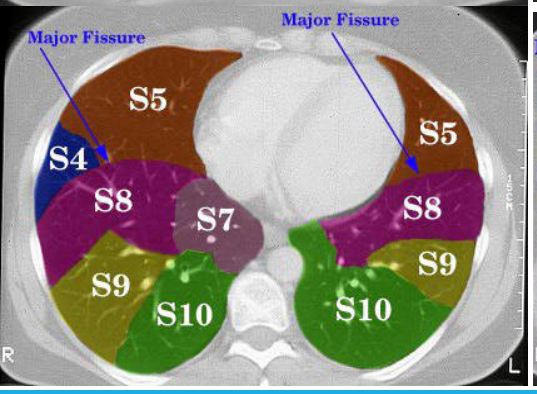
Computed Tomography (CT) Lung window

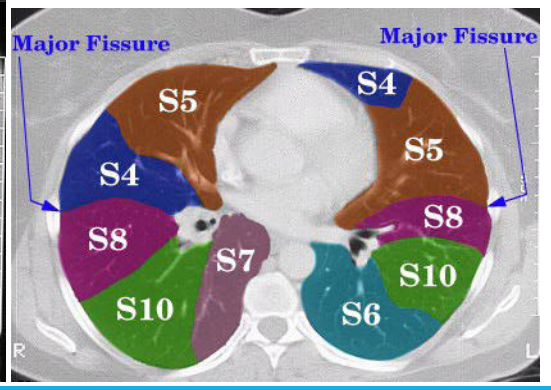










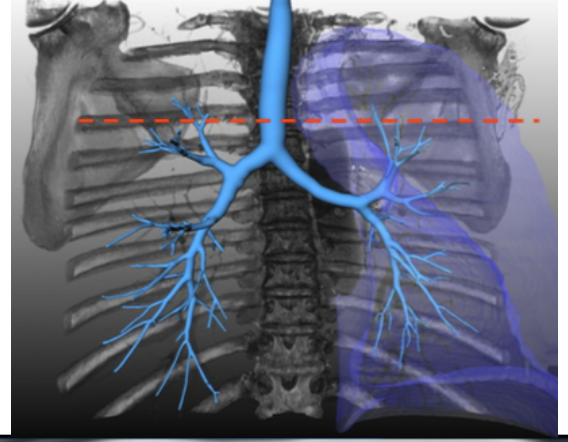


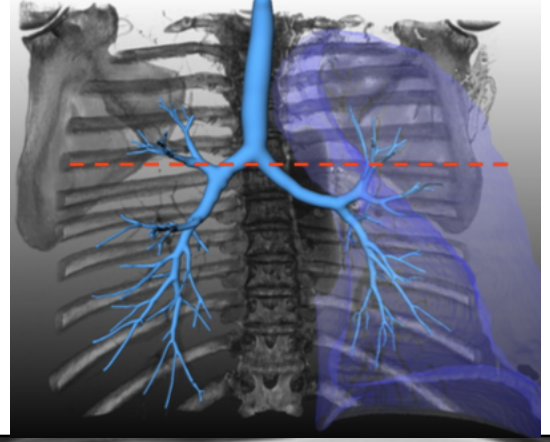
Broncho-pulmonary segmental:

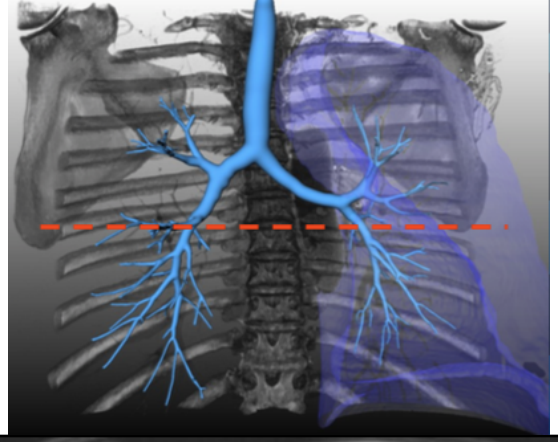
- **10 Segments on right lung**
- **8 Segments on left lung**

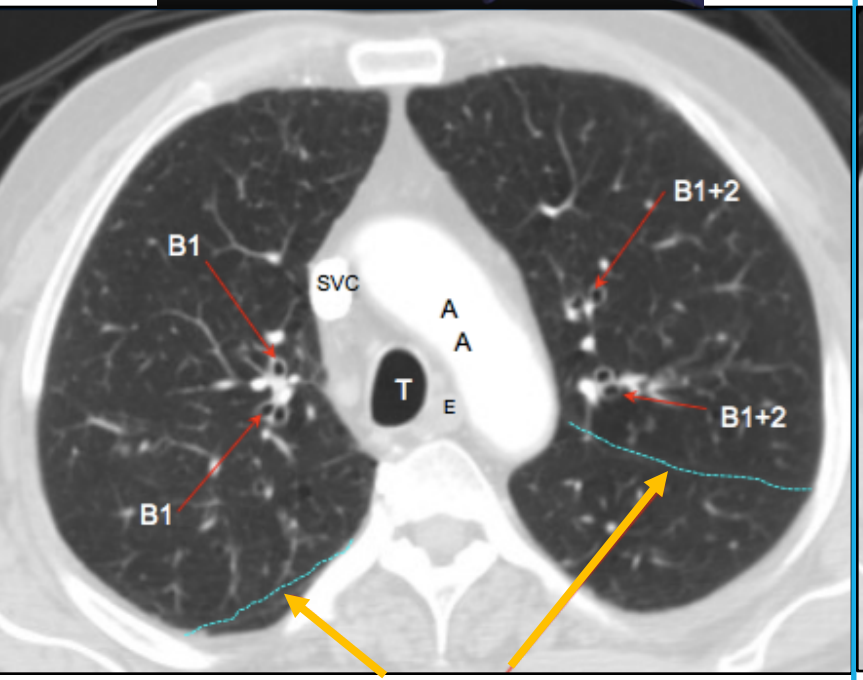
	Right lung	Left lung
Upper lobe	•apical segment •posterior segment •anterior segment	•apicoposterior segment •anterior segment •superior lingular segment •inferior lingular segment
Middle lobe	•lateral segment •medial segment	
Lower lobe	•superior segment •anterior segment •medial segment •lateral segment •posterior segment	•superior segment •anteromedial segment •lateral segment •posterior segment

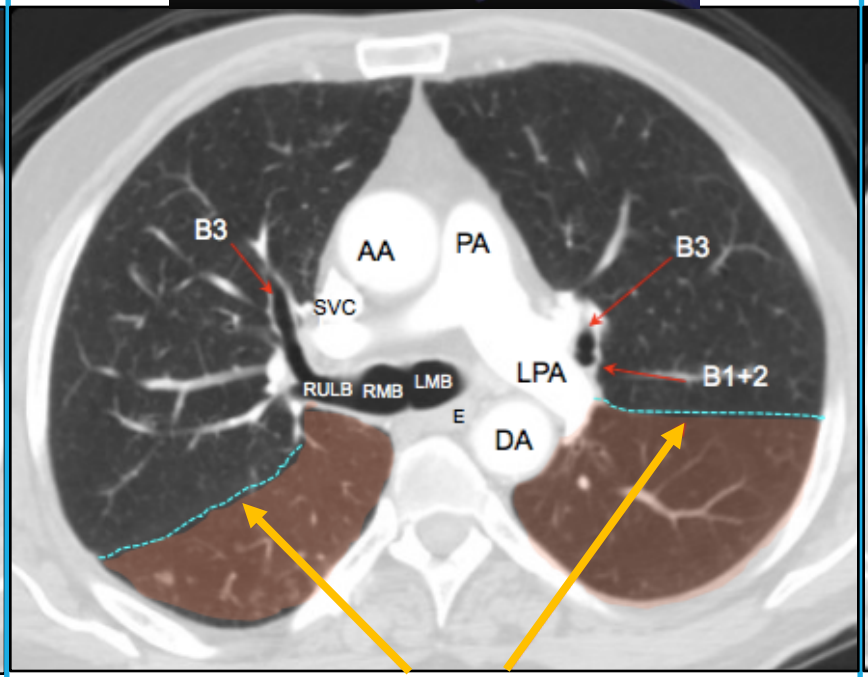
Normal Anatomy of the Chest
Cross Sectional CT

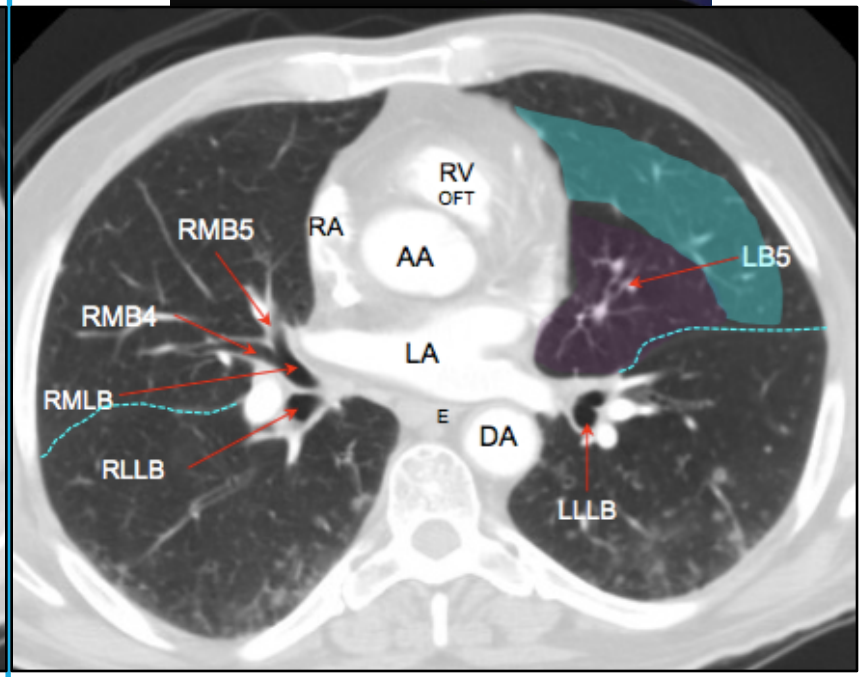










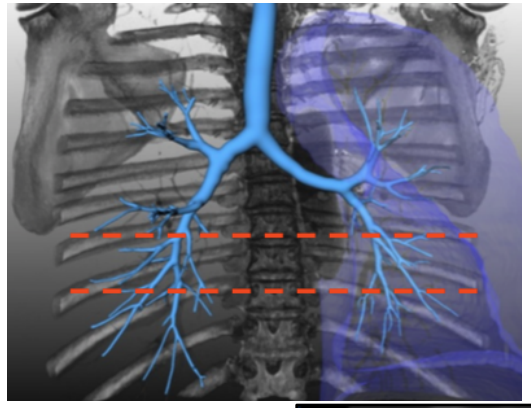


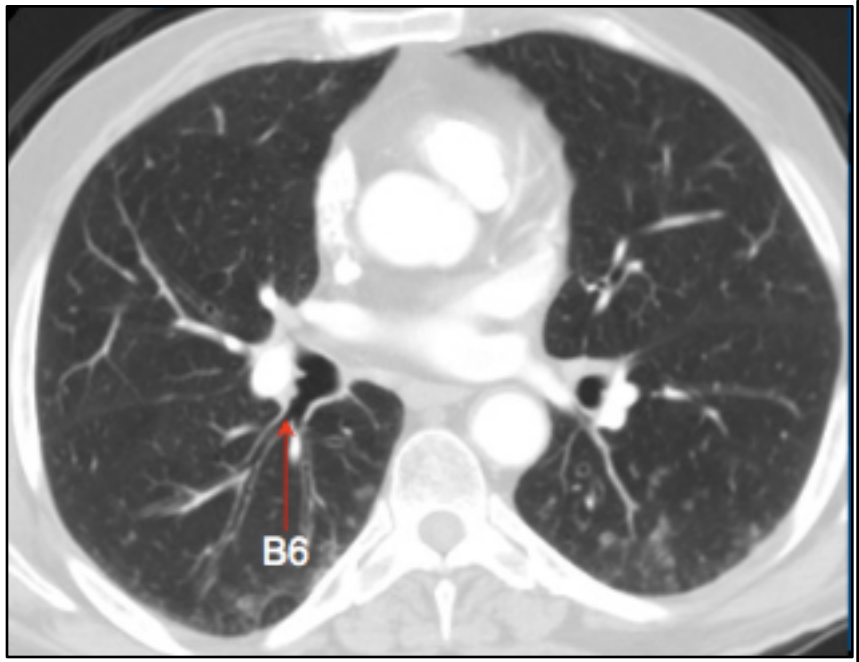
B1: Apical Upper Lobe B
B2: Posterior Upper Lobe B
B1+2: Apicposterior Upper Lobe B
Major Fissure appears as white hairline, lucent band, white band. (Orange Arrow)

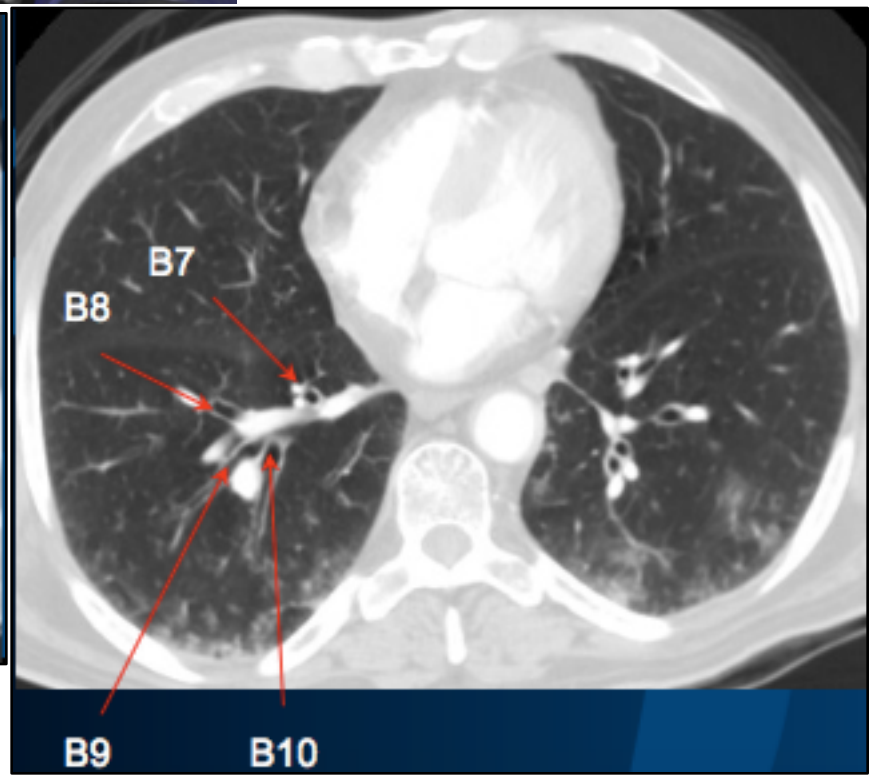
B1+2: Apicposterior Upper Lobe B
B3: Anterior Upper Lobe B

RLLB: right lower lobe bronchus
RMLB: right middle lobe bronchus
LLLB: left lower lobe bronchus

Normal Anatomy of the Chest
Cross Sectional CT



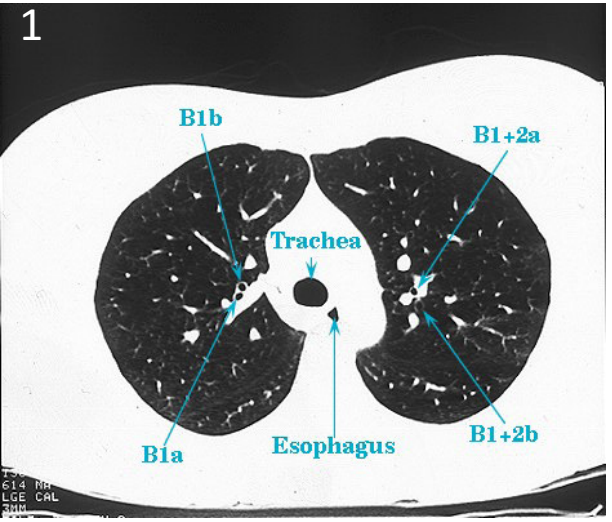


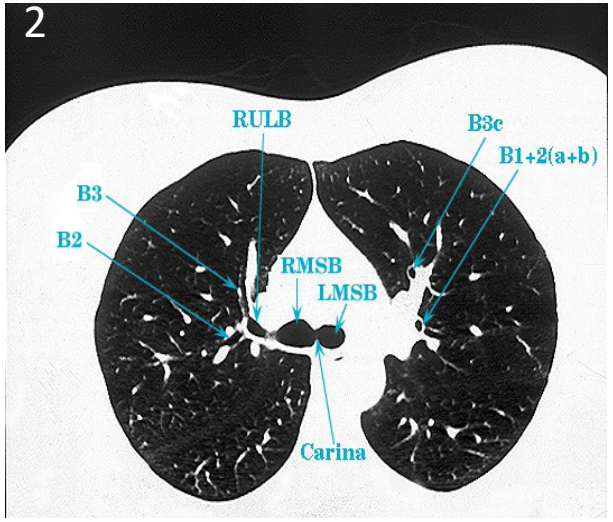


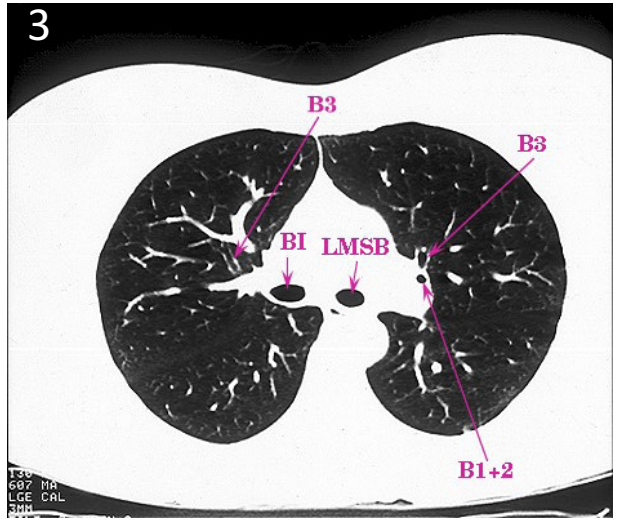
B6= Superior Lower Lobe B
B7= Medial Basal B
B8= Anterior Basal B
B9 = Lateral Basal B
B10= Posterior Basal B

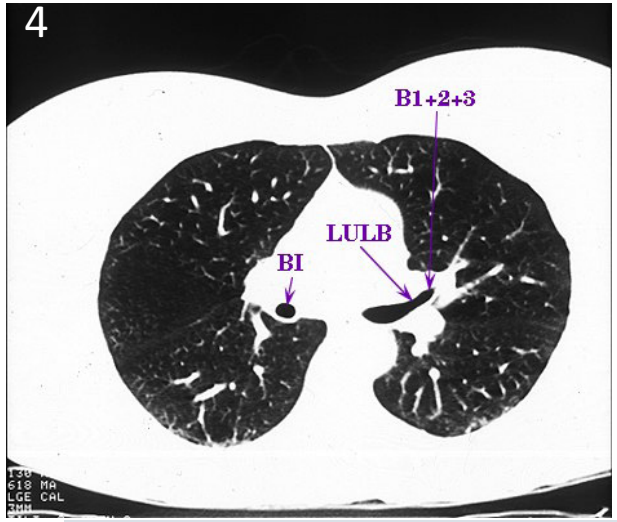
Normal Anatomy of the Chest
Cross Sectional CT

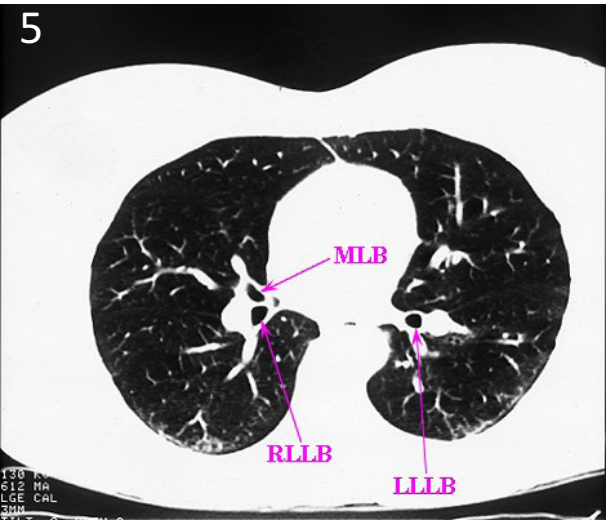
SUMMARRY OF LUNG WINDOW:

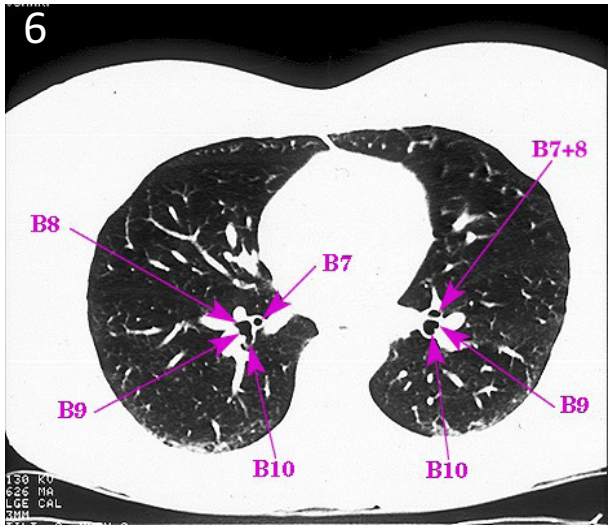












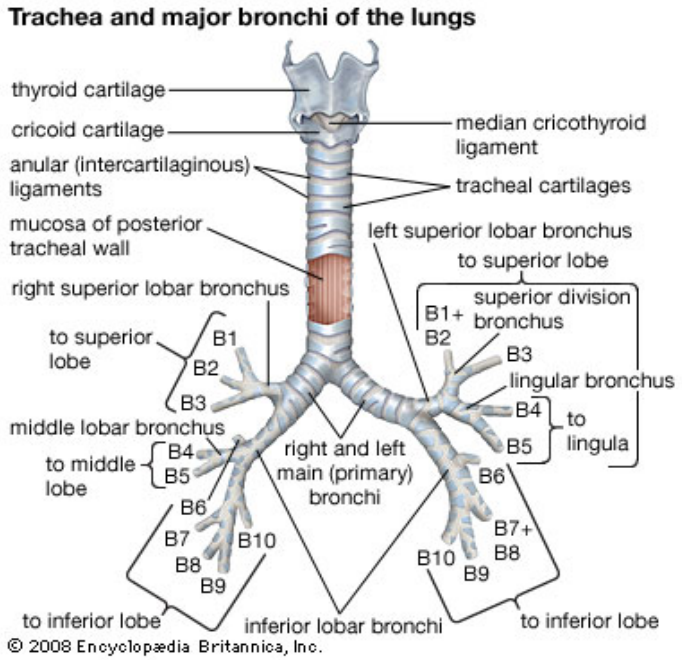


Image1: Level of trachea we could see upper lobe segmental bronchi

Image 2: Level of bifurcation and right upper lobe bronchus

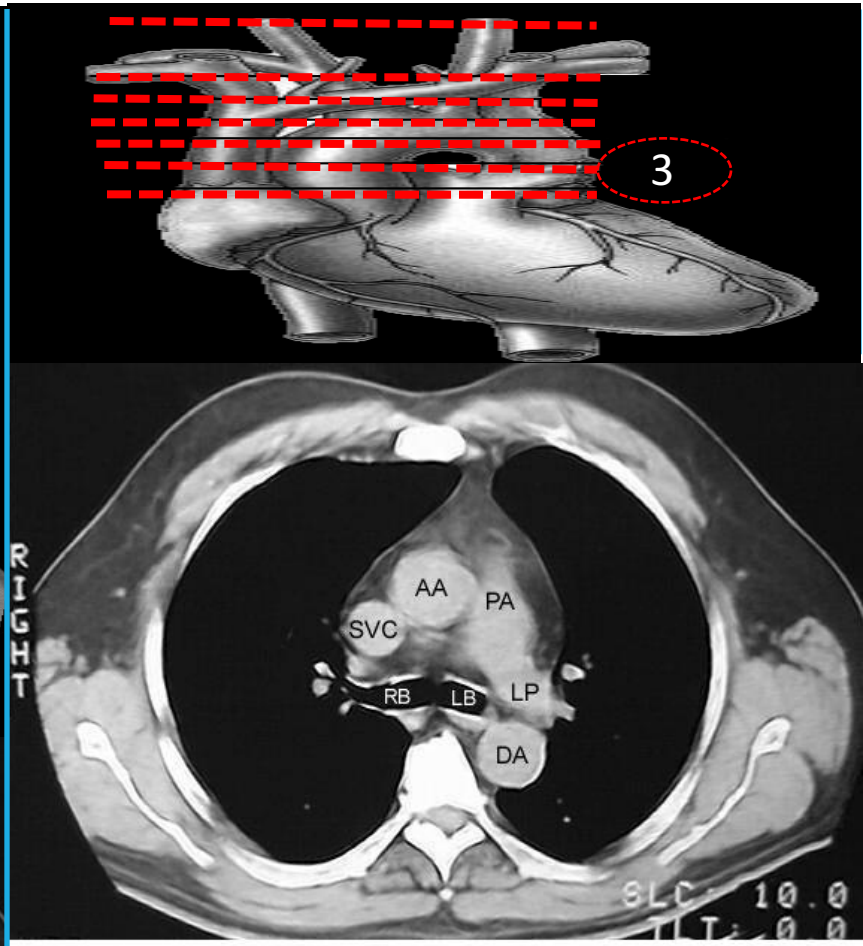
Image 3: Lower cut at right bronchus intermedius level (BI)

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.

Computed Tomography (CT) Mediastinal window

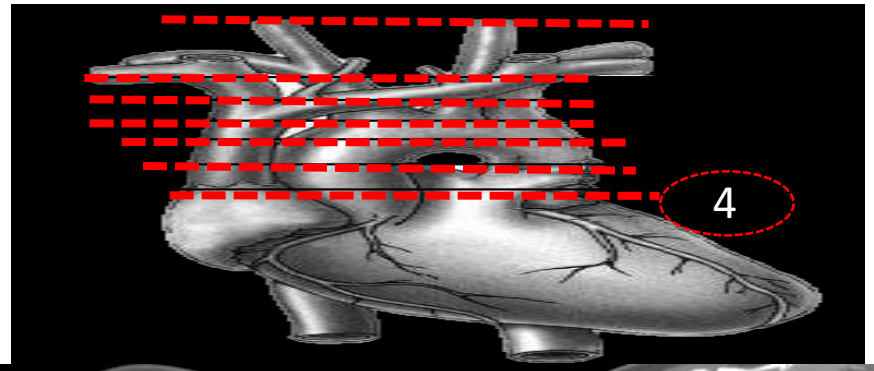
E esophagus R rib S scapula T trachea
TP transverse process of the thoracic vertebra
1 right brachiocephalic vein 2 brachiocephalic artery
3 left common carotid artery 4 left subclavian artery
5 left brachiocephalic vein

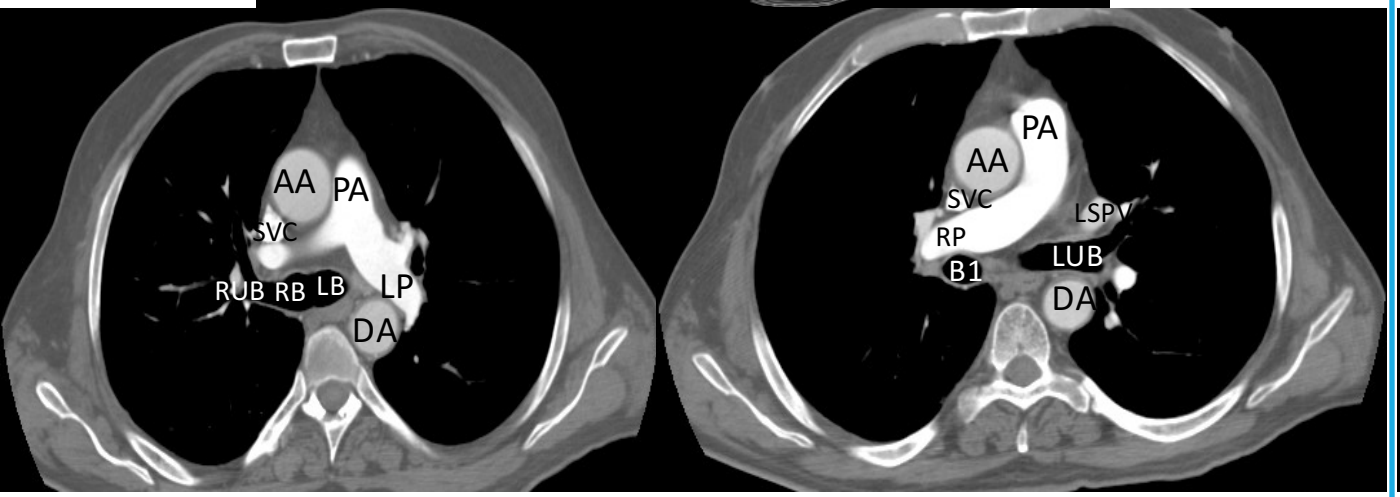
AA aortic arch T trachea 1 superior vena cava



AA ascending aorta DA descending aorta LB left main bronchus
LP left pulmonary artery PA top of main pulmonary artery
RB right main bronchus SVC superior vena cava

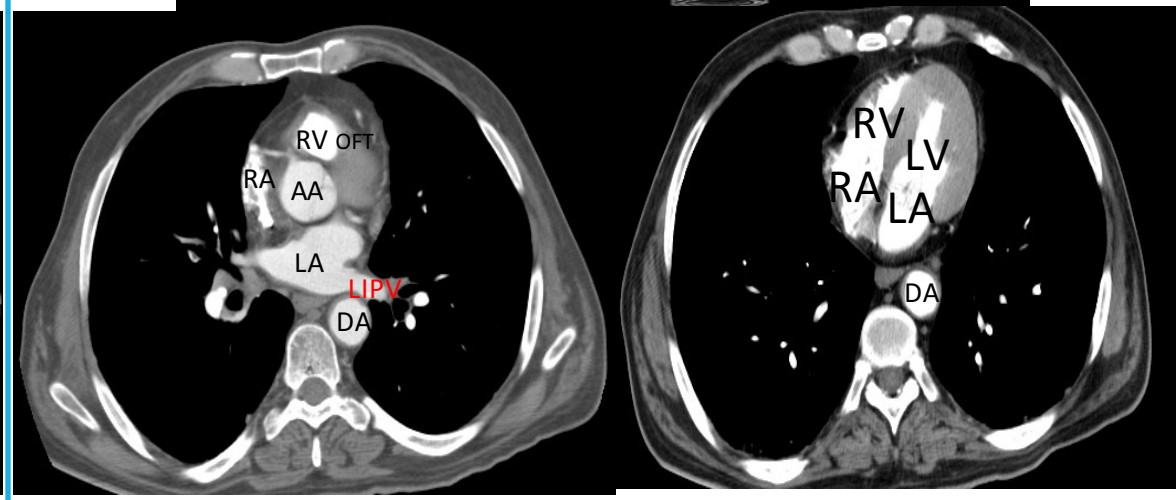
Computed Tomography (CT) Mediastinal window





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
LSPV superior pulmonary vein



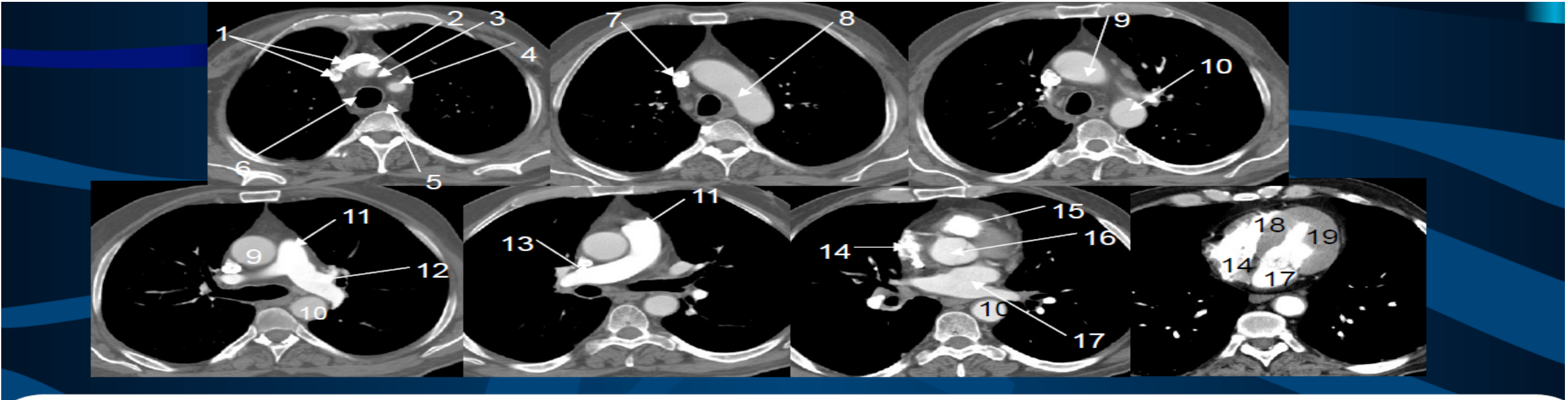
AA Ascending Aorta (root)
DA Descending Aorta
LA Left atrium
LV Left ventricle
RA Right atrium (auricle)
RV Right ventricle (outflow)
LIPV Left inferior pulmonary vein

Most anterior chamber: Right ventricle
Most posterior chamber: Left atrium

- Right pulmonary artery is lower than the left pulmonary artery. - Left superior pulmonary vein is just anterior to left upper lobe bronchus.
- Left inferior pulmonary vein is usually posterior (see next slide) **and the superior is anterior.**

Computed Tomography (CT) Summary:

Mediastinal window

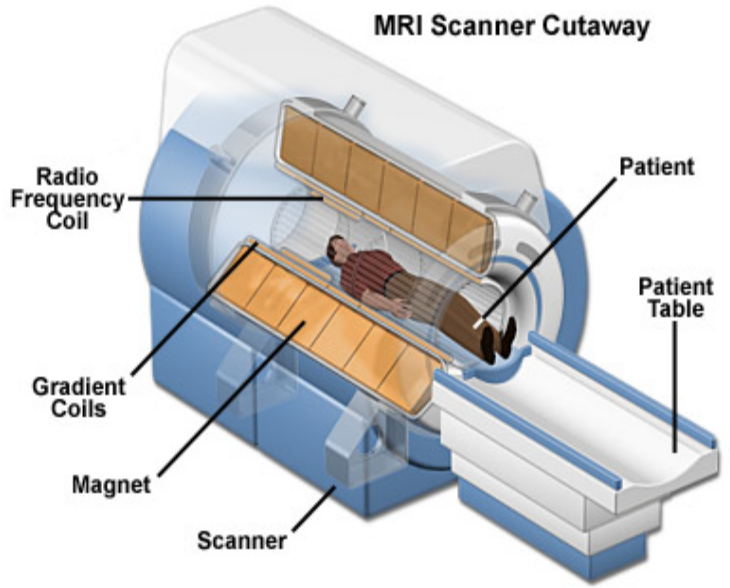


1: Rt & Lt innominate veins (brachiocephalic veins) 2: RT brachiocephalic artery 3: LT common carotid
4: LT subclavian artery 5: esophagus 6: Trachea 7: Superior vena cava 8: Aortic arch 9: Ascending Aorta
10: Descending Aorta 11: Pulmonary trunk (artery) 12: LT Pulm artery 13: RT Pulm artery 14: RT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

Magnetic Resonance Imaging (MRI)

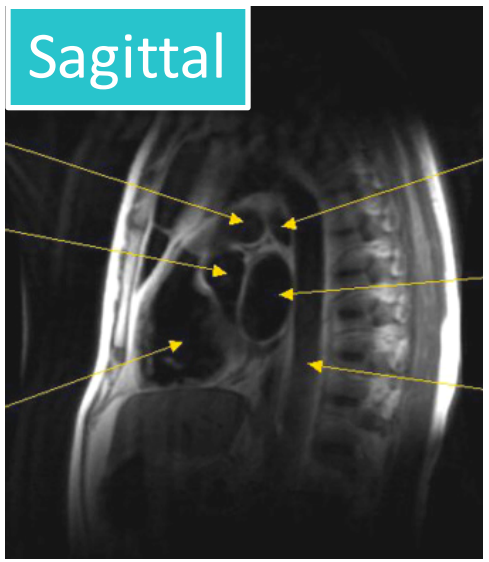
Simply, hydrogen atoms (protons) in water molecules and lipids
> magnetism affects all protons causes them to line up in one direction
> magnets can be switched on and off to change the direction of the magnetic field
> whenever the water molecule spin around they give a light radio wave
> MRI machine 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.

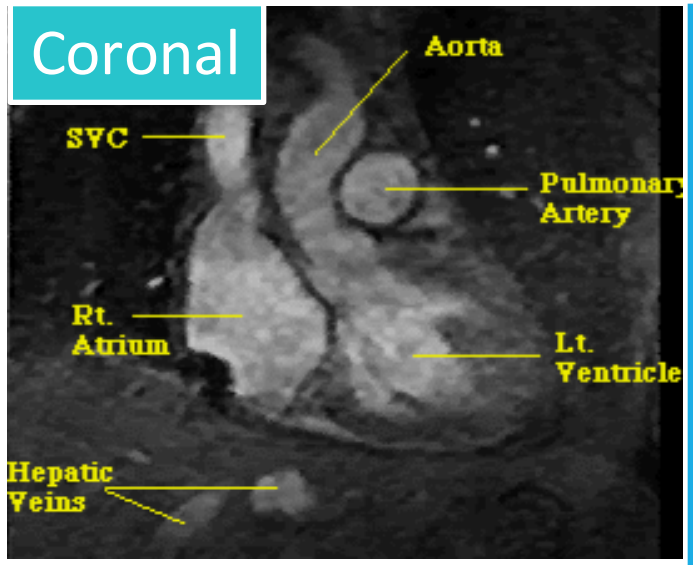
Advantage	Disadvantage
• Best for soft tissue imaging • There is no ionization • It can be done for pregnant women with caution • Images can be directly in any plane place	• expensive • Time consuming • patients fear it and dislike it because it is a narrow • Since it is magnetic no metals can be allowed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

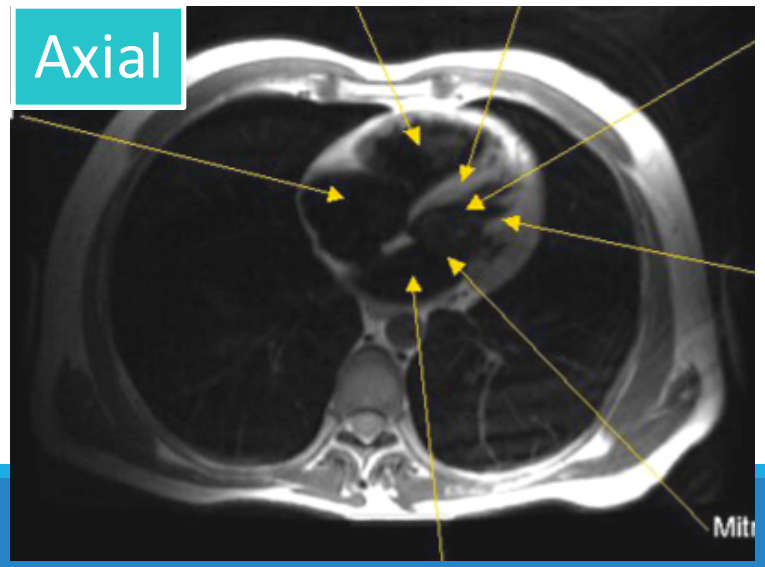


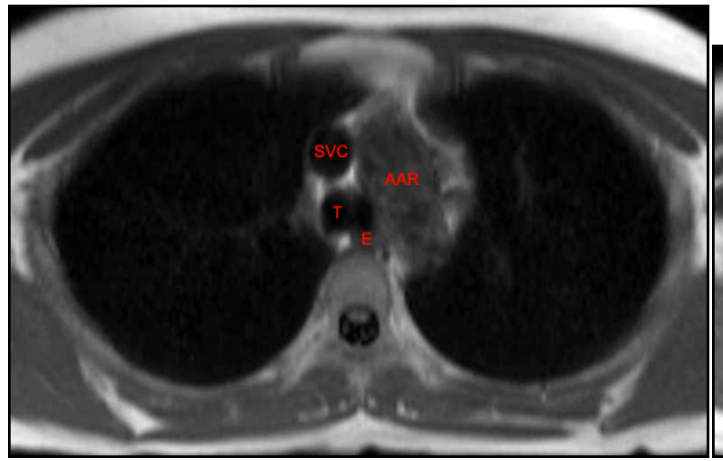
Magnetic Resonance Imaging (MRI)

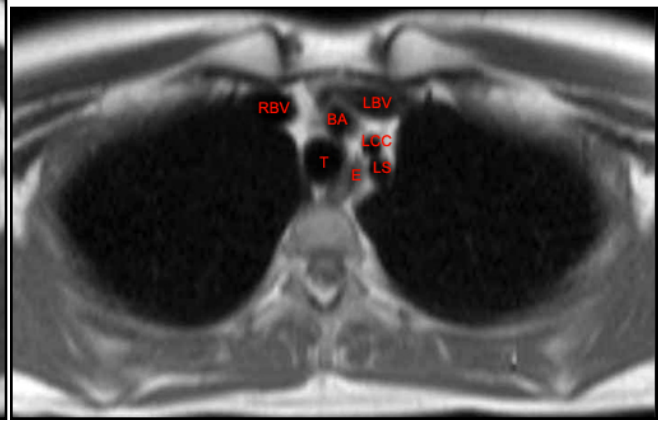
- On CT usually images are axial and we could rebuild images on coronal and sagittal from axial cuts because it is a ring.
- Here we can obtain segittal, coronal and axial directly because it is a tunnel.

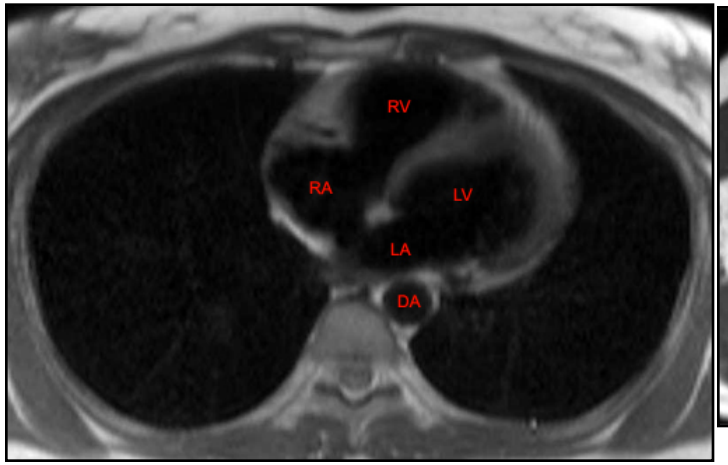


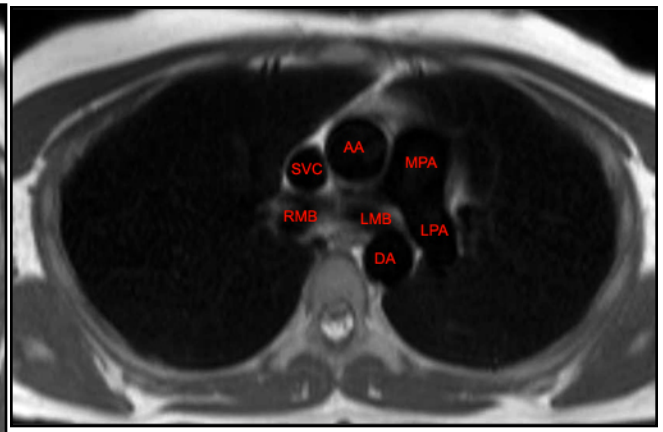




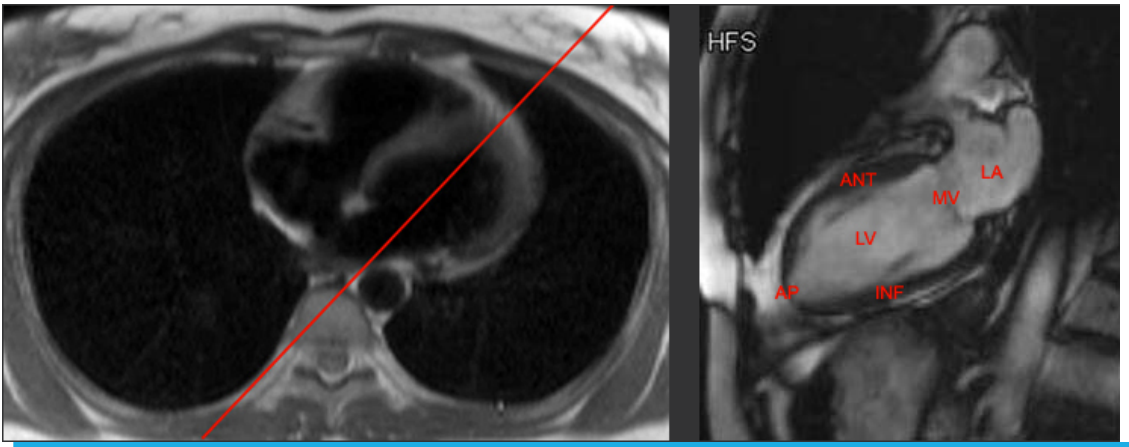






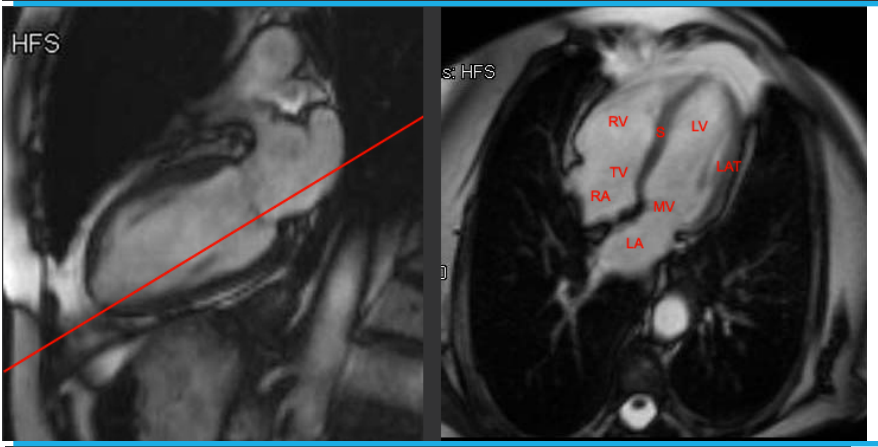


Magnetic Resonance Imaging (MRI)



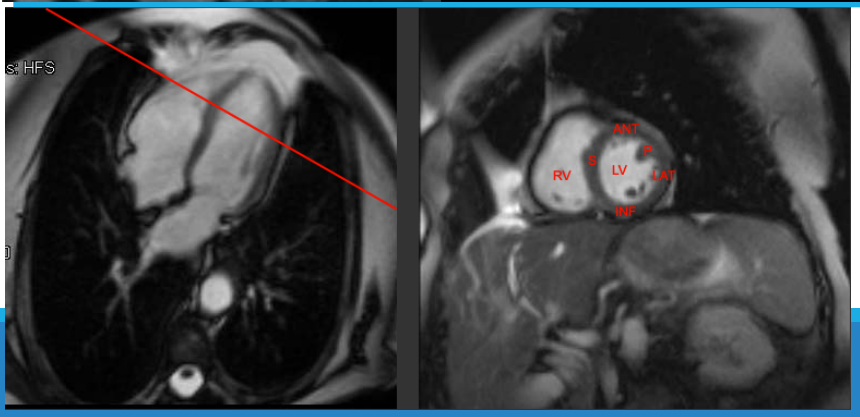
VERTICAL LONG AXIS VIEW:

- 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.



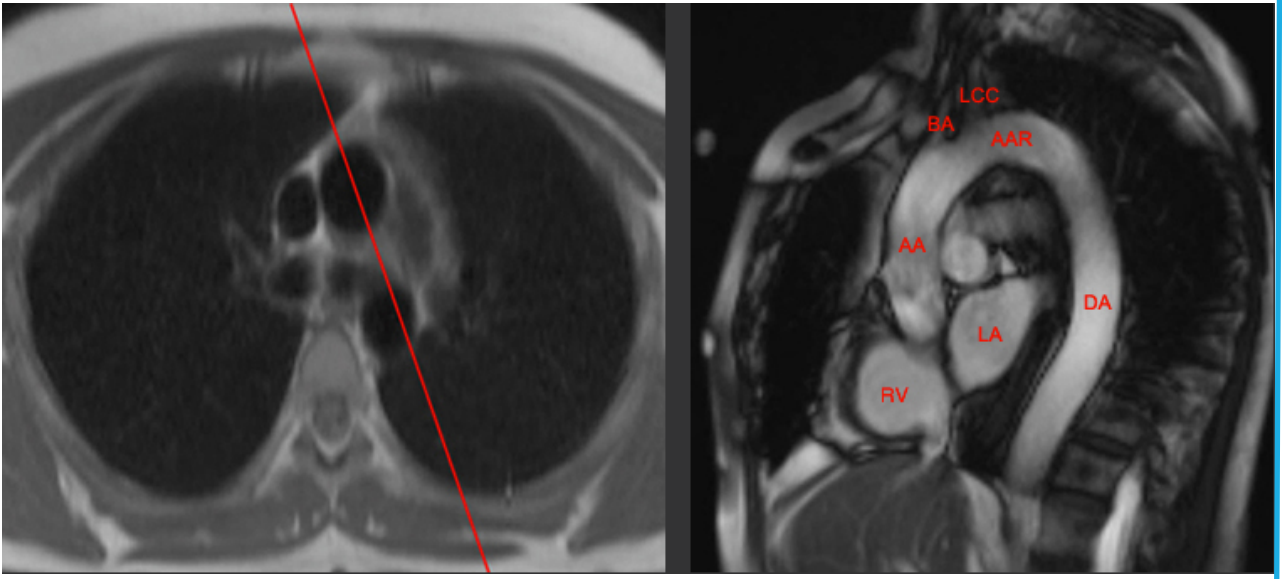
SHORT AXIS VIEW:

- 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.

•We could do dynamic study to evaluate contraction of muscles, valves and flow of blood

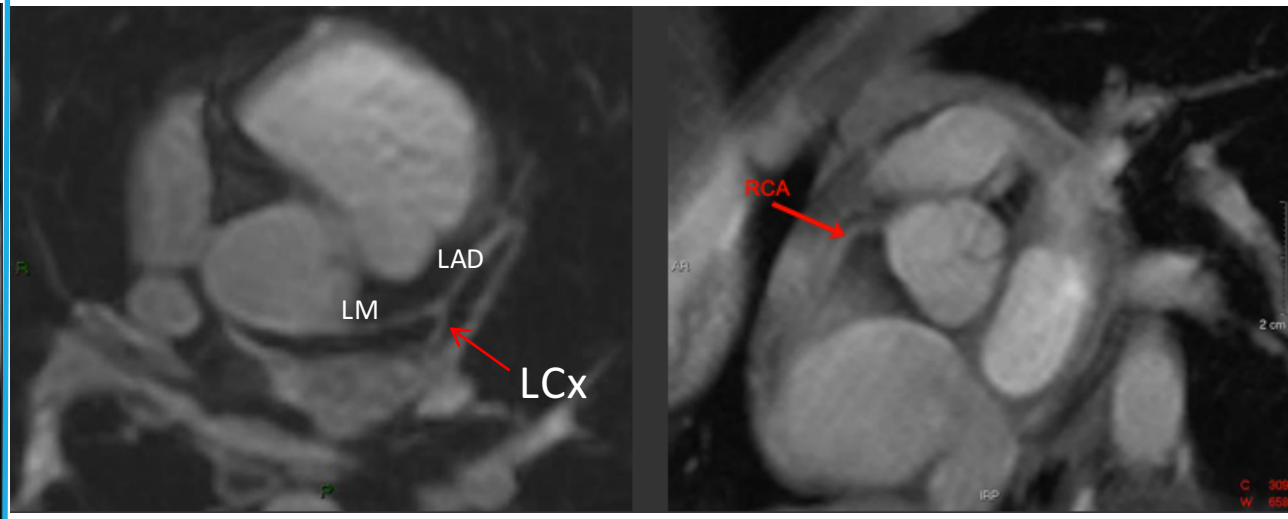
Magnetic Resonance Imaging (MRI)

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 plane is chosen that bisects both the ascending and descending aorta.

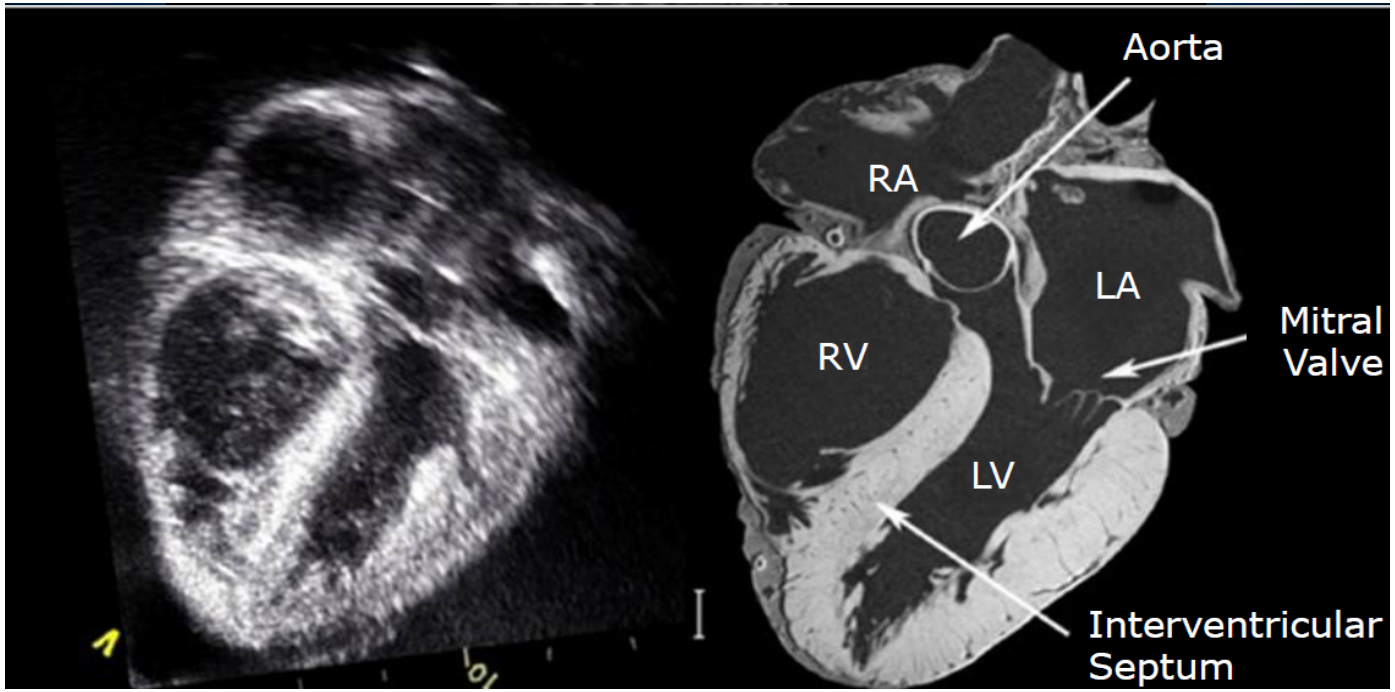
CORONARY ARTERIES VIEW

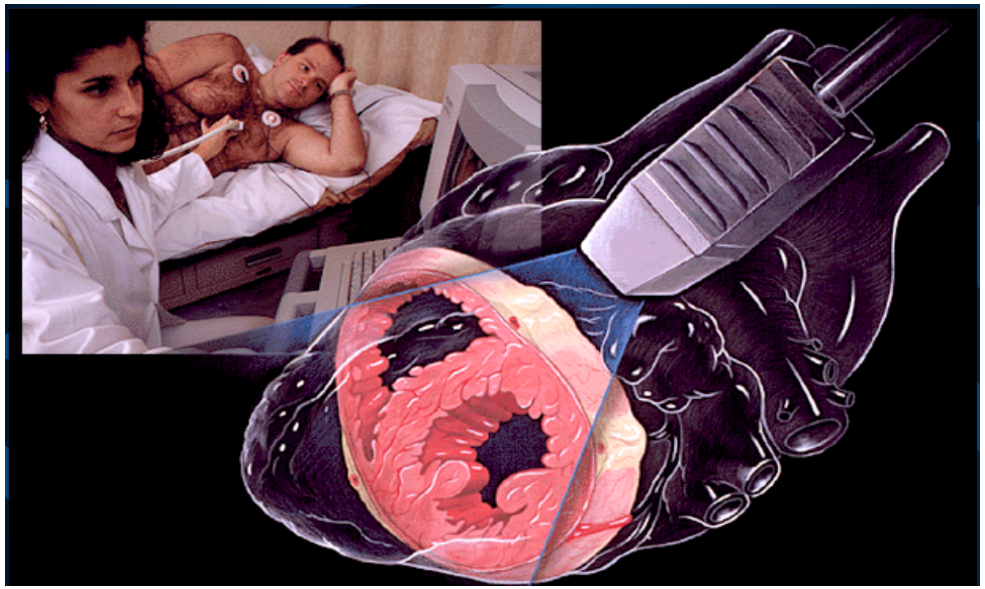


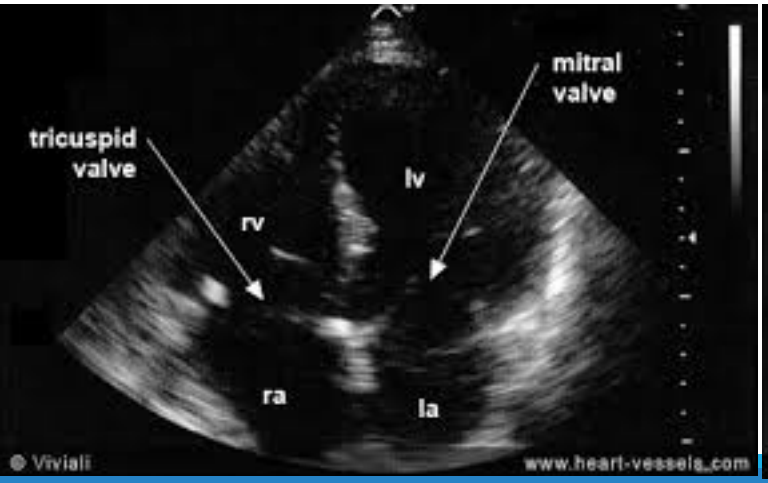
- The coronary arteries originate from the proximal portion of the ascending aorta from the Sinuses of Valsalva.
- The two coronary arteries arising from the aorta are the right coronary artery (RCA) and the left main coronary artery (LM). The LM branches into the left anterior descending (LAD) and left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

•In patient with ischemia or heart attack we could do dynamic study to defined the exact location of the injury and to see movement of muscles and septum

Ultrasound







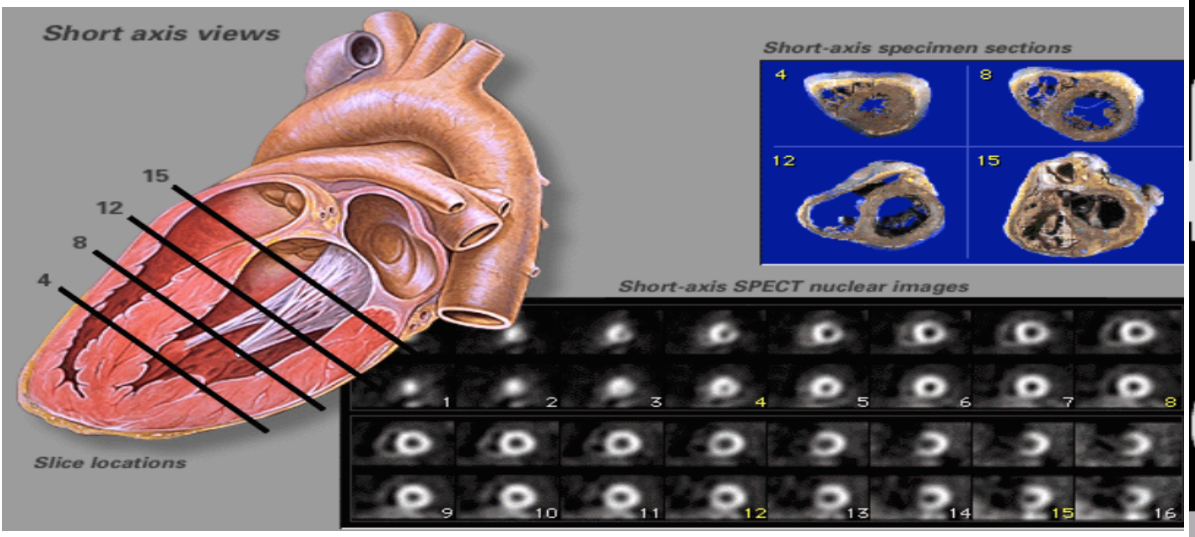
- Visualize all chambers of heart.
- Dynamic study to evaluate movement of leaflet of the valves.

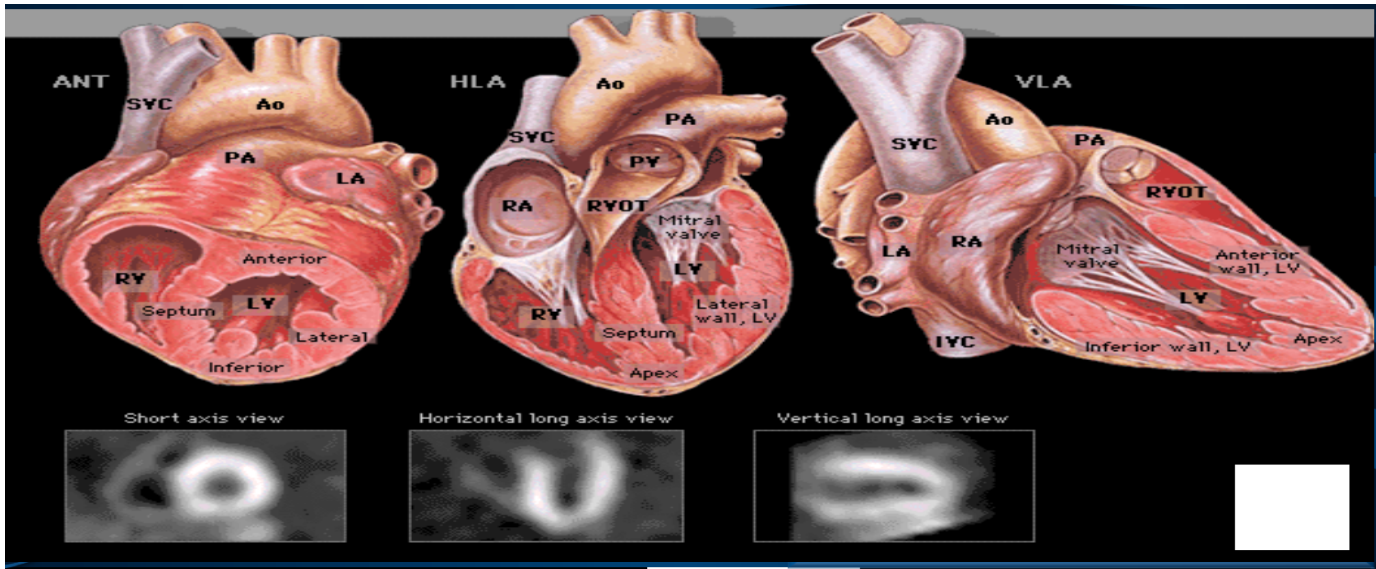
1. Transthoracic echo: most common type.
2. Transesophageal echo: typically performed to evaluate serious heart conditions.

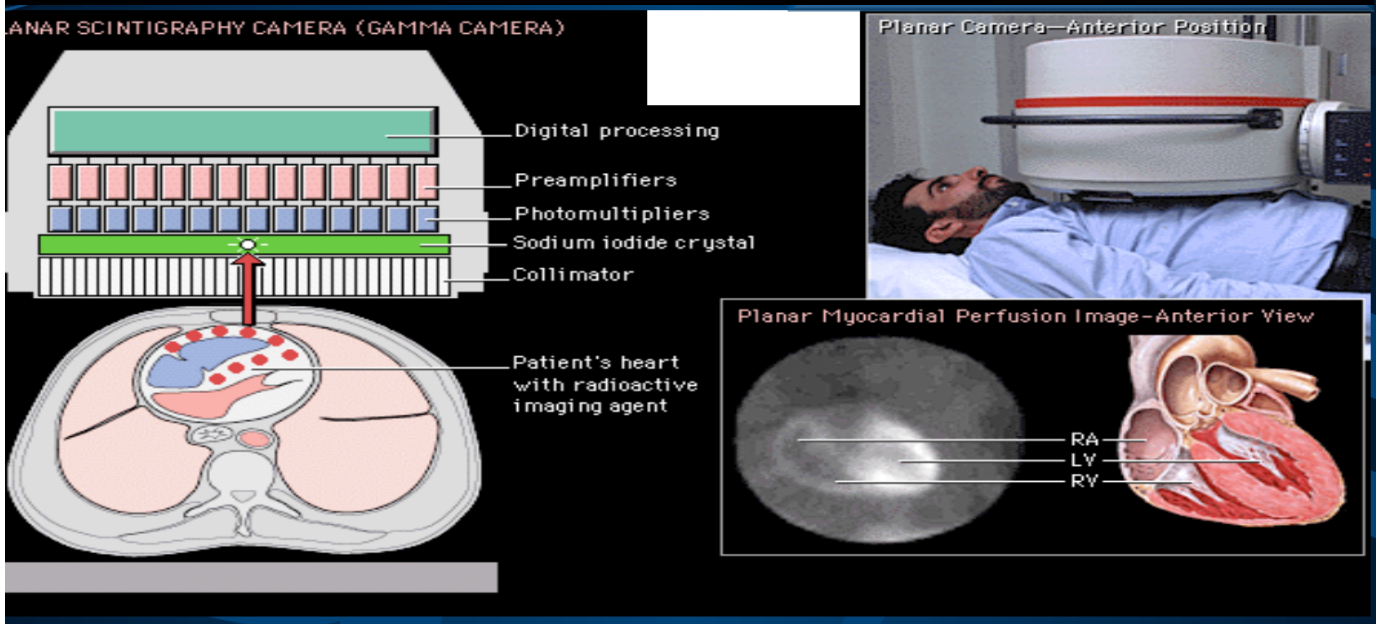
Nuclear Medicine

-Injection of **isotope material** that will target a specific organ such as the heart and images are obtained with a gamma camera:

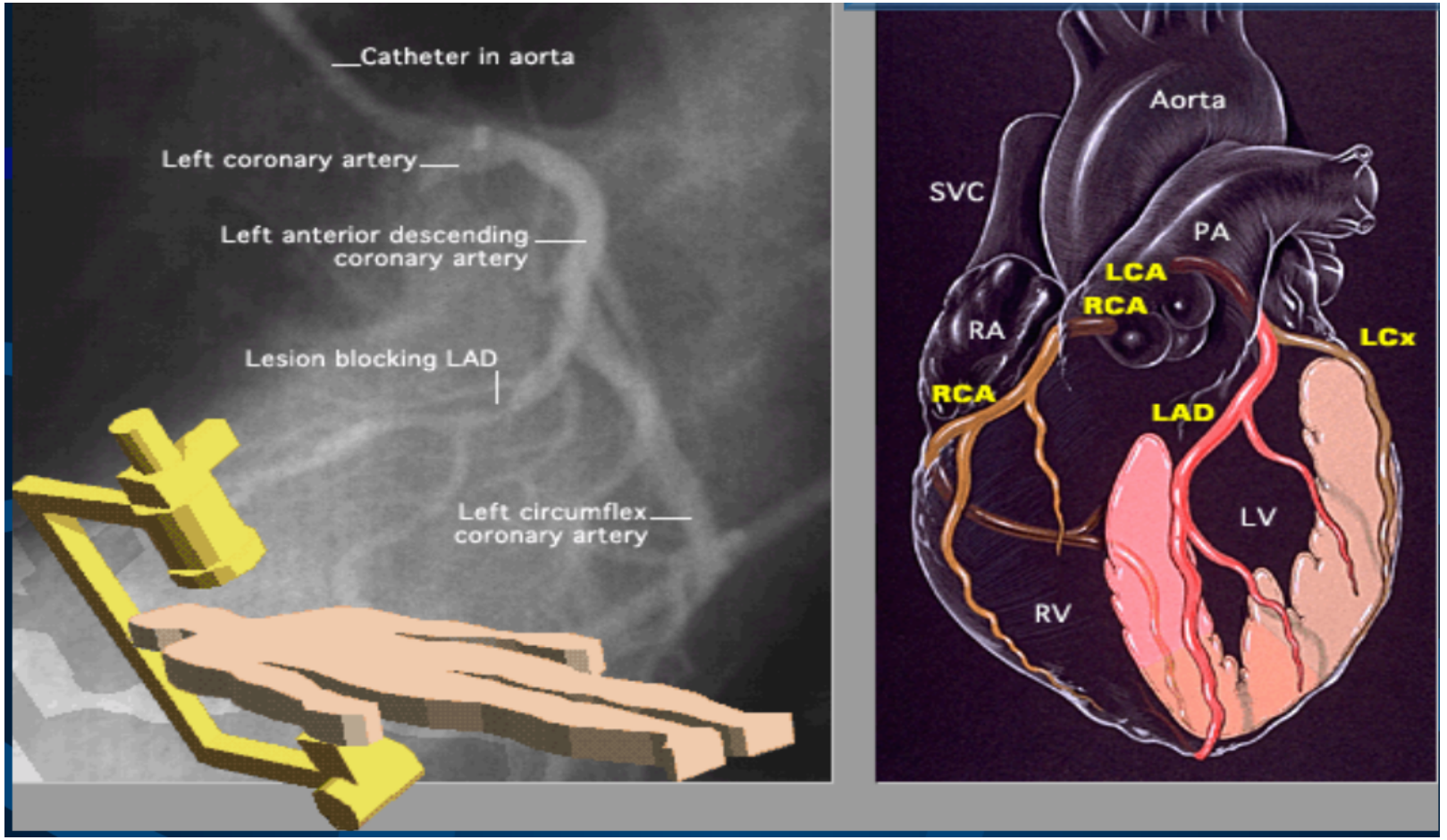
- ✓ To analyze blood supply to certain part of myocardium.
- ✓ To see thickness of muscle does it differ in systole or diastole therefore we could evaluate presence or absence of ischemia or infraction of the muscle.
- ✓ We could obtain a view from different angles.







Angiography



- ✓ It is a traditional method which was used to evaluate coronary arteries nowadays they use CT or even MRI.
- ✓ The advantage of this method is that if there is stenosis or narrowing we could manage patient by putting stent(this called **Angioplasty**).

Thank You!

We hope you found this helpful and informative.

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