Chest Imaging Refresher

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I have no relevant relationships with ineligible companies to disclose within the past 24 months

UVA Department of Radiology website

Drs. Rydzak and Primack OHSU Thoracic radiology

RadiologyMasterClass.co.uk

Society for Thoracic Radiology

American College of Radiology

Learning Objectives

- Review chest x-ray techniques
- Quick blurb on basic approach to the interpretation
- Review thoracic imaging anatomy- CXR and CT
- Define chest imaging terminology
  - Patterns
  - Distribution
- Review some cases!

Chest Imaging

- ~400 million medical imaging per year in the US (pre-COVID)
- Chest radiograph (“chest x-ray”) is the most common
  - About 80 million!
  - AP
  - PA
  - Special Views – less utilized
    - Lateral decubitus
    - Apical lordotic

First, a comment on technique

- Best technique as PA and lateral
- Radiation source positioned at the patient's back (posterior)
- Plate is in front of the patient (anterior)
- PA images will deliver higher quality and sharper images

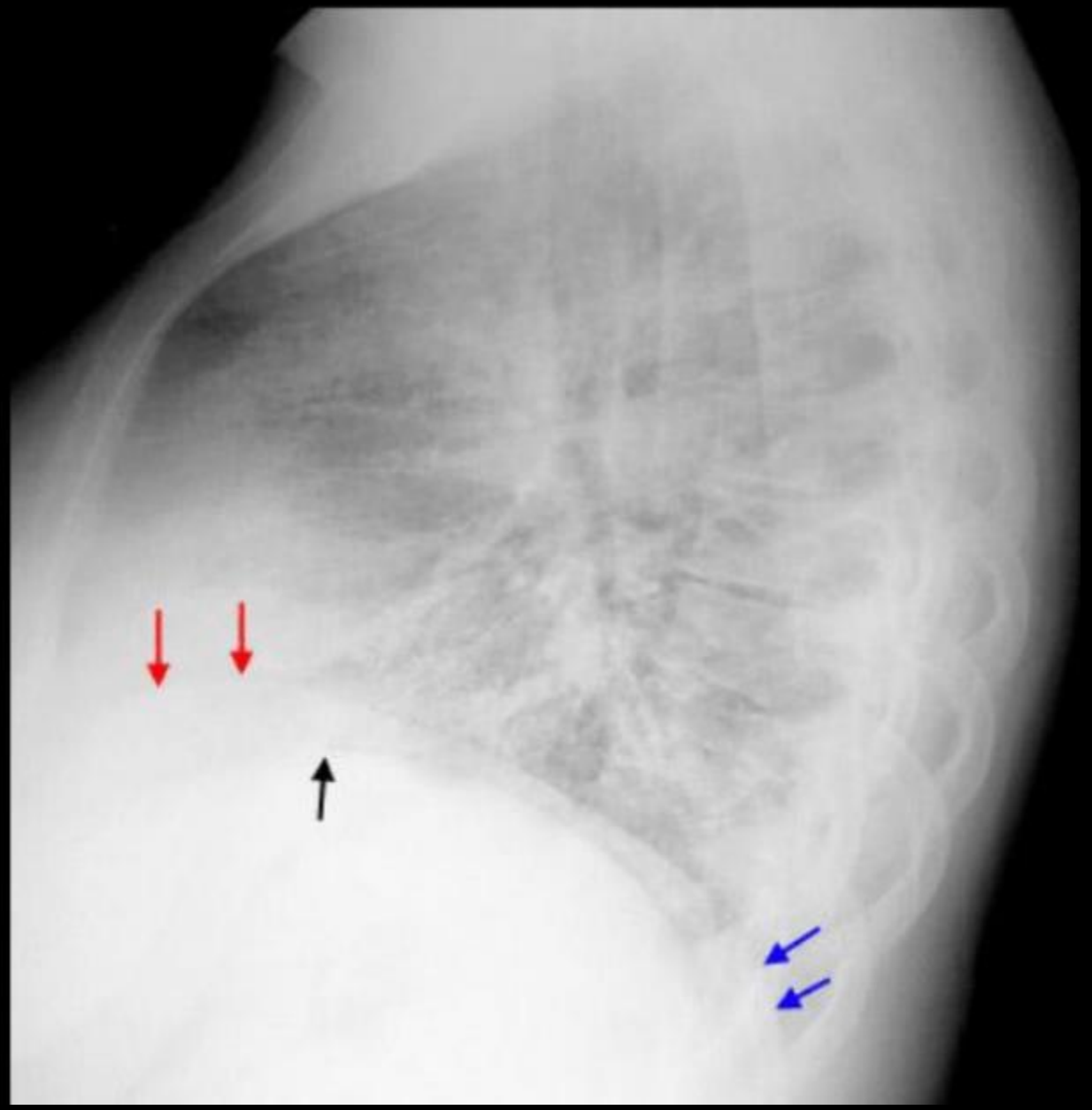
This is the simulated patient in PA (posterioranterior) position.
Note that the x-ray tube is 72 inches away.

First, a comment on technique

- Best technique as PA and lateral
- Radiation source is positioned on the patient's right side
- Plate is to the patient's left side
  - Right to left

Lateral CXR

- LEFT hemidiaphragm
  - Lower
- RIGHER hemidiaphragm (red arrows)
  - Continues anteriorly
- The LEFT hemidiaphragm disappears (black arrow) because it blends with the heart



PA image

- Hospitalized, ill patients sometimes cannot easily or safely stand
- AP images will be more blurry than PA images
- Can still interpret!

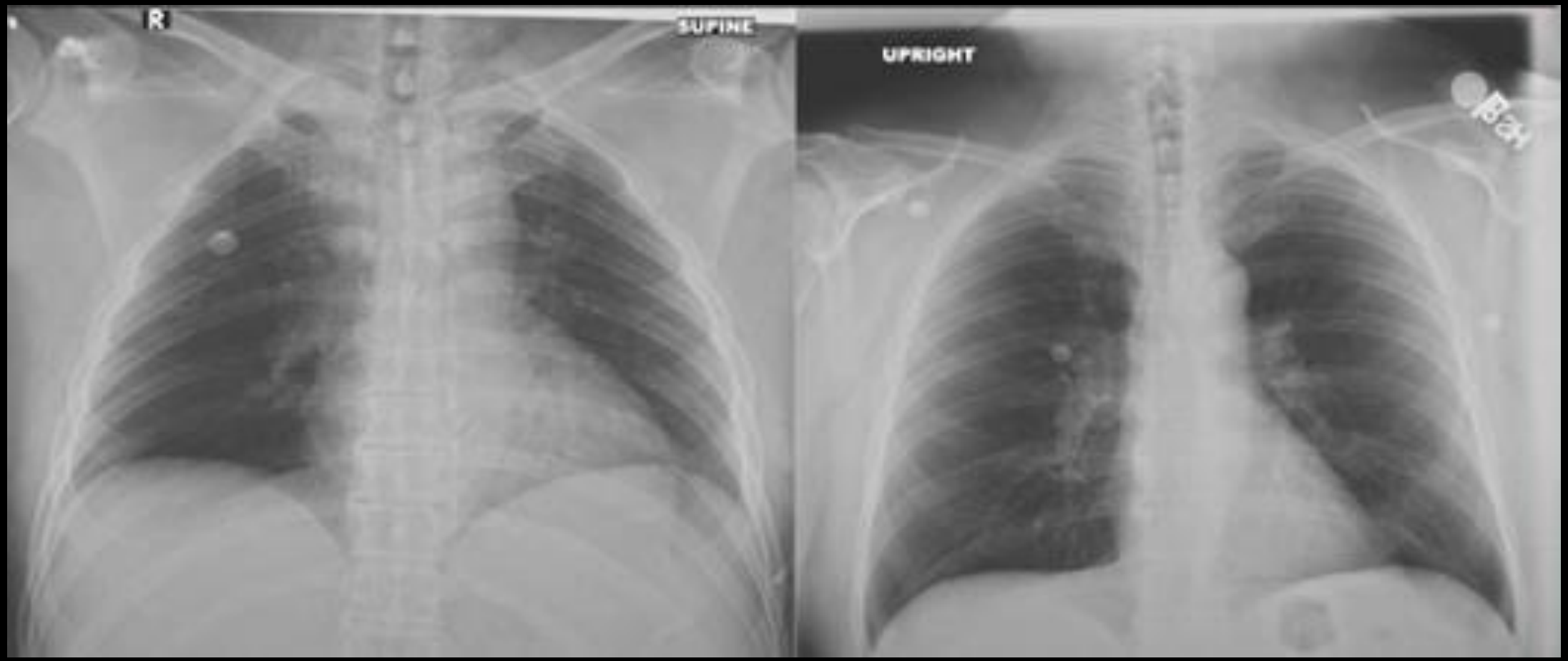
Radiation source is closer to patient that PA

Reading Chest Radiographs….

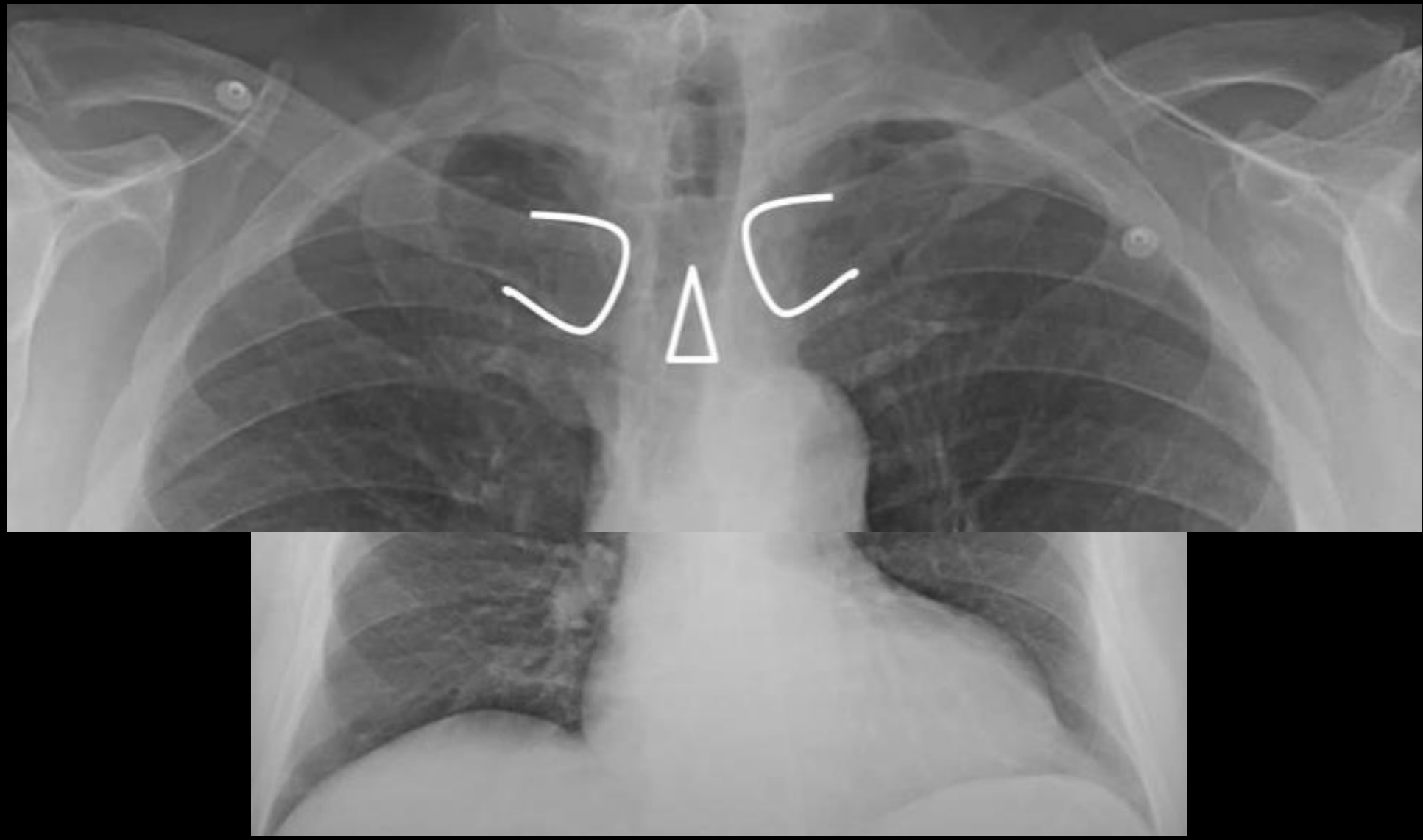
CXR Quality

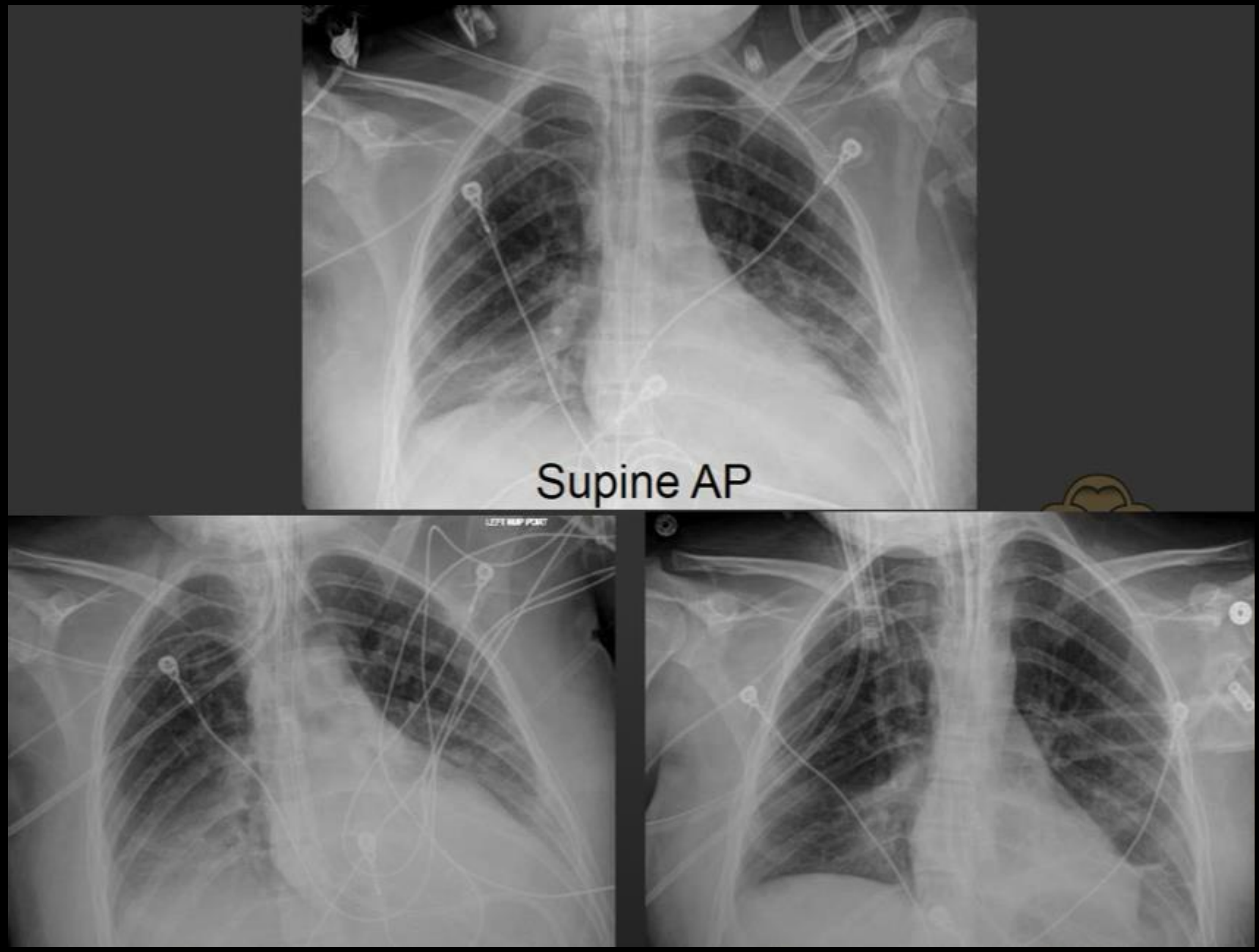
- T= Technique- AP, PA, etc…
- R= Rotation
- I= Inspiration
- P= Penetration

AP versus PA- Trauma patient

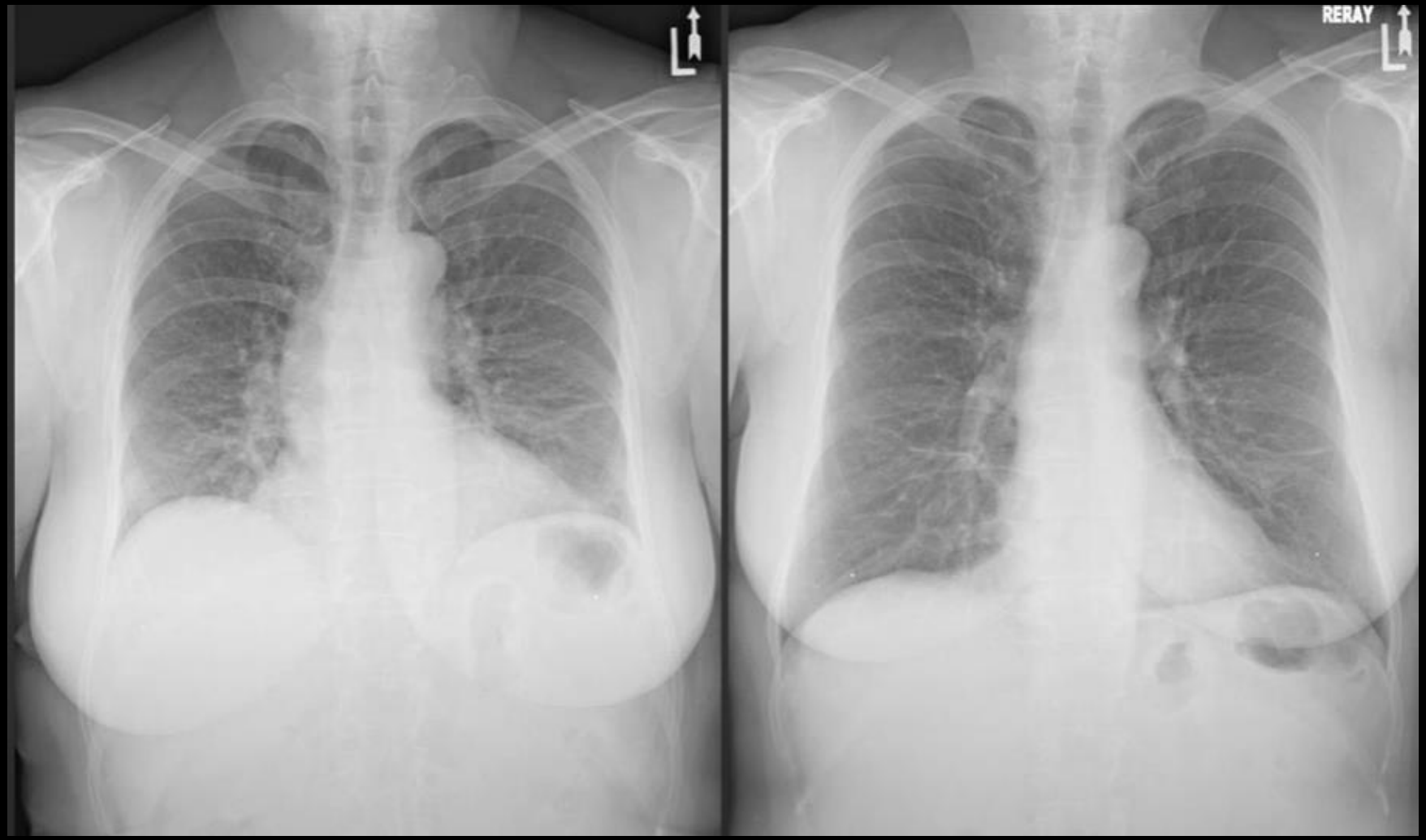


Rotation….




Supine AP

Effect of full inspiration…



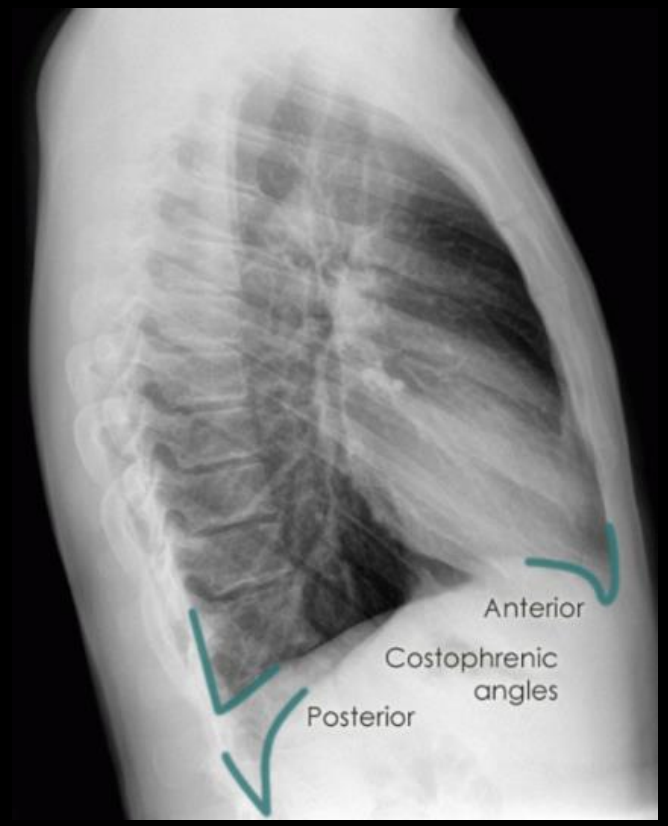
Is there a right way?

- Avoid “the Gaze”
- Have a systematic approach
  - Don’t stop till you are done
    - “Satisfaction of search” – finding one thing and then stopping your process

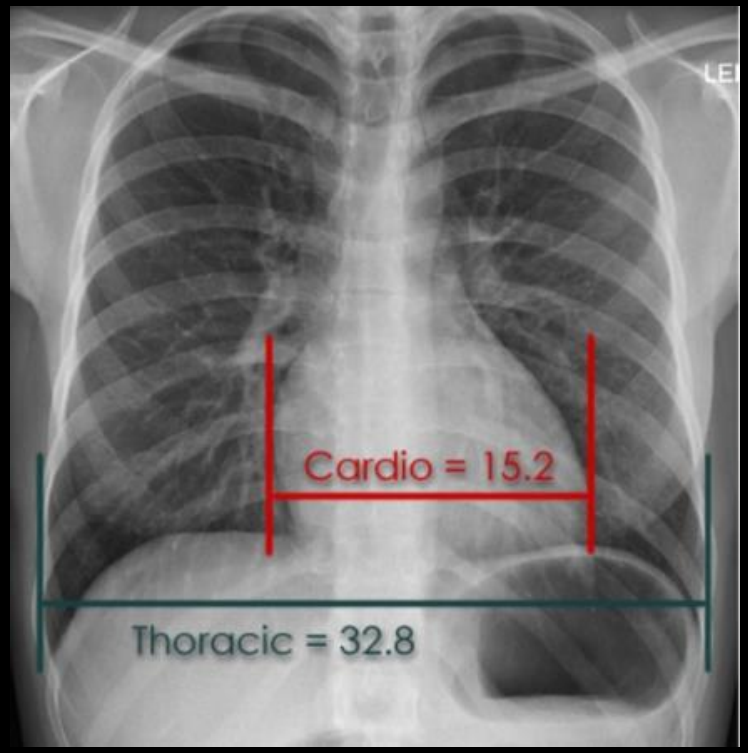
Mnemonics? Other ways?

- ABCDEFGH
  - Airways
  - Bones
  - Cardiac silhouette/Costophrenic angles
  - Diaphragm
  - Edges of fields (pleura) and Extrathoracic structures
  - Fields of lungs
  - Gastric bubble
  - Hilar regions

- "Between the lungs, outside the lungs, in the lungs"
- Scan for symmetry

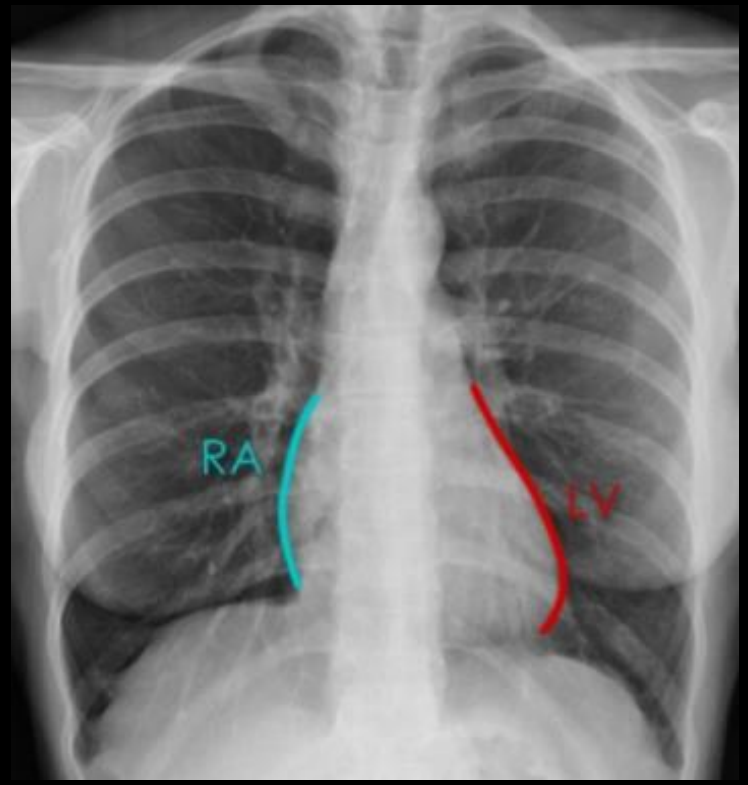


- Contents of the costophrenic (CP) recesses are better seen on lateral where the hemidiaphragm is not obscuring
- The CP angles (CPA) should be sharp. If not ‘something’ is there within or outside the lung abutting



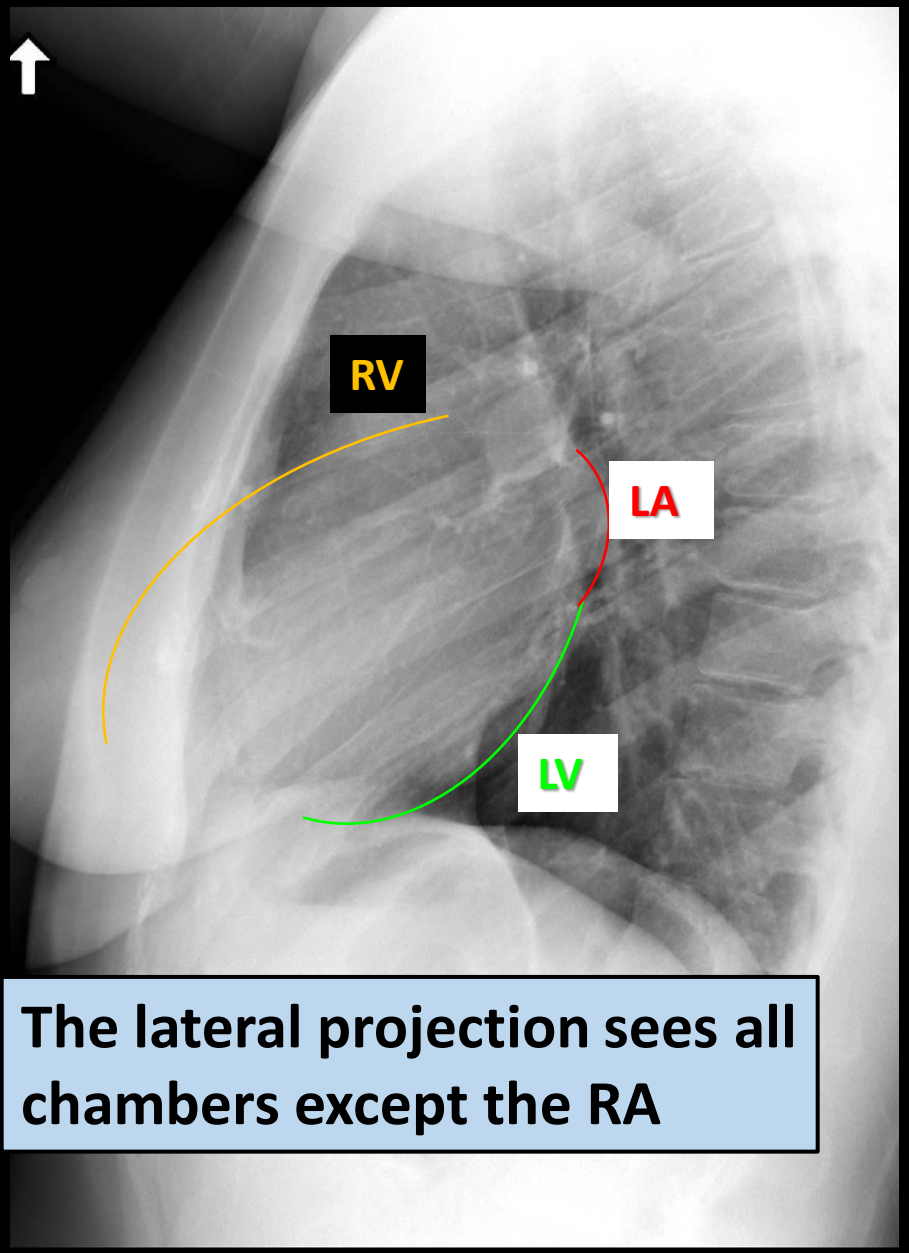
Cardiothoracic ratio (CTR)

- Cardiac size = widest length
- Thoracic width = widest length
- Normal CTR < 0.50 on a PA
  - Sensitivity for rEF = 88%
  - Specificity for rEF = 41%
  - Not useful for HFpEF
- No clear guideline for AP
  - Prior AP may help

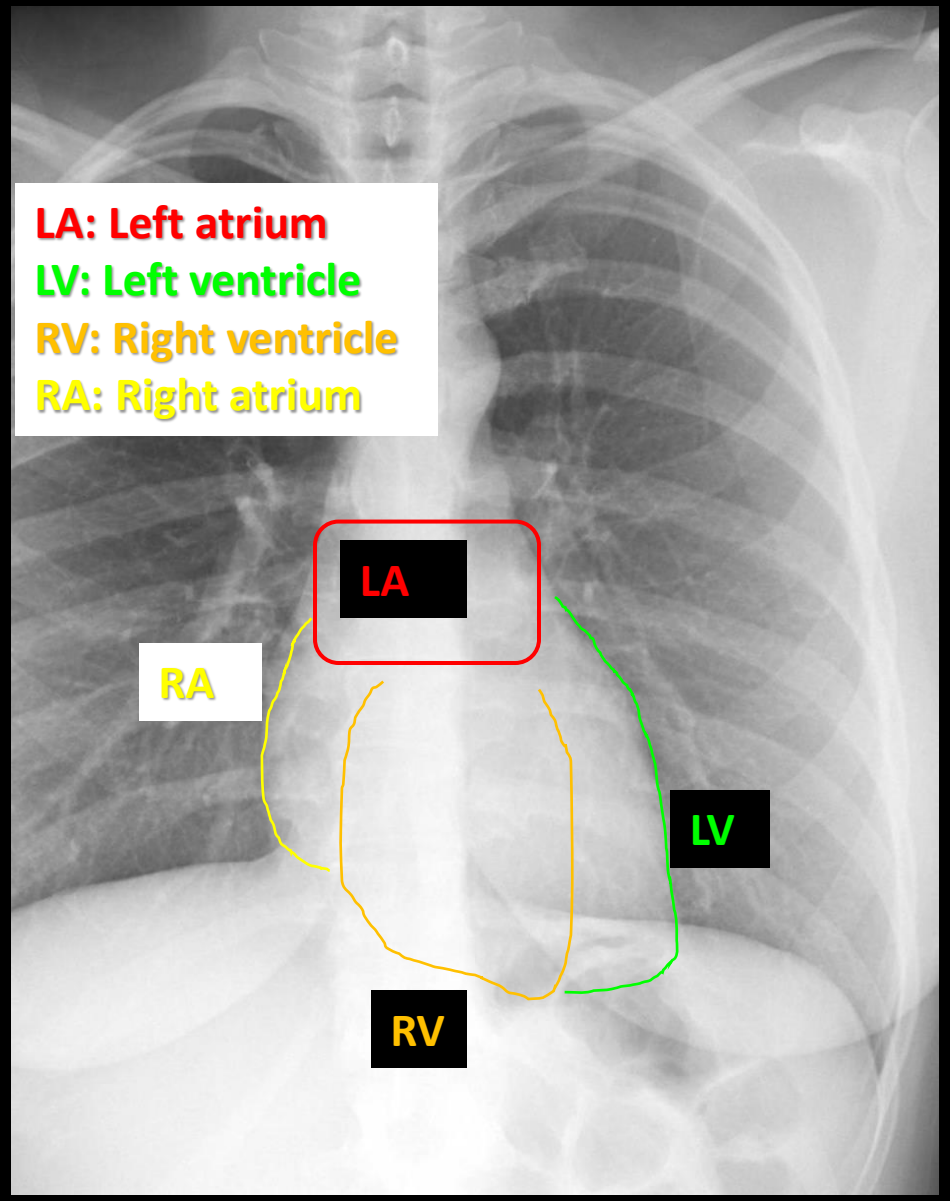


Heart Boarders

- Right heart border = Right Atrium
- Left heart border = Left Ventricle



The lateral projection sees all chambers except the RA

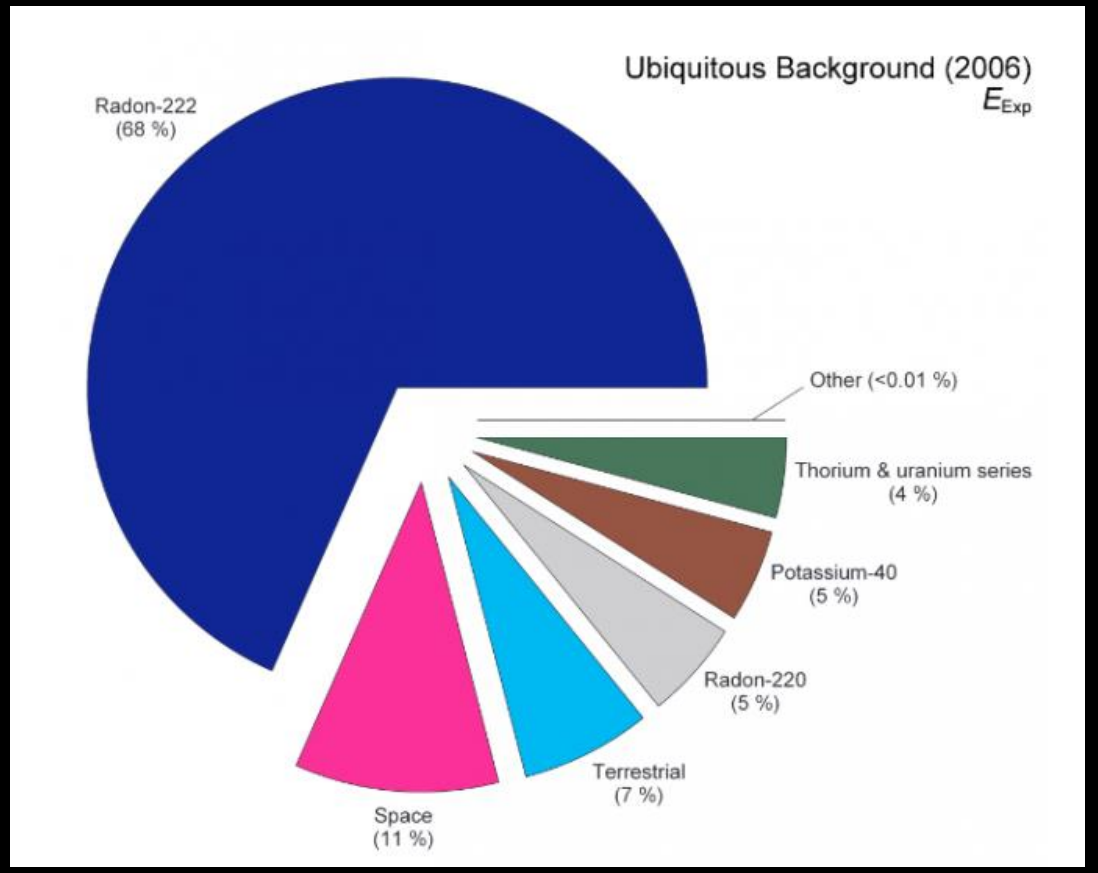


Breast asymmetry

- Example of Not Seeing something
- Densities within the boxes differ
- Asymmetry is common
  - Not necessarily mastectomy

CXR – Radiation exposure and cost

- PA- 0.02 mSv (millisievert)
- Lat – 0.08 mSv
- Round trip flight (NYC-Austin) ~ 0.04 mSv
- 10 days of background radiation = 0.10 mSv
- CXR –PA/lateral ~ $350



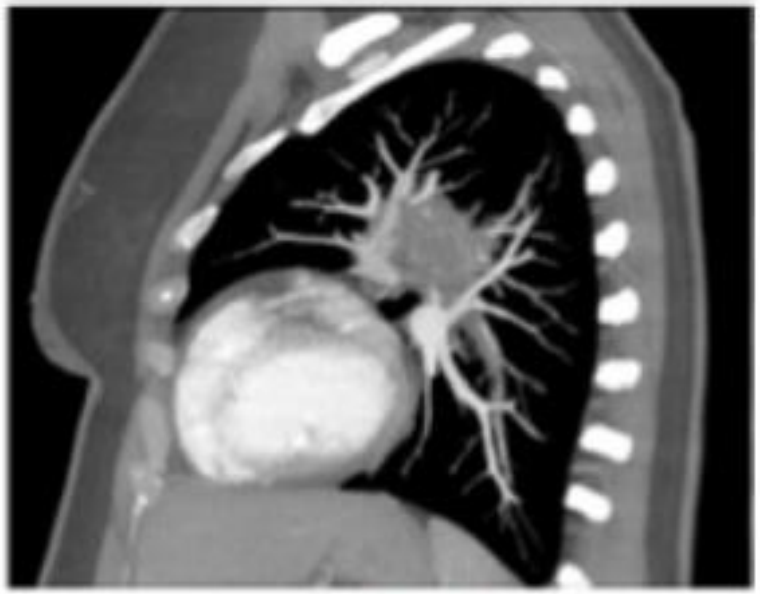
Chest Imaging- Cost and Radiation

Modality	Cost	Radiation
CXR	$	+
CT (w/ or w/o contrast)	$$	+/++
USN- Formal	$$	None
USN- Bedside	$	None
MRI chest	$$$	None
PET/CT	$$$	++++
V/Q	$$	+

Chest CT Anatomy

Axial view
Top to bottom

Coronal view
Front to back

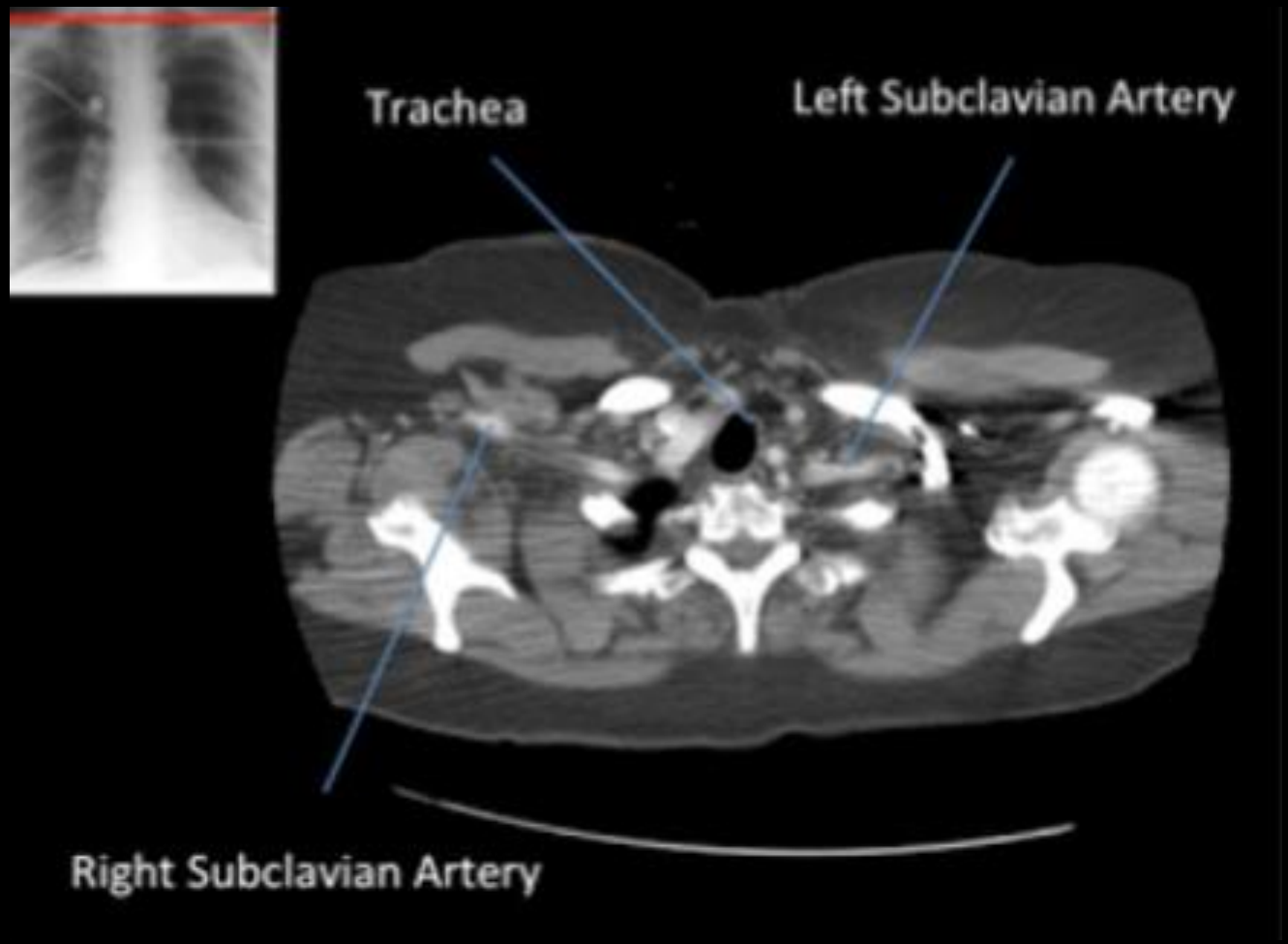


Sagittal view
Side to side

Lung windows
-Lung parenchyma

Soft Tissue windows
-Vessels
-Lymph nodes
-Calcifications
-Pleura
-Muscle
-Organs

Chest CT Anatomy- Great Vessels region



Trachea
Esophagus
Subclavian vessels
Carotid vessels
Lung Apices
Bony structures

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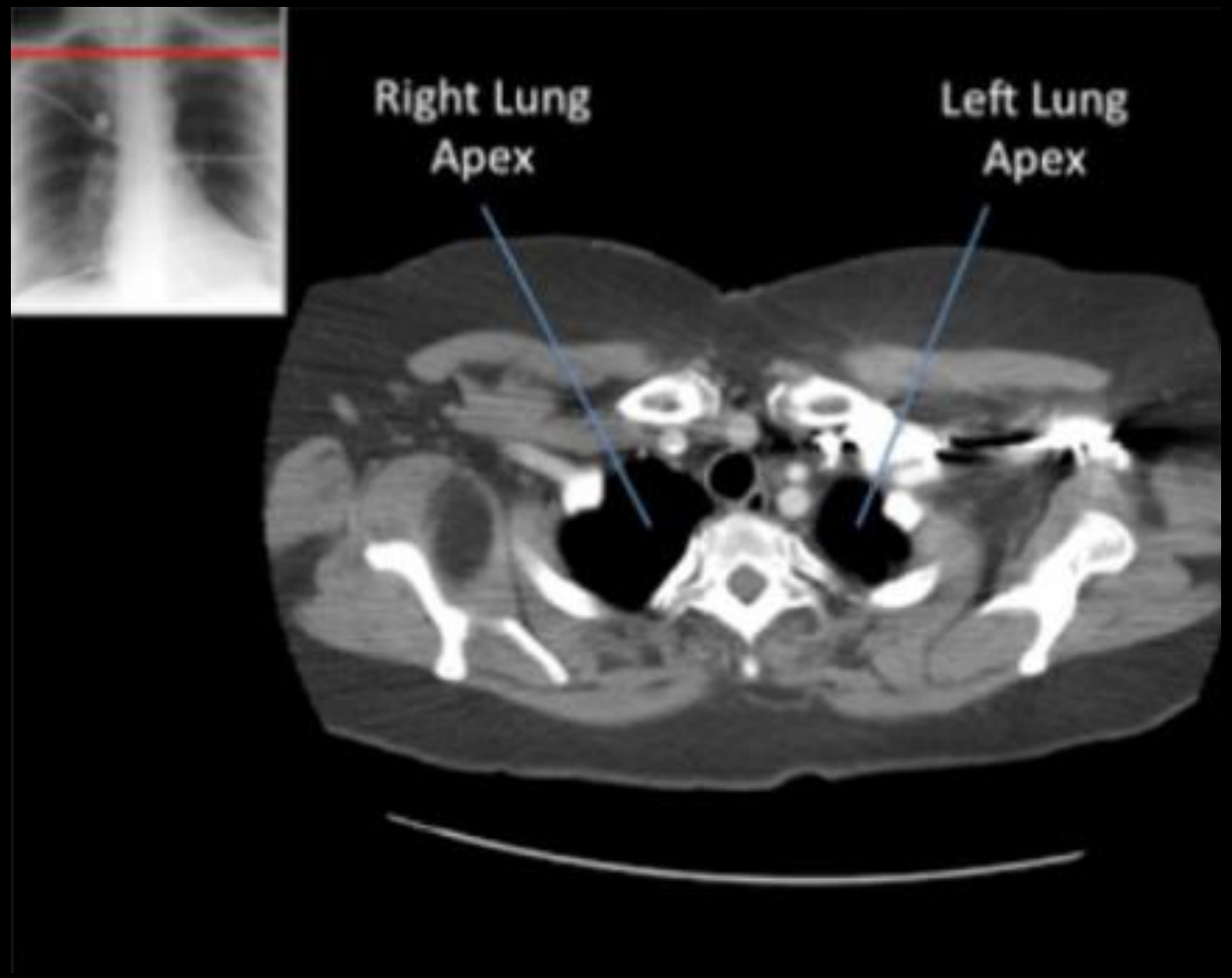

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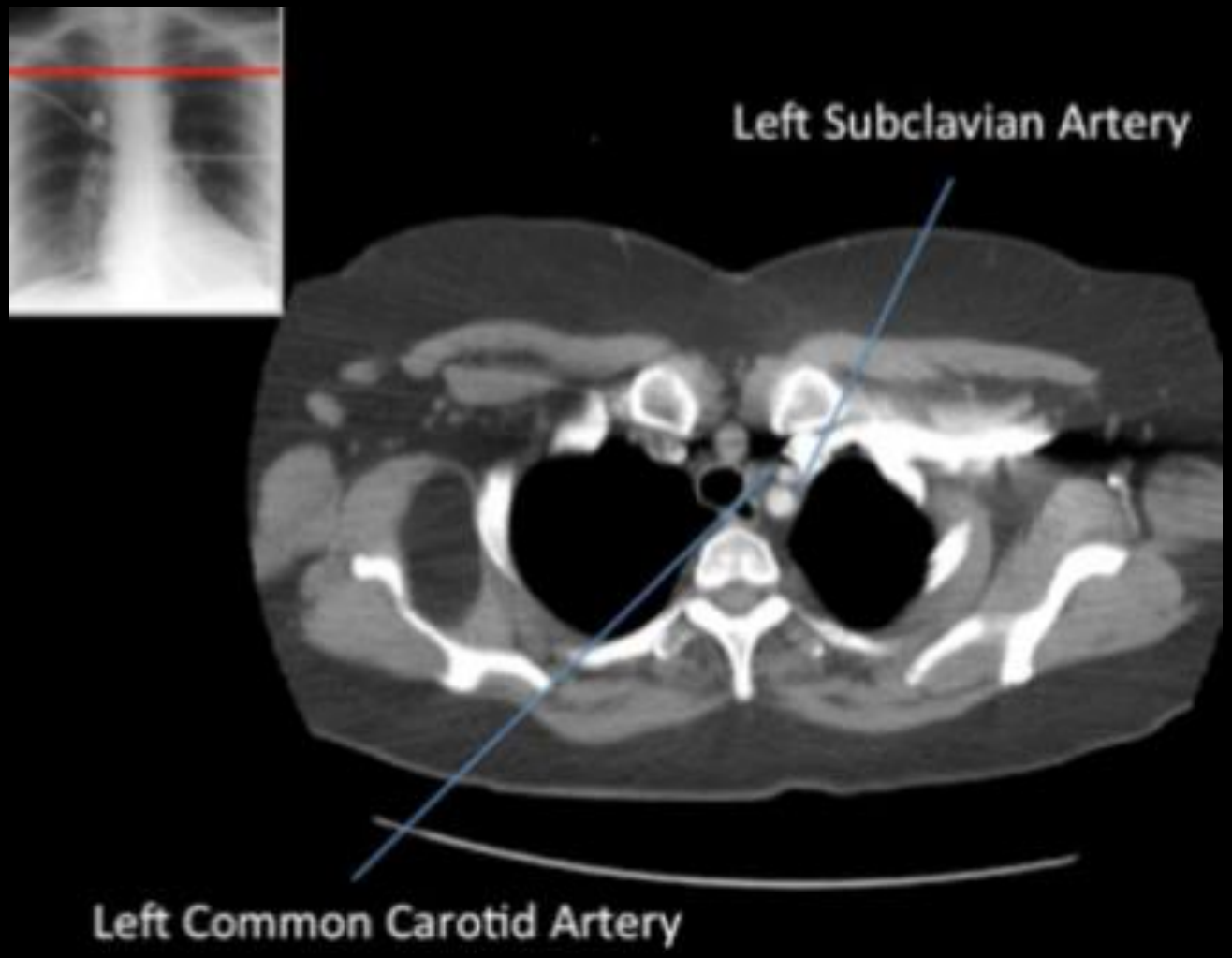

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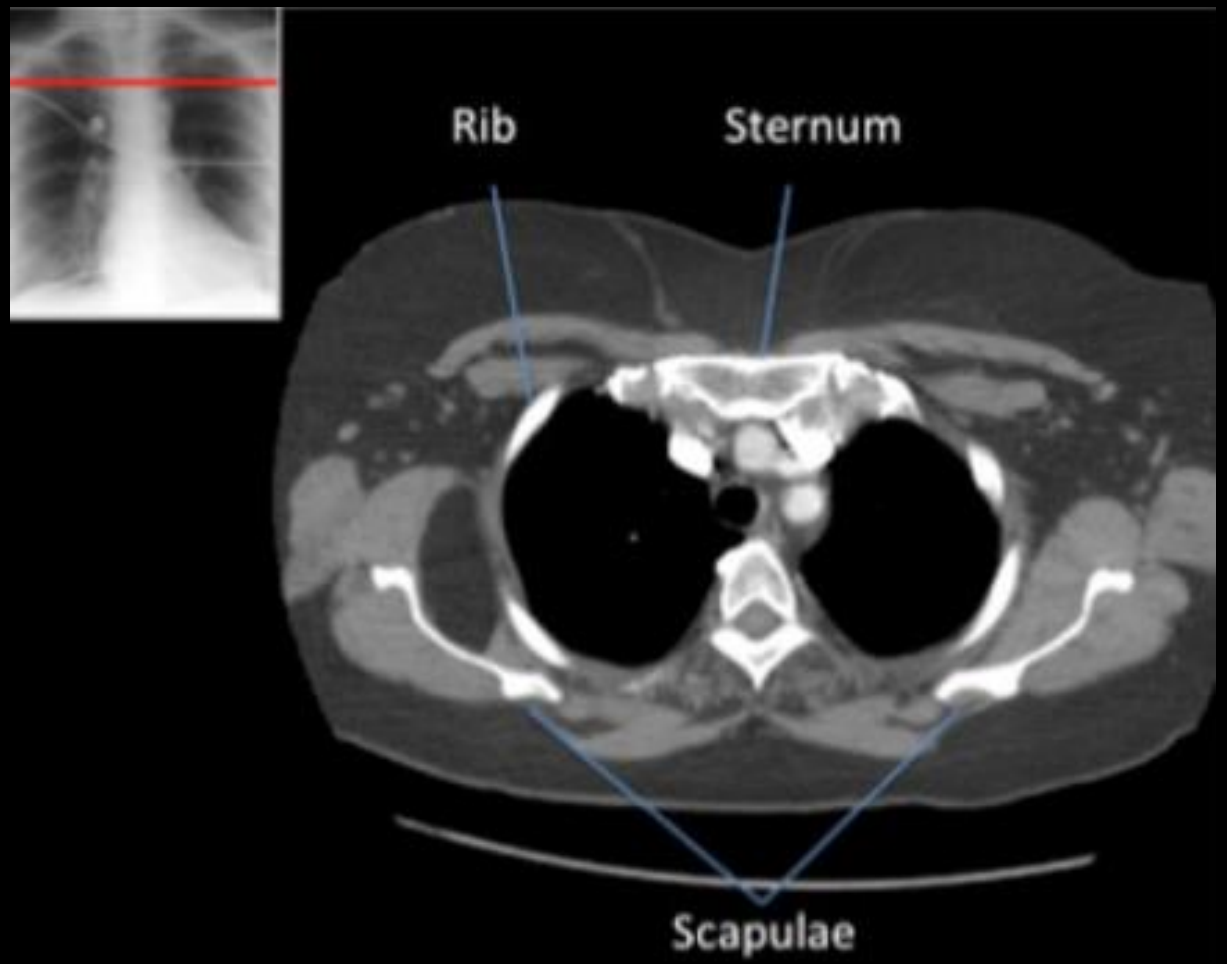

Trachea
Esophagus
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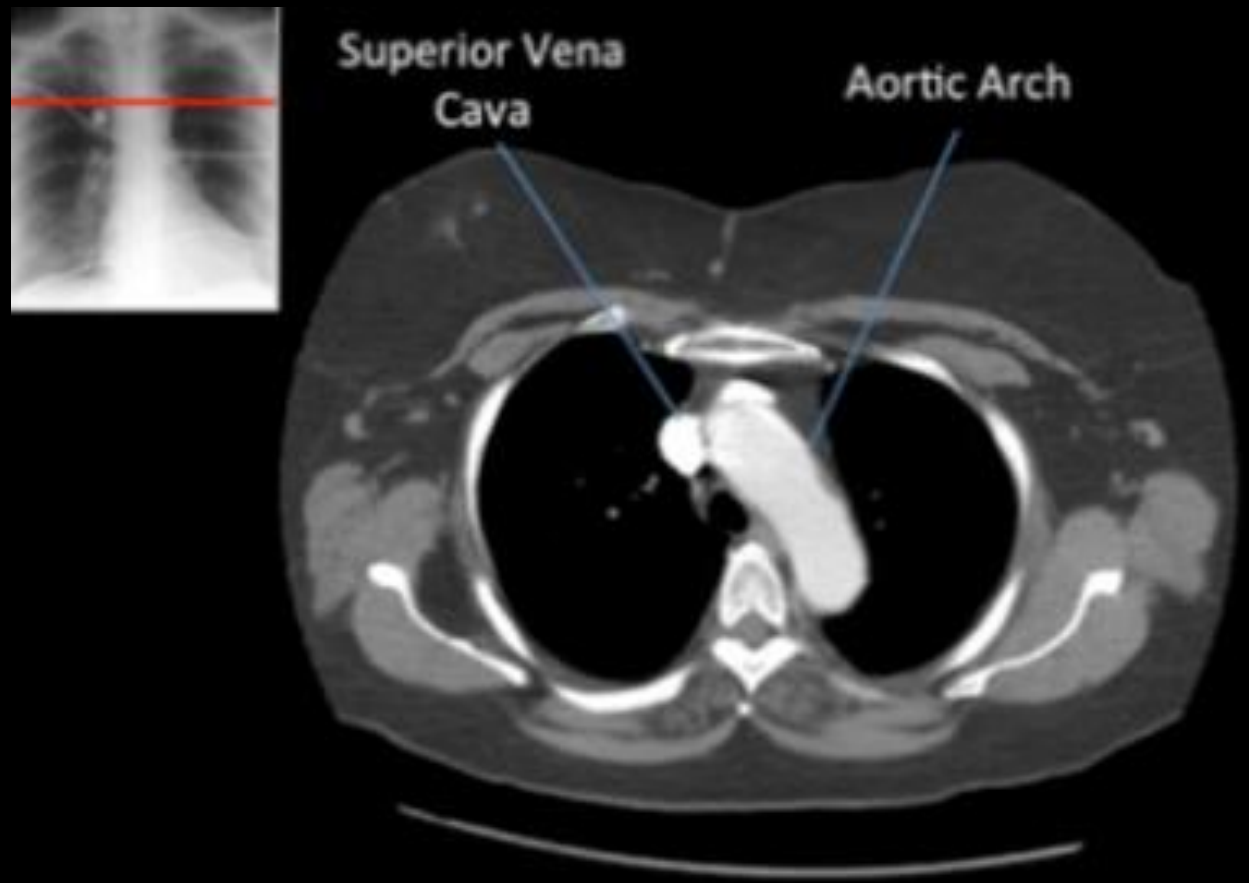
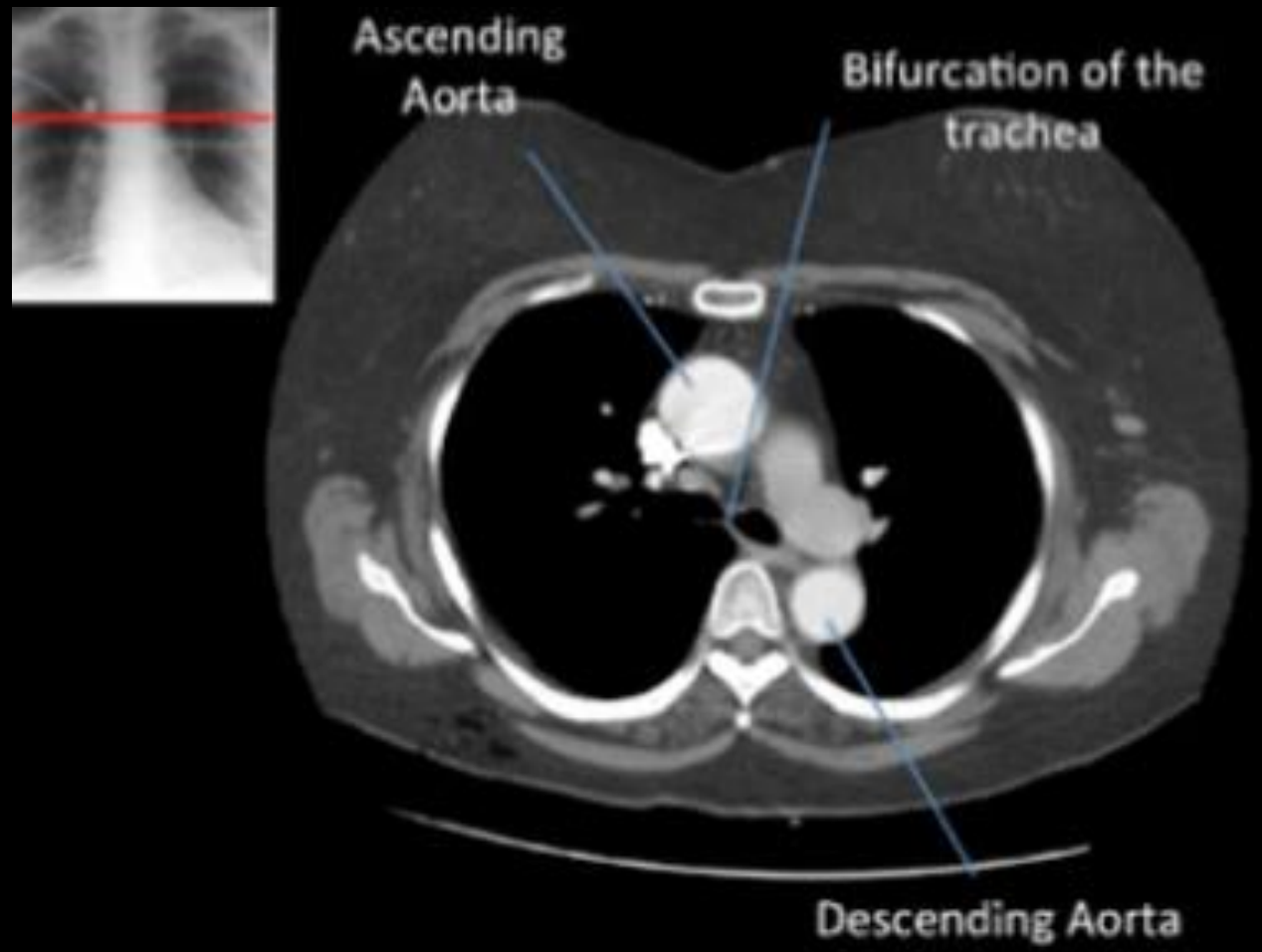
Bony structures

Chest CT Anatomy- Aortic Arch region



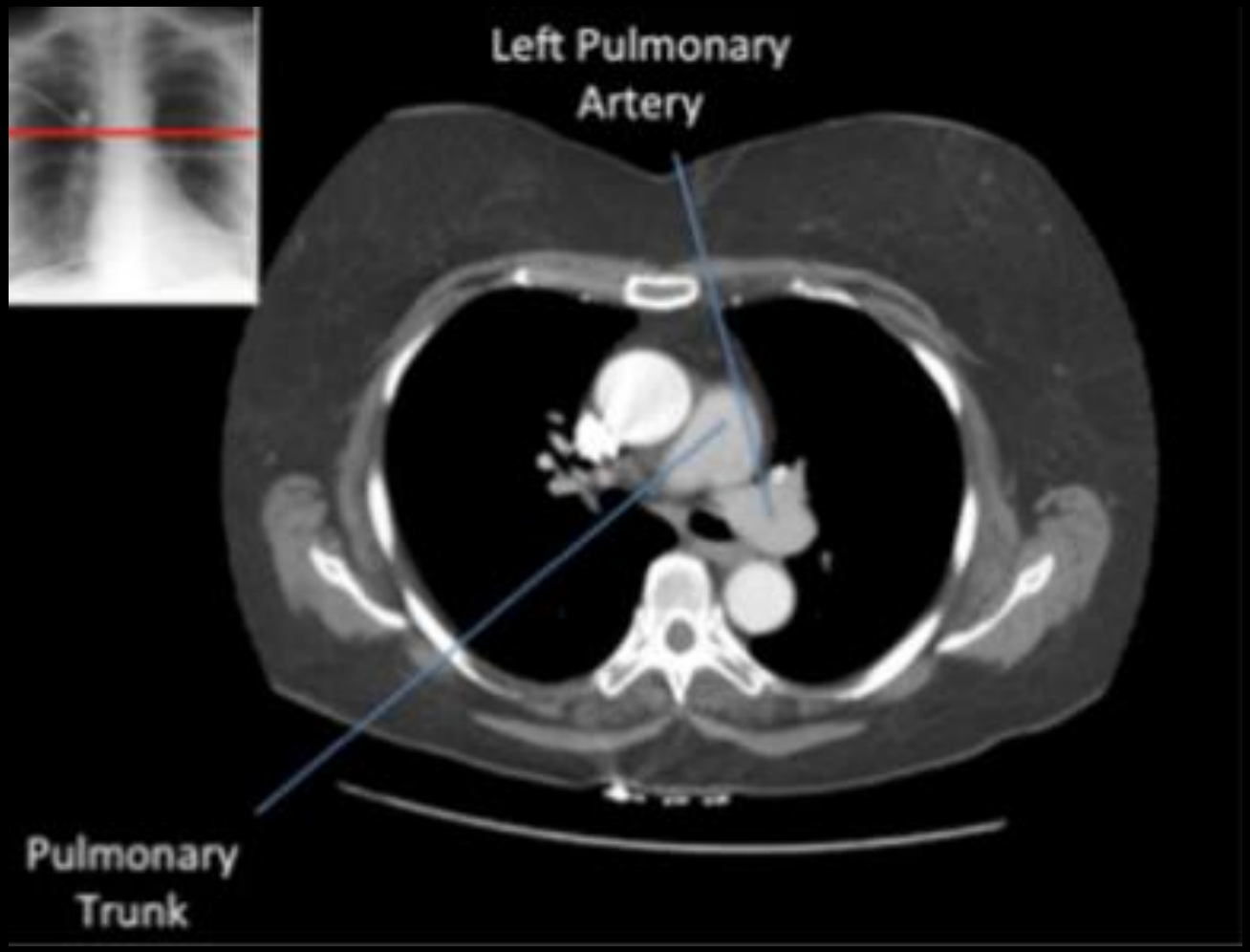
Superior Vena Cava
Aortic Arch

Chest CT Anatomy- Carina/Pulmonary vessels



Ascending and Descending aorta
Tracheal bifurcation
Aortic Arch
Pulmonary arteries
Pulmonary trunk

Chest CT Anatomy- Carina/Pulmonary vessels



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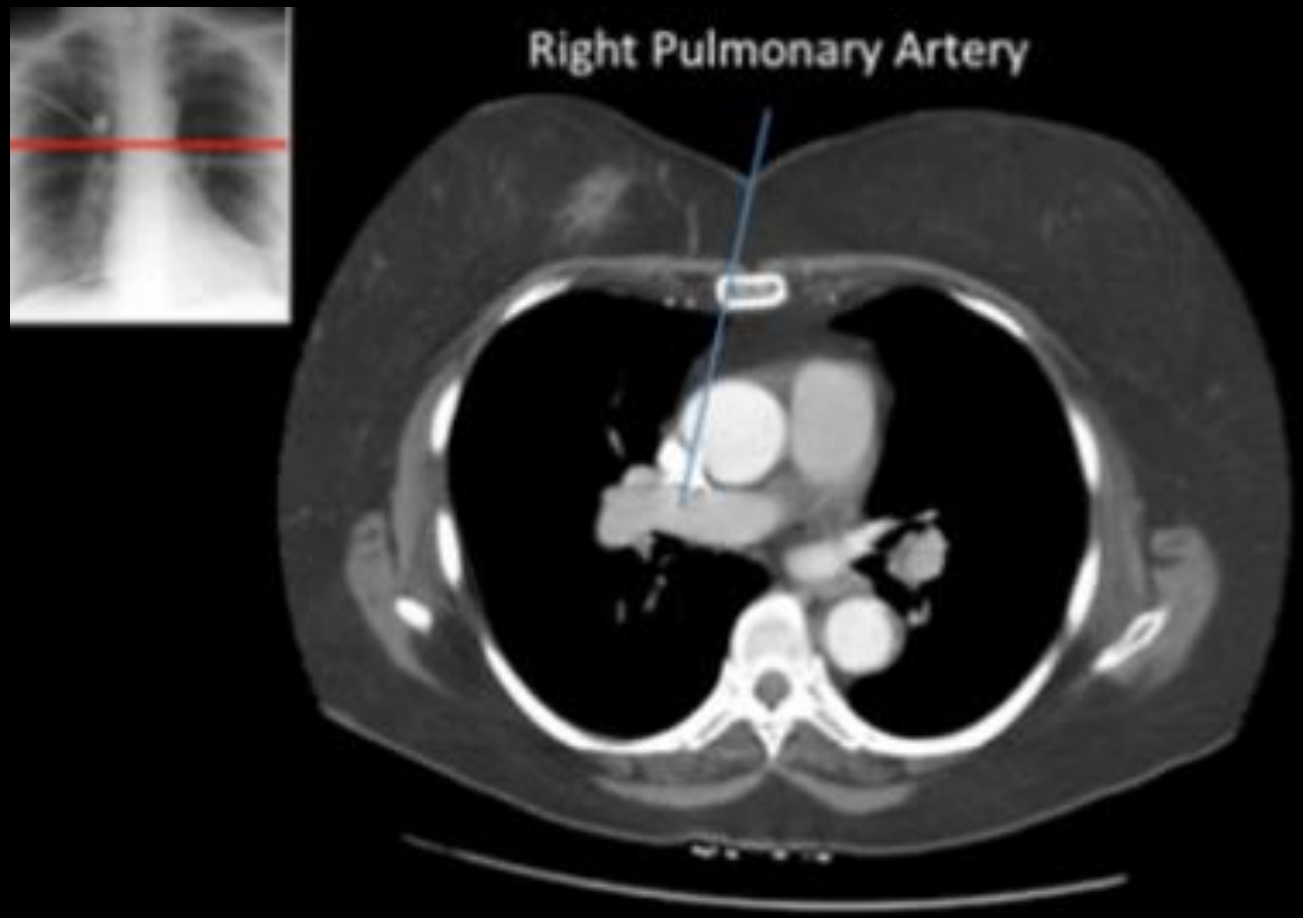
Chest CT Anatomy- Carina/Pulmonary vessels



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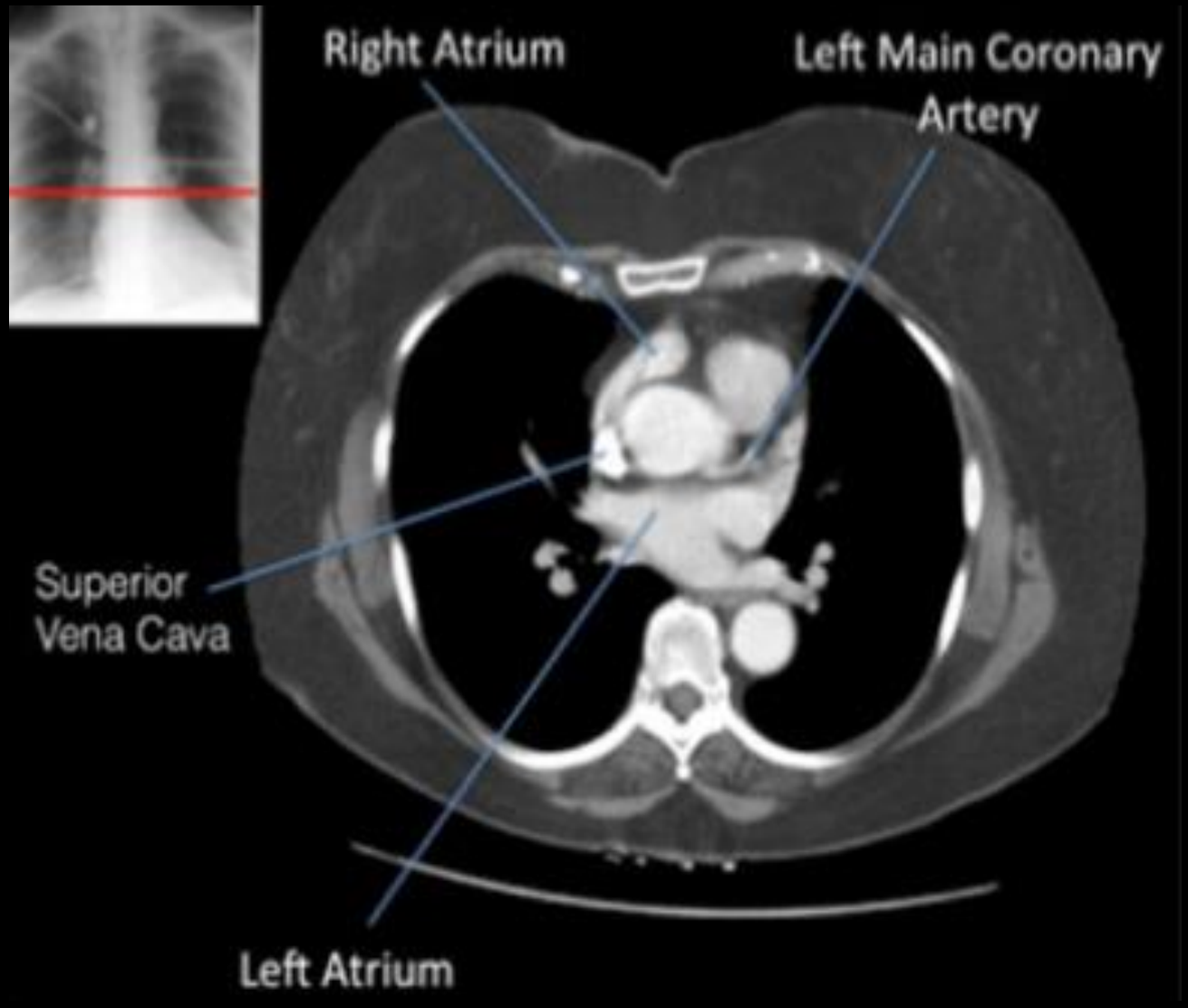
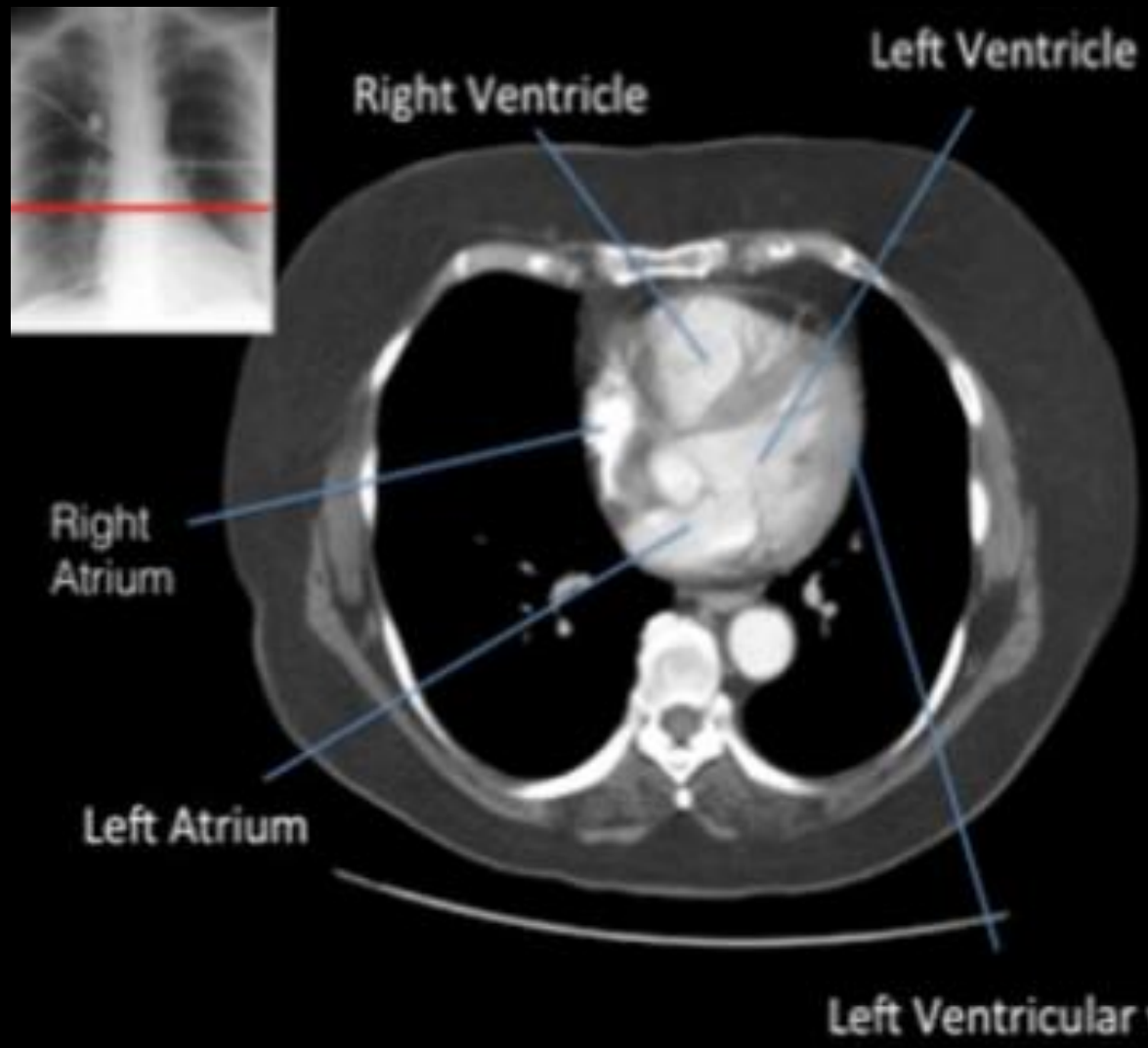
Chest CT Anatomy- Atria region



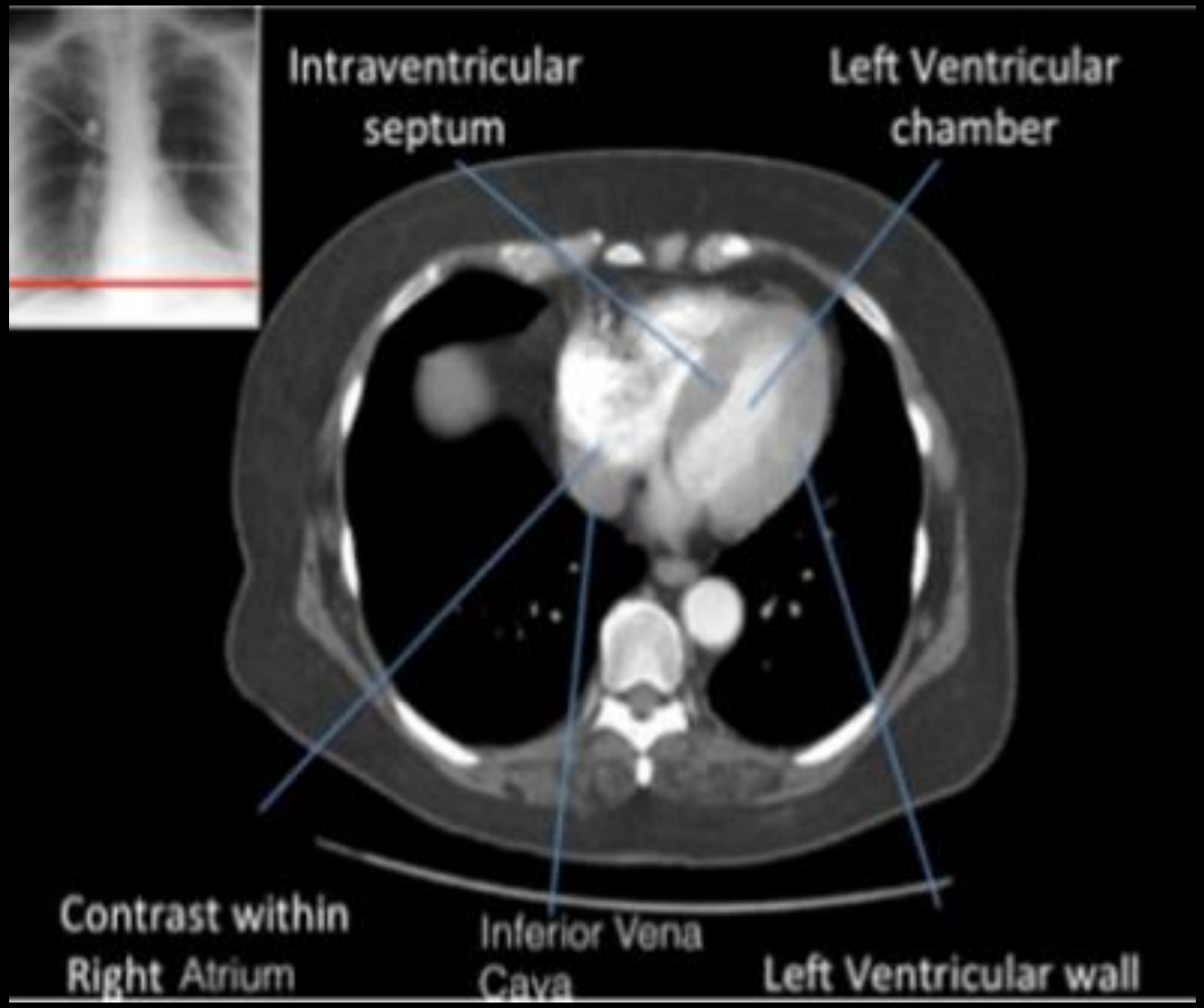
Atria
Coronary arteries
Top of ventricles

Chest CT Anatomy- Atria region



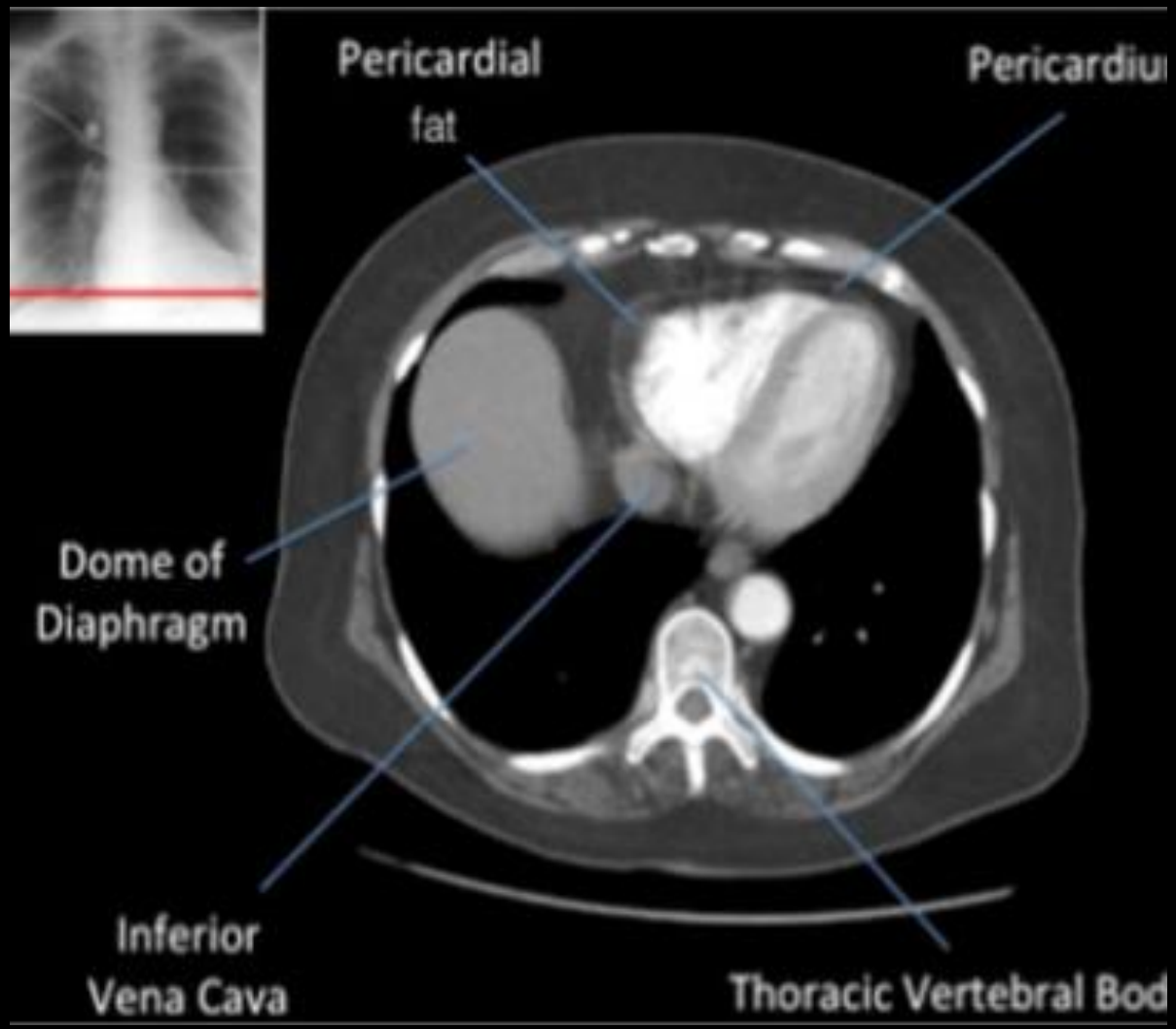
Atria
Coronary arteries
Top of ventricles

Chest CT Anatomy- Ventricular region



Ventricles
Interventricular septum
Pericardium
Pericardial sac
Dome of diaphragm

Chest CT Anatomy- Ventricular region



Ventricles
Interventricular septum
Pericardium
Pericardial sac
Dome of diaphragm


USE YOUR
WORDS

Thoracic Radiology Terms

Pattern

- Consolidation
- Air bronchogram
- Ground Glass
- Bronchiectasis
- Nodules/Mass
- ~~Infiltrate~~ “Opacity”

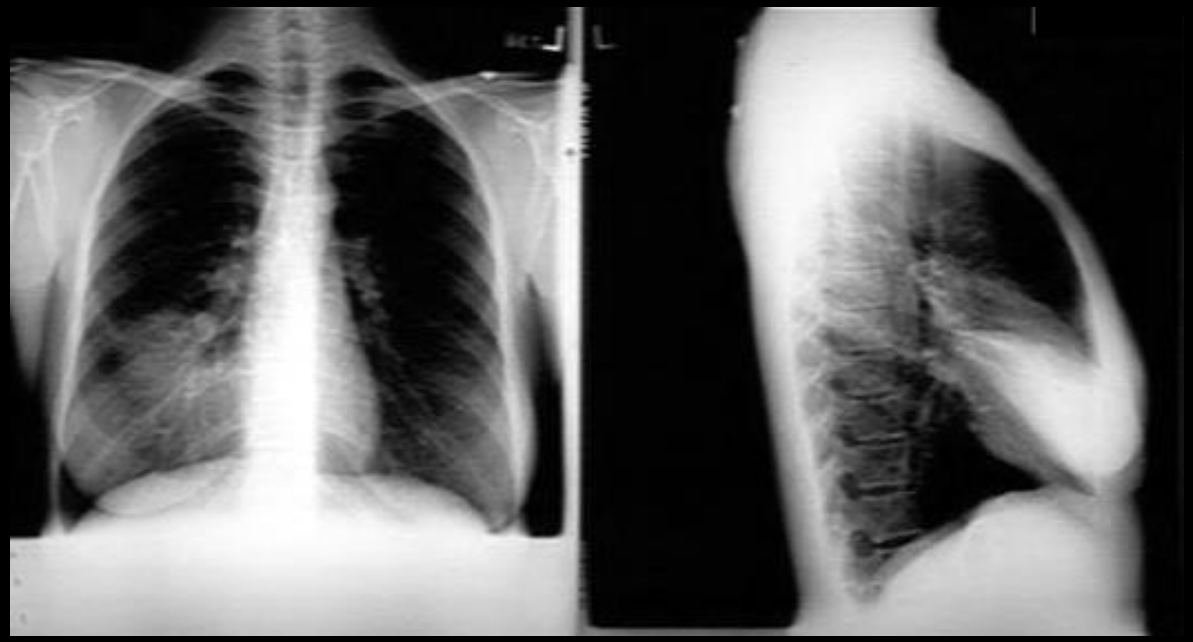
Distribution

- Upper, mid, lower
- Central/perihilar
- Peripheral
  - Subpleural
- Bronchovascular/Bronchocentric
- Diffuse vs Extensive

Consolidation

- Replace of air with disease
  - The density can either correspond to a lobe or segment of lung
  - Obscures pulmonary vessels
- Air bronchogram
  - Suggests alveolar filling process
- Can be mass forming
- No loss of lung volume
  - Consolidation = alveolar **filling**
  - Atelectasis = alveoli **deflating**

Consolidation – RML. Value of the lateral



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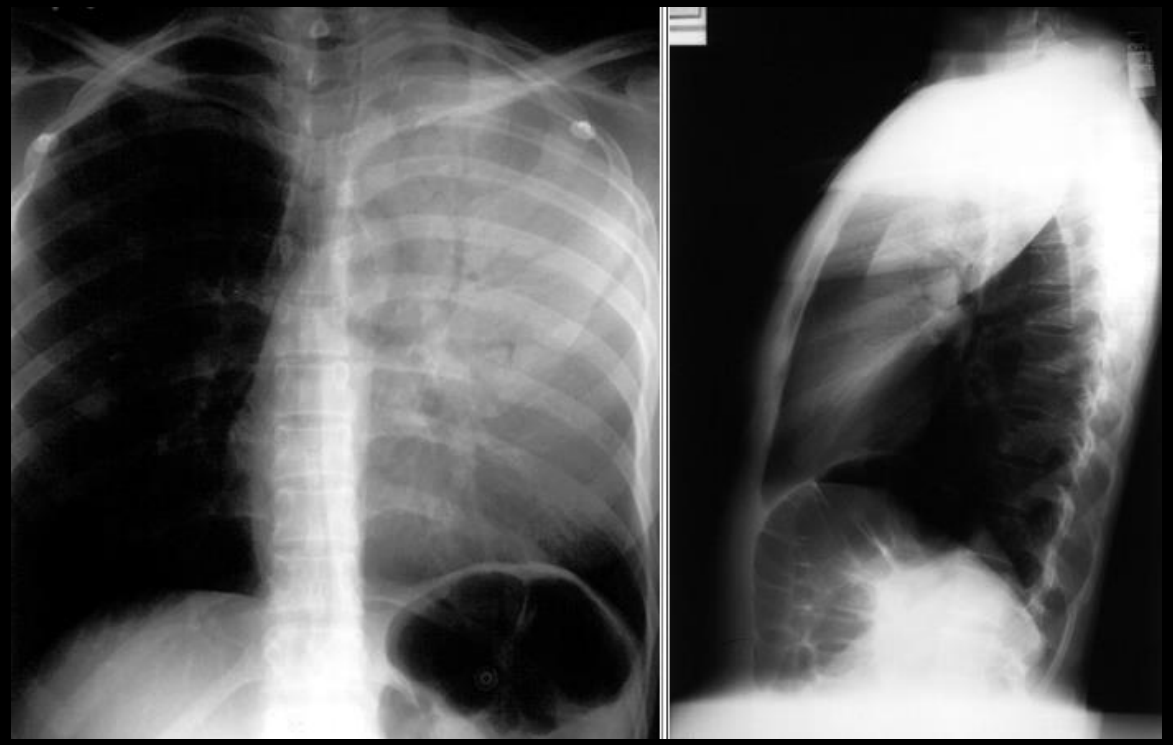
Consolidation – LUL. Value of the lateral



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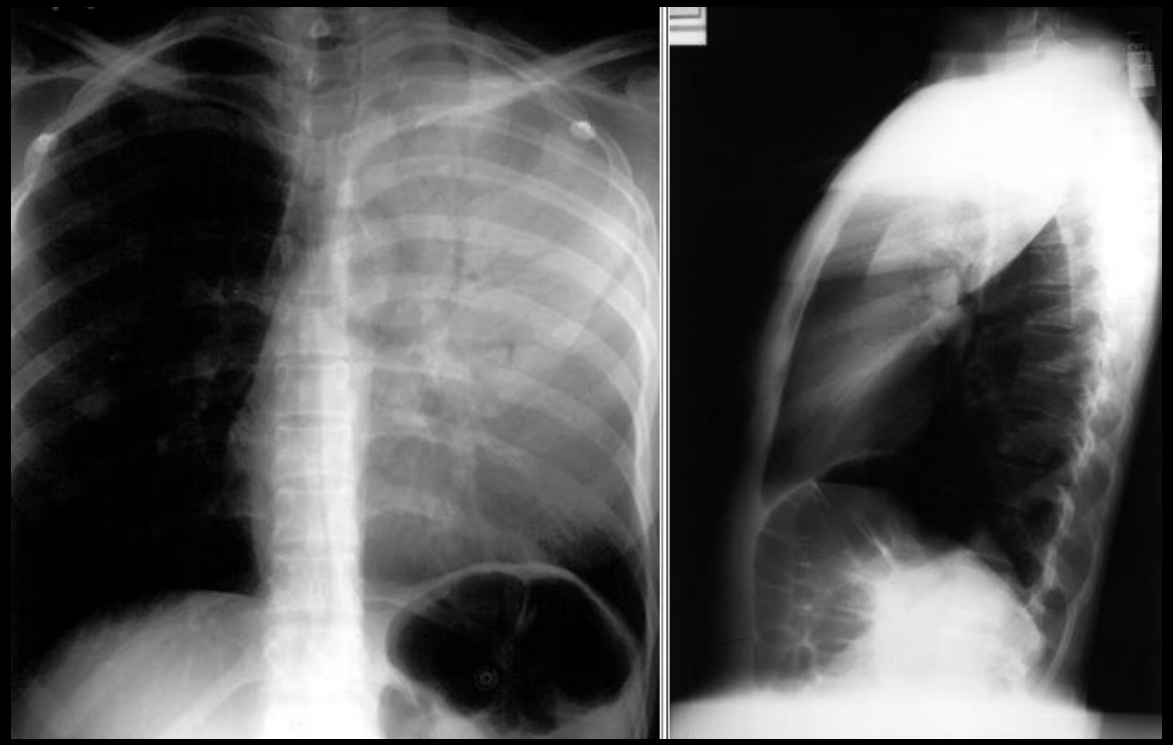
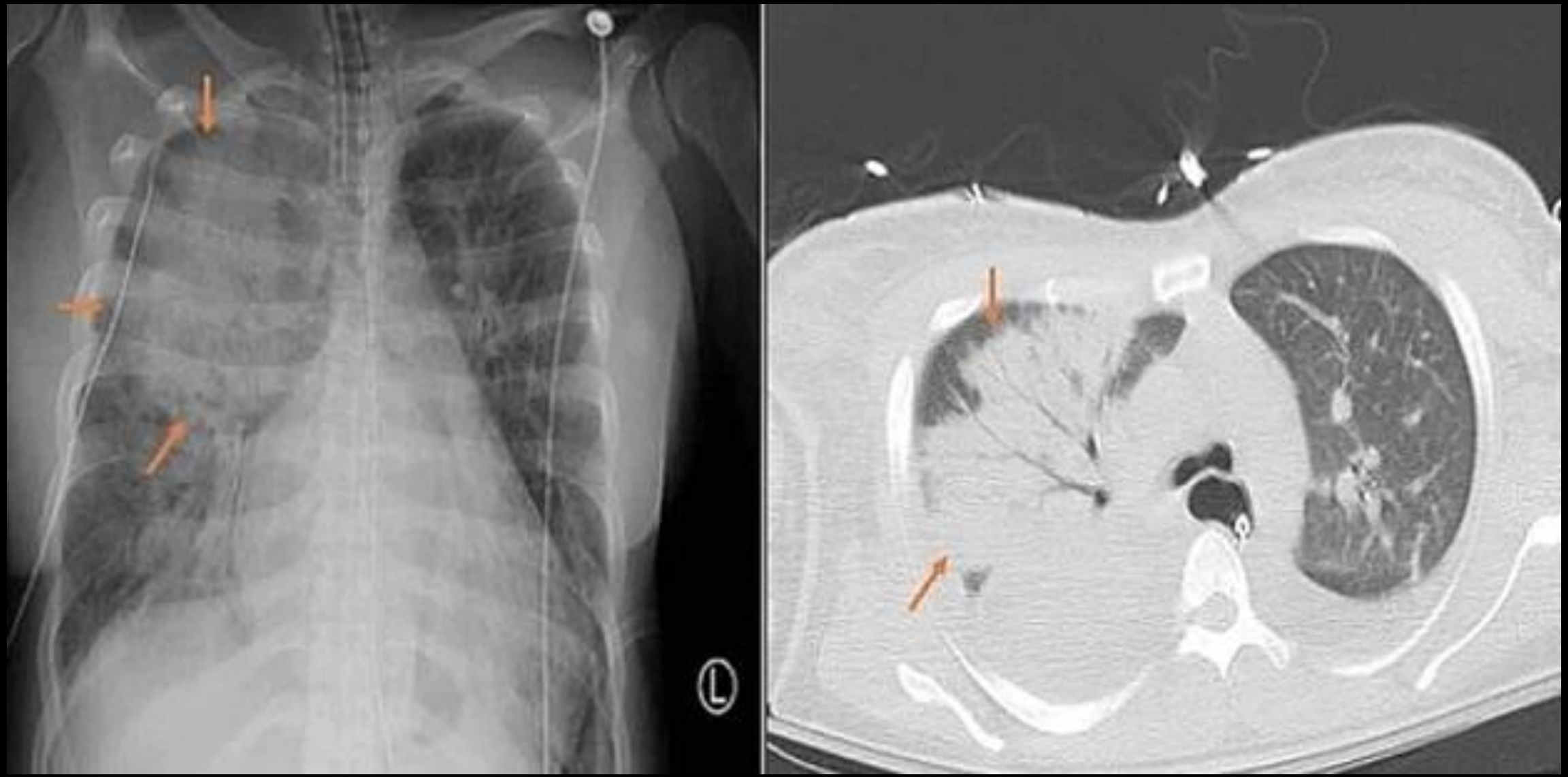
Consolidation – DDx -most are acute



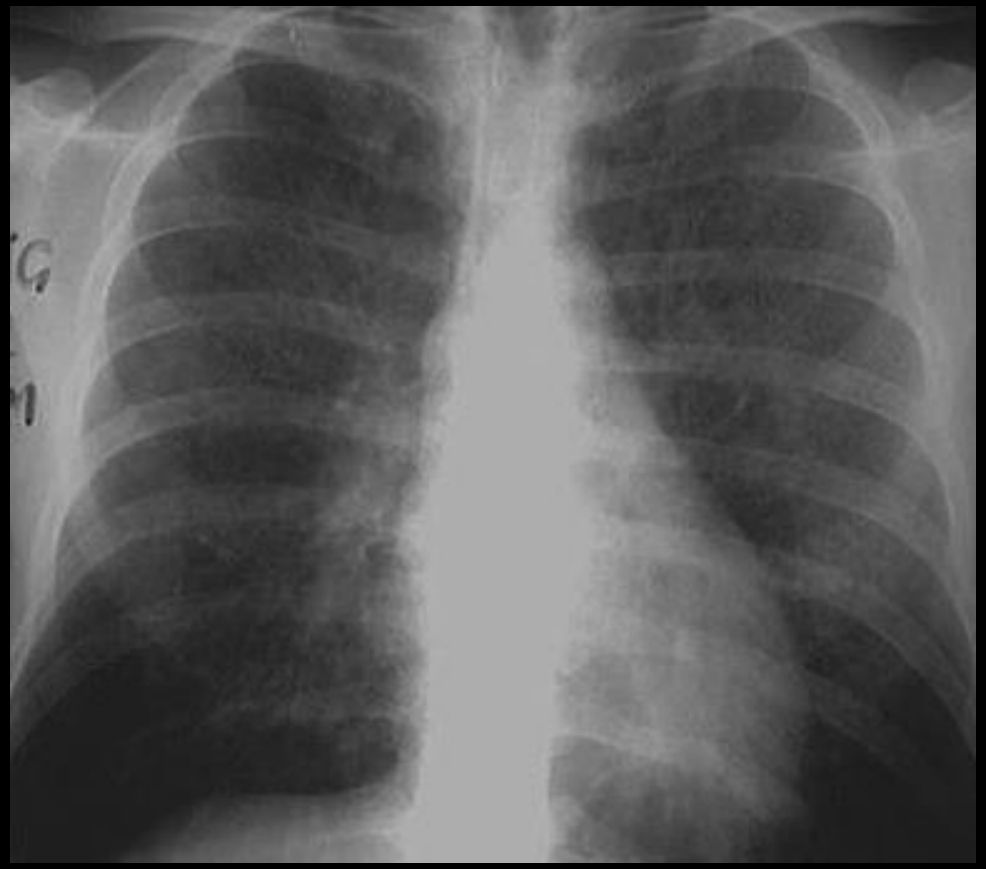
- Causes
  - Blood - uncommon
    - Hemorrhage (rare outside of trauma)
  - Pus – very common
    - Asymmetric or symmetric
    - Pneumonia; aspiration (acute)
    - Mycobacterial/fungal (subacute)
  - Water – very common
    - Likely symmetric
    - Cardiogenic edema
    - Non-Cardiogenic edema (ARDS)
  - Cells – very uncommon
    - Drug toxicity
    - Uncommon ILD's
    - Some cancers



Ground glass

- Hazy increased lung opacity that does not obscure vessels
  - Partial filling of airspaces or interstitium
  - Margins of pulmonary vessels are hazy, but can be seen
- Can occur with consolidation
  - On the spectrum?
  - Similar causes as consolidation
  - “Early stages of consolidation”
  - “Resolution of consolidation”

Ground glass



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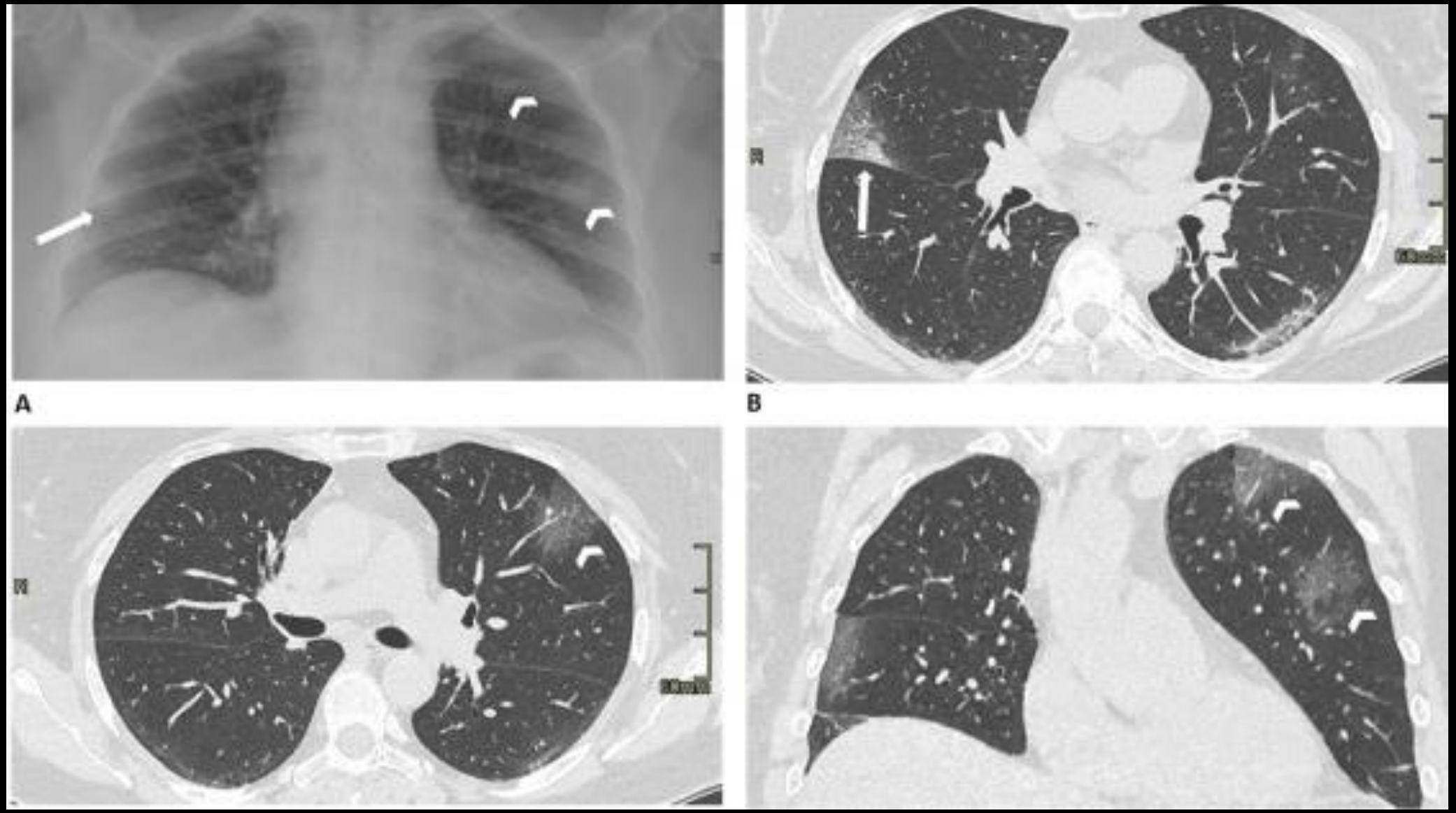

A
B

Ground Glass Opacities – DDx

Acute

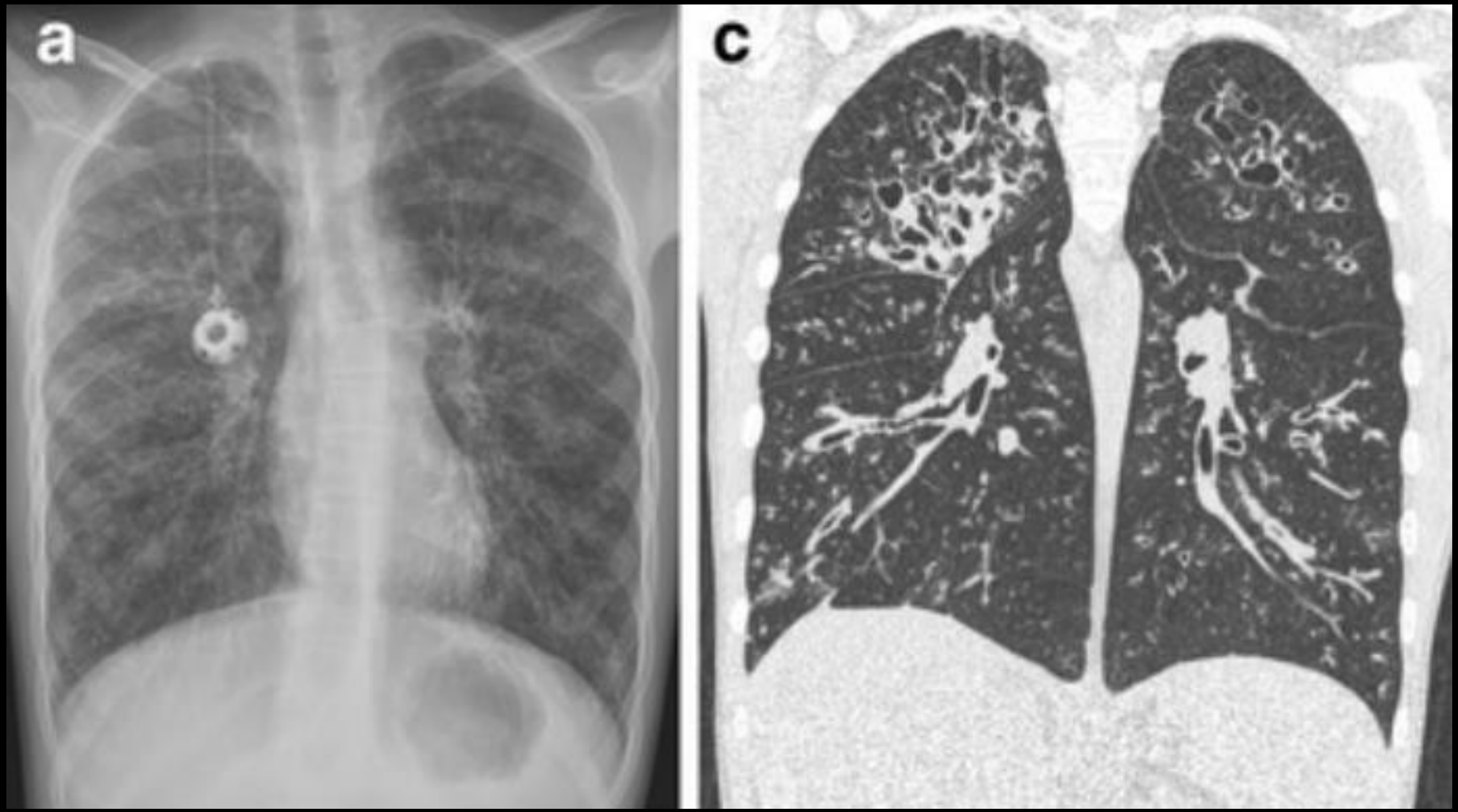
- Pulmonary edema
- Hemorrhage
- Pneumonia (interstitial)
  - PJP
  - Some viruses
- Acute lung injury ("pneumonitis")
  - Drug toxicity
- Partially aerated lung
  - Incomplete atelectasis
  - "Dependent hypoventilatory change"

Subacute or Chronic

- Some interstitial lung diseases
  - DIP, NSIP, LIP, HP
- Organizing pneumonia
- Eosinophilic lung diseases
- Lipoid pneumonia
- Adenocarcinoma

Bronchiectasis

- Dilation of bronchioles
  - Thickened bronchial walls
- Causes
  - Inflammation of the airways (purulent)
    - Immune deficiency?
    - Cystic fibrosis
  - Associated with fibrosis (non-purulent)
    - Traction bronchiectasis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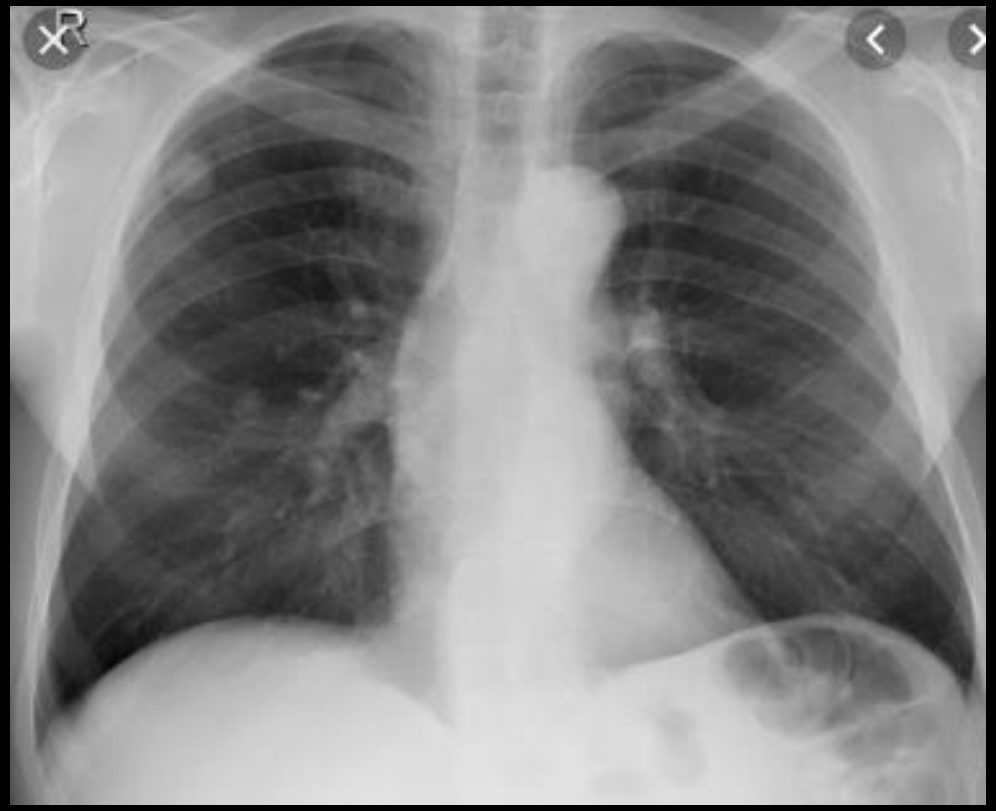
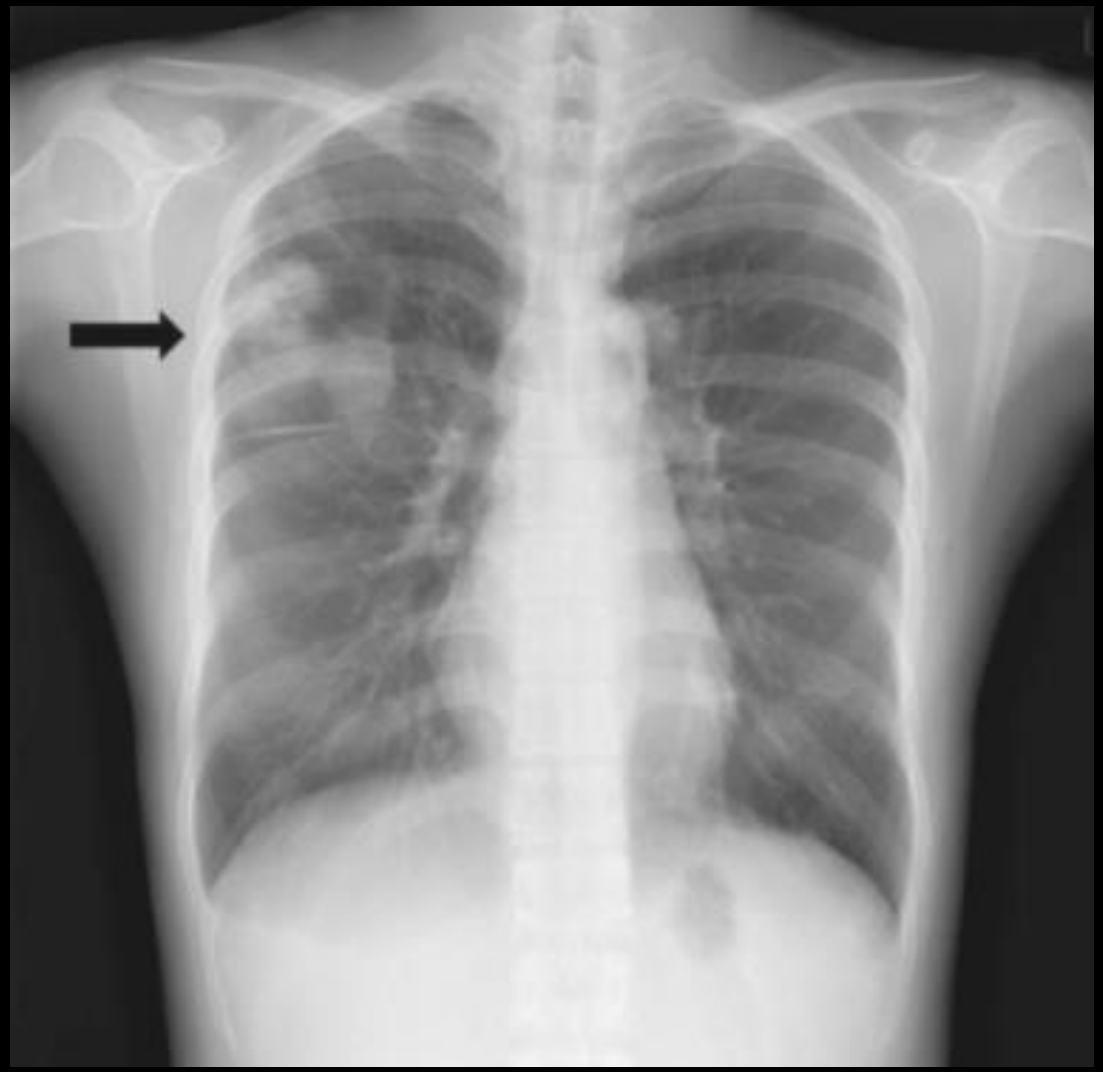
Nodules/Mass

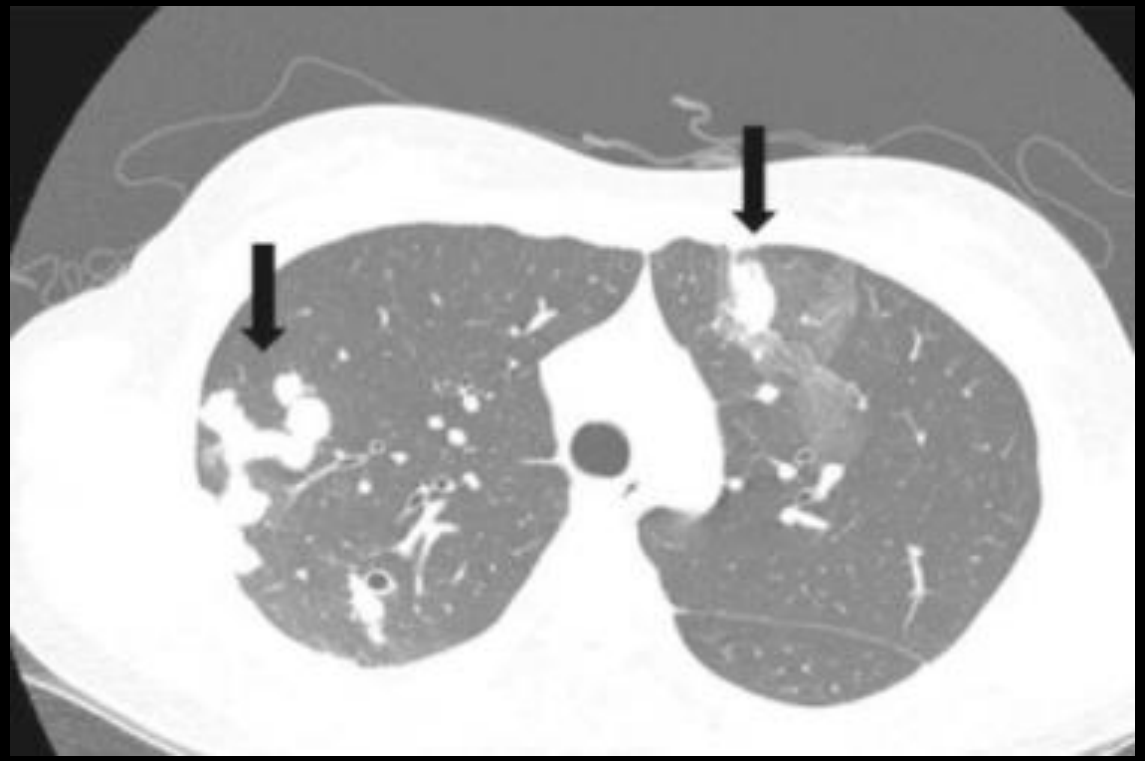


- Round, discreet, spherical
  - Micronodules- 1-3 mm
  - Nodule 3- 30 mm
  - Mass 3+ cm. Usually cancer
- Solitary pulmonary nodule
  - Lung cancer
    - Irregular borders
  - Granuloma
  - Hamartoma
  - Infection

Nodules/Mass

- Round, discreet, spherical
  - Micronodules- 1-3 mm
  - Nodule 3- 30 mm
  - Mass 3+ cm. Usually cancer
- Multiple nodules
  - Metastases
    - Smooth, well-circumscribed
  - Opportunistic infection
    - Borders less smooth
    - Fungal
    - Mycobacterial

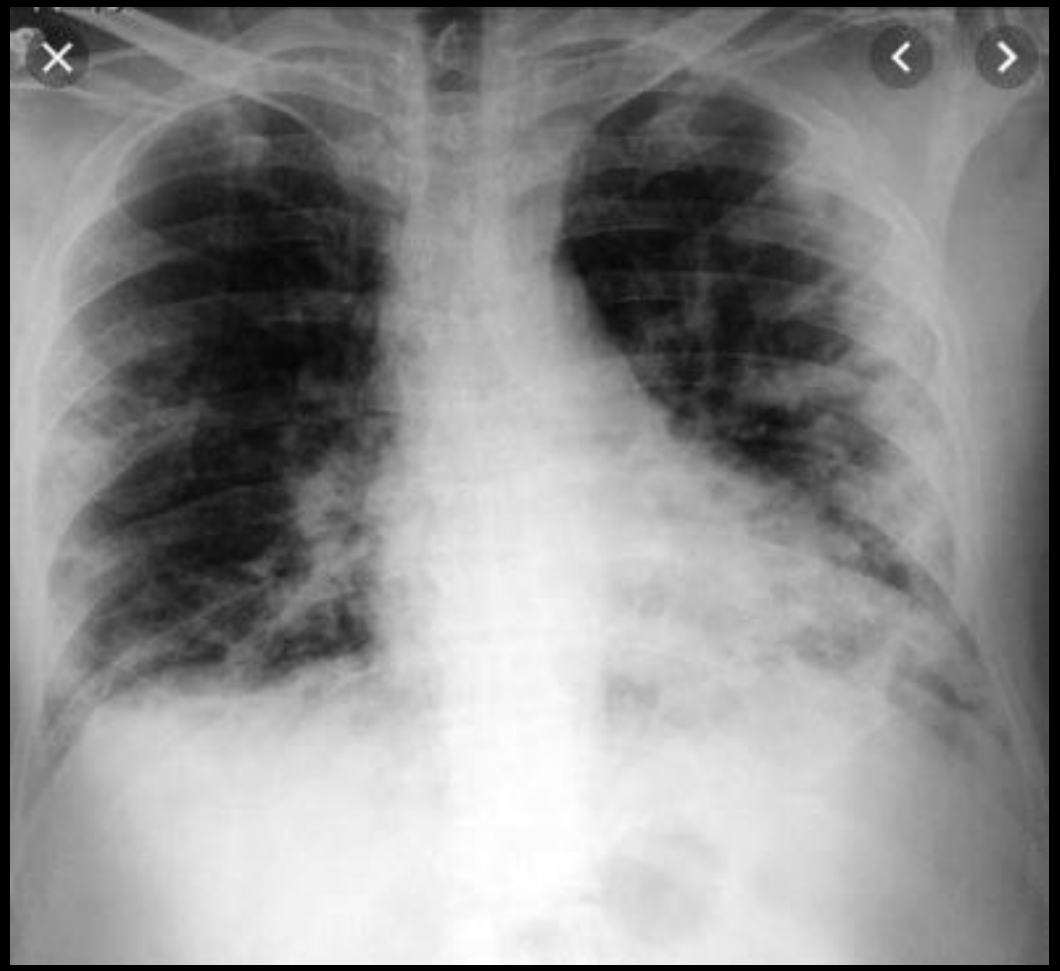


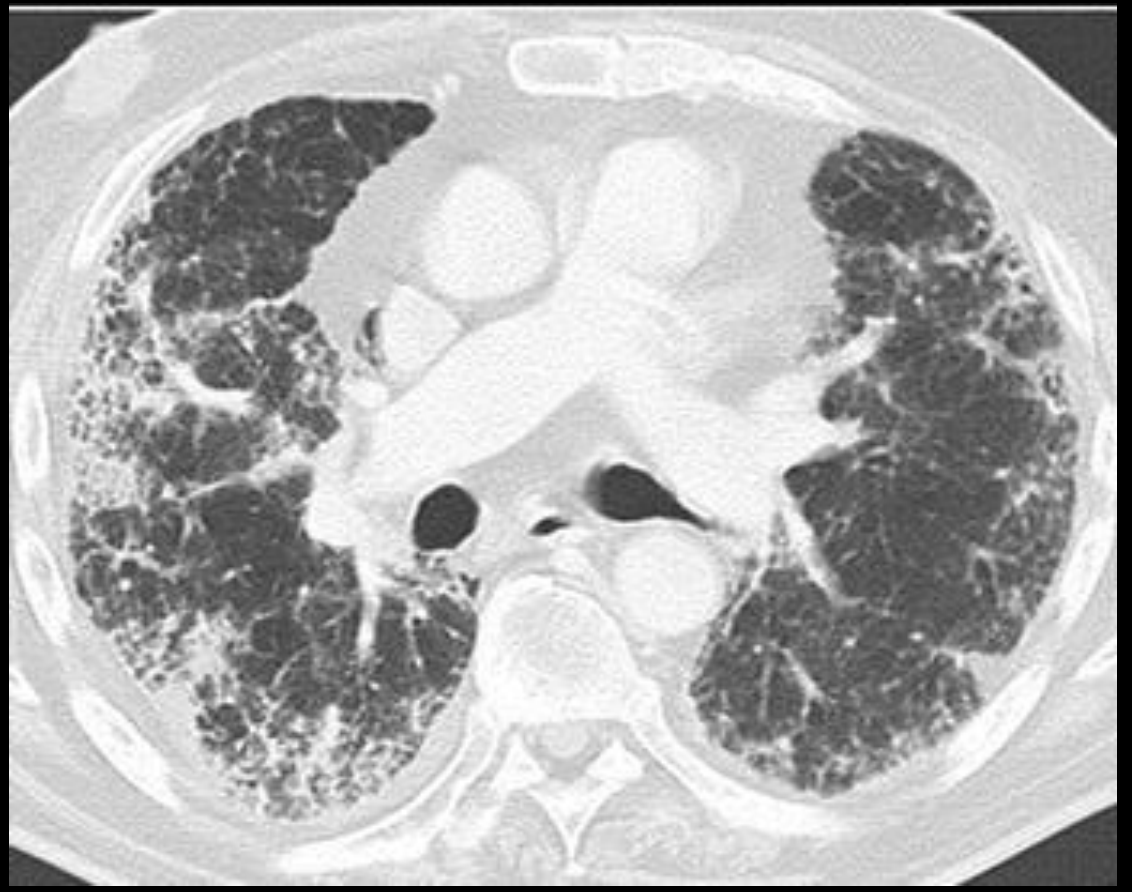


Distribution

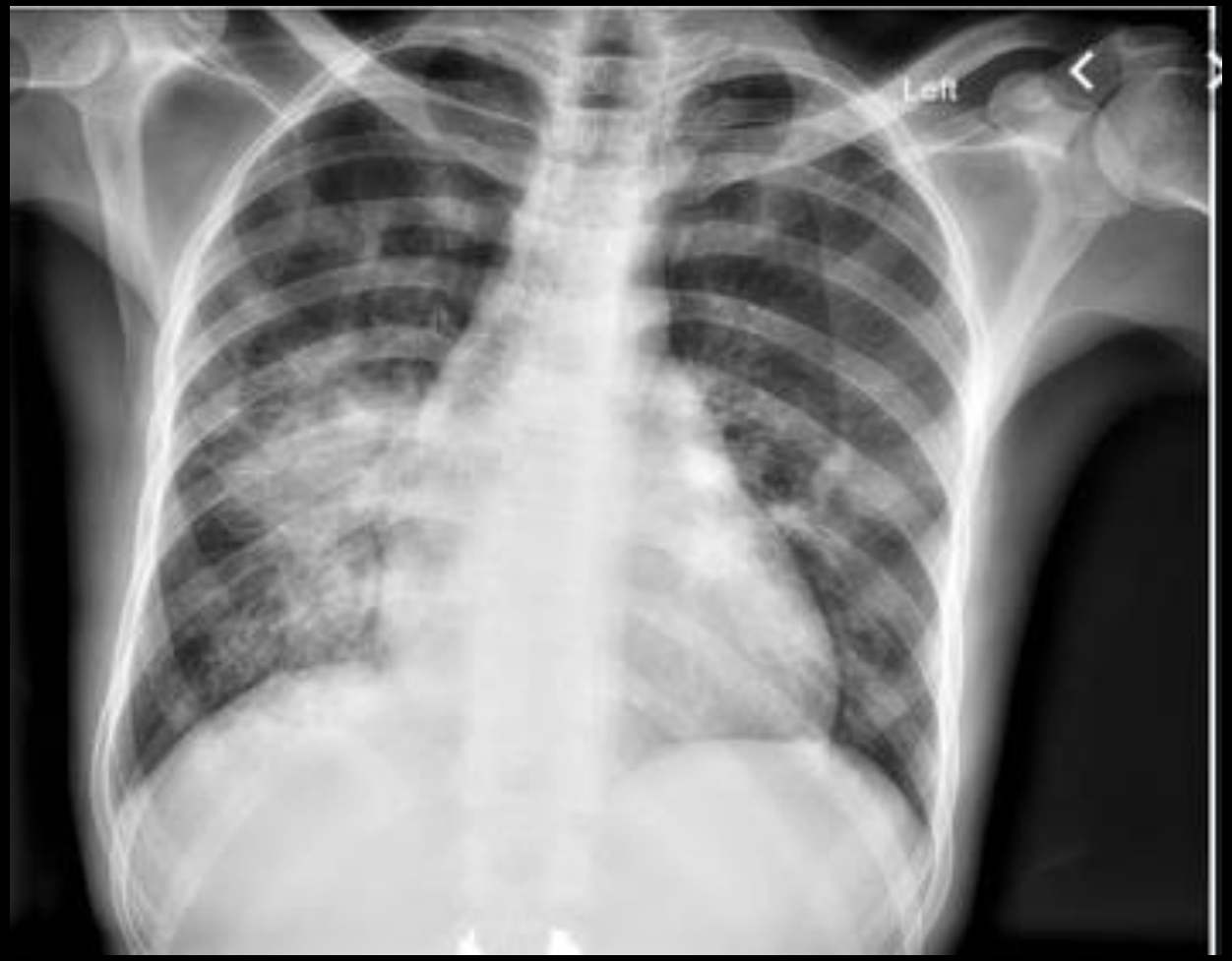
Peri-hilar

Peripheral



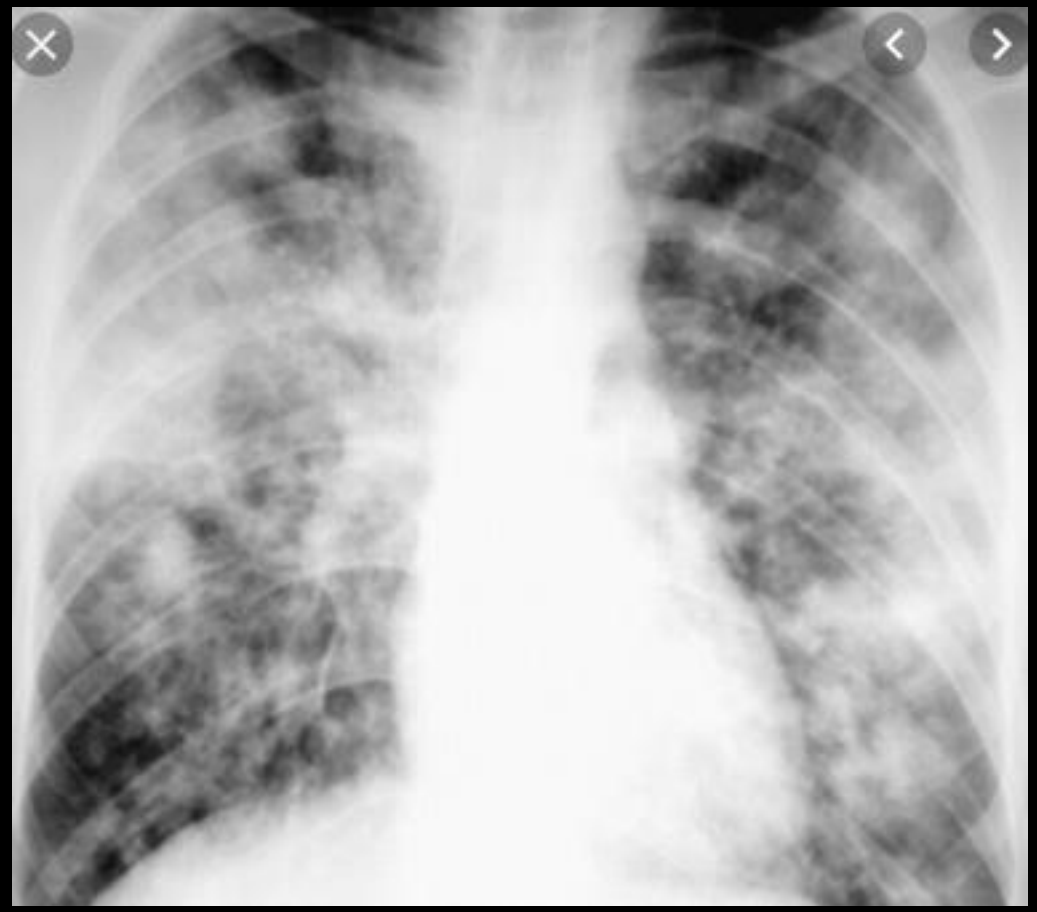


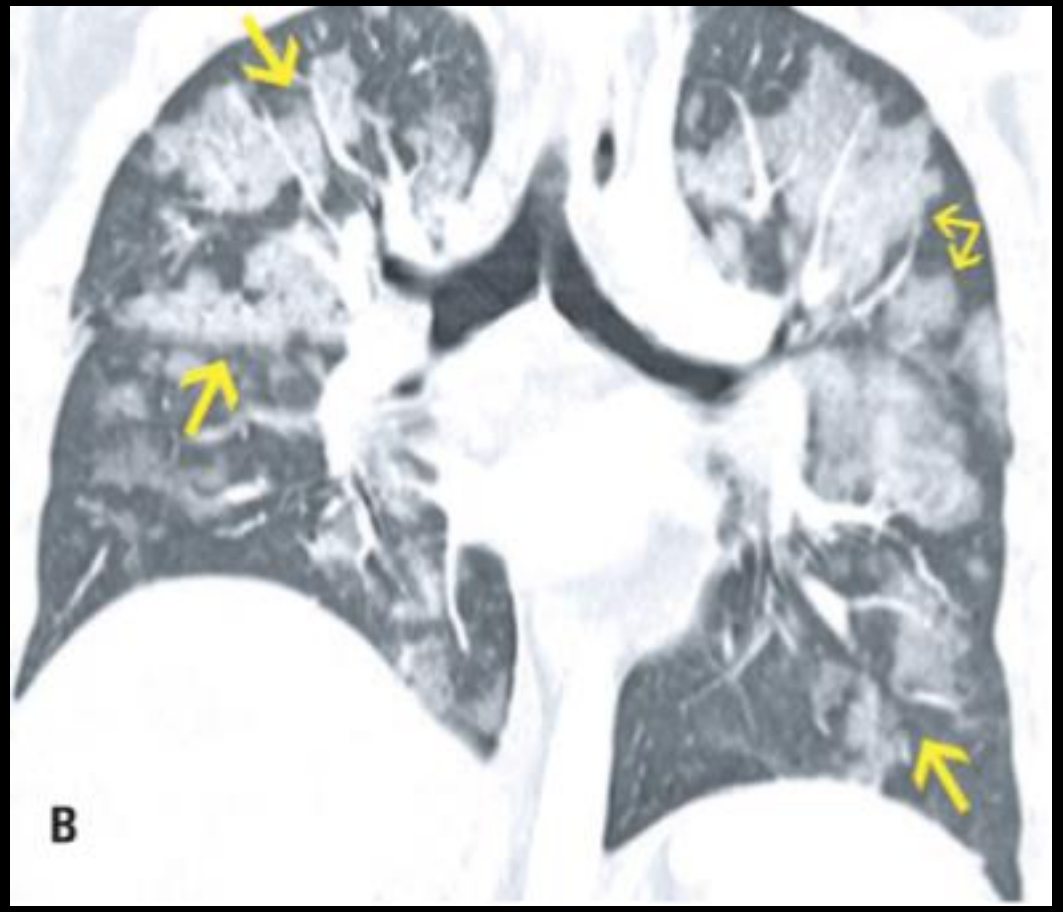
Bronchovascular/Bronchocentric



Diffuse

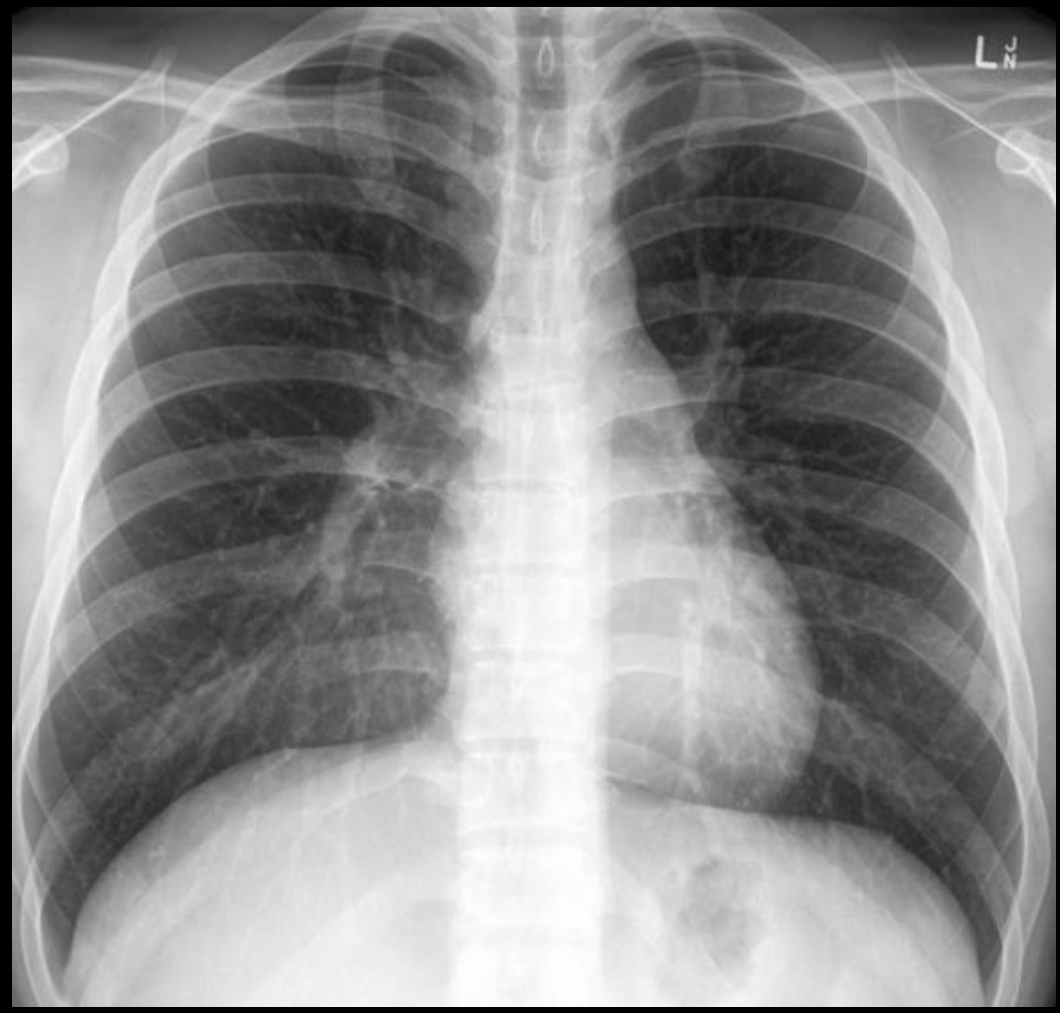
Extensive





“Okay, when is CXR enough?”

- CXR is fine for…
  - Most thoracic issues for initial assessment
  - Mild, respiratory issues
  - Rib fractures
  - Possible Tb
  - Checking lines and tubes

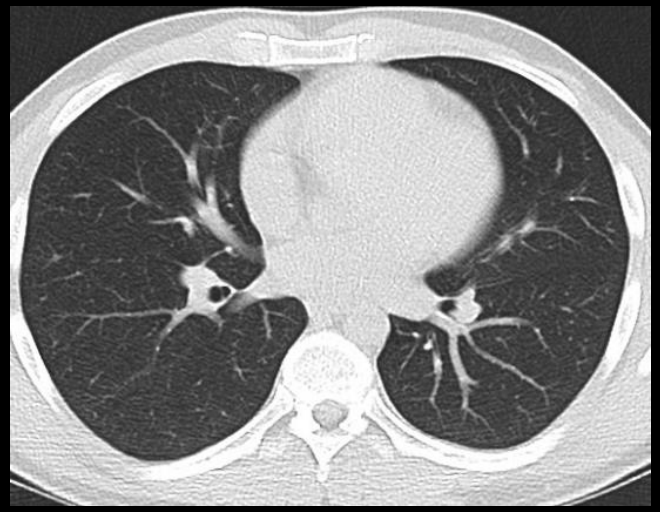


“Okay, when is CXR not enough?”

- CXR less likely to find the answer by itself…
  - Dangerous issues- Trauma! Immunocompromised hosts
  - Cancer – hemoptysis; staging
  - Chronic unexplained respiratory symptoms - dyspnea
  - Occupational lung disease – asbestos, bird fancier’s, metal workers, etc…
  - CXR done and does not explain symptoms



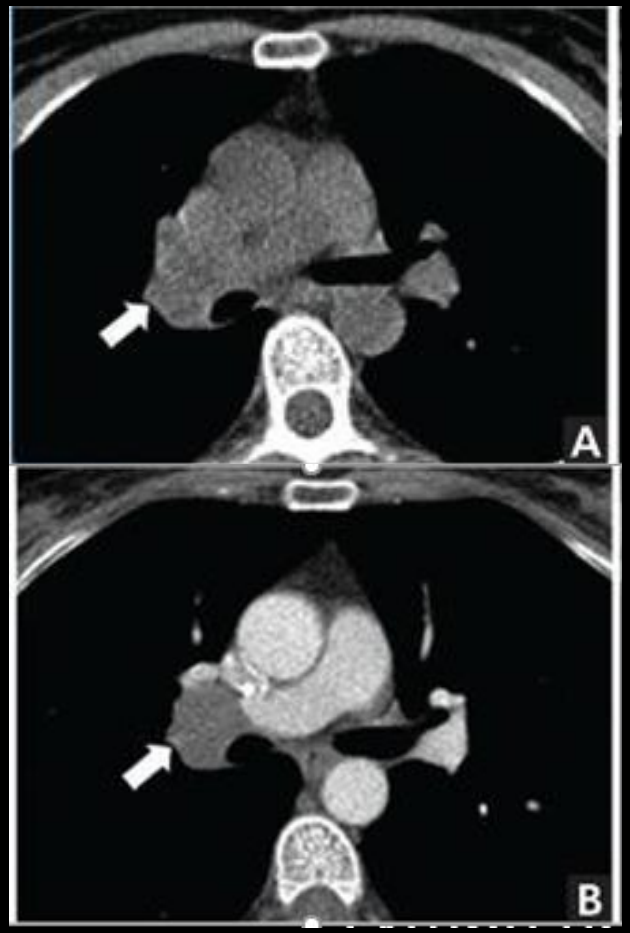

Which CT scan? Non-contrast for most lung issues…



- Soft tissues look the same ☹
  - Vessels, LN, muscle

- Lung parenchyma
- Lung nodules
- Infection
- Airways
- Bones

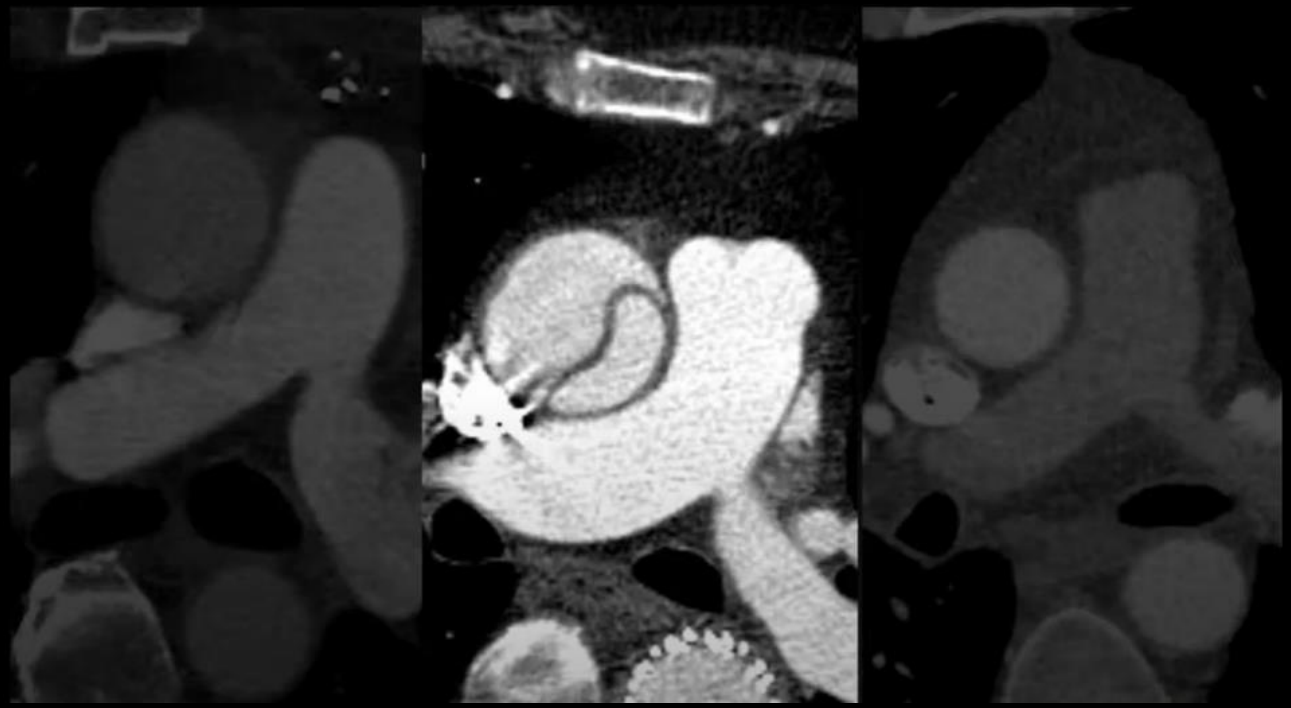
Which CT scan? Contrast can be helpful…



- Soft tissues take up contrast in different amounts

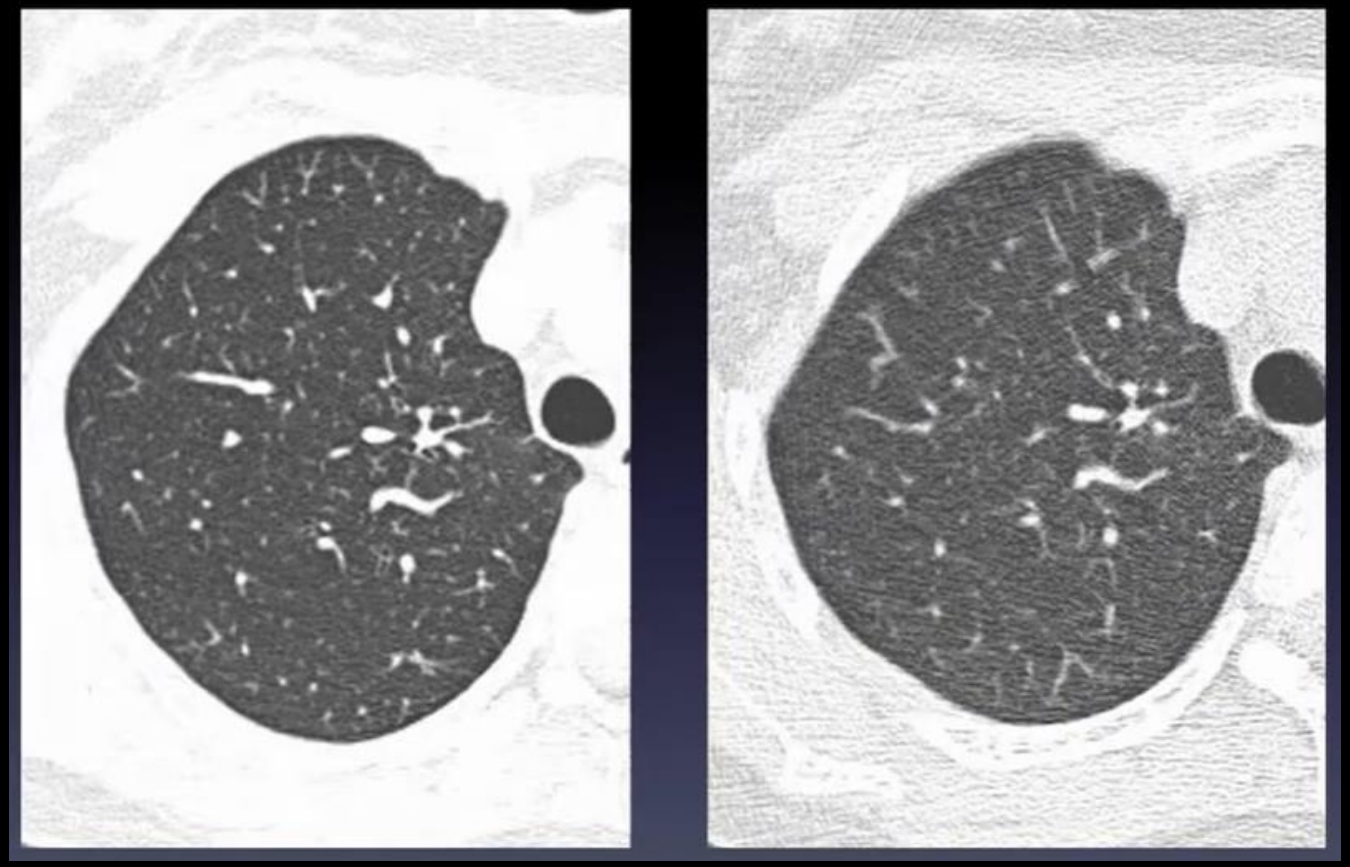
- Mediastinum
- Lymph nodes
- Pleura
- Chest wall
- Trauma
- Cancer
- Vessels

Which CT scan? Contrast Angiogram can be helpful…



- Target different vessels
  - CT Pulmonary artery Angiogram
  - CT Aorta protocol

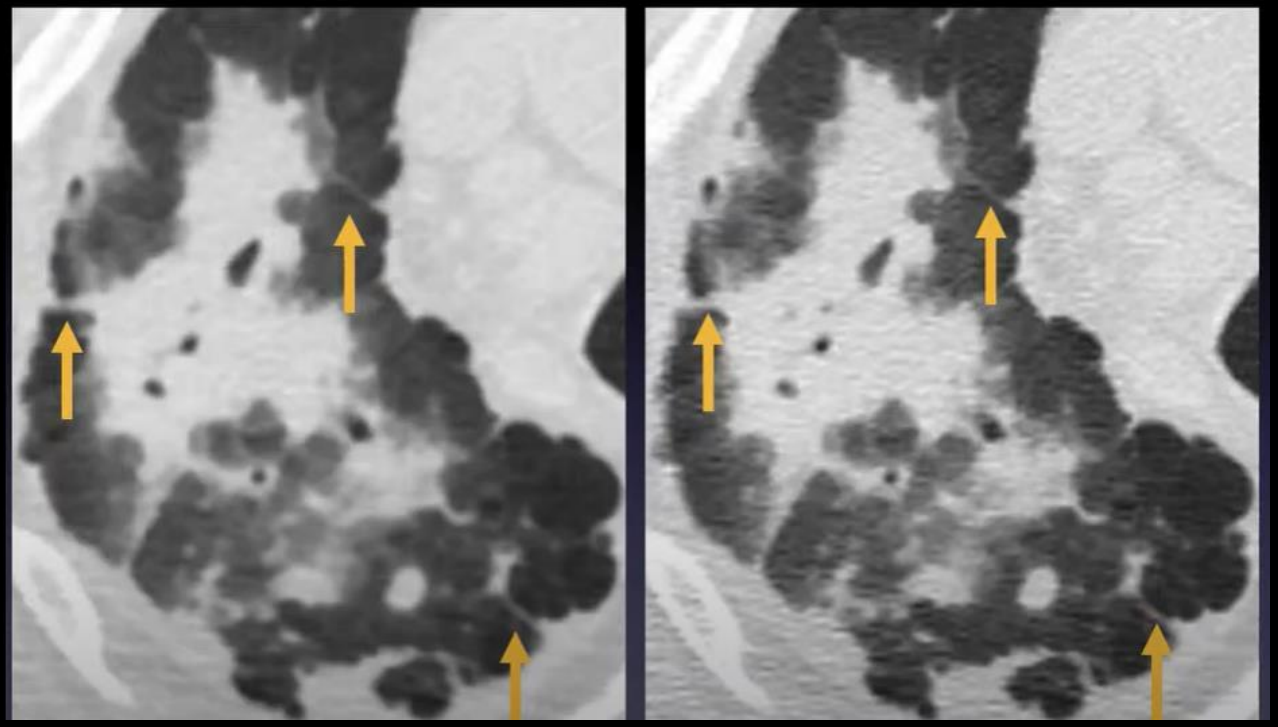
Which CT scan? Low-dose non-con can be helpful…



- Don’t need high fidelity
  - Lung CA Screening
  - Nodule follow up
  - Radiation Sensitive (kids!)

1.7 CXRs

Which CT scan? Hi-Res non-con…Hmmmm…



- Interstitial Lung disease
  - Need really fine details
- Often paired with expiratory views (air trapping)

ACR Appropriateness Criteria

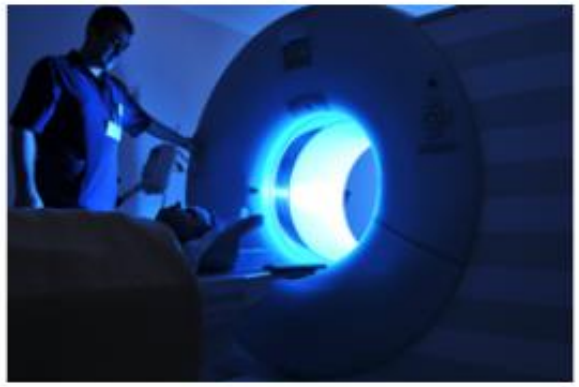
The ACR Appropriateness Criteria® (AC) are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition. Employing these guidelines helps providers enhance quality of care and contribute to the most efficacious use of radiology. Learn more »

The newest ACR AC are listed below.

ACR® American College of Radiology

Explore by topic

Explore by scenario



Explore by procedure

Cases

Nodule

- A 59 year old male smoker complains of cough x 3 months. There is occasional clear phlegm.
- 32 pack year smoker
- Physical exam is unremarkable
- CXR reveals the following…


L

Nodule

- What is the next best step in evaluation
  - A. Chest CT
  - B. Surgical consultation for removal
  - C. CT-guided needle biopsy
  - D. Obtain prior chest imaging
  - E. MRI with contrast

Old imaging is your best friend!

- New versus old
- Stable versus growing
- It's worth the effort
  - Save unnecessary referrals, procedures and cost
- Patient had nodule on CXR 3 years prior; unchanged

What if this nodule were new….

- …What would be the next appropriate step?
- A. Chest CT
- B. Chest CT pulmonary artery angiogram
- C. MRI with contrast
- D. PET/CT
- E. Biopsy or removal of nodule

Chest CT

- Chest CT has value in distinguishing malignant from benign
- Contrast?
  - Ask your friendly radiologist
    - OHSU thoracic radiologist – “I don’t need it. Our scanners are really good”
- Why not PET/CT?
  - It may not be malignant!
  - $$$ and XRT!!!!
- Why not biopsy?
  - CT may demonstrate benign features (scar, granuloma, etc…)
  - CT helpful if biopsy needed

•. 2013 Sep 5;369(10):910-9.

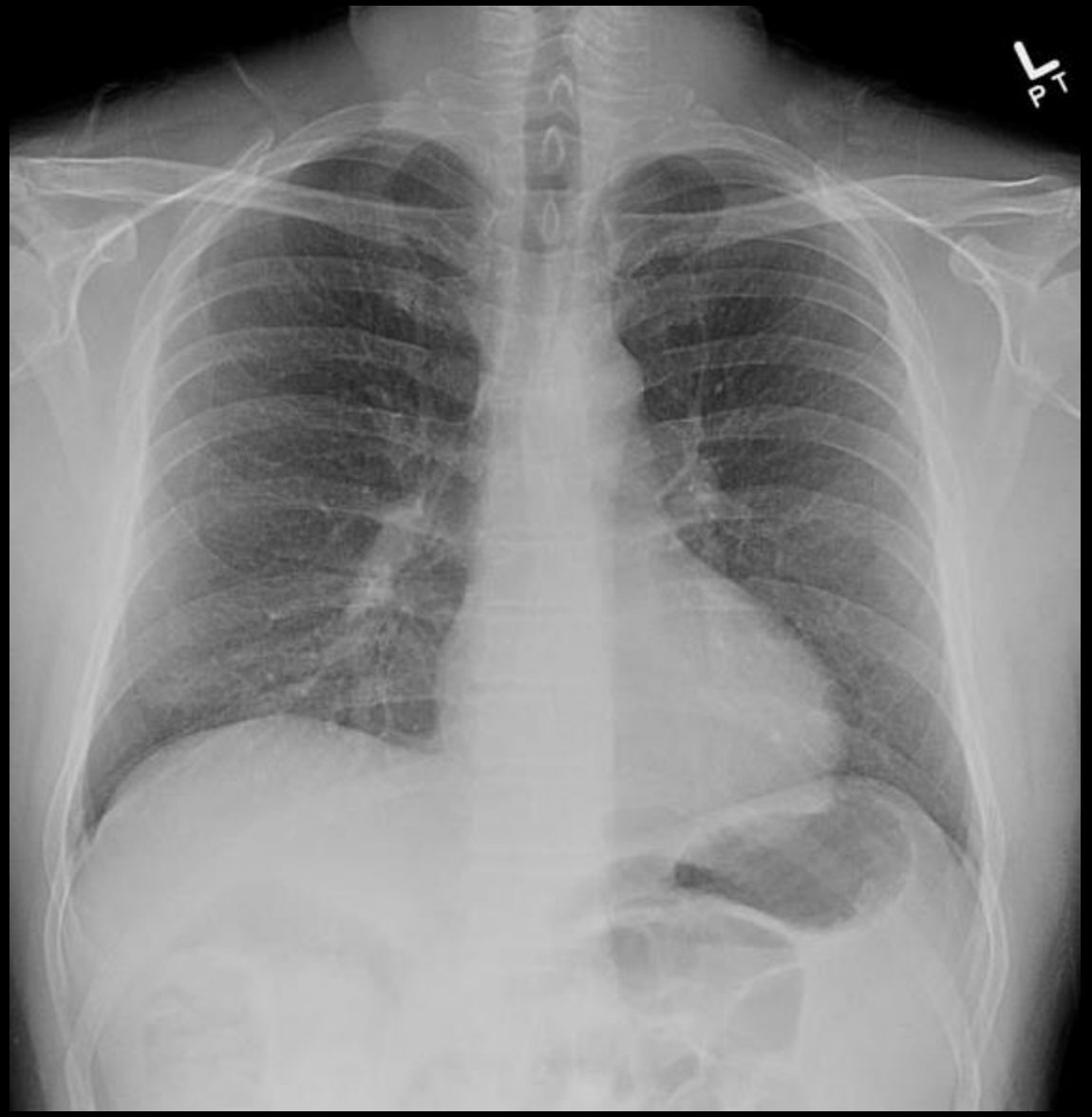
CT revealed irregular nodule

- Cancer Probability of lung nodule on Chest CT dictates next stops
  - Brock University Lung nodule calculator*
- If high probability for lung cancer, PET/CT is appropriate
  - Nodule
  - Lymph nodes
  - Metastases
- Patient had PET that revealed “hot” RUL nodule and no evidence of disease elsewhere
- Surgical resection confirmed stage 1A non-small cell lung cancer

*NEJM 2013 Sep 5: 369 (10):910-9.

Chronic SOB

- 48 year old gentleman with SOB x 12 weeks
  - Gradually worsening and now notices when going to the mailbox at the end of the driveway; mild non-productive cough
  - Non-smoker; farmer
  - Exam reveals a thin man; faint wheezing. O/w normal exam
  - You order spirometry which reveals mild obstruction and restriction
  - CXR demonstrates the following



Case courtesy of The Radswiki, Radiopaedia.org, rID: 11512

You decide to order a CT…

- What type of CT scan would you like to get?
- A. Chest CT with contrast
- B. Chest CT without contrast
- C. Chest CT with inspiratory and expiratory images
- D. Chest CTA pulmonary arteries
- E. Chest CT – High resolution

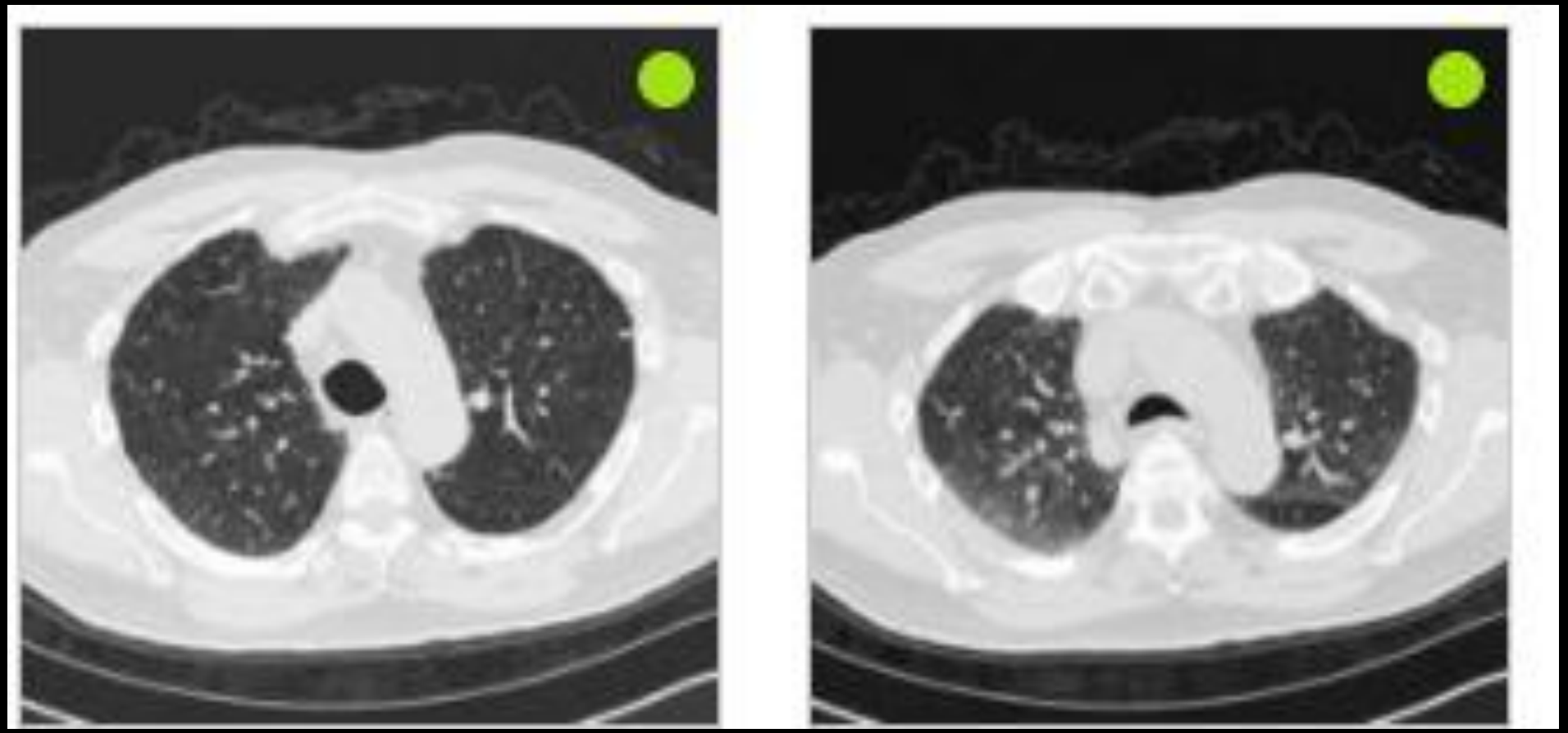
Yeah! You were likely right!

- A (CT), C (CT with I/E views) and E (CT-HR) would all be acceptable
- Most non-contrast chest CT's are good enough for ILD
  - HR-CT may give a little more detail
- CT with I/E views
  - Underutilized for "subacute/chronic dyspnea of unclear etiology"
    - Inspiratory = Standard
    - Expiratory – Pick up on obstructive lung disease (asthma, COPD, tracheal/bronchial collapse and some odd ILD)
- Contrast not helpful
  - Clinically, no suspicion for PE; no LN, pulmonary vessel, pleural, mediastinal issues

Hypersensitivity Pneumonitis

- Associated with inhalation of mold on hay
- Small granulomas in lung
- Improved with avoiding hay piles and starting steroids
- Returned to normal in 4 weeks

Tracheomalacia



Acute SOB!

- A 20 year woman, previously healthy, fell off an 8 foot ladder and presents to the ED with acute SOB and right sided chest pain
- Exam – RR 36, HR 125; BP 160/90; O2 sat 93% on room air
  - Distressed and tachypneic; conversant
  - Bruising and tender right side of chest wall
  - Decreased BS on right side
  - Remainder of exam unremarkable

Acute SOB!

- What is most appropriate initial imaging to confirm diagnosis?
- A. USN
- B. CXR – PA/Lateral
- C. CXR – AP
- D. Chest CT non-contrast
- E. Chest CTA pulmonary arteries

You have options again!

- Unstable patient should have air aspirated
- USN- Bedside portable USN may be quickest way to identify pneumothorax. ~~USN in radiology dept~~
- CXR- AP. Standard for PTX. Can also establish size of PTX and possible rib fractures. PA/Lateral not needed for diagnosis and takes patient off the unit.
- Chest CT may *eventually* be appropriate but takes more time and patient off the unit in the short term. Gold standard for PTX.
- Chest CTA. No suspicion of PE

Pneumothorax- B and M modes

PTX- Absence of pleural sliding

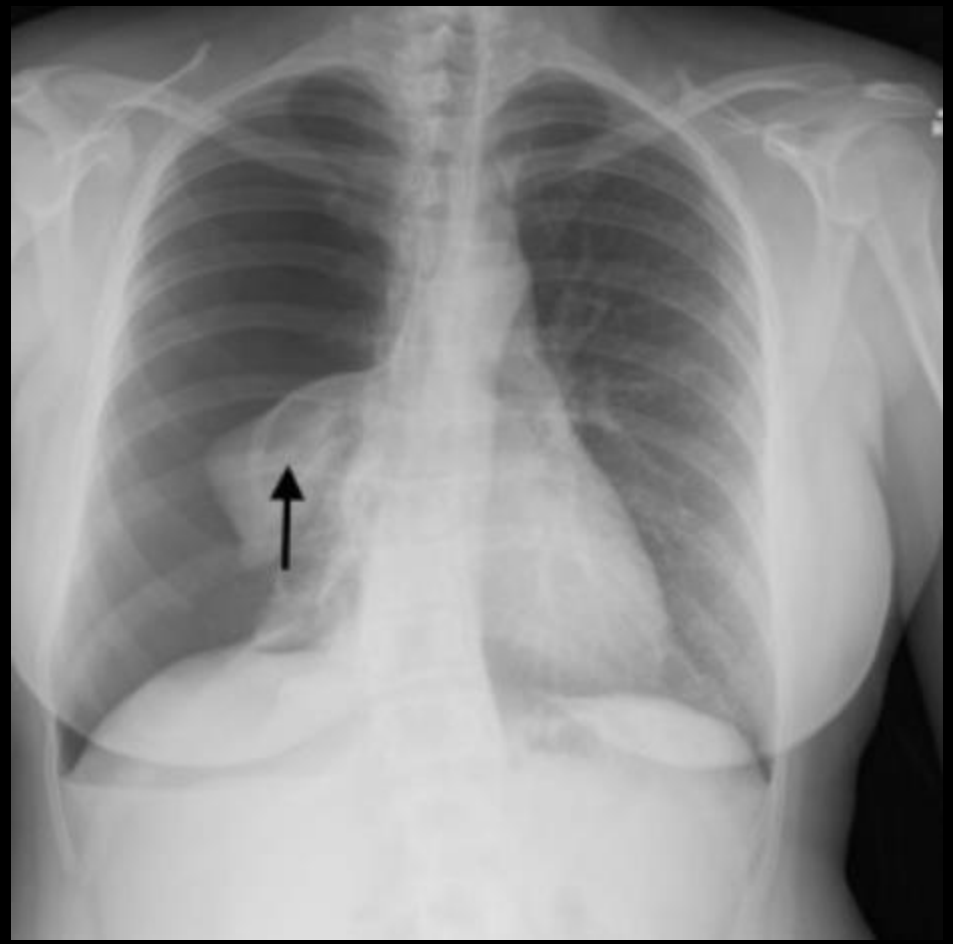
Normal- Seashore sign

PTX – Barcode sign

B mode (brightness mode)

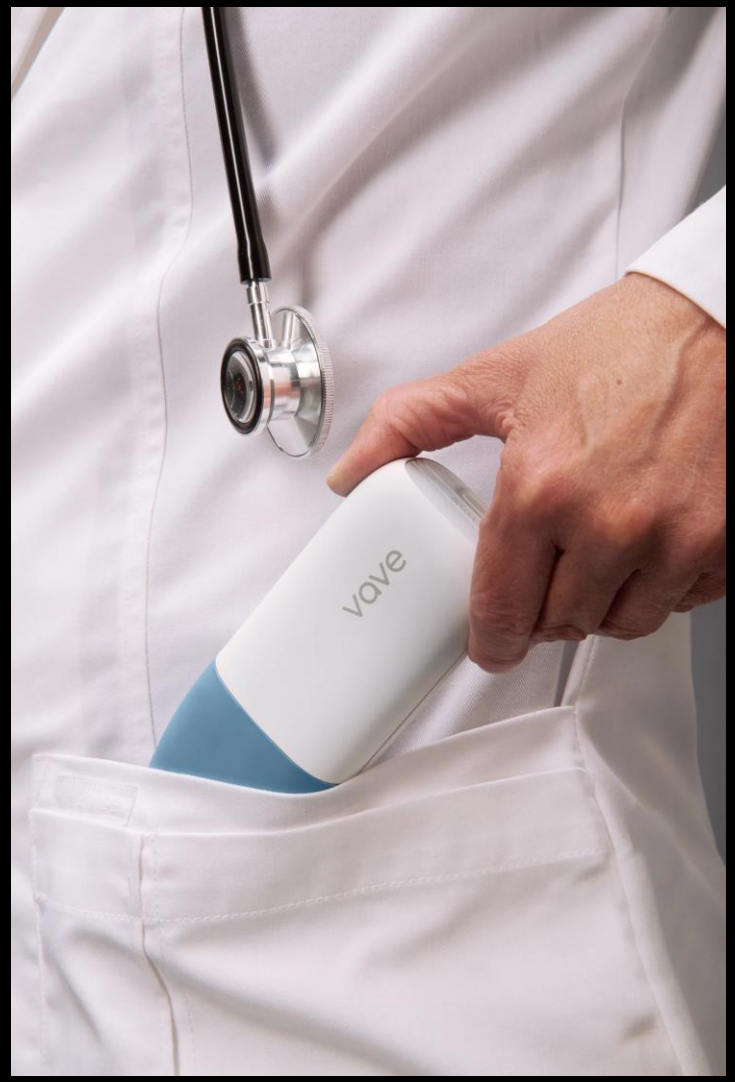
M mode (motion mode)

CXR- AP confirmed large right PTX



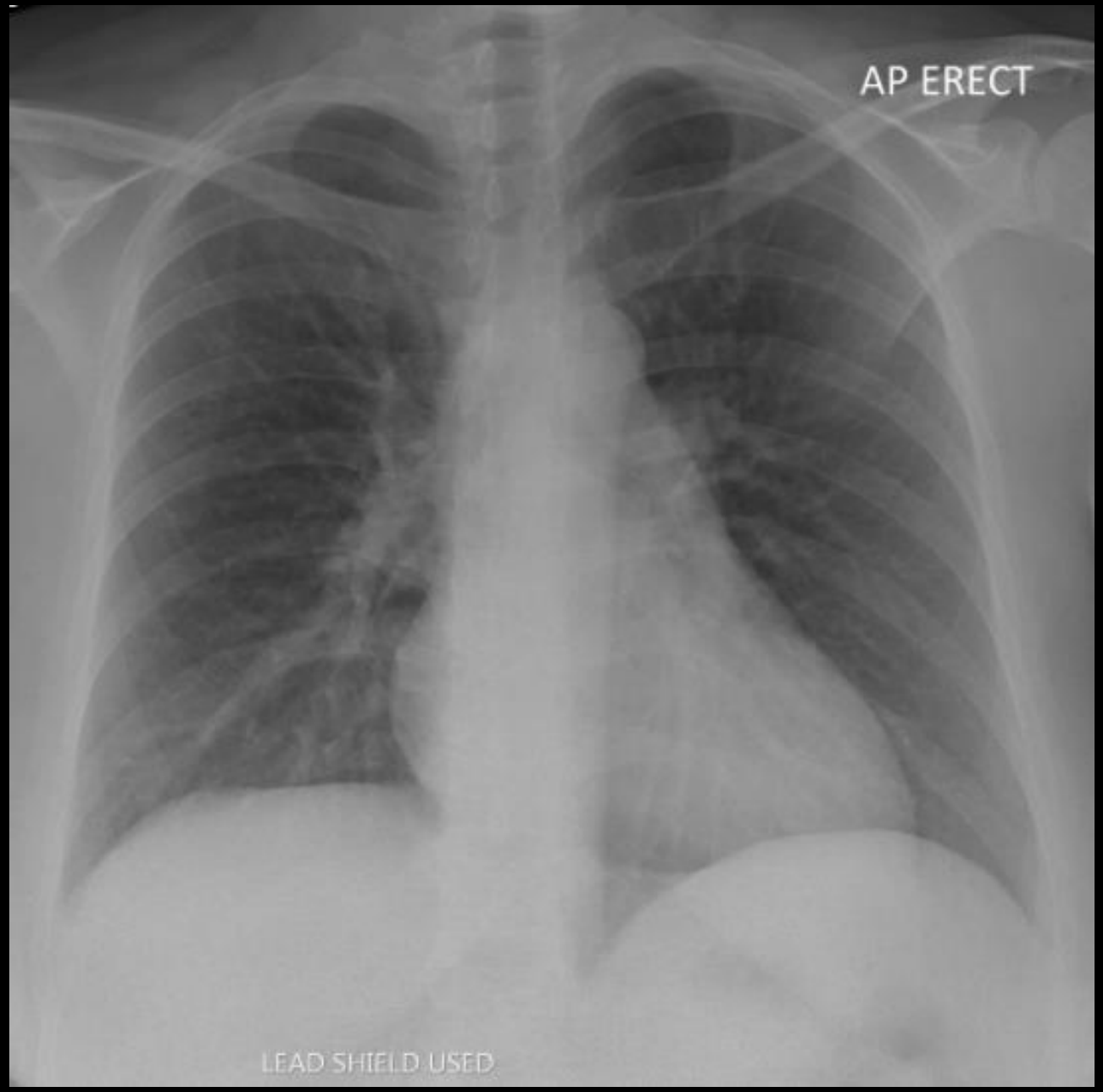
Thoracic ultrasound is coming…

- Pleural disease
  - Effusions
  - Pneumothorax
- In the right hands….
  - Pulmonary edema
  - Interstitial lung disease
  - Pneumonia



More SOB!

- 27 yo woman, 24 weeks pregnant with acute SOB
  - Sudden onset and causing moderate respiratory distress
  - Otherwise healthy
  - Broke ankle 6 weeks prior to presentation
  - Exam is unremarkable other than mildly swollen ankle
  - CXR reveals the following…


AP ERECT
LEAD SHIELD USED

- What is next most appropriate imaging test?
- A. Pulmonary Arteriogram (interventional radiology)
- B. Chest CTA pulmonary arteries
- C. Leg Ultrasound
- D. MRI with contrast
- E. V/Q scan

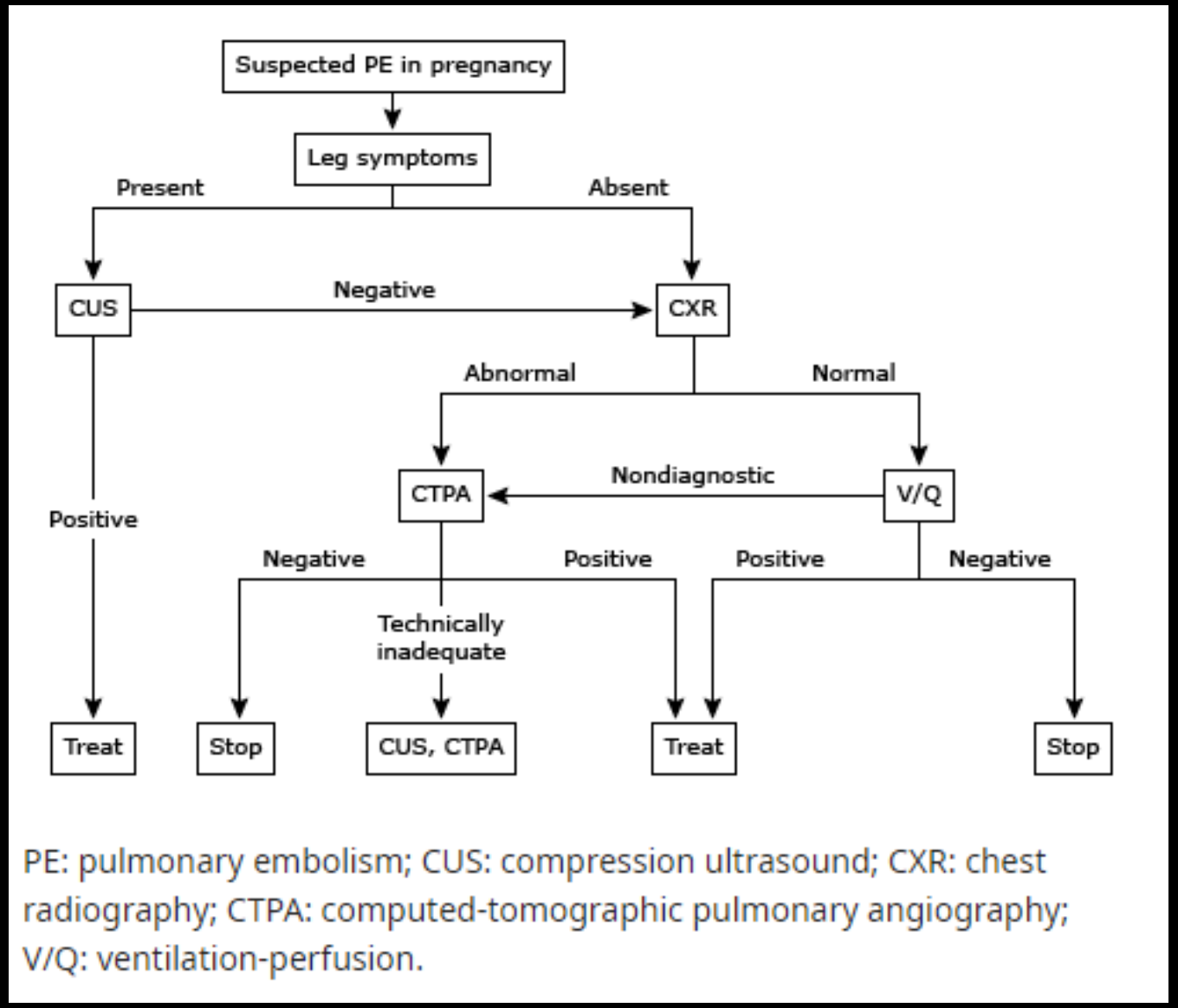
Tough case!

- Leg USN appropriate first step if there are signs of DVT
- CXR is best initial test for dyspnea in pregnancy in absence of leg symptoms
- V/Q scan is test of choice to assess PE in pregnancy.
  - Most effective when no lung pathology (CXR helpful!)
  - The “Q” part (perfusion scan) alone can rule out PE if normal
- Chest CTA pulmonary artery
  - Okay for non-diagnostic V/Q
  - Radiation dose coming down with shorter scan times
- MRI with contrast- unclear contrast (gadolinium) effects on fetus
- PA arteriogram- high radiation exposure

Fetal radiation doses associated with common radiologic examinations

Type of examination	Fetal dose* (mGy)
Very low-dose examinations (<0.1 mGy)	
Cervical spine radiography (anteroposterior and lateral views)	<0.001
Radiography of any extremity	<0.001
Mammography (two views)	0.001 to 0.01
Chest radiography (two views)	0.0005 to 0.01
Low- to moderate-dose examinations (0.1 to 10 mGy)	
Radiography	
Abdominal radiography	0.1 to 3.0
Lumbar spine radiography	1.0 to 10
Intravenous pyelography	5 to 10
Double-contrast barium enema	1.0 to 20
CT	
Head or neck CT	1.0 to 10
Chest CT or CT pulmonary angiography	0.01 to 0.66
Limited CT pelvimetry (single axial section through the femoral heads)	<1
Nuclear medicine	
Low-dose perfusion scintigraphy	0.1 to 0.5
Technetium-99m bone scintigraphy	4 to 5
Pulmonary digital subtraction angiography	0.5

Up to Date adapted from Radiographics 2012; 32:897.



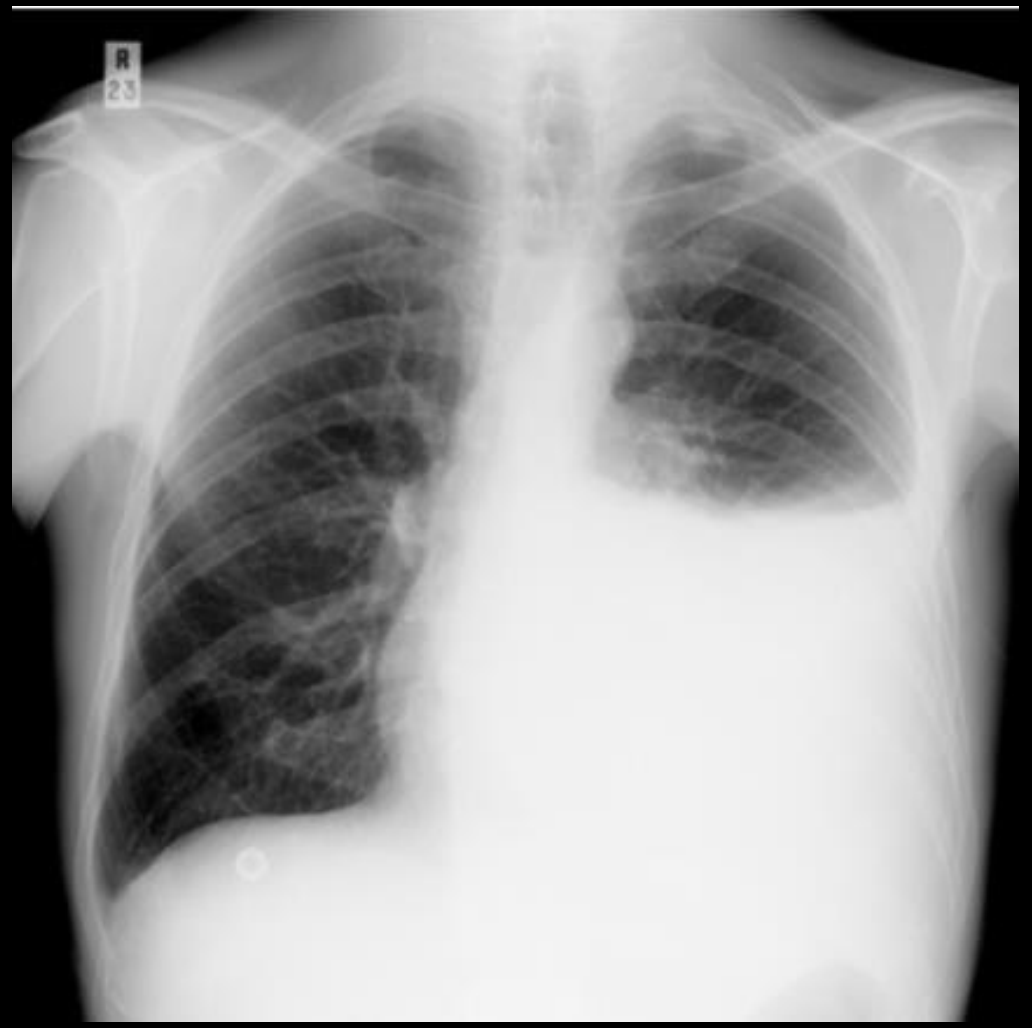
PE: pulmonary embolism; CUS: compression ultrasound; CXR: chest radiography; CTPA: computed-tomographic pulmonary angiography; V/Q: ventilation-perfusion.

Up to Date adapted from Respir Crit Care Med 2011; 184:1200.

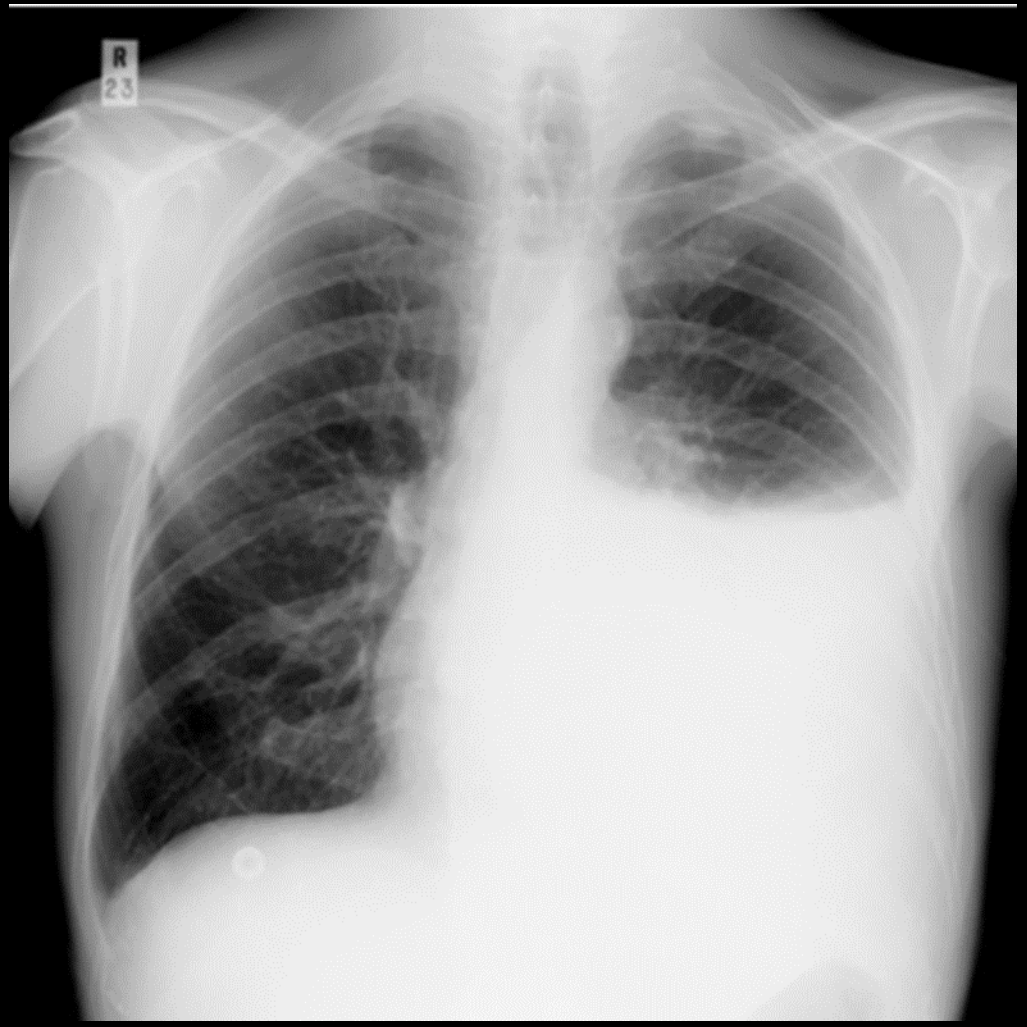
Scenario	Procedure	Adult RRL	Peds RRL	Appropriateness Category	
PE suspected, pregnant	Radiography chest	<0.1 mSv ☢	<0.03 mSv [ped] ☢	Usually appropriate	
	US duplex Doppler lower extremity	0 mSv O	0 mSv [ped] O	Usually appropriate	
	CT chest with IV contrast	1-10 mSv ☢☢☢	3-10 mSv [ped] ☢☢☢☢	Usually appropriate	
	CTA chest with IV contrast	1-10 mSv ☢☢☢	3-10 mSv [ped] ☢☢☢☢	Usually appropriate	
	V/Q scan lung	1-10 mSv ☢☢☢	Null	Usually appropriate	
	Arteriography pulmonary with right heart catheterization	10-30 mSv ☢☢☢☢	Null	May be appropriate	
	MRA chest without IV contrast	0 mSv O	0 mSv [ped] O	Usually not appropriate	
	MRA chest without and with IV contrast	0 mSv O	0 mSv [ped] O	Usually not appropriate	
	CTA chest with IV contrast with CTV lower extremities	1-10 mSv ☢☢☢	Null	Usually not appropriate	

Case: SOB x 6 weeks

- 35 year old man has had fevers, SOB and weight loss over the last 6 weeks
- Lost 10 pounds



Case – CXR assessment



- Very dense opacity in left lower chest
- Curvilinear border superiorly
- Common question…
  - Effusion?
  - Atelectasis?
  - Both?

Case – Large pleural effusion

- Effusions
  - Mass effect – pushes thoracic structures away
  - Meniscus sign superiorly suggest fluid
- Atelectasis
  - Volume loss – pulls thoracic structures toward
  - Lobar collapse can result in sharp linear edge to dense, deflated lung
- Diagnosis – Large left pleural parapneumonic effusions

Case – Large pleural effusion

- What is next appropriate step?
- A. Ultrasound
- B. Chest CT non-contrast
- C. Chest CT with IV contrast
- D. Start levofloxacin
- E. Place chest tube

Lots to choose!

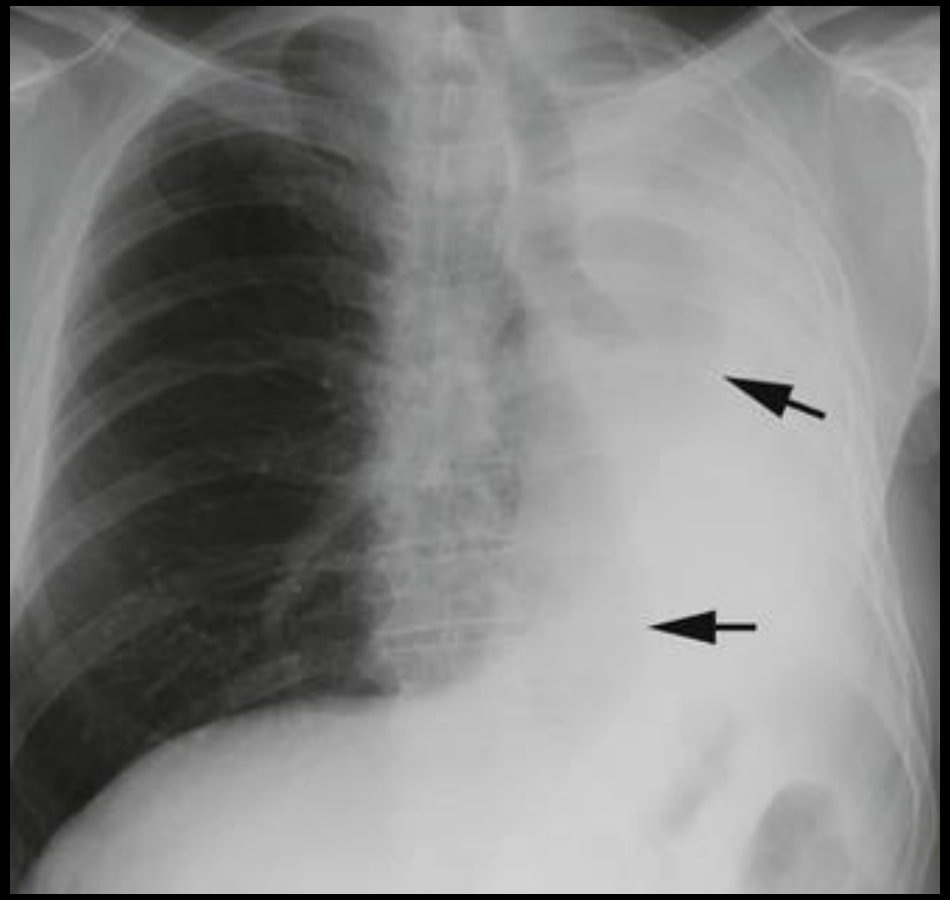
- Ultrasound
  - Great before thoracentesis!
  - Better at identifying septations than CT
  - Bedside USN cheap (if available) and no XRT
- Chest CT – Great pictures of the lung
  - With Contrast - Radiologists like contrast to identify pleura better (enhancement, nodules)
  - Without contrast- Pretty good at looking at the pleura, though less optimal
- Would not start antibiotics without identifying cause (thoracentesis)
- Chest tube- quite possibly may need, but would sample first

USN identified complex septations

Chest tube inserted and revealed purulent fluid

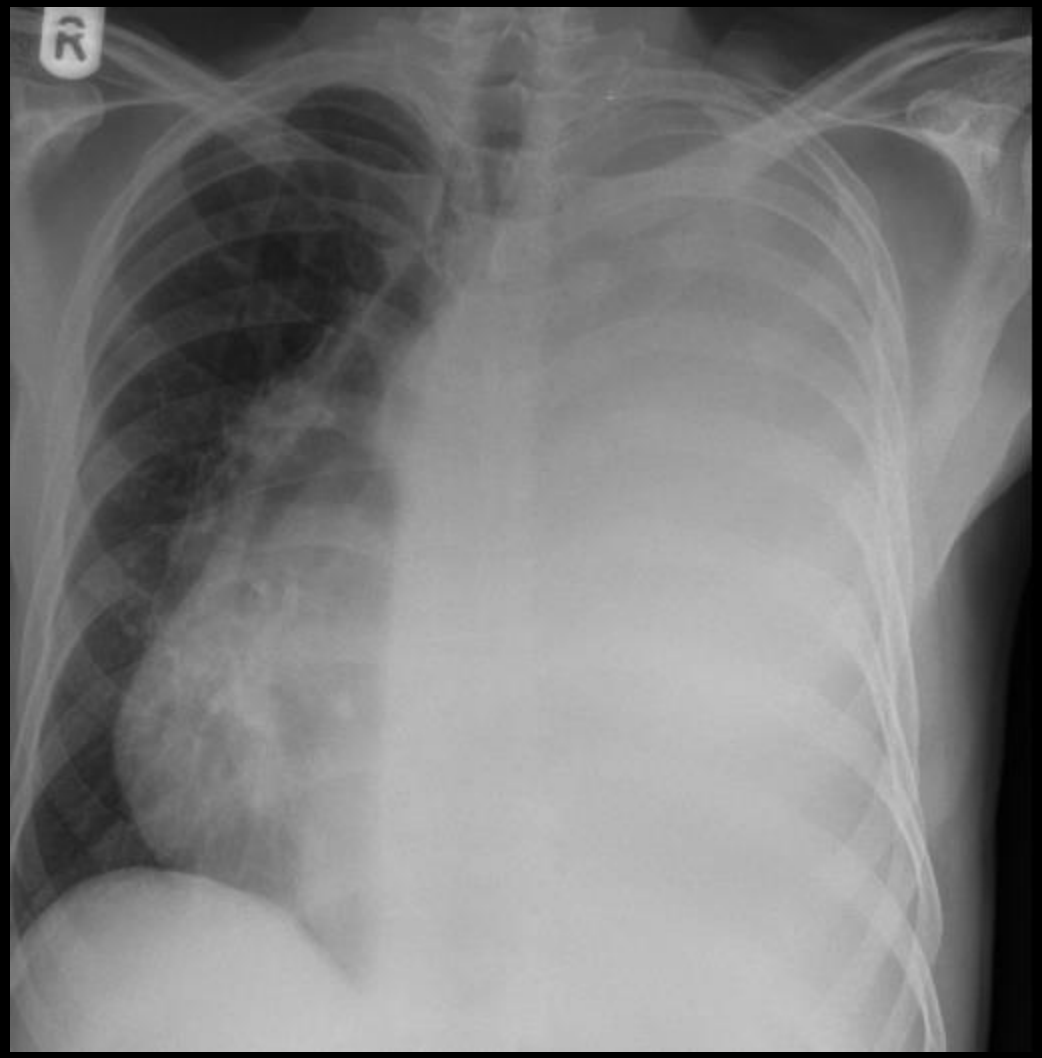
Diagnosis- Bacterial empyema with staph aureus

The “white out lung”



- Atelectasis
  - “White out” on left side of the chest
  - Thoracic structures shifted TOWARD the atelectic area
    - Volume loss
  - Don’t stick a needle here!
  - Get more imaging!

The “white out lung”



- Massive pleural effusion
  - “White out” on left side of the chest
  - Thoracic structures shifted AWAY from the effusion
    - Mass effect

Thank you!!!

Please send me an email if you have any questions

alladag@ohsu.edu