Pulmonary Imaging Overview

Marcus John Julius, M.D.

Chest Imaging Overview

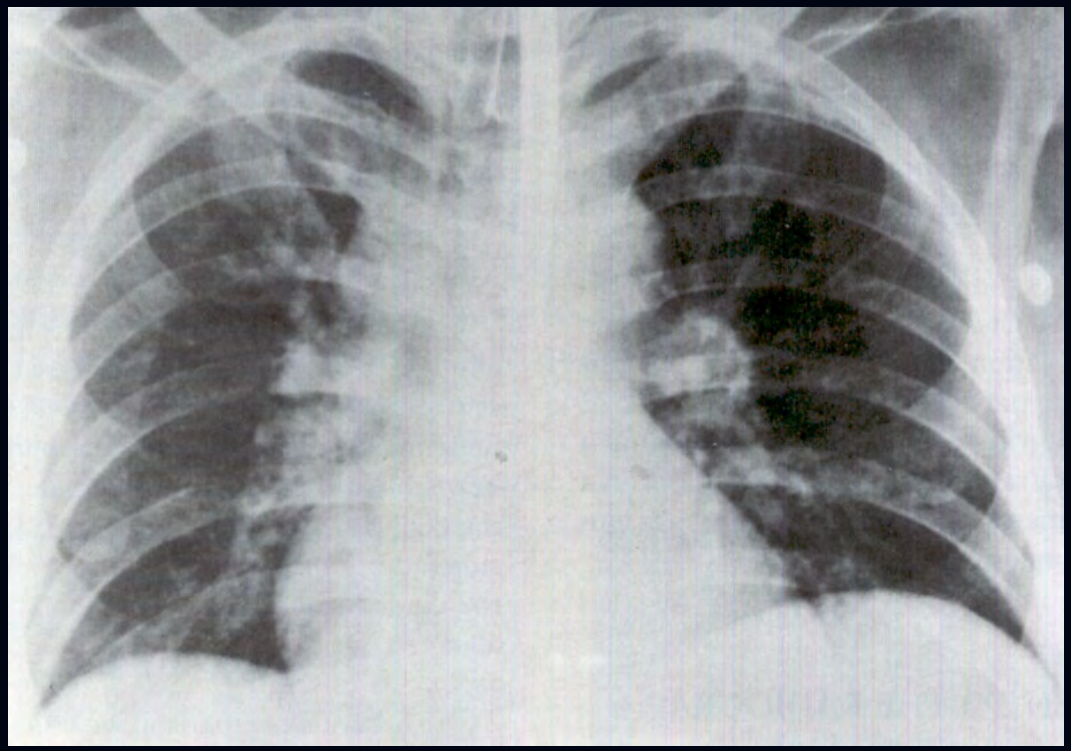
- **Objectives**
  - To present the imaging modalities available for assessment of the pulmonary system
  - To impress upon the student physician the benefits and limitations of each imaging modality
  - To display normal anatomy on imaging examinations

Chest Imaging Overview

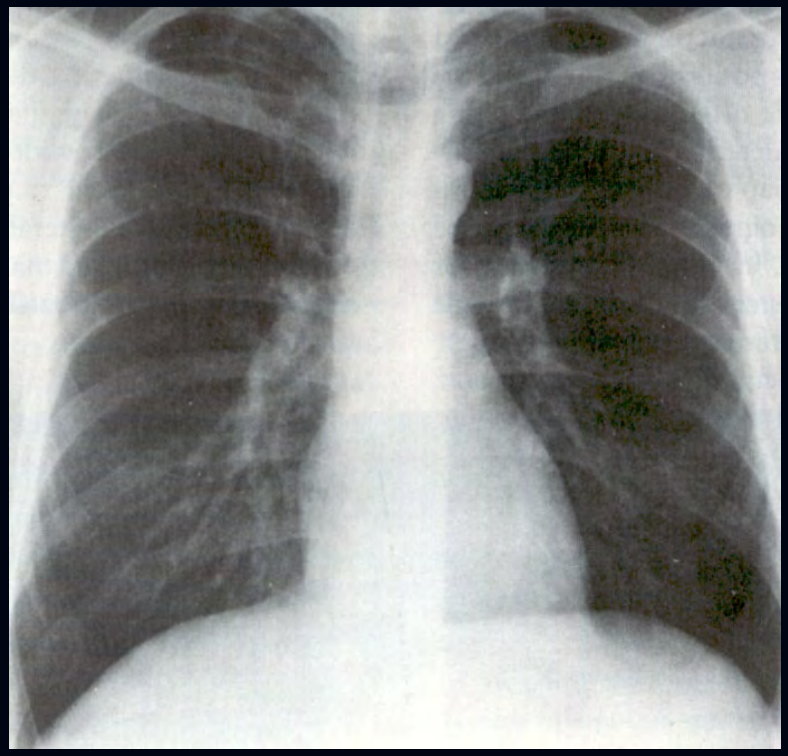
- Imaging modalities available for pulmonary evaluation
  - Plain film imaging (chest radiograph; chest x-ray; CXR)
  - Chest computerized axial tomography (CT)
  - Pleural space sonography
  - Nuclear medicine imaging (V/Q scan)
  - Positron emission tomography (PET)
  - Magnetic resonance imaging (MRI)

Chest Imaging Overview

- **CXR**
  - Most common radiologic procedure (up to 50% of imaging studies in some practices)
  - Standard imaging is performed in posterior-anterior (PA) and (left) lateral projections (at full inspiration in upright positioning)
  - Portable CXRs are performed in anterior-posterior projection (with various Pt positions: supine>recumbent>upright, depending on Pt condition)



Portable AP

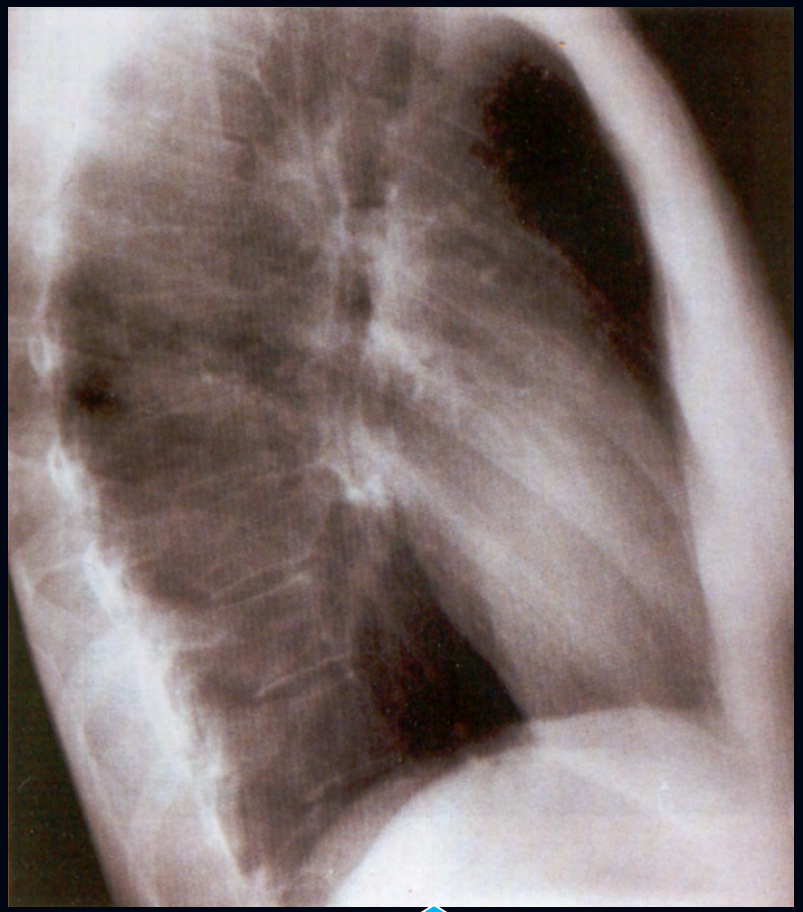


Upright PA view

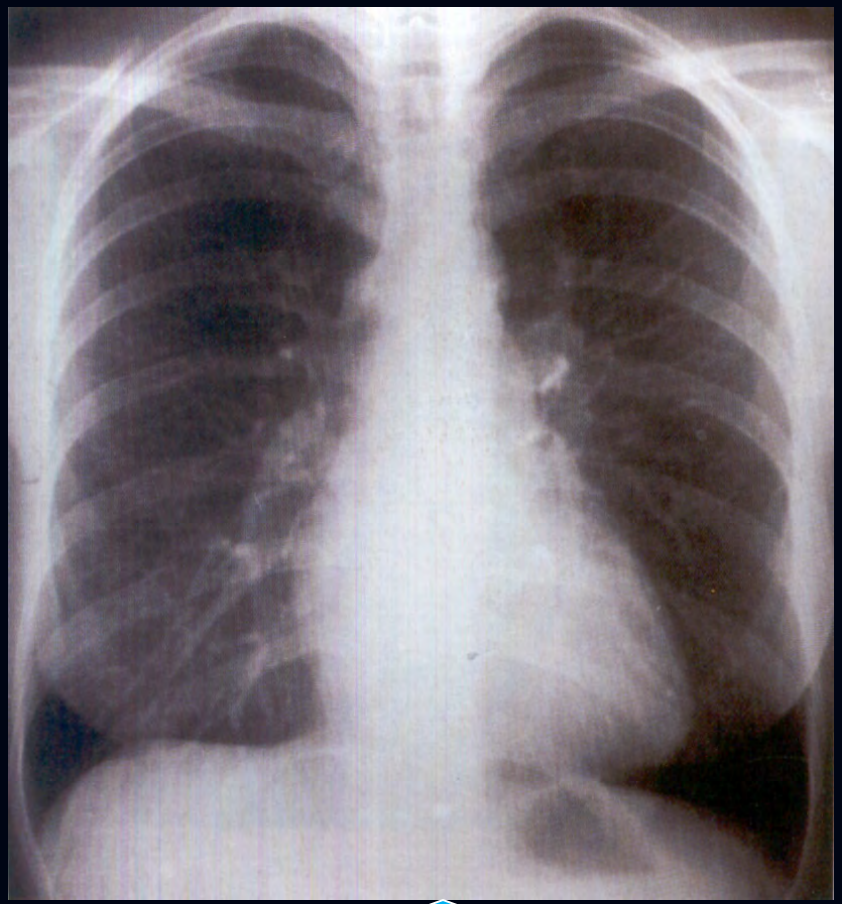
Source: M J Julius, M.D.

Chest Imaging Overview

- **CXRs (continued)**
  - **In plain film imaging, when examinations are labeled with two positions (I.e. posterior-anterior CXR or cranio-caudal mammographic imaging), the first position is the location of the x-ray source and the second position is the film location**



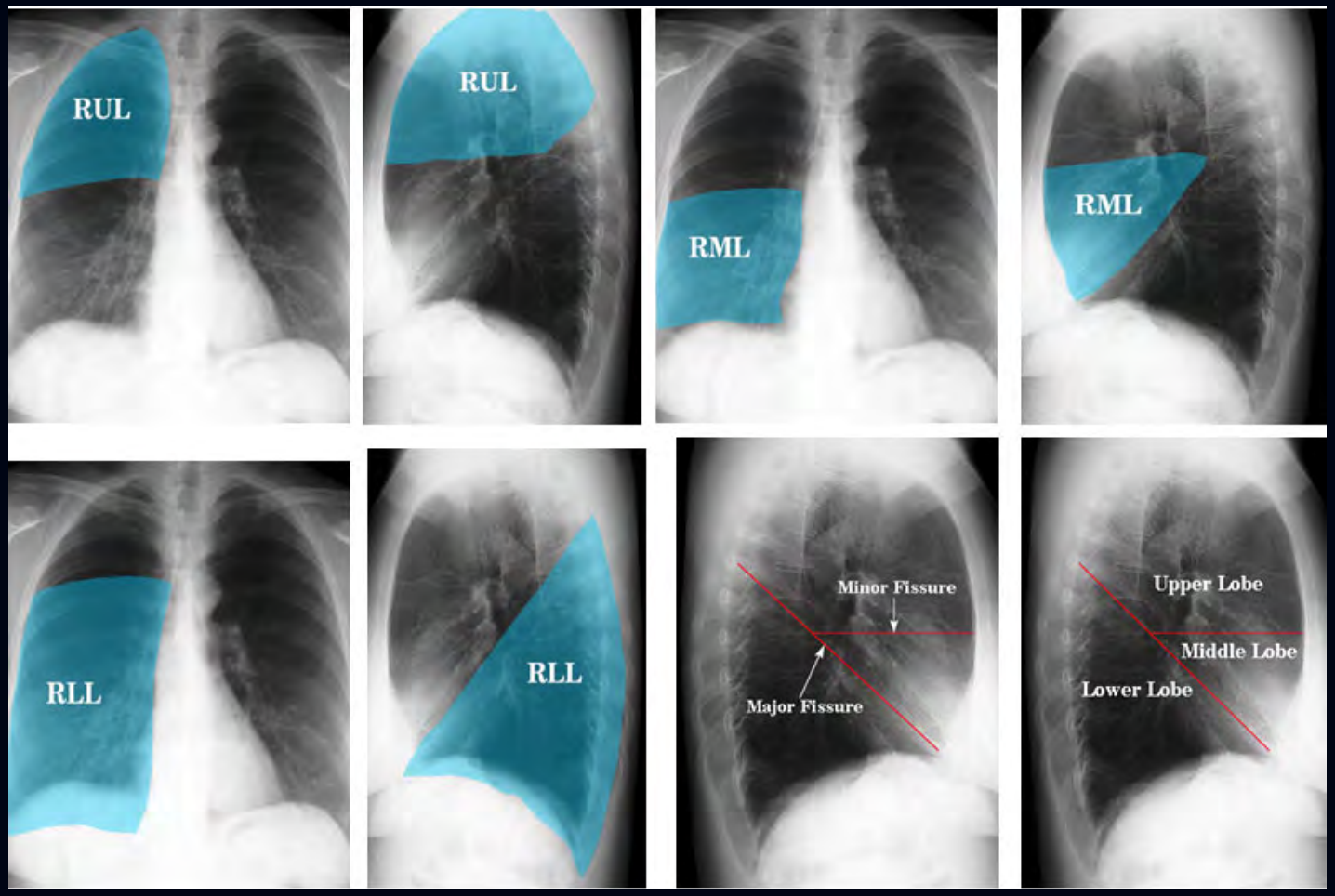
Lateral view



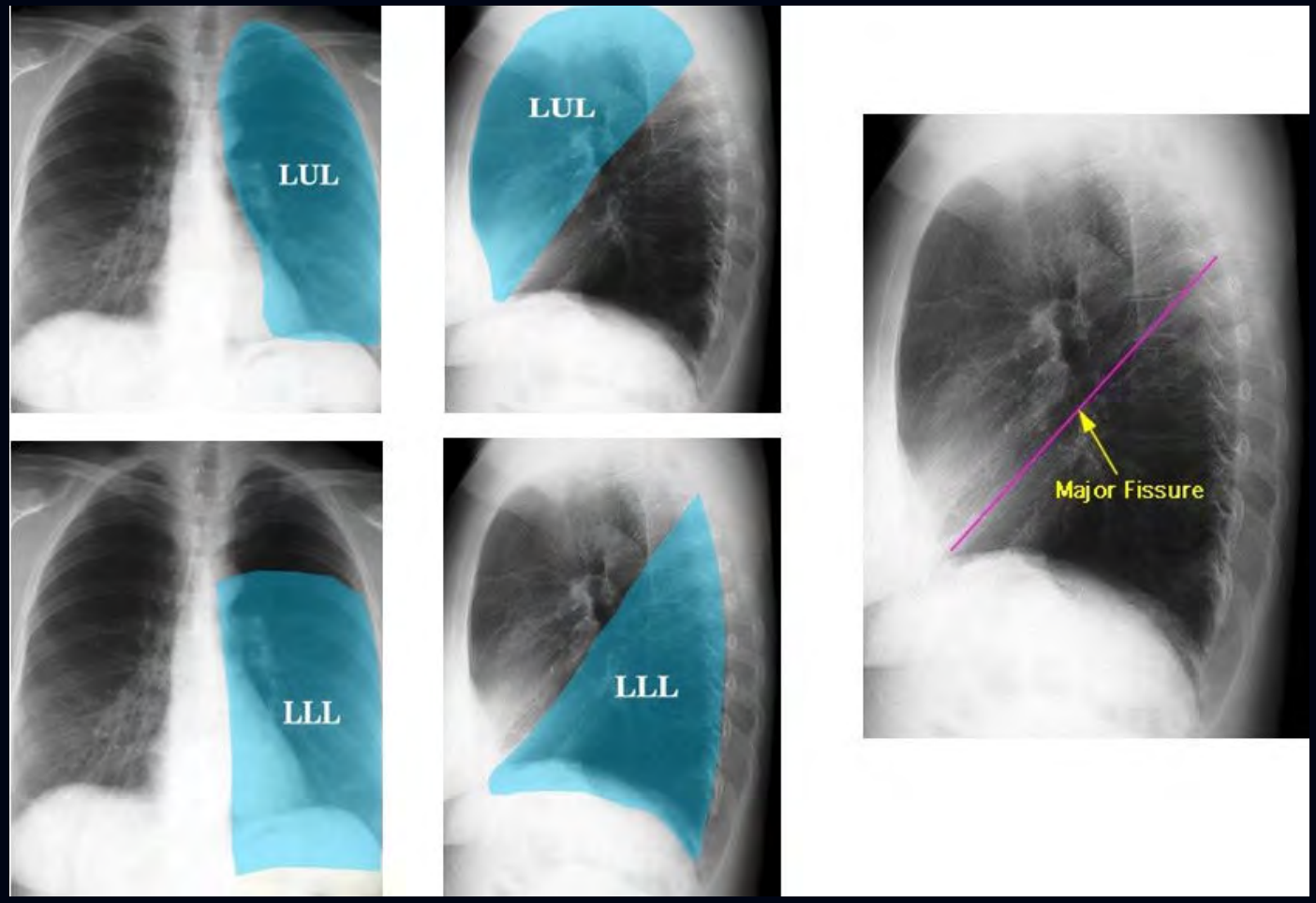
Upright PA View

Source: M J Julius, M.D

Right lobar anatomy



Left lobar anatomy



Chest Imaging Overview

- Clinical indications for CXRs
  - Chest pain
  - Fever/cough
  - Dyspnea
  - Wheezing
  - Orthopnea
  - Hemoptysis

Chest Imaging Overview

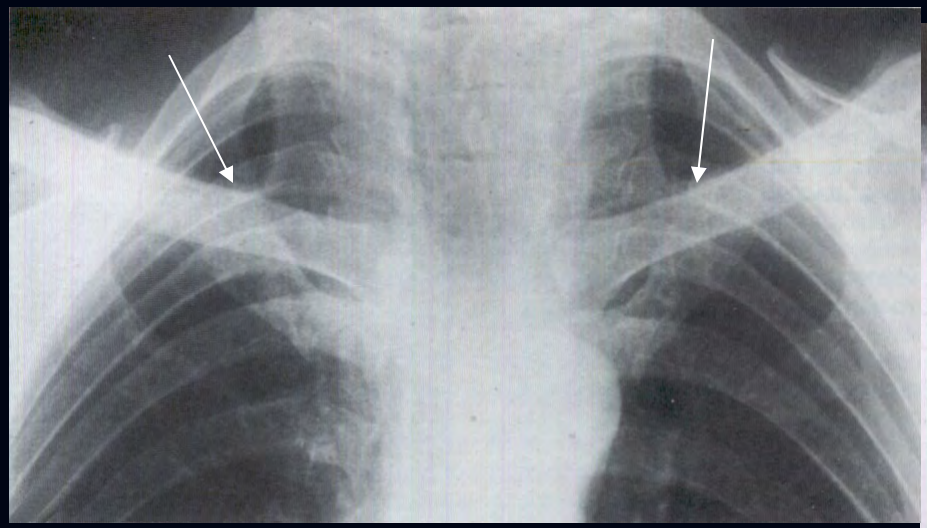
- Clinical indications for CXRs (continued)
  - Occupational exposure
  - Suspected pleural fluid
  - Trauma
  - Vascular disease (aortic aneurysm/aortic dissection/pulmonary emboli)

Chest Imaging Overview

- CXRs (continued)
  - Plain film chest imaging also includes additional specialized projections:
    - Apical lordotic view
    - Inspiration/expiration views
    - Decubitus views
    - Fluoroscopy

Chest Imaging Overview

- Apical lordotic view
  - Projects clavicles above the thoracic inlet
    - Allows for visualization of lung apices
      - Assess apices for nodules
      - Assess for apical fibrosis
      - Assess for reactivation TB
    - Allows for additional projection of the RML (and lingula)



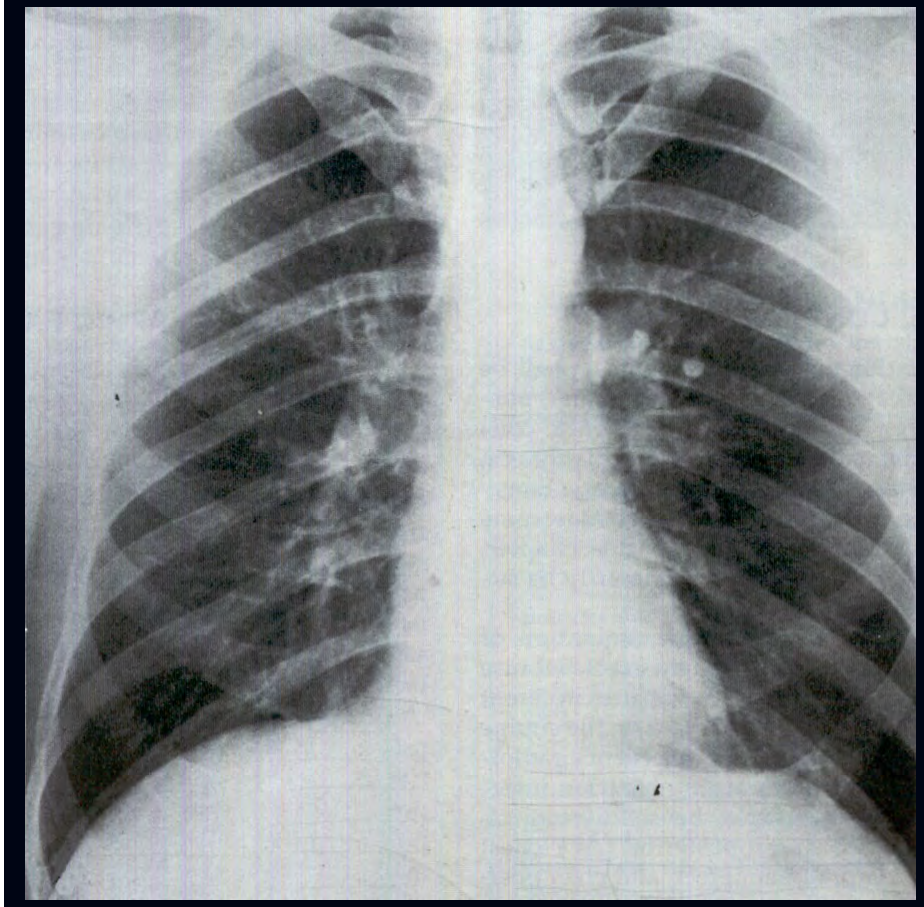
Upright PA view
(Clavicles marked by arrows)

Apical lordotic view
(clavicles projected above lung apices)

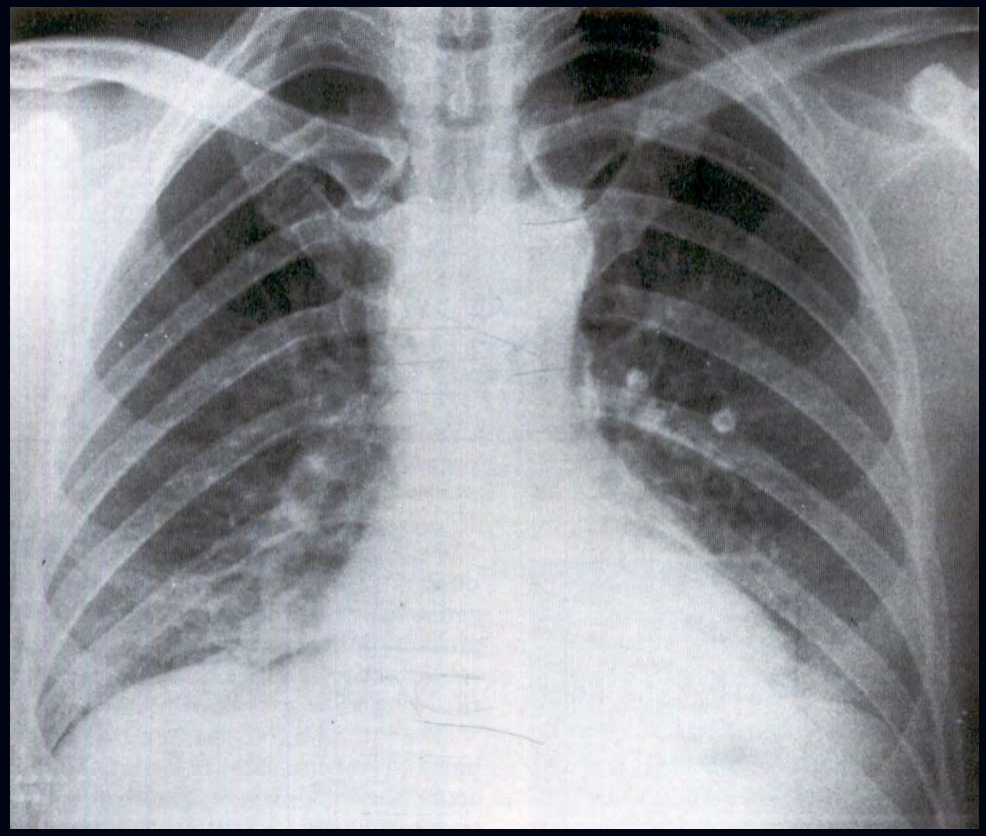
Source: M J Julius, M.D.

Chest Imaging Overview

- Inspiration/expiration views
  - Assess air-trapping (I.e. foreign body)
    - Unobstructed lung deflates during expiration
    - Obstructed lung remains inflated during expiration
    - In pediatric Pts, decubitus imaging may be also be utilized to assess for foreign body (see below)
  - Assess pneumothoraces
    - Compared with imaging at full inspiration, expiration view makes extrapulmonary air more conspicuous (I.e. At expiration, intrapulmonary air diminishes while pneumothorax remains constant in volume)

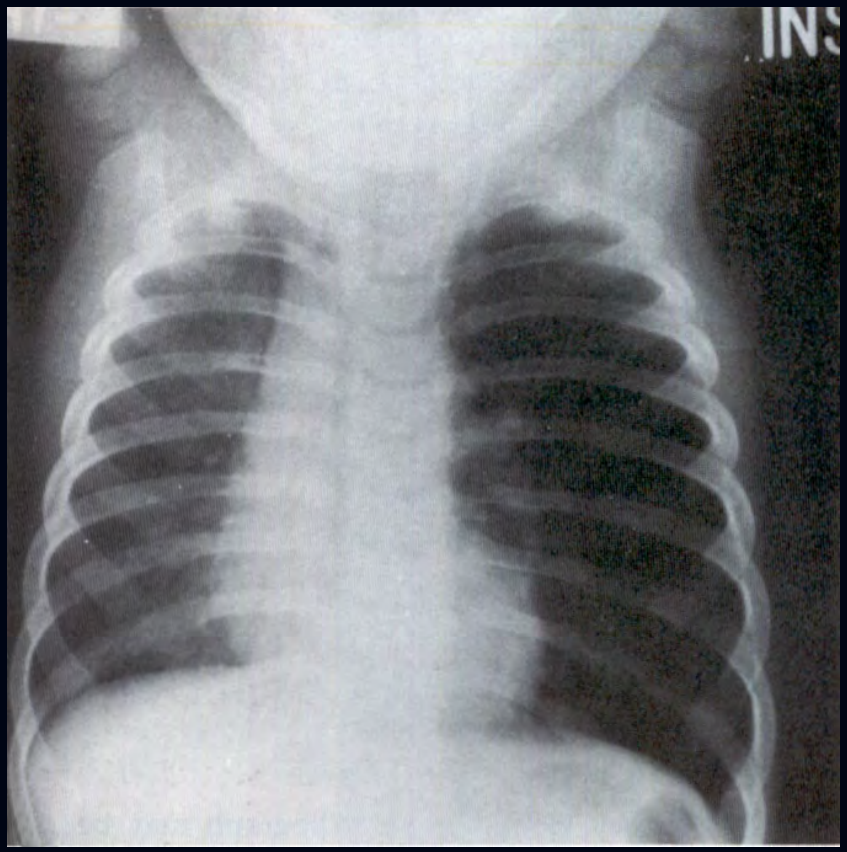


Inspiration view: well-inflated lungs

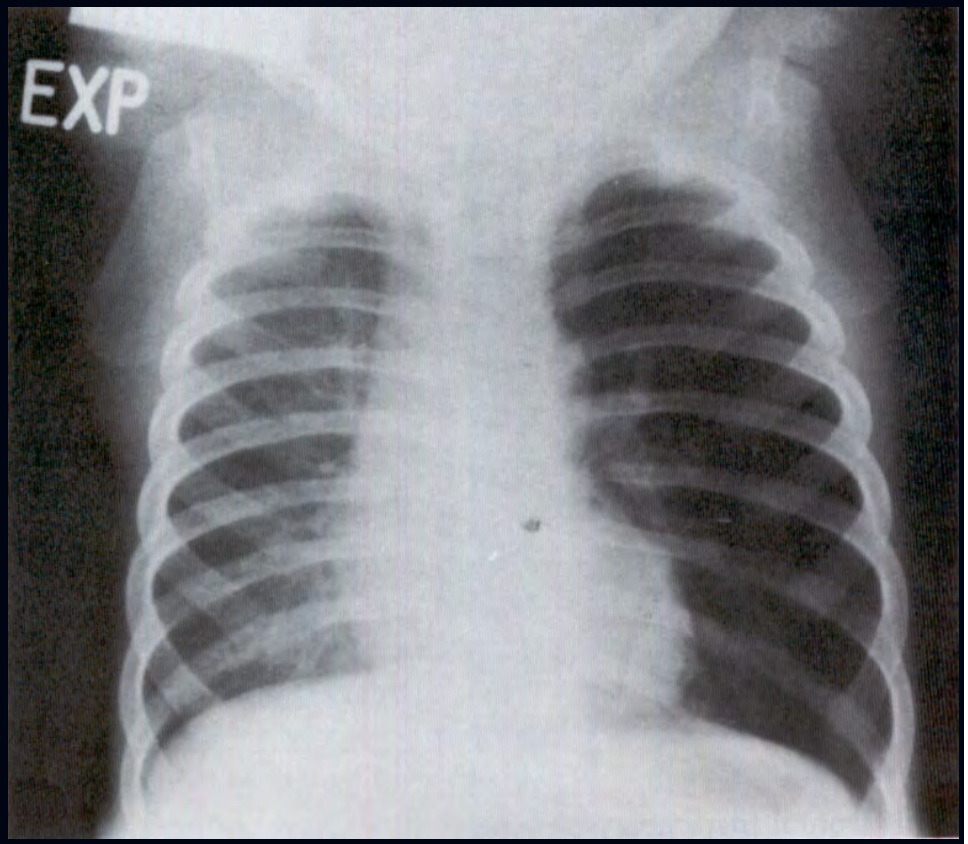


Expiration view: physiologic bibasilar compressive atelectasis/volume loss

Source: M J Julius, M.D.

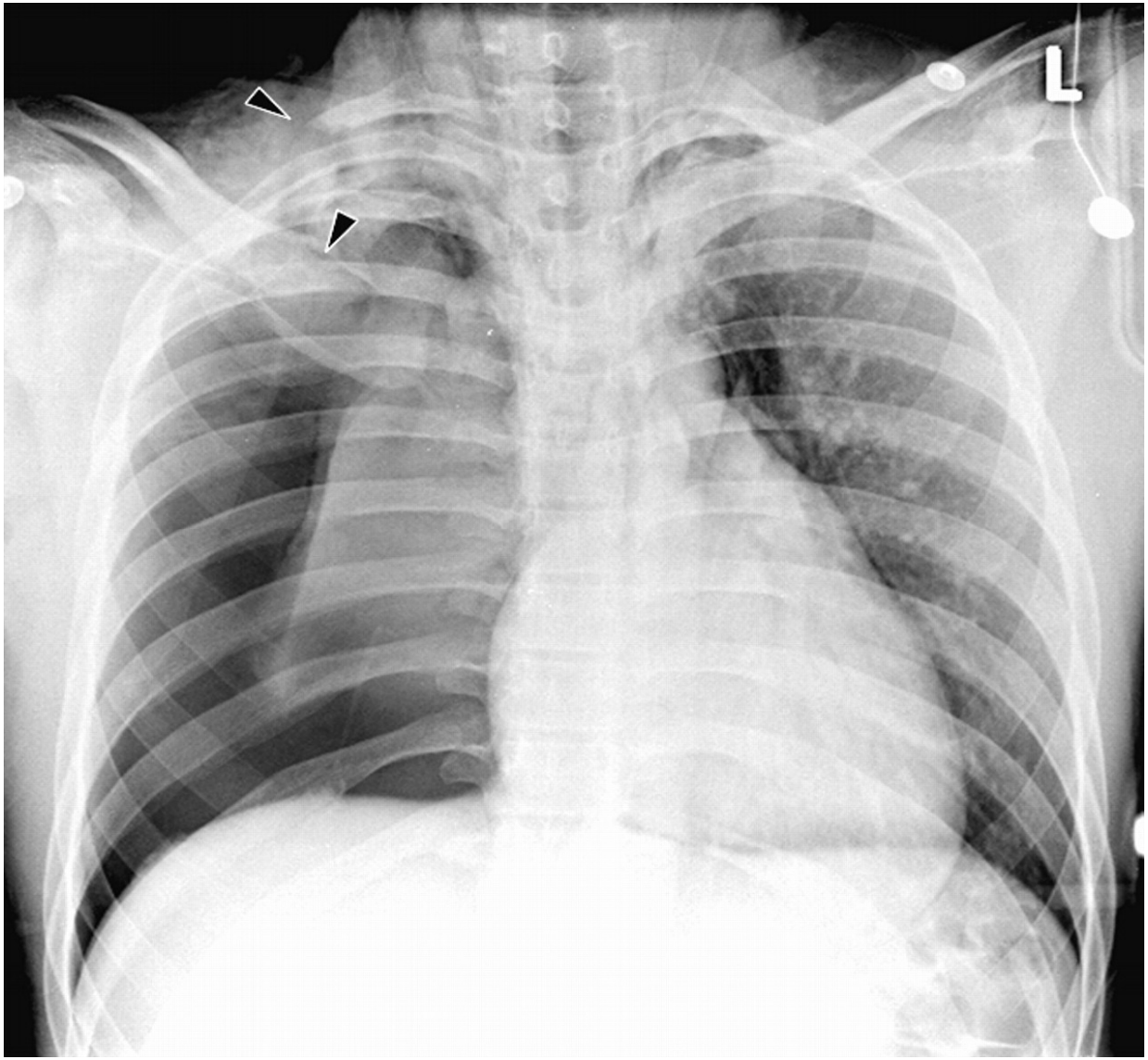


Inspiration view: No radiopaque foreign body. Slight hyperinflation/hyperlucency of left lung



Expiration view: Persistent hyperinflation of left lung secondary to outflow obstruction. Physiologic volume loss in right lung secondary to expiration.

Source: M.J.Julius, M.D.



Pneumothorax

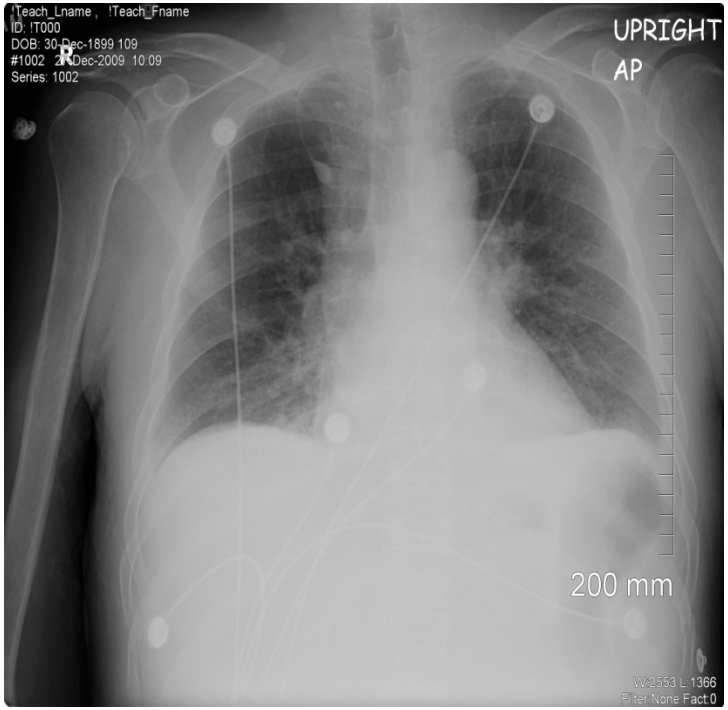
Source: Approved on-line images (Access medicine, Web MD, et al)

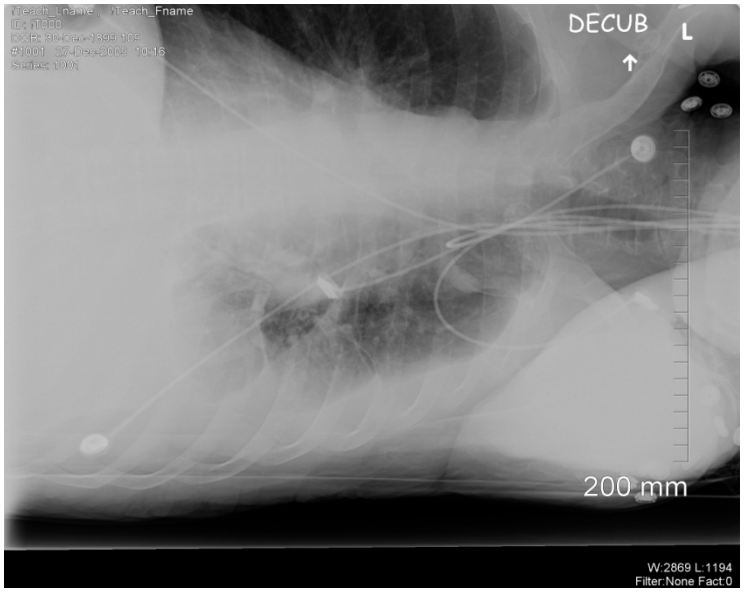
Chest Imaging Overview

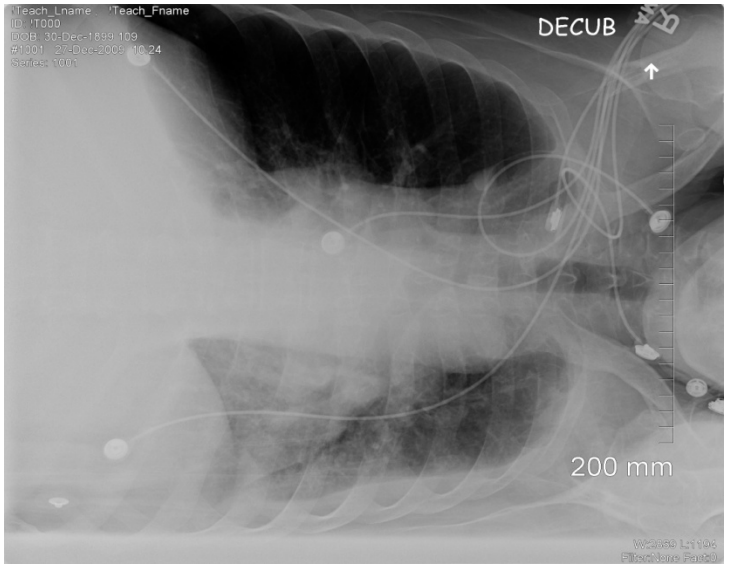
- Decubitus imaging
  - Pt is placed on their side (I.e. “left-side down” or “right-side down” decubitus views) and imaged anterior-to-posterior
    - Free-flowing pleural fluid moves along dependent portion of the thorax
    - On non-dependent side, free fluid migrates to the mediastinal margin
    - Loculated fluid is immobile

Chest Imaging Overview

- Decubitus Imaging (continued)
  - Small pneumothoraces may be visualized in non-dependent hemithorax on decubitus imaging [in Pts who cannot cooperate with inspiration/expiration imaging(I.e. pediatric Pt)]
  - Air-trapping (I.e. foreign body) may be assess with decubitus imaging [in Pts who cannot cooperate with inspiration/expiration imaging (I.e. pediatric Pt)]







Pleural effusion

Source: M J Julius, M.D.

Chest Imaging Overview

- Chest fluoroscopy
  - Assess diaphragmatic excursion
  - "Sniff test'
    - Rapid respiratory manuever
    - Paralyzed diaphragm leaflet paradoxically moves upward
    - Normal diaphragm leaflet moves downward

Chest Imaging Overview

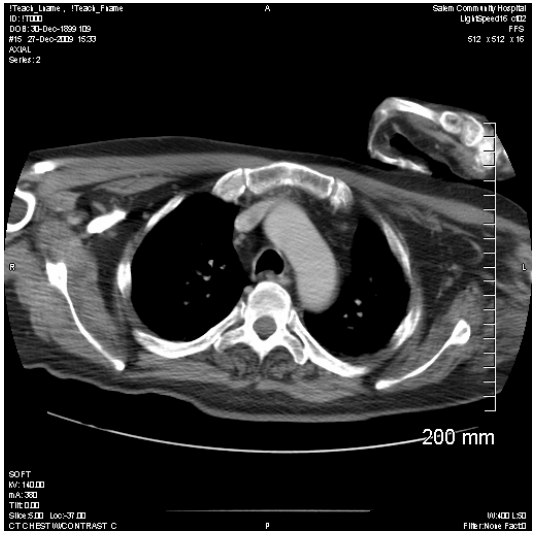
- Computerized axial tomography (CT)
  - Helical/spiral imaging (utilizing ionizing radiation) at full inspiration (single breathhold)
  - Field of view: Above thoracic inlet to below the level of the adrenal glands
  - Visualized densities are those noted with standard radiography (air>fat>water>calcium>metal), assessment of which is maximized with different computer algorithms (I.e. mediastinum, lung, bone)

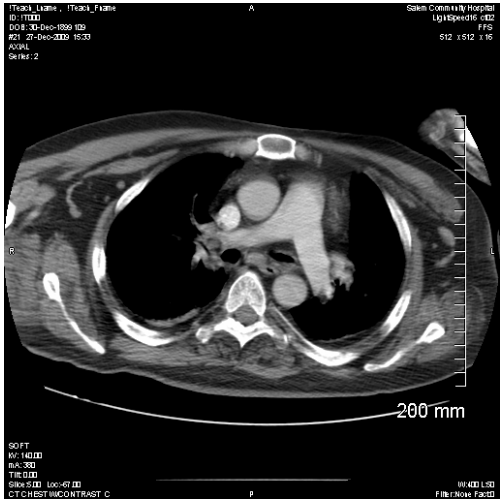
Chest Imaging Overview

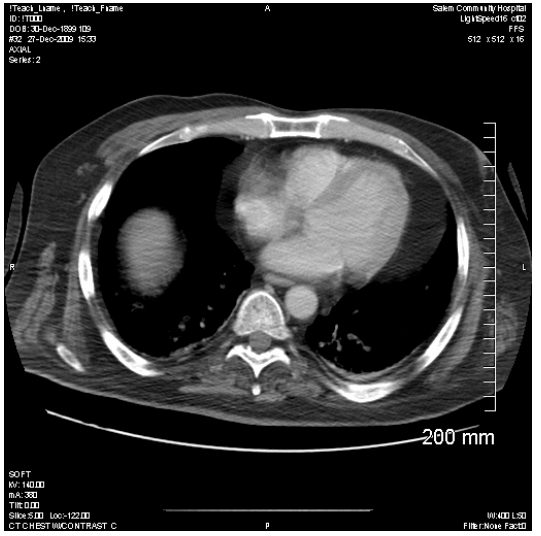
- Computerized axial tomography (CT)
  - Submillimeter imaging is possible with helical imaging
    - Useful for pulmonary nodule assessment
  - 2D reformatted images (sagittal/coronal) and 3D recontructions may be created
    - Useful for vascular assessment (pulmonary artery and thoracic aorta)
    - Useful for differentiation of vessels from small lymph nodes
  - High-resolution imaging utilizes bone algorithm and thin-section imaging (for interstitial assessment)

Chest Imaging Overview

- CT (continued)
  - Intravenous contrast is often utilized (administered by peripheral vein)
  - Rate of contrast administration differs depending on clinical indication
    - Up to 2cc/sec for standard imaging
    - 3cc/sec for CT-angiography (aorta/pulmonary artery)
    - Volume of administered contrast: 100-150 cc

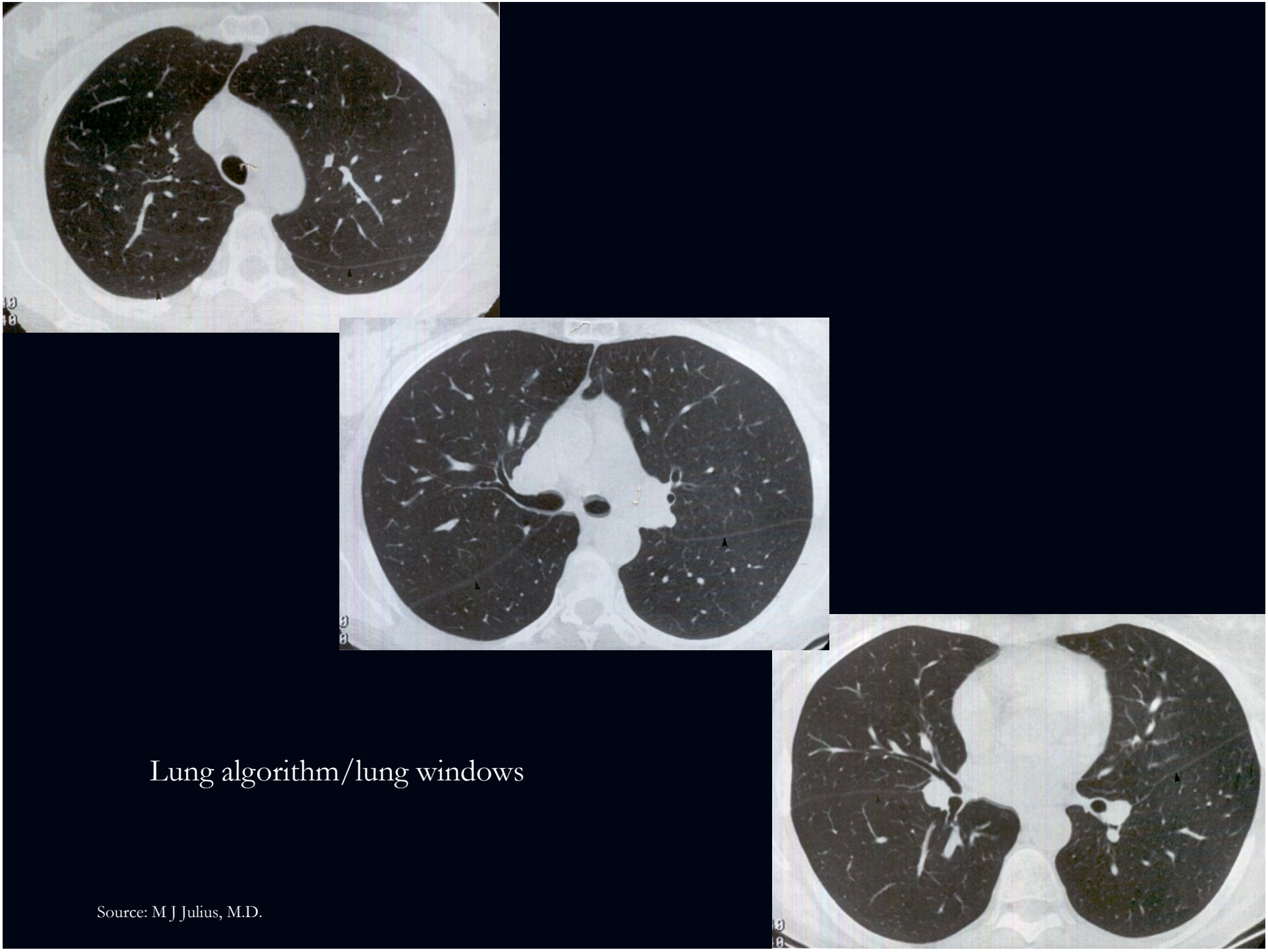






CT: Mediastinal/soft tissue algorithm

Source: M J Julius, M.D.



Lung algorithm/lung windows

Source: M J Julius, M.D.

Chest Imaging Overview

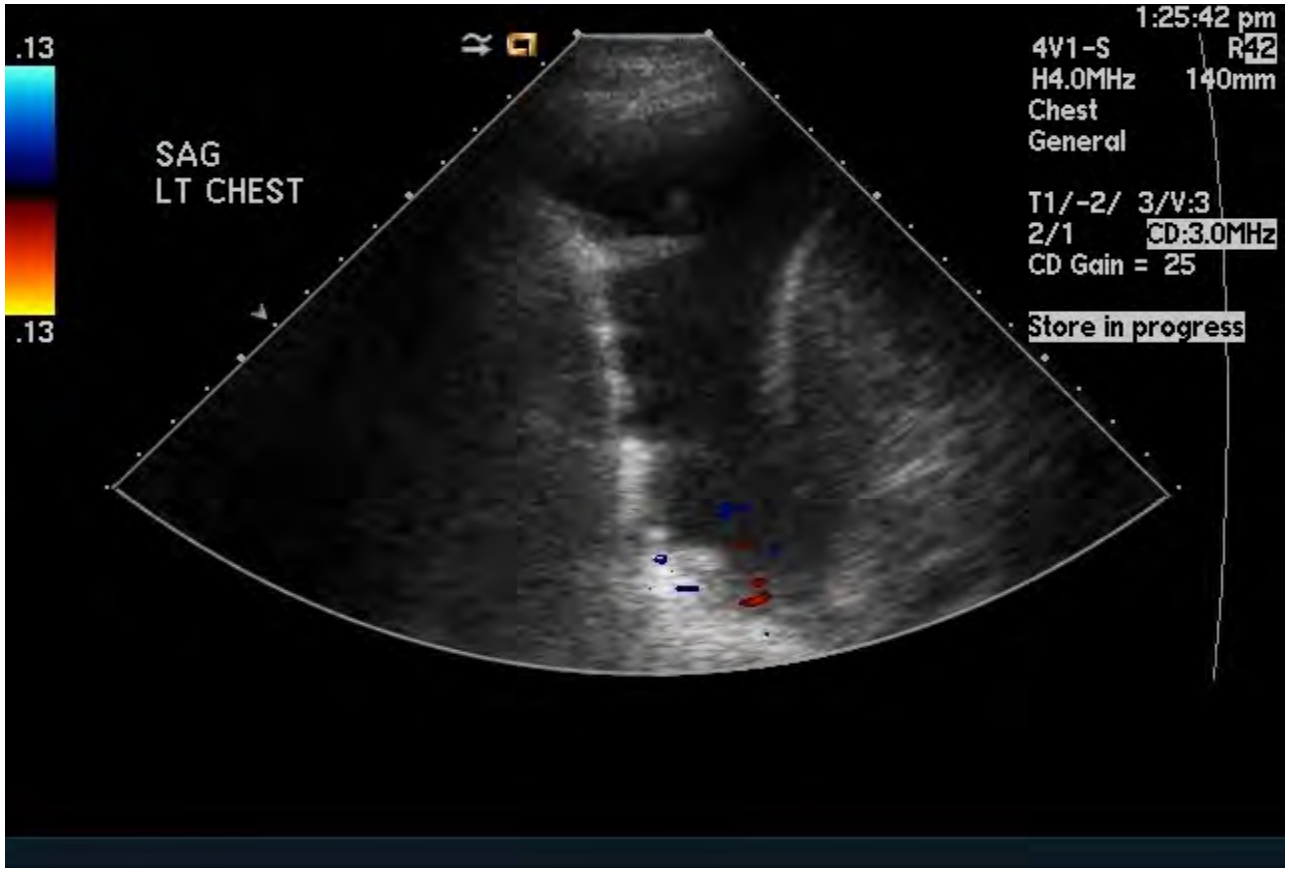
- Clinical indications for chest CT
  - Chest pain (pulmonary emboli/thoracic aortic dissection/thoracic aortic aneurysm): CT angiography (CTA)
  - Persistent cough
  - Persistent dyspnea/occupational lung disease (interstitial/infiltrative lung disease): high resolution chest CT
  - Hemoptysis

Chest Imaging Overview

- Clinical indications for chest CT (continued)
  - Characterize pleural fluid
  - Trauma
  - Solitary pulmonary nodule (SPN)
  - Assess primary/secondary neoplasia (including staging)

Chest Imaging Overview

- Sonography
  - Localization of pleural fluid for drainage (thoracentesis)
  - Lung parenchyma is not well-visualized with sonography



Sonography of pleural space

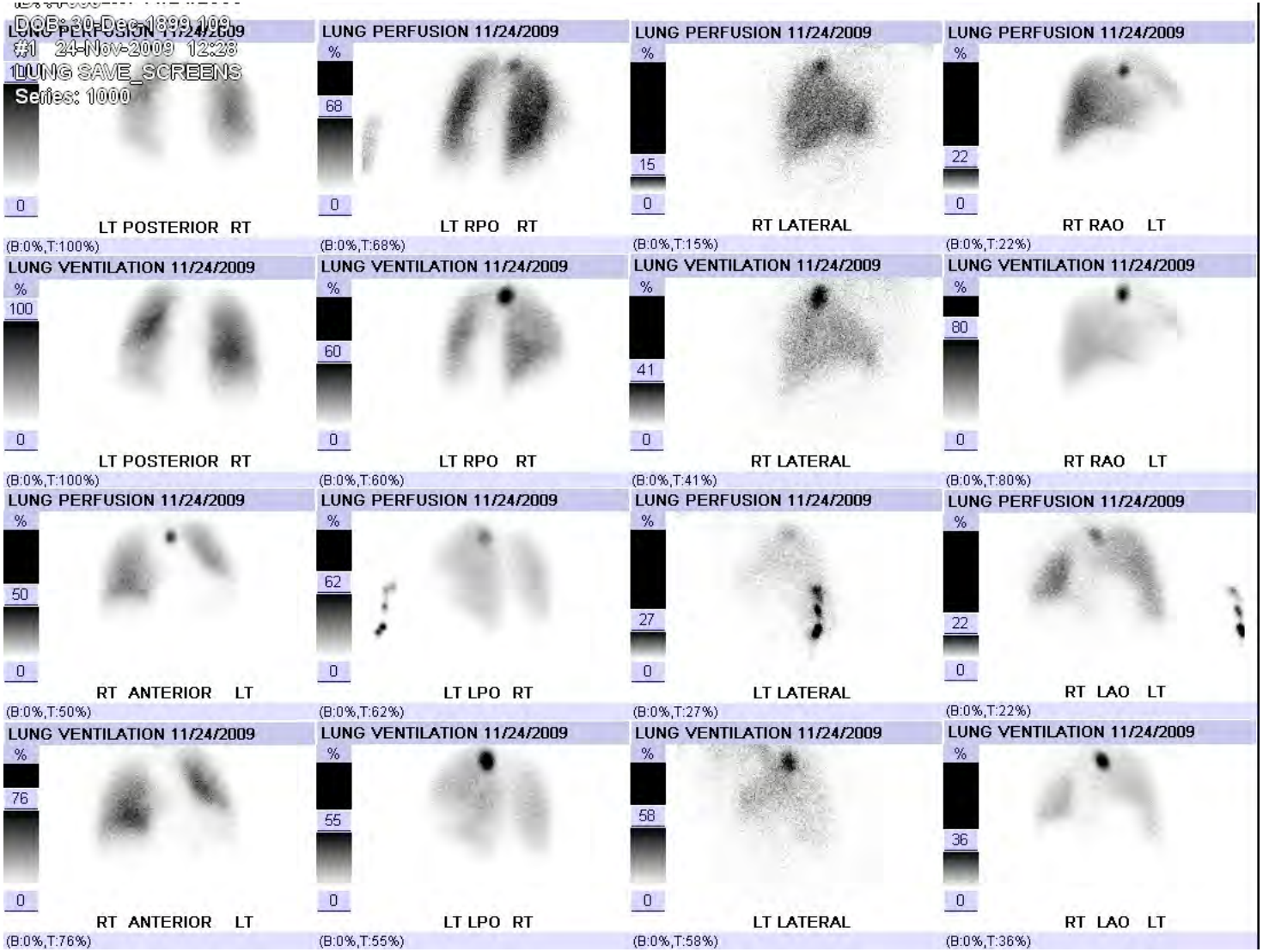
Source: M J Julius, M.D.

Chest Imaging Overview

- Nuclear medicine imaging
  - Ventilation/perfusion imaging (V/Q scan)
  - Ventilation agents: Inhaled
    - Xe133 gas
    - Tc99m DTPA aerosol
    - Utilized to functionally visualize lung parenchyma

Chest Imaging Overview

- Perfusion imaging agent: Intravenously administered
  - Tc99m macroaggregated albumin (MAA)
  - Size: 10 micrometers<X< 90 micrometers
  - Number: 200,000 to 500,000
  - Diagnostically-useful embolization



Ventilation/perfusion imaging (V/Q scan)

Source: M J Julius, M.D.

Chest Imaging Overview

- Lung lobes (RUL/RML/RLL/LUL/LLL)
- Lobes are made up of segments
- Segmental involvement is based on size
  - "small": <25% of segment volume
  - "moderate": 25%<X<75% of segment volume
  - "large": >75% of segment volume

Chest Imaging Overview

- Based on size and number of ventilation/perfusion mismatches, a probability of pulmonary embolic disease is generated
  - "mismatch" means lung parenchyma which is ventilated but does not perfuse (blocked bloodflow with maintained aeration)

Chest Imaging Overview

- Probability of pulmonary emboli
  - "Low": <10% chance of embolic disease
  - "Intermediate": 20%<X<40% chance of embolic disease
  - "High": >85% of embolic disease
  - Assumption is that embolic disease is a multifocal process
  - Pulmonary embolism does not always progress to pulmonary infarction (I.e. accessory and collateral circulation may continue to perfuse lung parenchyma, preventing its "death")

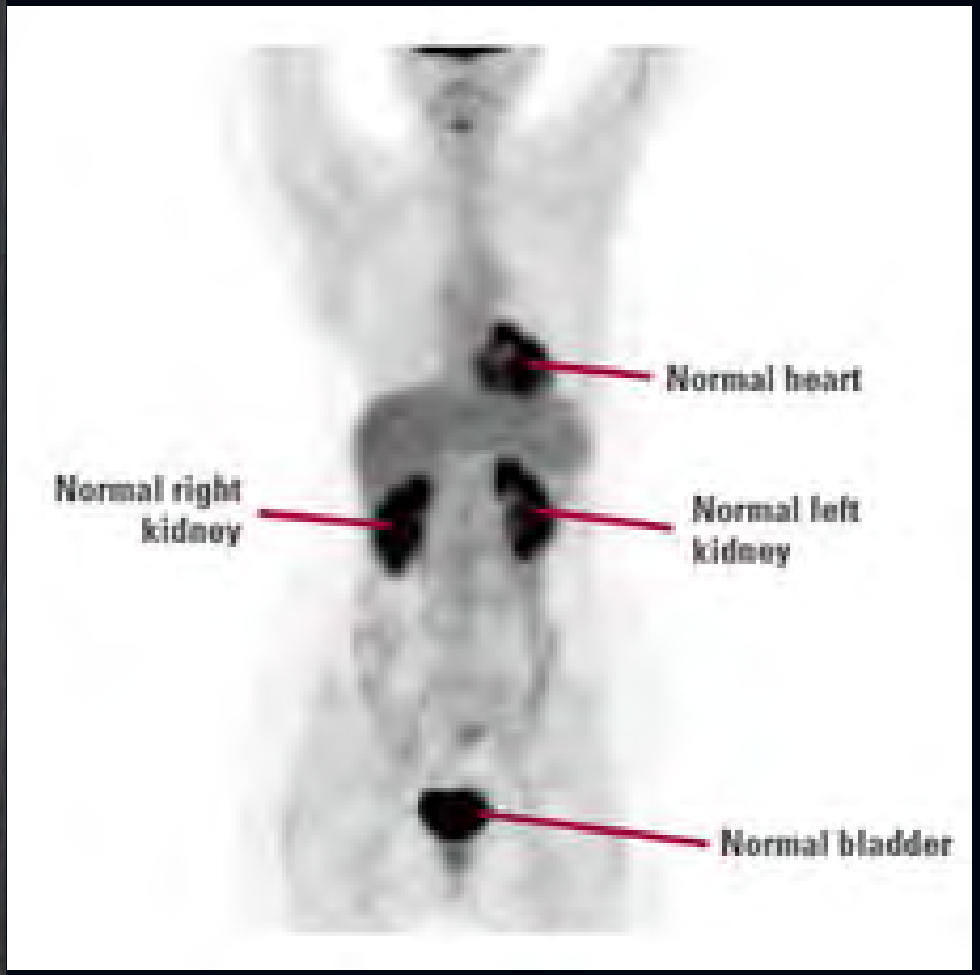
Chest Imaging Overview

- Nuclear medicine imaging
  - Lung perfusion (relative contribution of each lobe) may be assessed preoperatively
  - Lung aeration (relative contribution of each lobe) may be assessed preoperatively
  - Functionally useful modality

Chest Imaging Overview

- Positron emission tomography (PET)
  - Utilizes radiopharmaceutical (18 fluorodeoxyglucose: FDG) to assess for hypermetabolic foci
  - Useful in the assessment of solitary pulmonary nodules (SPNs)
  - Diagnosis/staging/restaging of lung neoplasia
  - Diagnosis/staging/restaging of lymphoma

Normal PET scan



Source: M J Julius, M.D.


CT
PET Attenuation Corrected
PET & CT Fusion
PET Non-Attenuation Corrected

Chest Imaging Overview

- Magnetic resonance imaging (MRI)
  - Utilizes strong magnetic field and administered radiofrequency pulses to analyze/characterize the structures of the body in health and disease
  - No ionizing radiation is used
  - (Infinite) multiplanar imaging is possible
  - Can be utilized in Pts with iodinated contrast allergy

Chest Imaging Overview

- Cannot be performed in Pts with contraindicated devices (pacemakers, neurostimulators, unapproved aneurysm clips)
- Lung parenchyma is not well-characterized
- Requires ECG and respiratory gating (to minimize artifacts)

MRI of the thorax (coronal plane)

Source: M J Julius, M.D.

Chest Imaging Overview

- Clinical indications for MRI
  - Vascular assessment (thoracic aortic aneurysm/thoracic aortic dissection) in Pts with iodinated contrast allergy
  - Assessment of superior sulcus, chest wall, brachial plexus (in Pts with neoplasia)
  - Mediastinal assessment (posterior mediastinal masses, lymphoma follow-up)

Summary

- Please correlate this lecture with your additional pulmonary-based medicine, pathology, and pharmacology lectures
- Plan to utilize this ‘Pulmonary Imaging Overview’ lecture in correlation with your ‘Pulmonary Imaging PI session’ preparatory reading (for optimal performance during your pulmonary PI session).