Basic chest X-ray interpretation

- Anton Litvin, assistant of Internal Medicine Department
- Maryna Shevchuk, associate professor of Internal Medicine Department
- Elvira Aydinova, assistant of Propaedeutics of Internal Medicine and Physical Rehabilitation Department

V. N. Karazin Kharkiv National University

Part 2

Content

- §4. CXR abnormalities
- §5. Common pathologies review
- §6. Test

§4. CXR abnormalities

- Pathologic findings on CXR

- Opacity patterns
  1. *Consolidation*
     - *Silhouette sign*
     - *Air bronchogram*
     - *Batwing sign*
  2. *Atelectasis*
  3. *Nodule or mass*
     - *Solitary nodule/mass*
       - *Nipple markings*
     - *Multiple masses*
  4. *Interstitial*
     - *Kerley lines*

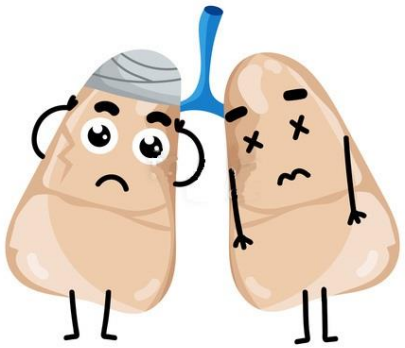
- Translucency patterns
  1. *Cavity*
  2. *Cyst*
  3. *Emphysema*

Pathologic findings on CXR

- **Lung abnormalities** are represented on CXR with:

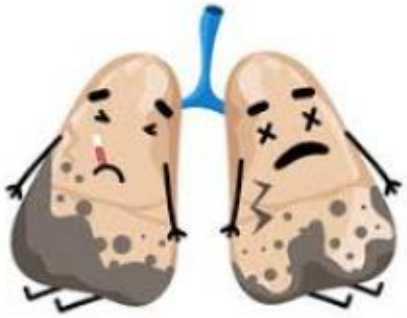
- **Areas of increased density**
  => Opacity

- **Areas of decreased density**
  => Translucency

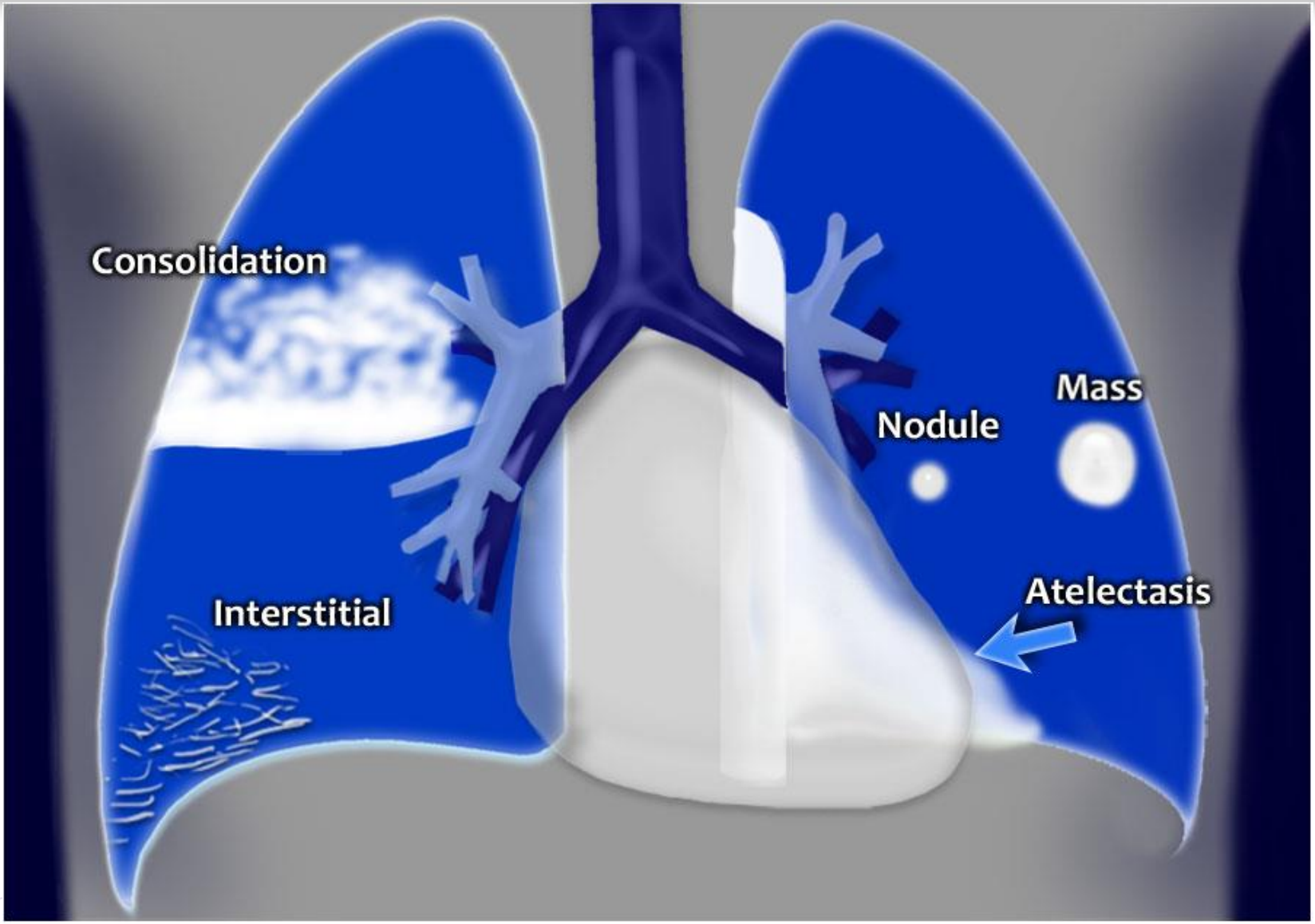


Opacity patterns

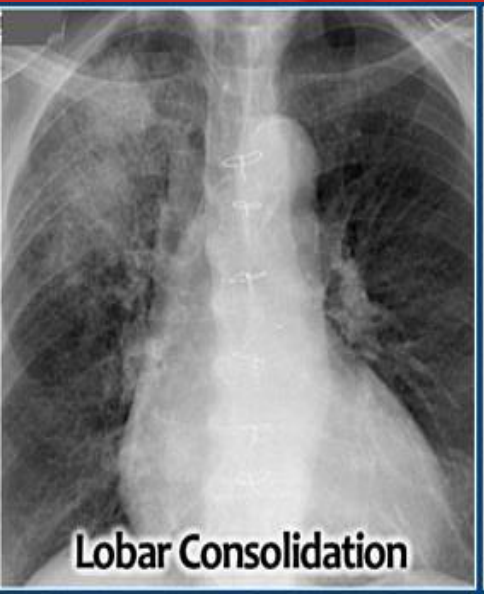
- Areas of **increased density (opacity)** are divided into the following patterns:
  - ***Consolidation***
  - ***Atelectasis***
  - ***Nodule or mass*** *(solitary or multiple)*
  - ***Interstitial***

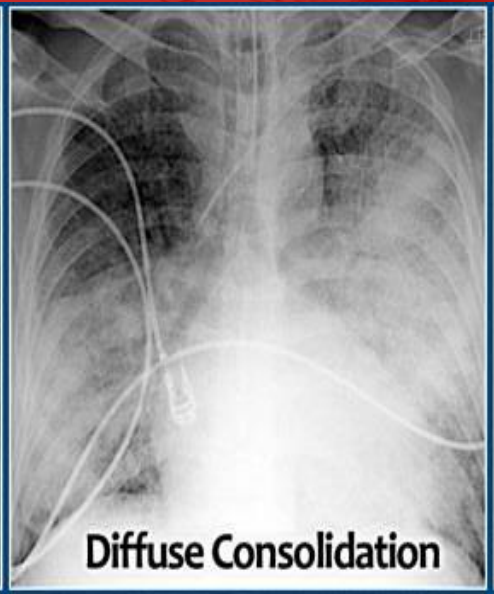


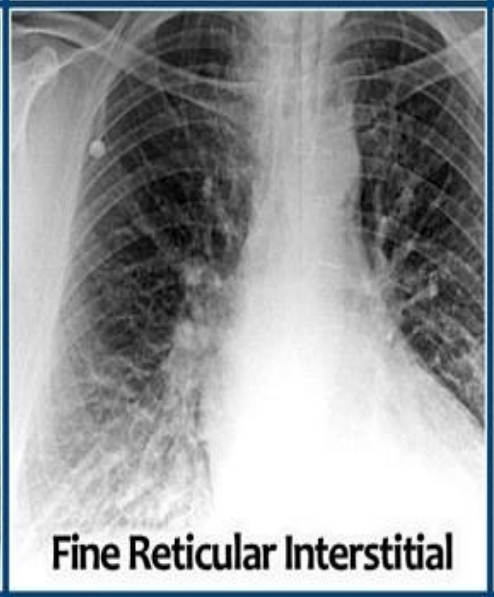
Opacity patterns



Opacity patterns

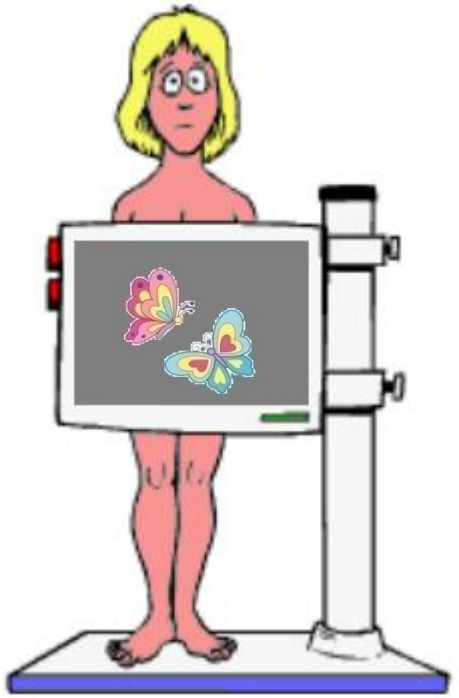






Opacity patterns

- ***Consolidation***
- ***Atelectasis***
- ***Nodule or mass***
- ***Interstitial***



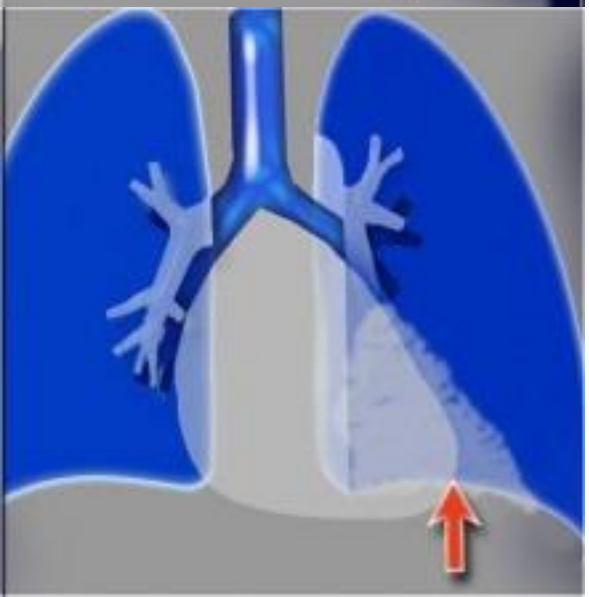
Consolidation

- **Consolidation** is the result of replacement of air in the alveoli by transudate, pus, blood, cells or other substances.
  Pneumonia is by far the most common cause of consolidation.

The key-findings on the X-ray are:

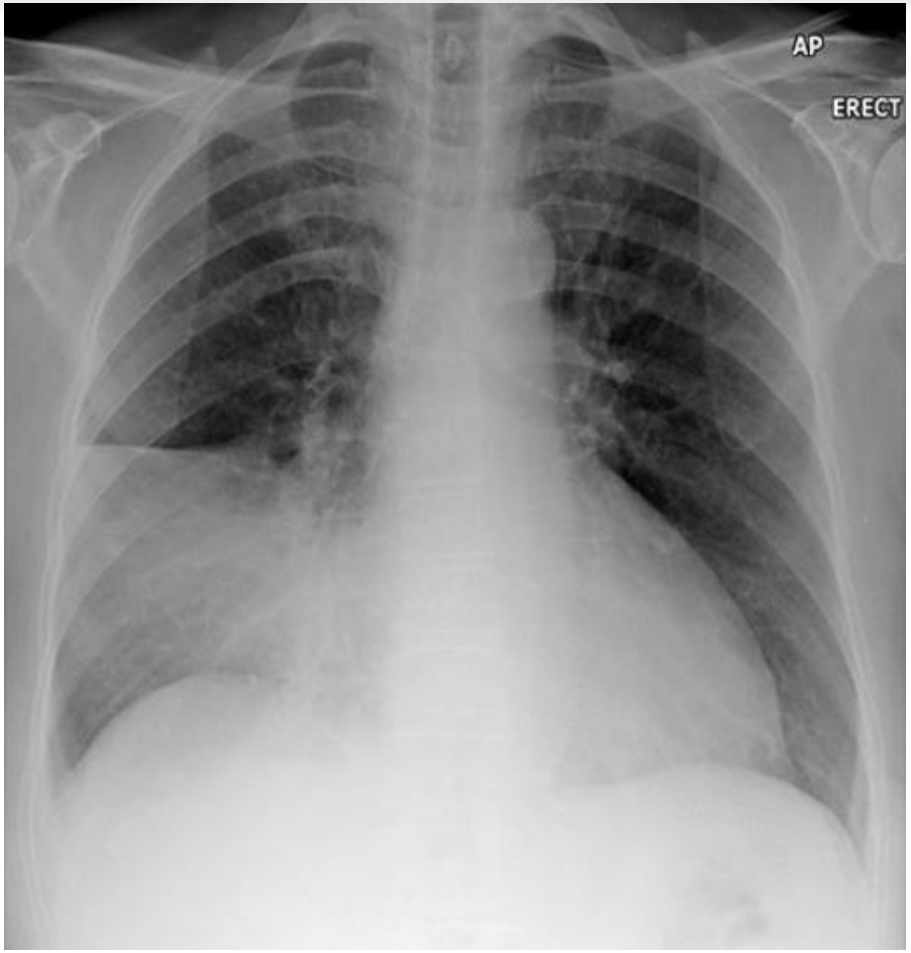
- Homogeneous ill-defined opacity obscuring vessels
- **Silhouette sign**: loss of lung/soft tissue interface
- **Air-bronchogram**
- Extention to the pleura or fissure, but not crossing it
- **No volume loss**

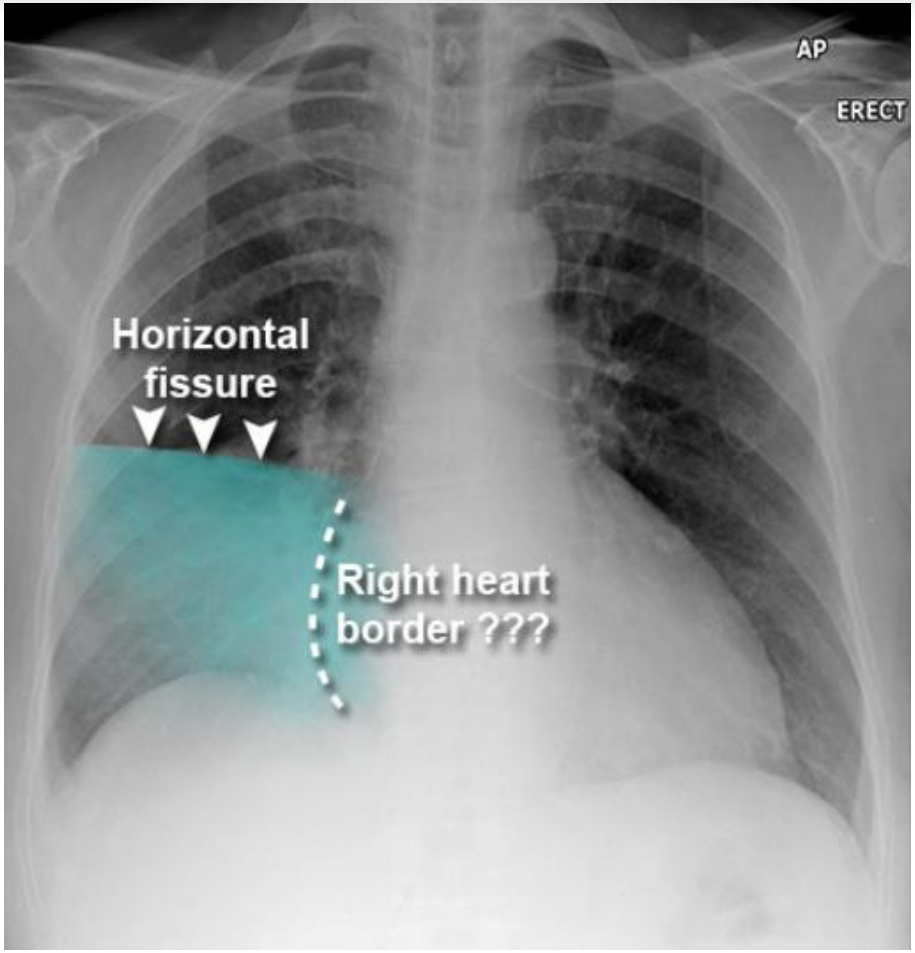
Silhouette sign



- **Silhouette sign** - the **loss** of the normal silhouette of a structure.
- The heart is located anteriorly and it is bordered by the lingula of the left lung. The difference in density between the heart and the air in the lung enables us to see the silhouette of the left ventricle. When there is something in the lingula with the same density as the heart, the normal silhouette will be lost **(blue arrow).**
- When there is a pneumonia in the left lower lobe, the left ventricle will still be bordered by air in the lingula and we will still see the silhouette of the heart **(red arrow)**.

Silhouette sign

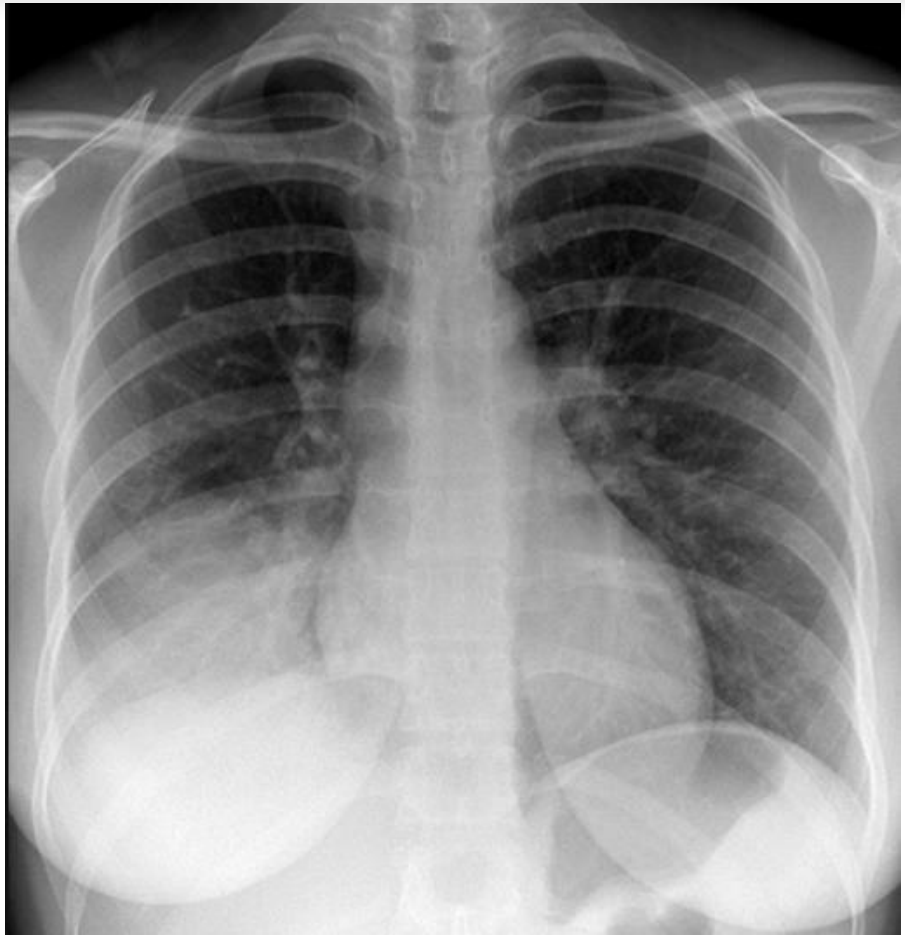


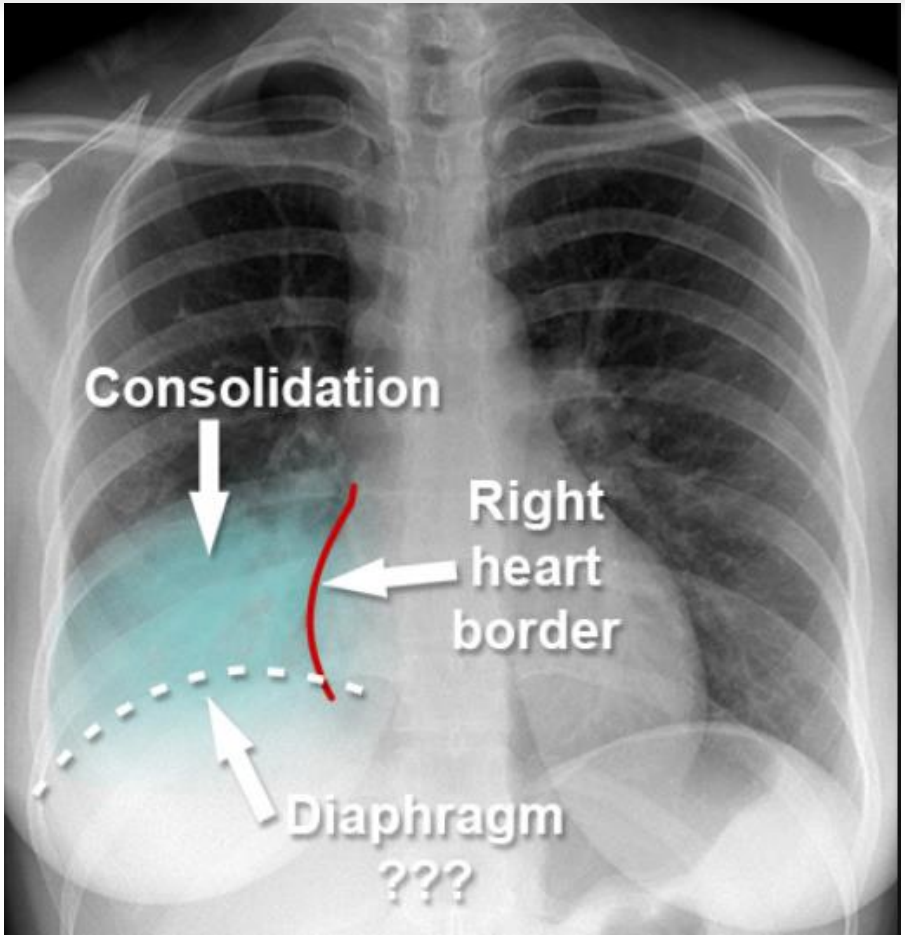


Ds: Right middle lobe opacification (RML pneumonia).

Silhouette sign – positive.

Silhouette sign





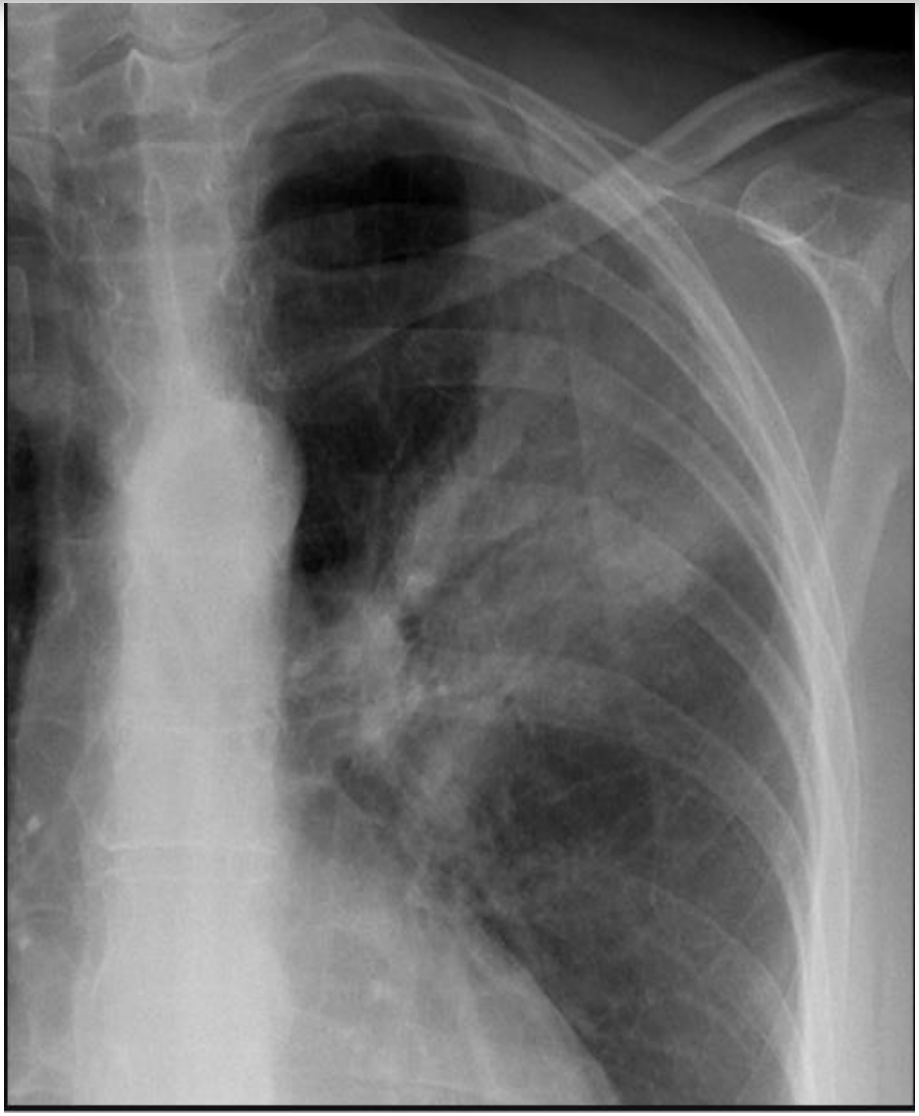
Ds: RLL pneumonia.

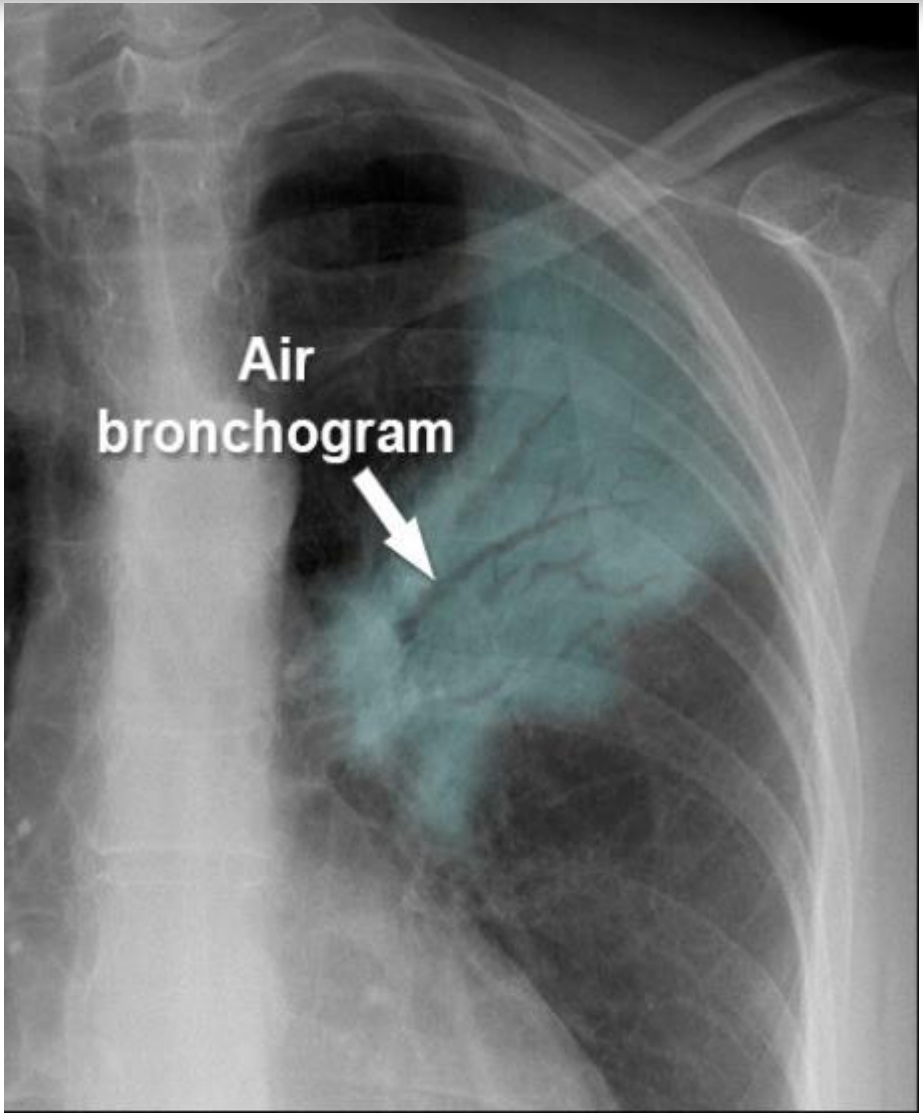
Silhouette sign – negative.

Air bronchogram

- **Air bronchogram** is a tubular outline of an airway made visible by filling of the surrounding alveoli by fluid or inflammatory exudates.
- It refers to the phenomenon of **air-filled bronchi (dark)** being made **visible by the opacification of surrounding alveoli (grey/white)**.
- It is almost always caused by a **pathologic airspace/alveolar process**, in which something other than air fills the alveoli.
- Air bronchograms **will not be visible** if the bronchi themselves are opacified.

Air bronchogram

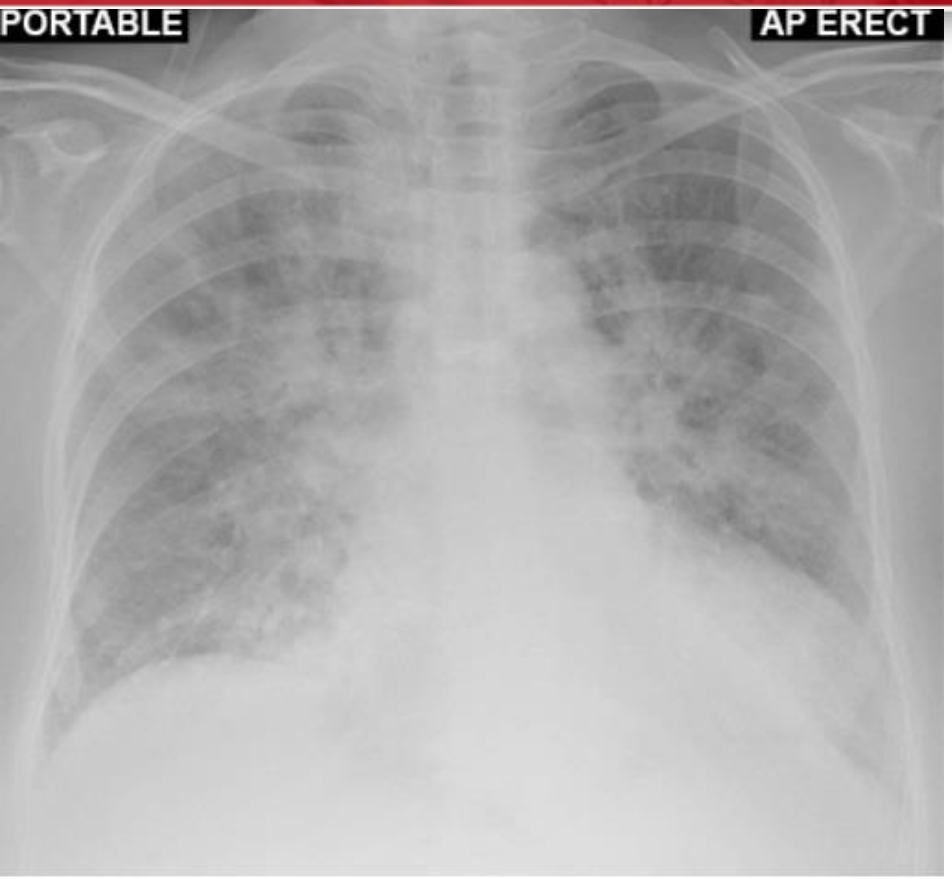


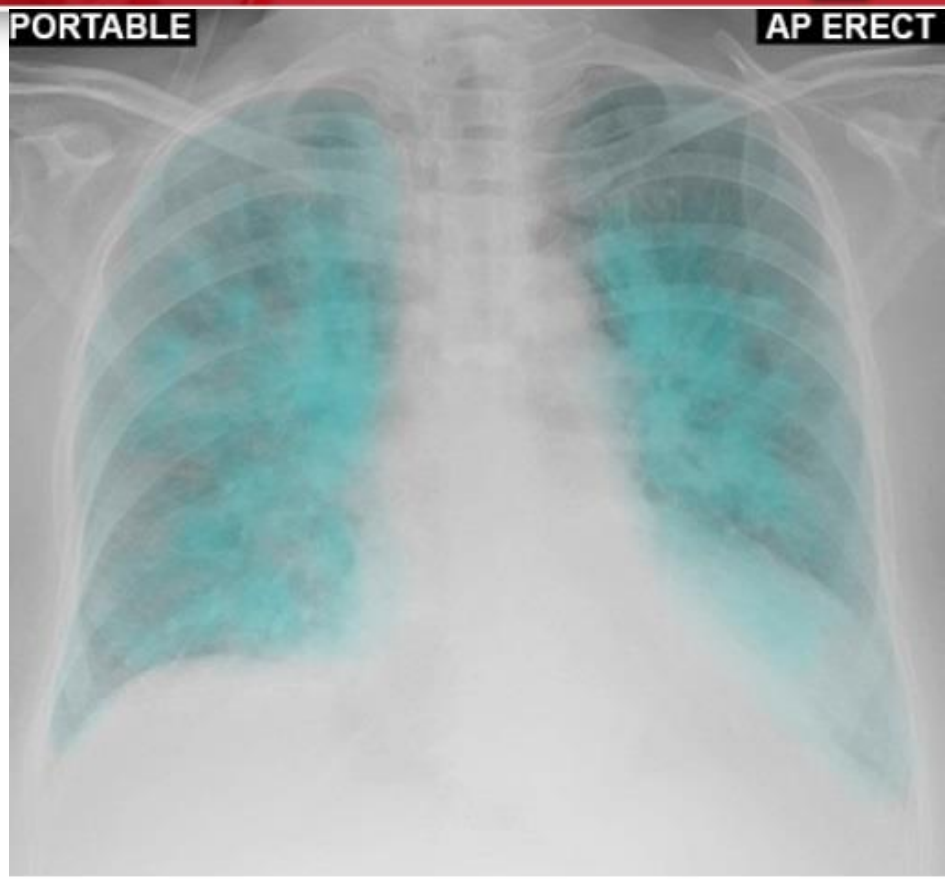


Batwing sign

- **Batwing** or **butterfly pulmonary opacities** refer to a pattern of **bilateral perihilar shadowing** on frontal CXR.
- Considered to be one of the most valuable imaging signs of **pulmonary edema**.

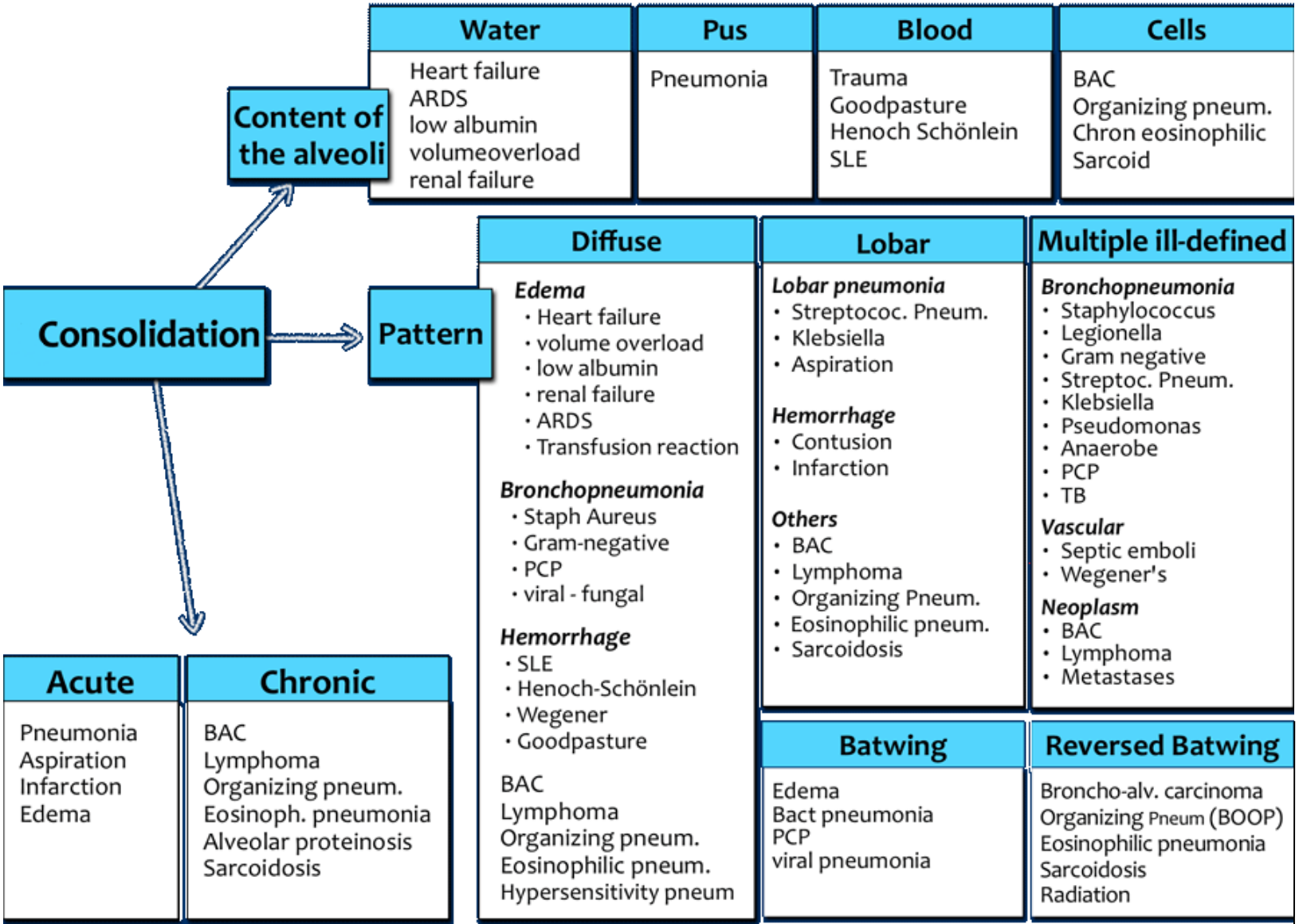
Batwing sign





Ds: Alveolar pulmonary edema (dense airspace shadowing caused by fluid filling the alveoli and small airways; batwing sign).

Consolidation diff. diagnosis



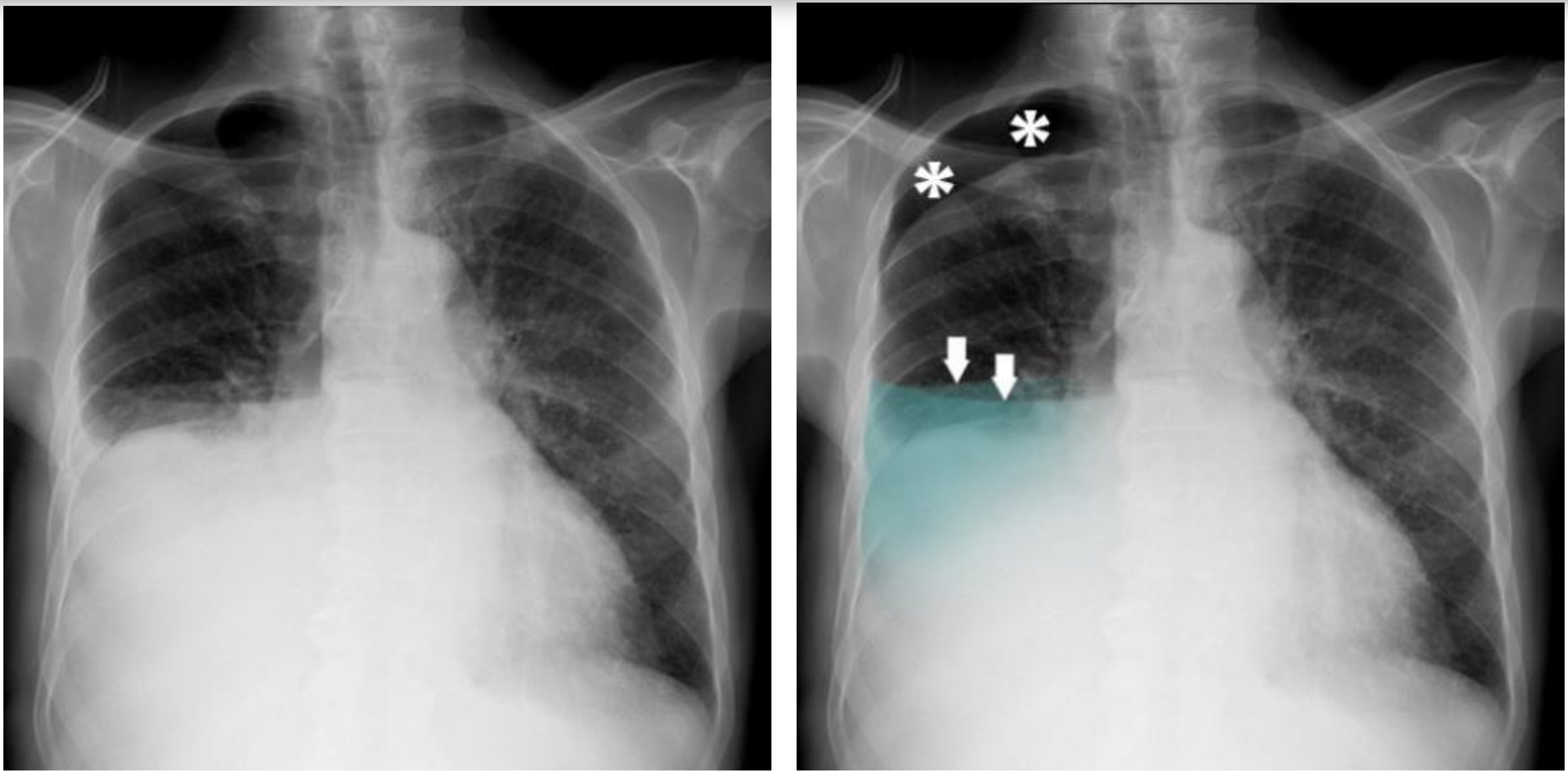
Opacity patterns

- ***Consolidation***
- ***Atelectasis***
- ***Nodule or mass***
- ***Interstitial***

Atelectasis pattern

- **Atelectasis (lung-collapse)** is the result of loss of air in a lung or part of the lung with subsequent **volume loss** due to airway obstruction or compression of the lung by pleural fluid or a pneumothorax.
- Therefore, atelectasis refers to ***pneumothorax*** and ***pleural effusion.***
- In many cases atelectasis is the first sign of a ***lung cancer*****.**
- **The key-findings on the X-ray are:**
  - Sharply-defined **opacity** obscuring vessels **without air-bronchogram.**
  - **Volume loss** resulting in **displacement** of diaphragm, fissures, hili or mediastinum.

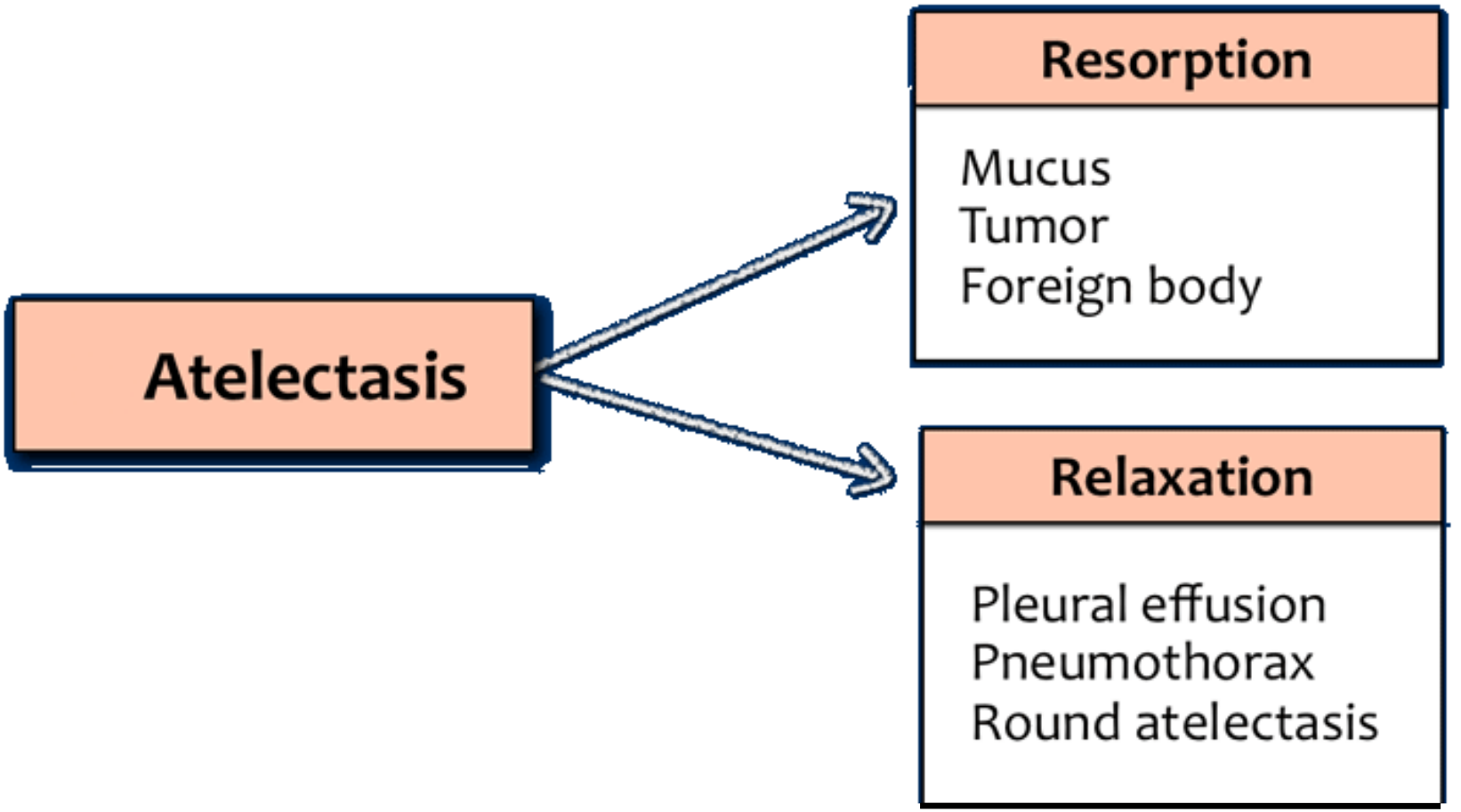
Pneumothorax & Pleural effusion (Hydropneumothorax)



•**Iatrogenic pneumotorax** – result of unsuccessful thoracocentesis (pleural aspiration) in a patient with pleural effusion.

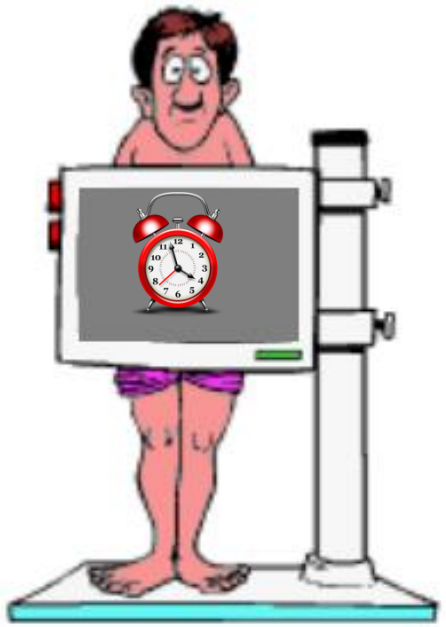
•This X-ray shows dense opacification of the right lower zone - due to consolidation and a residual **effusion** (**arrows**) - and a **pneumothorax** (**asterisks**).

Atelectasis diff. diagnosis



Opacity patterns

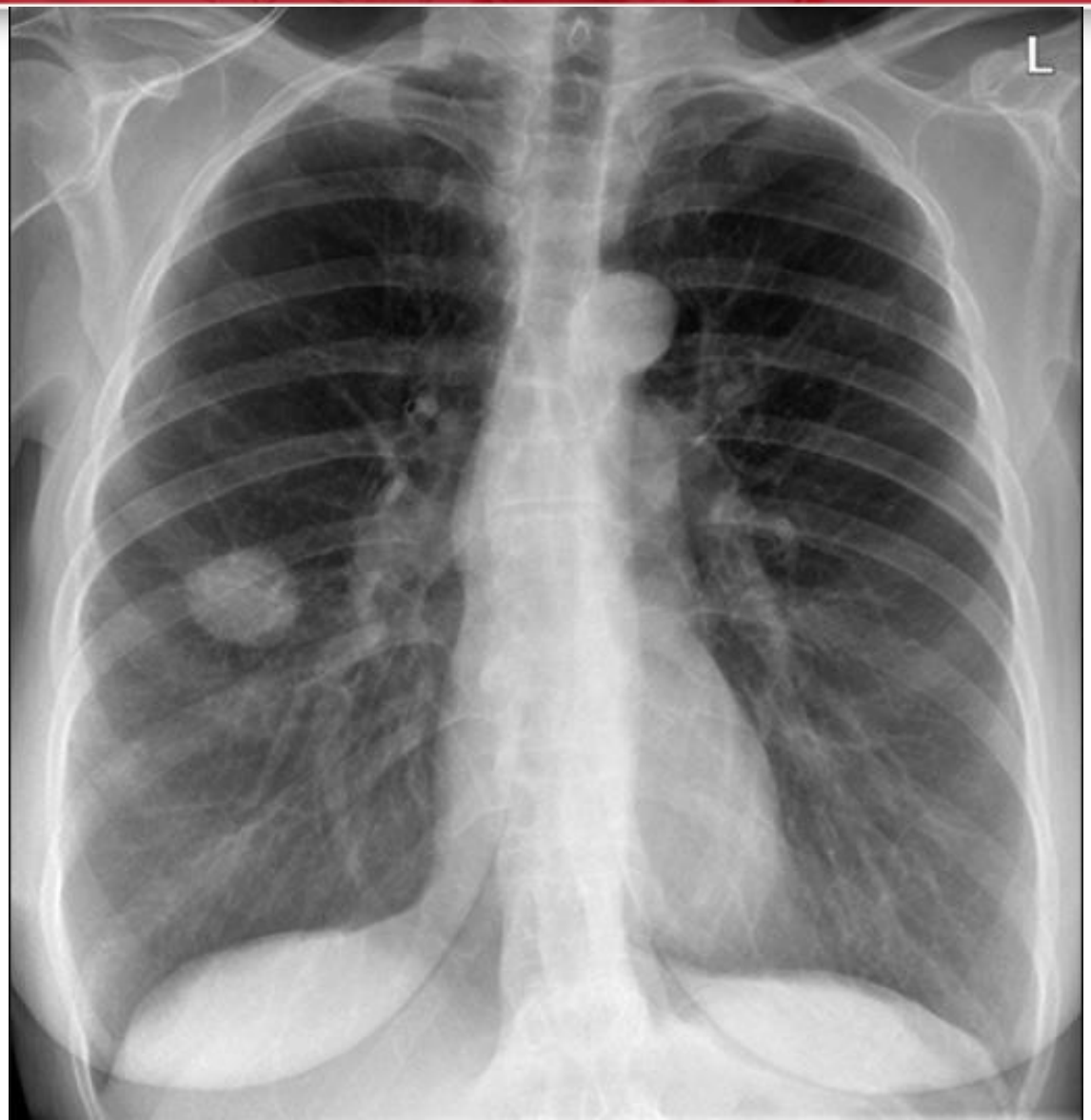
- ***Consolidation***
- ***Atelectasis***
- ***Nodule or mass***
- ***Interstitial***



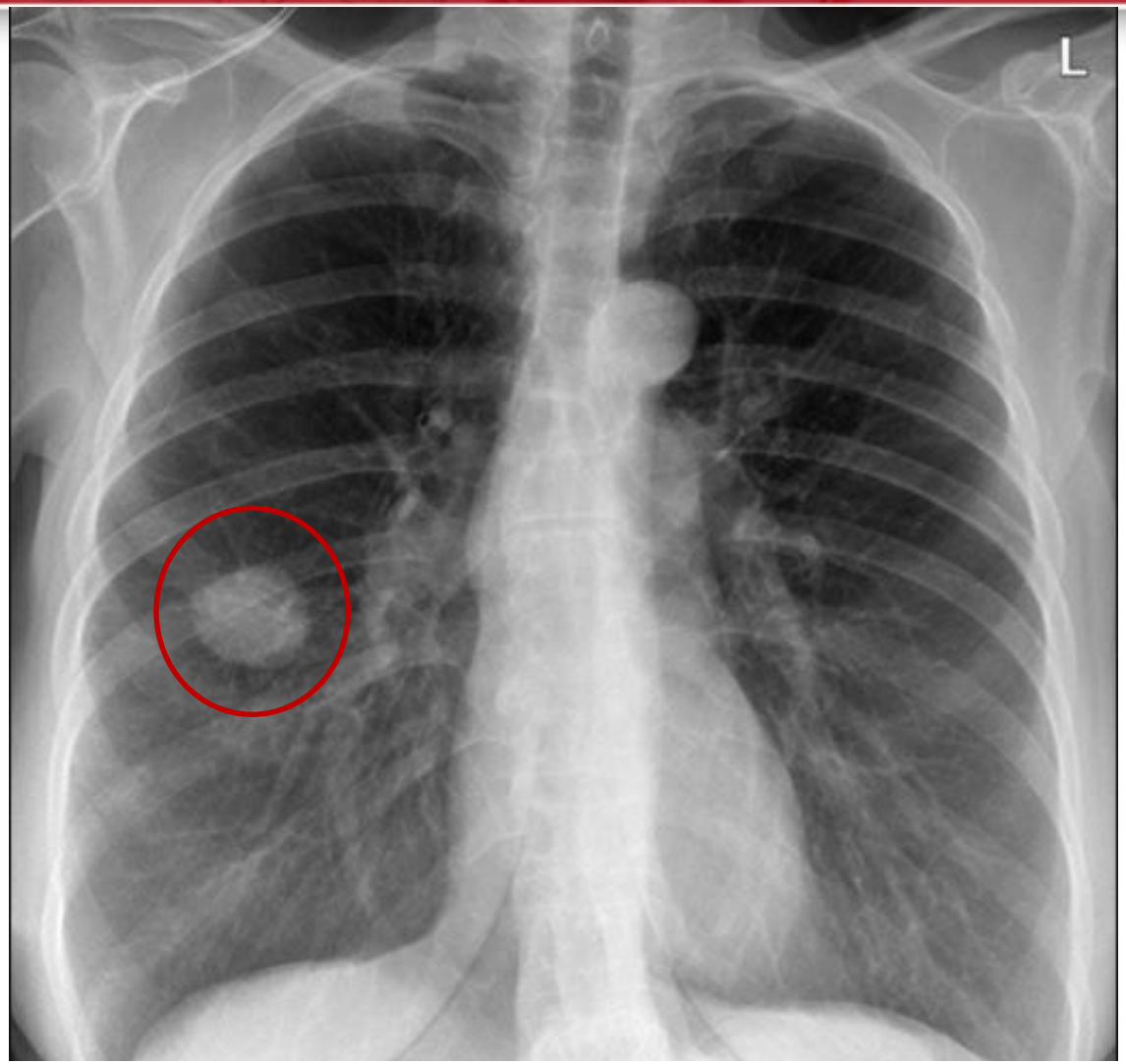
Nodule/mass pattern

- Solitary pulmonary **nodule (coin lesion)** is a discrete, well-marginated, rounded opacity ≤ 3 cm in diameter that is completely surrounded by lung parenchyma, does not touch the hilum or mediastinum, and is not associated with adenopathy, atelectasis, or pleural effusion.
- Refers to a number of pathologies, foremost – ***metastases*** and ***TB***.
- **Masses** are the lesions larger than 3 cm and they are treated as ***malignancies*** until proven otherwise.
- **Multiple masses** commonly refer to ***metastases***.

Solitary nodule/mass

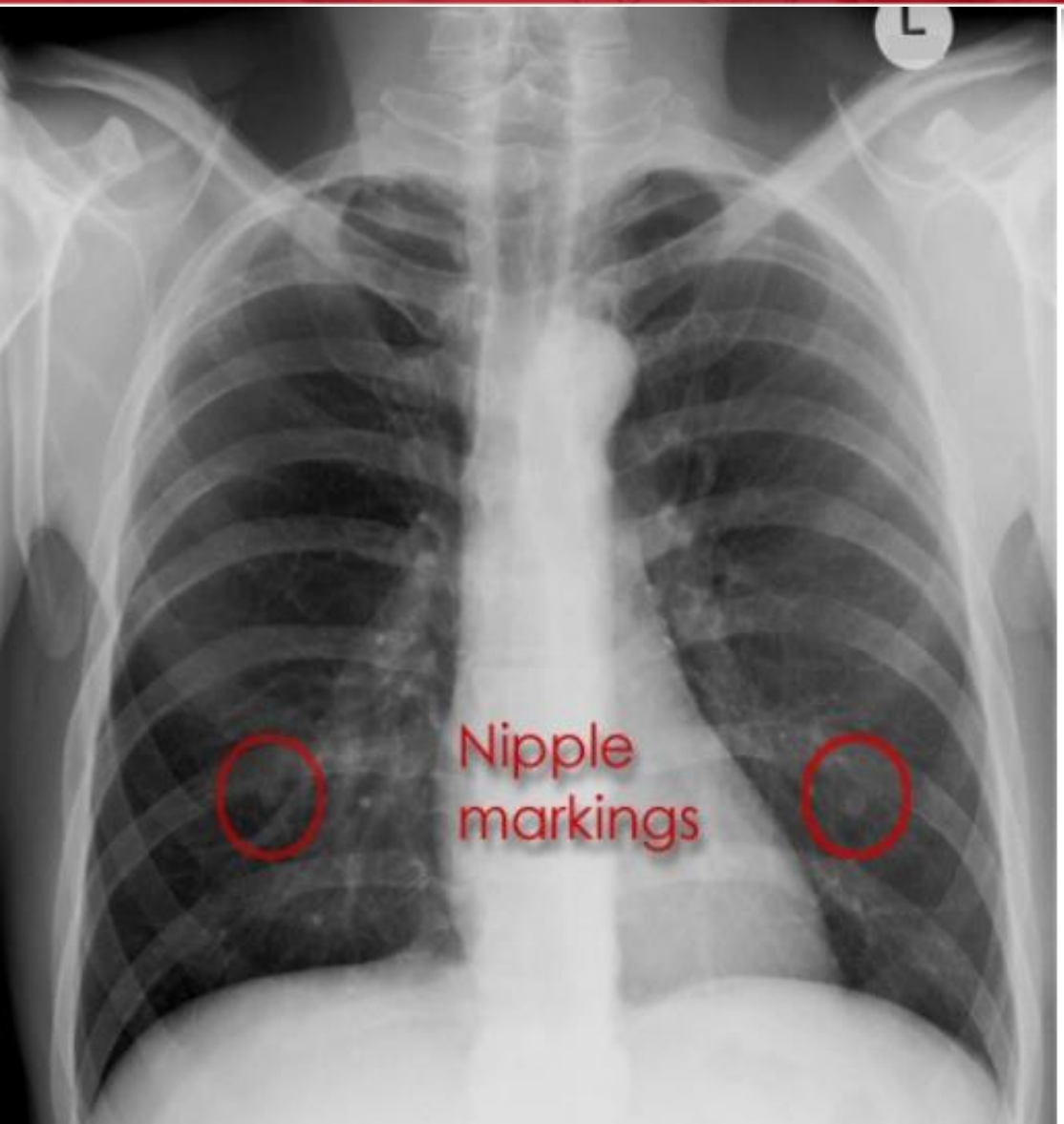


Solitary nodule/mass



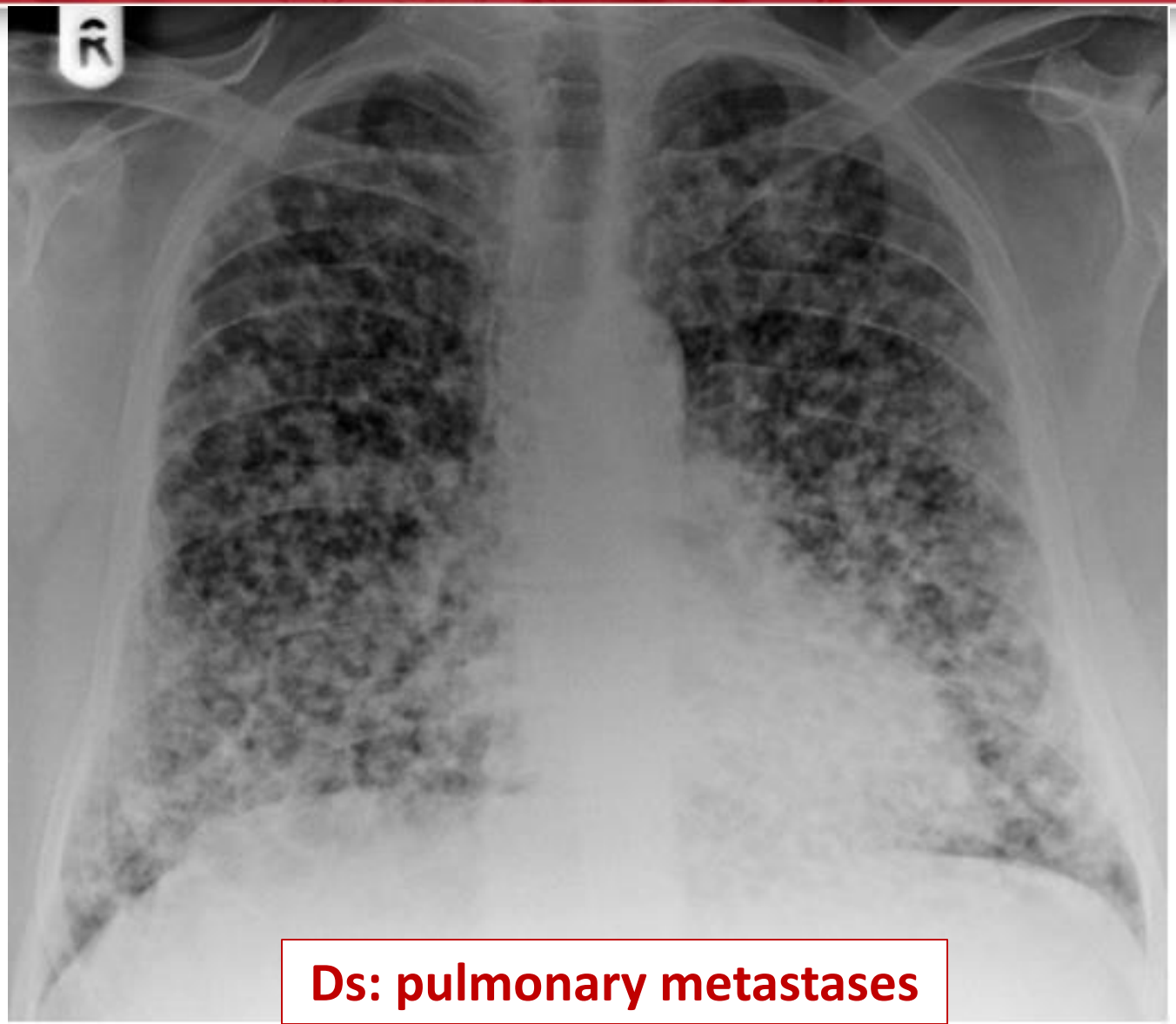
Ds: Large rounded nodule in the right mid-zone; lung cancer?

Nipple markings



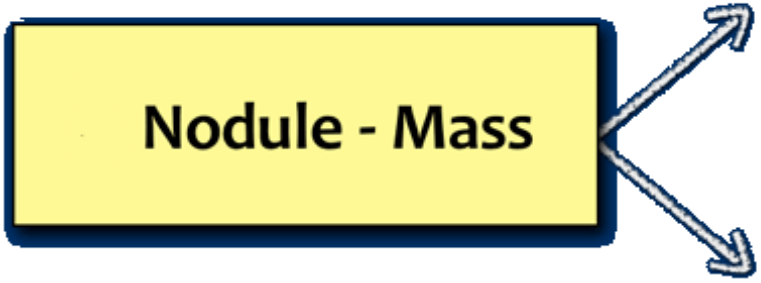
- The **nipples** are clearly seen on this CXR, but care is needed whenever there is a chance that the markings may represent underlying lung **nodules**.
- If there is any doubt then a repeat chest X-ray should be performed, with metallic markers used to indicate the position of the nipples.
- Nipples are apparent on ~7.5% of all CXRs.

Multiple masses



Ds: pulmonary metastases

Nodule/mass diff. diagnosis

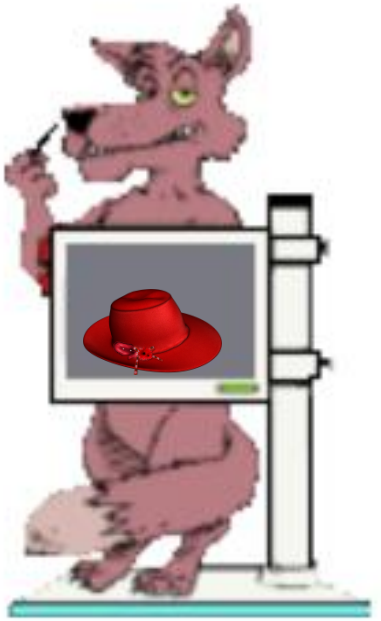


Nodule < 3cm	Mass > 3cm
Granuloma - *Fungal* - *TB* Lungca Metastasis Hamartoma	Lungca Granuloma Hamartoma

Multiple masses	
Infection: - TB - Histoplasmosis - Fungi - Sept emboli	Metastases BAC Sarcoidosis Wegener RA Rendu-Osler

Opacity patterns

- ***Consolidation***
- ***Atelectasis***
- ***Nodule or mass***
- ***Interstitial***



Interstitial pattern

- **Interstitial** lung pattern refers to subtle thin lines and small dots interspersed throughout the lungs.
- The most effective way to evaluate imaging findings in interstitial lung disease is **High Resolution Computer Tomography (HRCT)**.
- On **HRCT** there are four patterns:
  - Reticular
  - Nodular
  - High and low attenuation

On a **CXR** the most common pattern is **reticular**, while the others can be hardly determined.

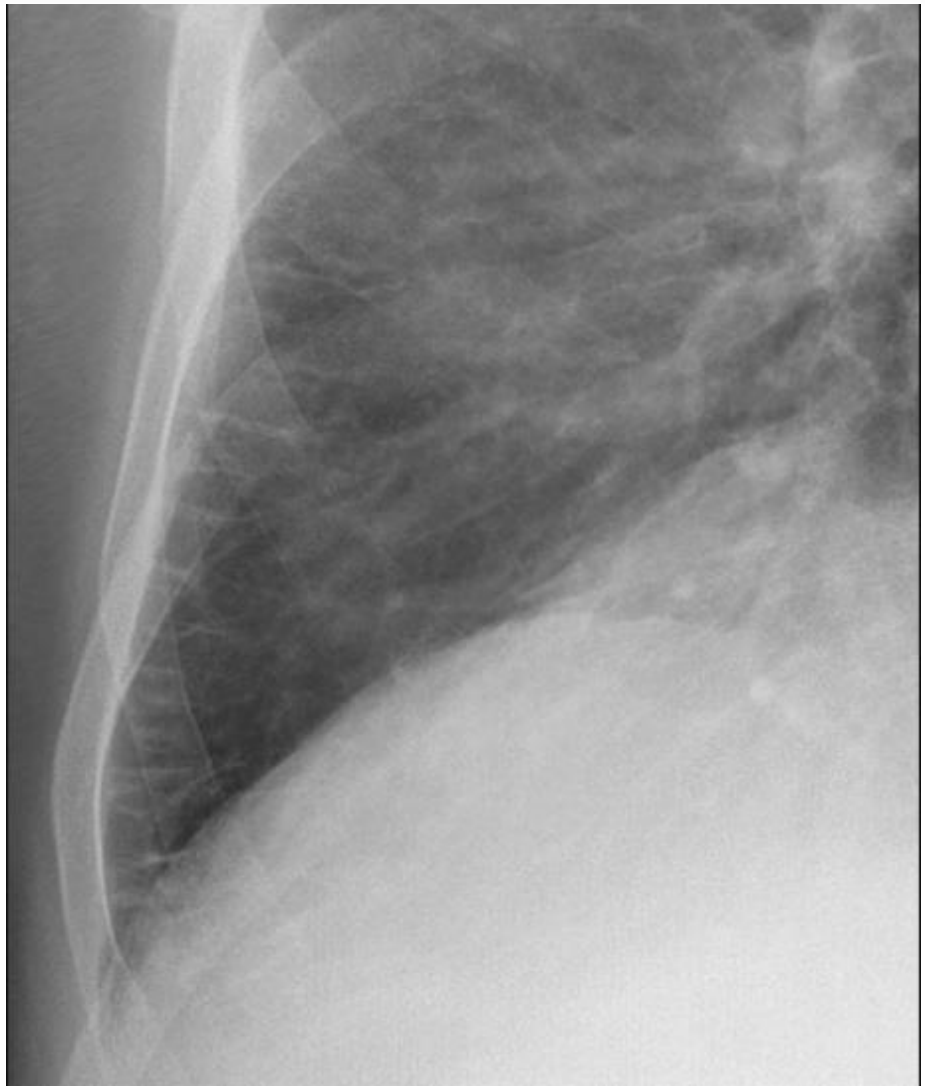
Reticular pattern (Kerley lines)

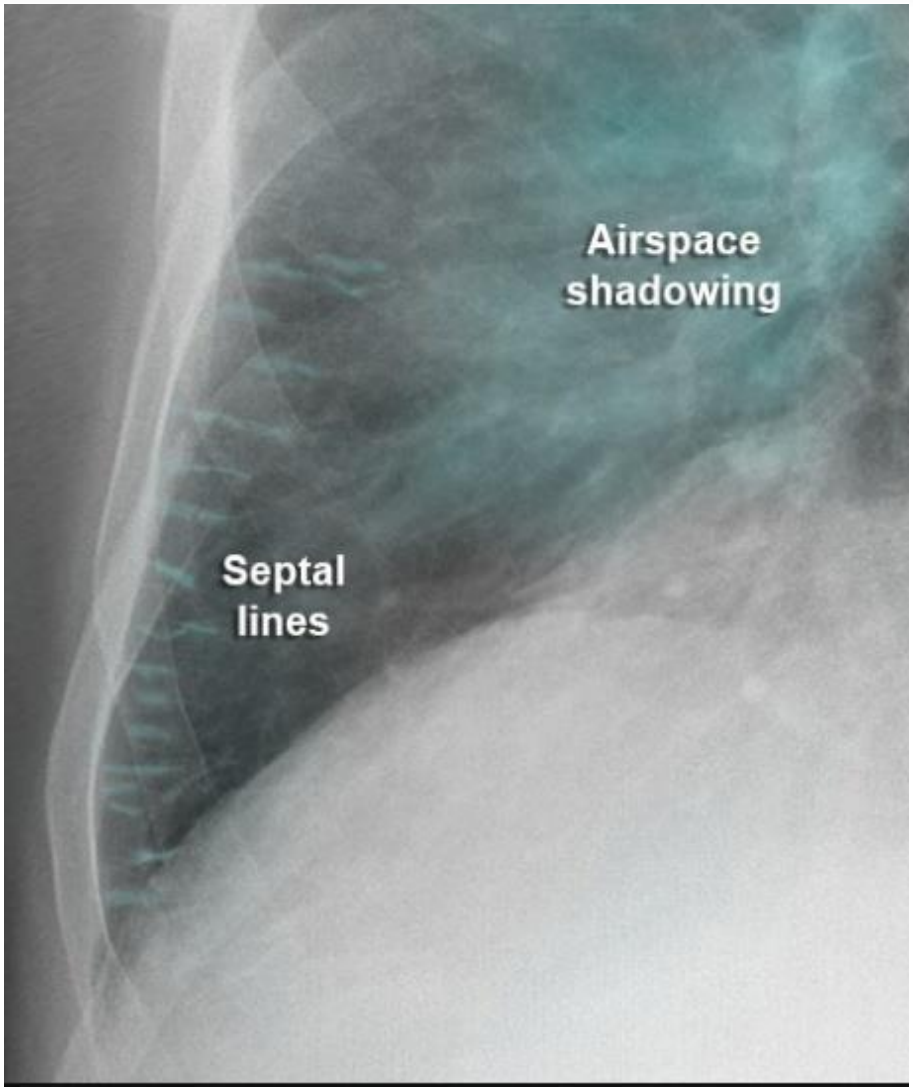
- **Reticular interstitial pattern** is represented on CXR with **Kerley lines (septal lines).**
- **Kerley lines (septal lines)** are thin linear pulmonary opacities caused by fluid or cellular infiltration into the interstitium of the lungs.
- A valuable sign of many pulmonary pathologies, first and foremost – ***pulmonary edema*** and ***pulmonary fibrosis***.

Reticular pattern (Kerley lines)

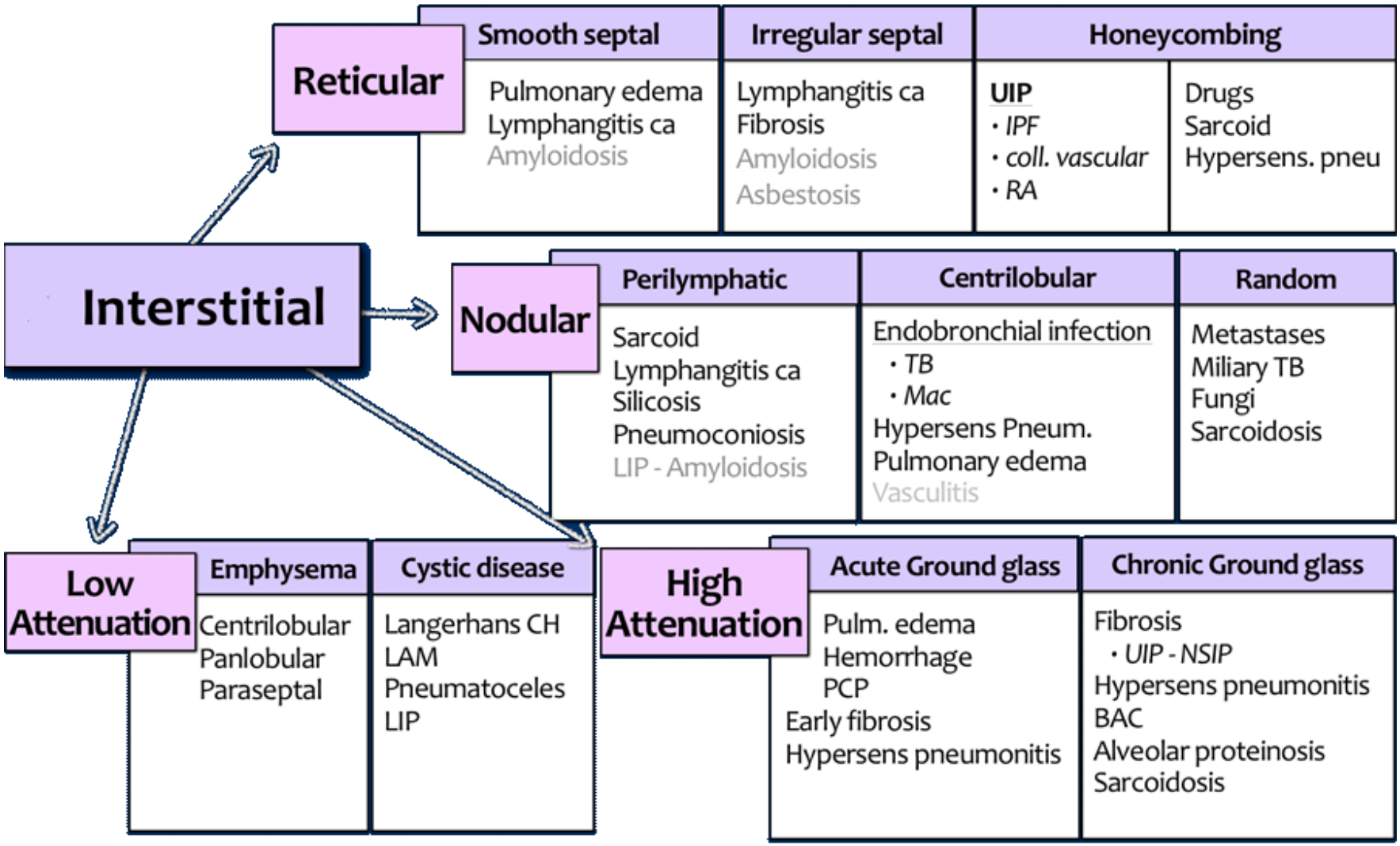
- There are **3 types** of **Kerley lines (septal lines)**:
  - Kerley A lines are long (2-6cm) unbranching lines coursing diagonally from the hila out to the periphery of the lungs. Kerley A lines are never seen without Kerley B or C lines .
  - Kerley B lines are short parallel lines at the lung periphery. Most common causes are ***pulmonary edema*** and ***interstitial pulmonary fibrosis***; ***most commonly seen***.
  - Kerley C lines are short, fine lines throughout the lungs; least commonly seen.

Kerley B lines





Interstitial diff. diagnosis



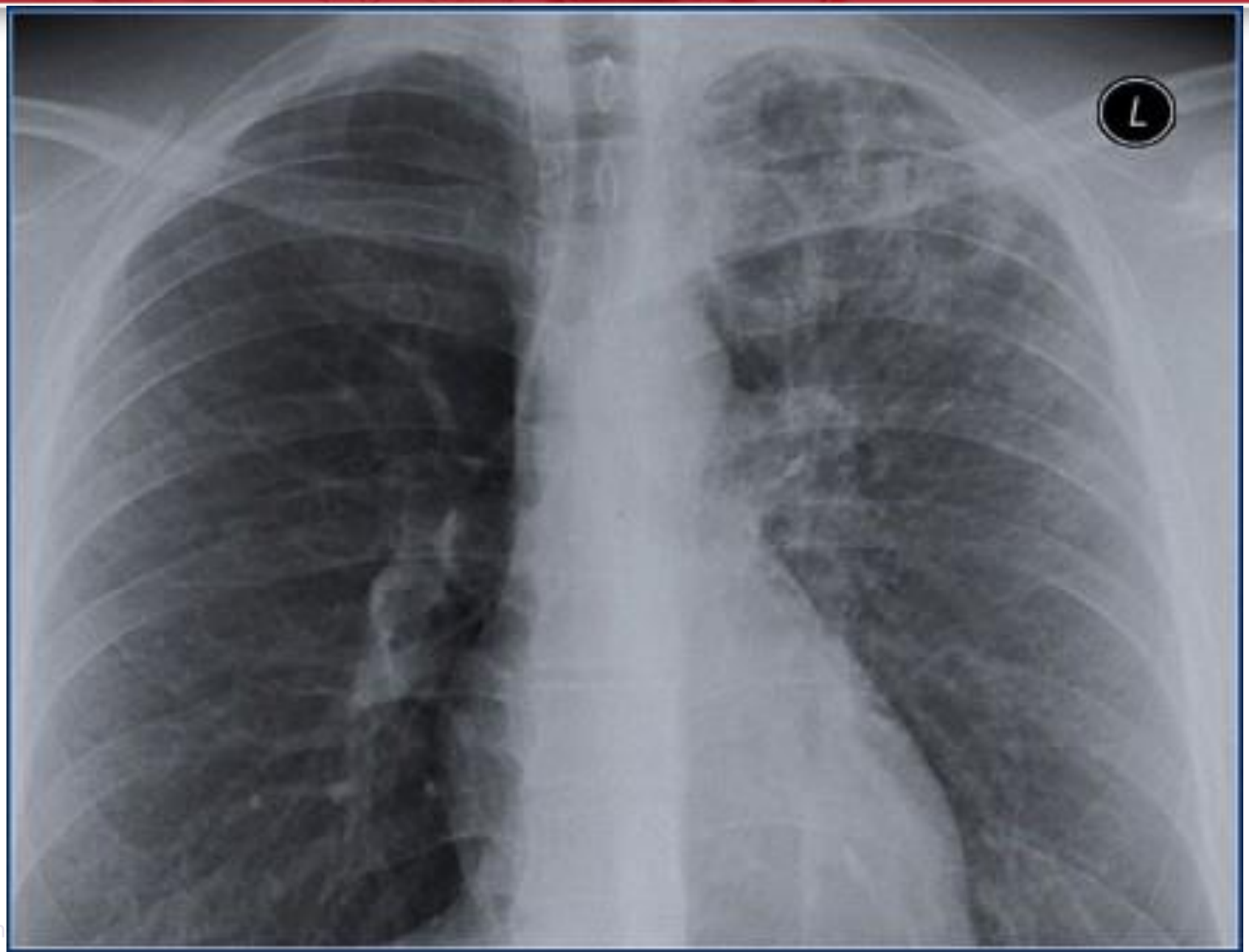
Translucency patterns

- Areas of **decreased density (lucency/translucency)** are described as:

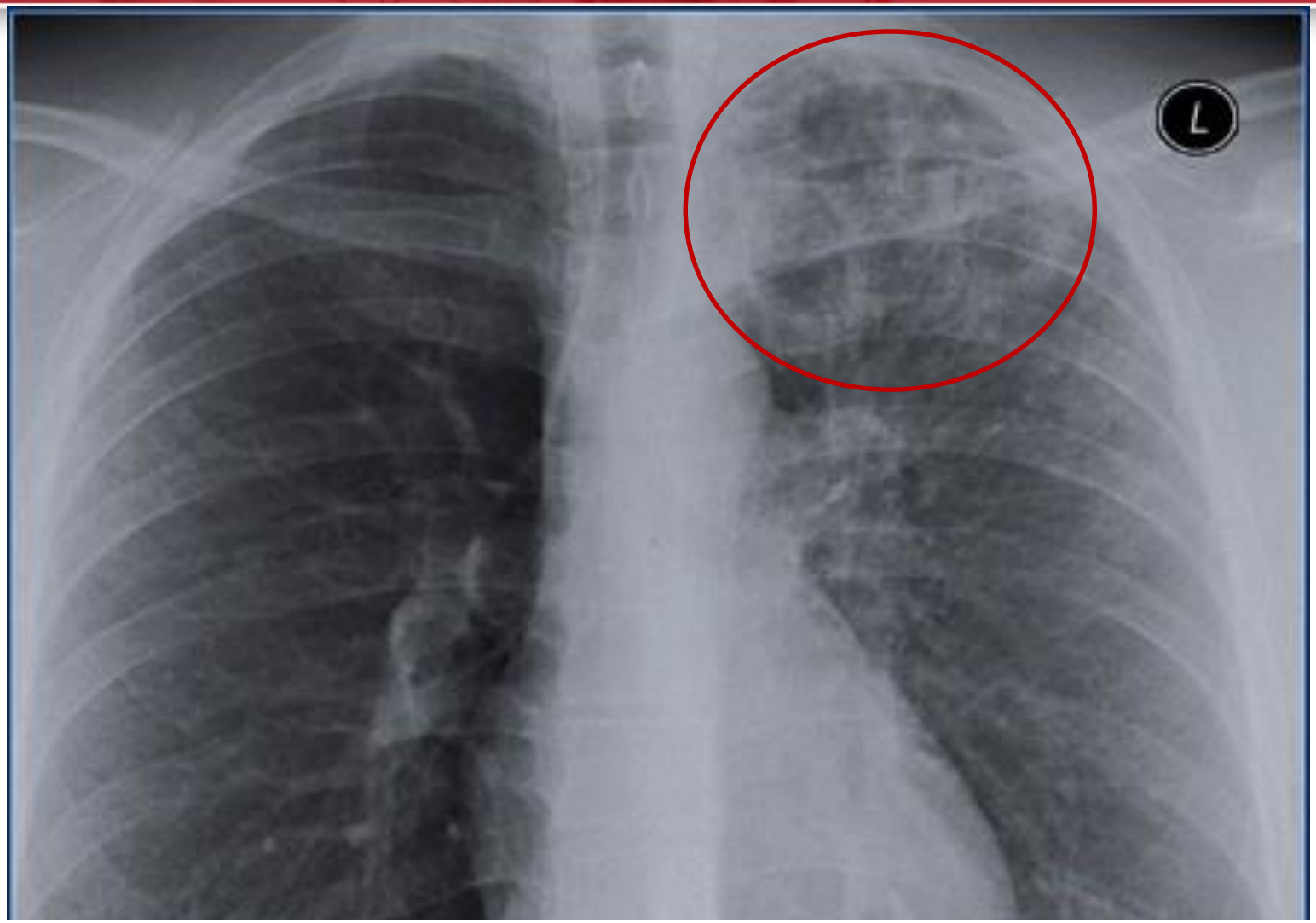
- **Cavity -** lucency with a thick wall and usually with a visible air-fluid level.
- **Cyst** - lucency with a thin wall.
- **Emphysema** - lucency without a visible wall.

- Generally refer to ***abscess***, ***pneumothorax***, ***TB*** and ***COPD***.

Cavity

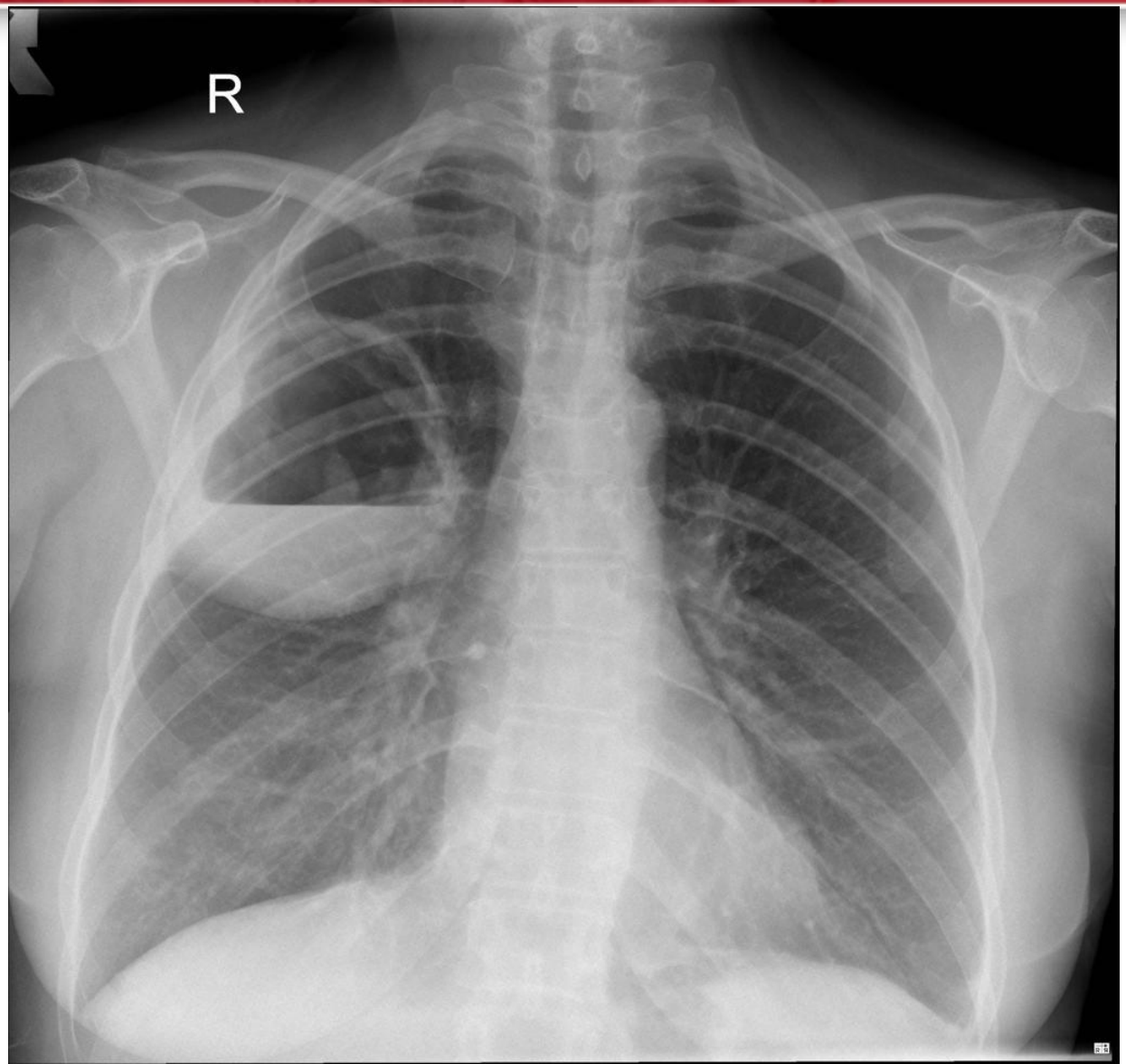


Cavity

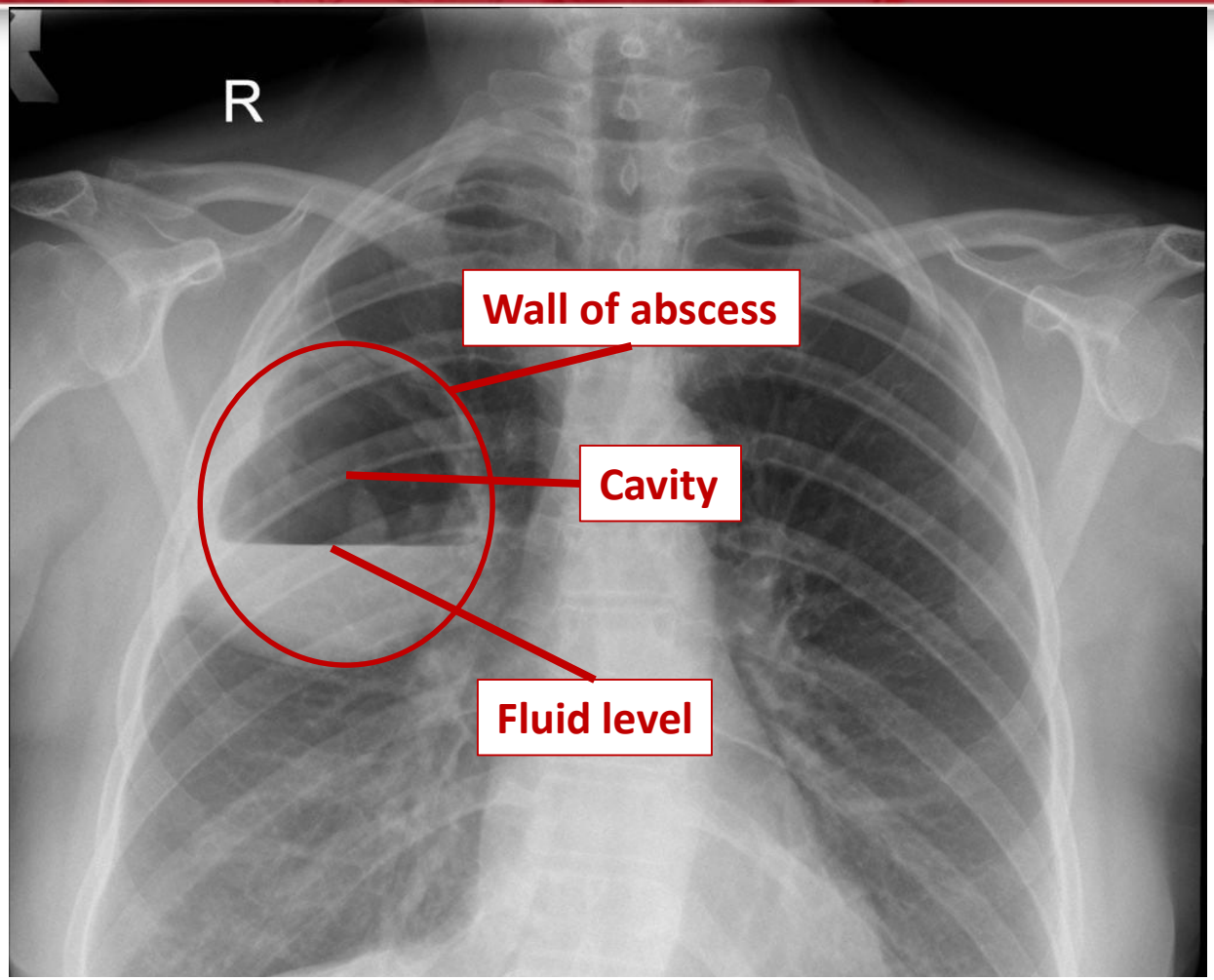


Ds: Postprimary TB with cavities formation in the left upper lobe.

Cavity

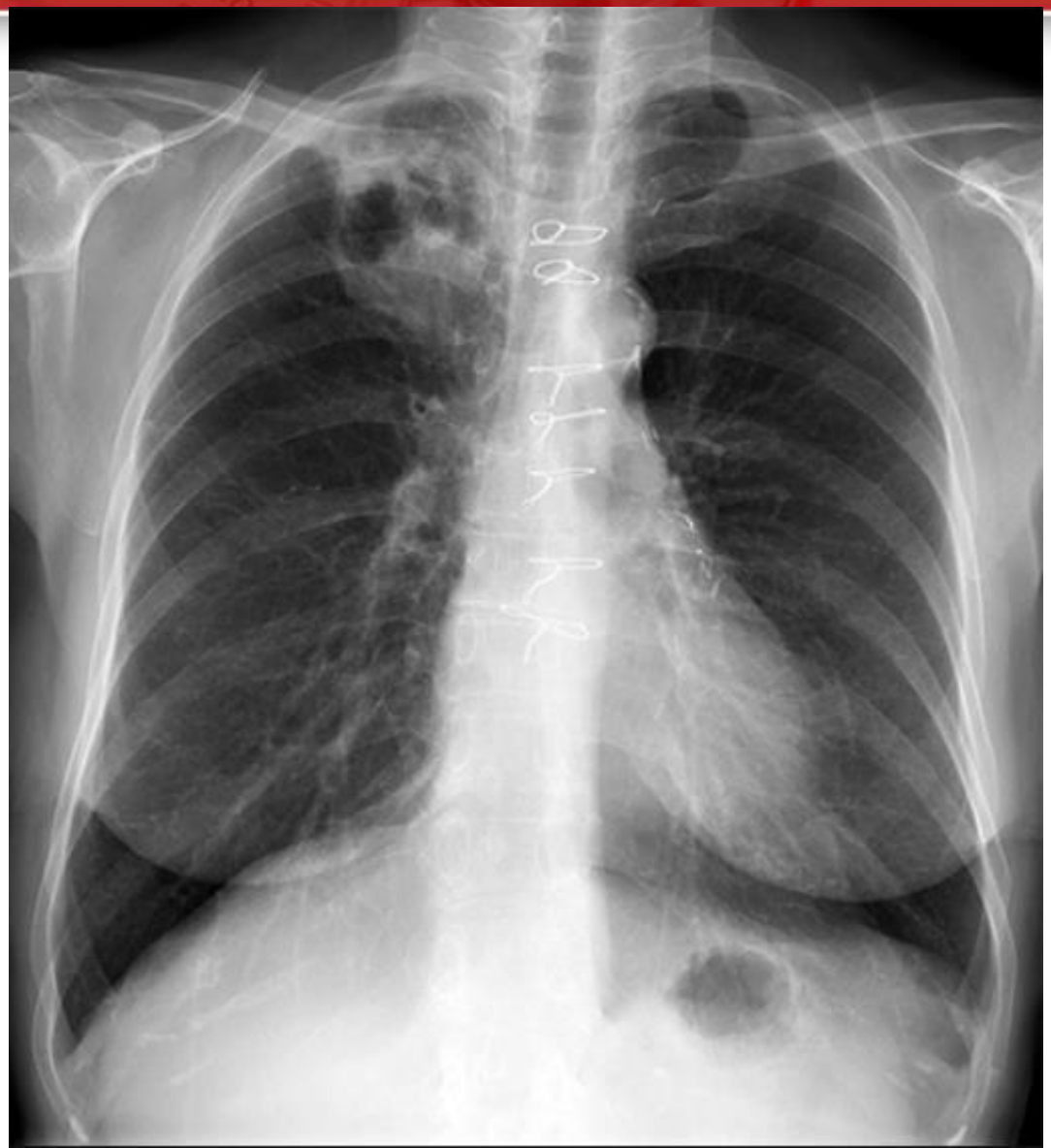


Cavity

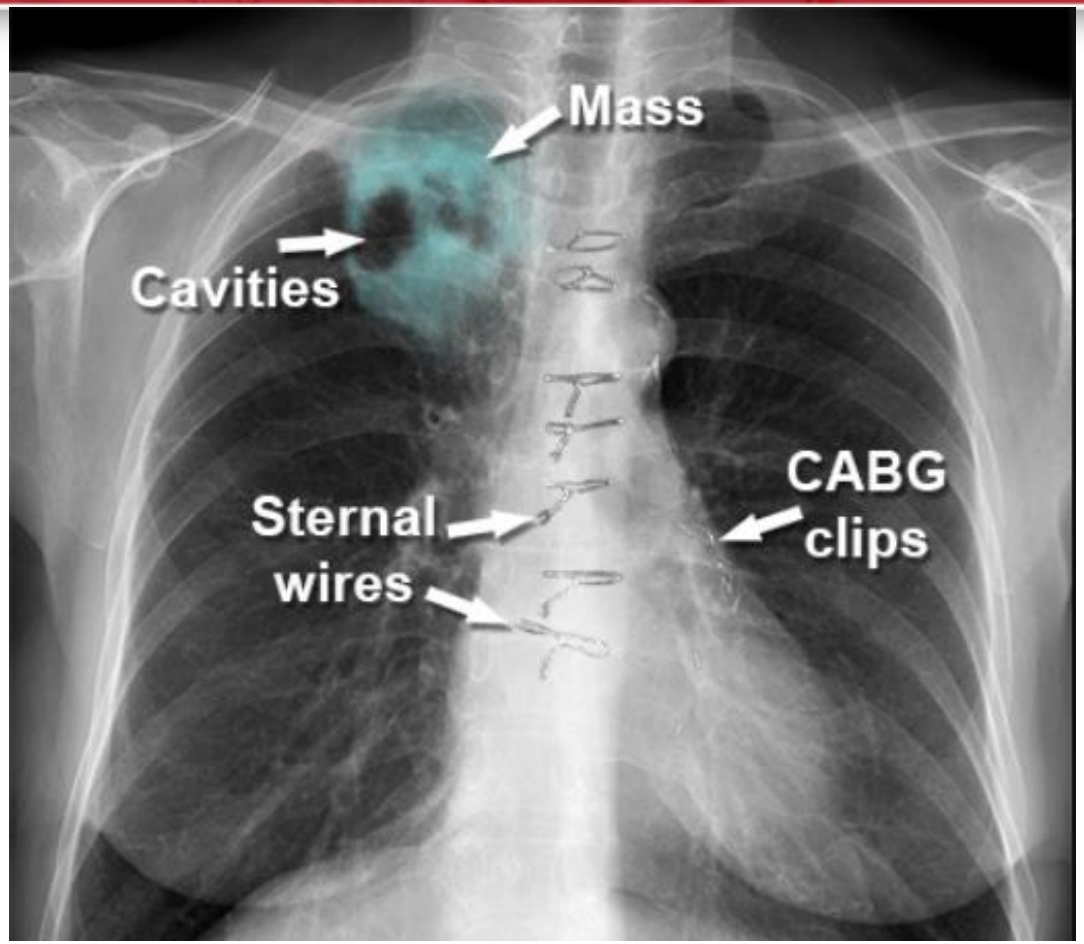


Ds: Large right upper lobe cavitating lung mass with a thick wall and air-fluid level within (abscess, probably of infectious origin).

Cavity



Cavity

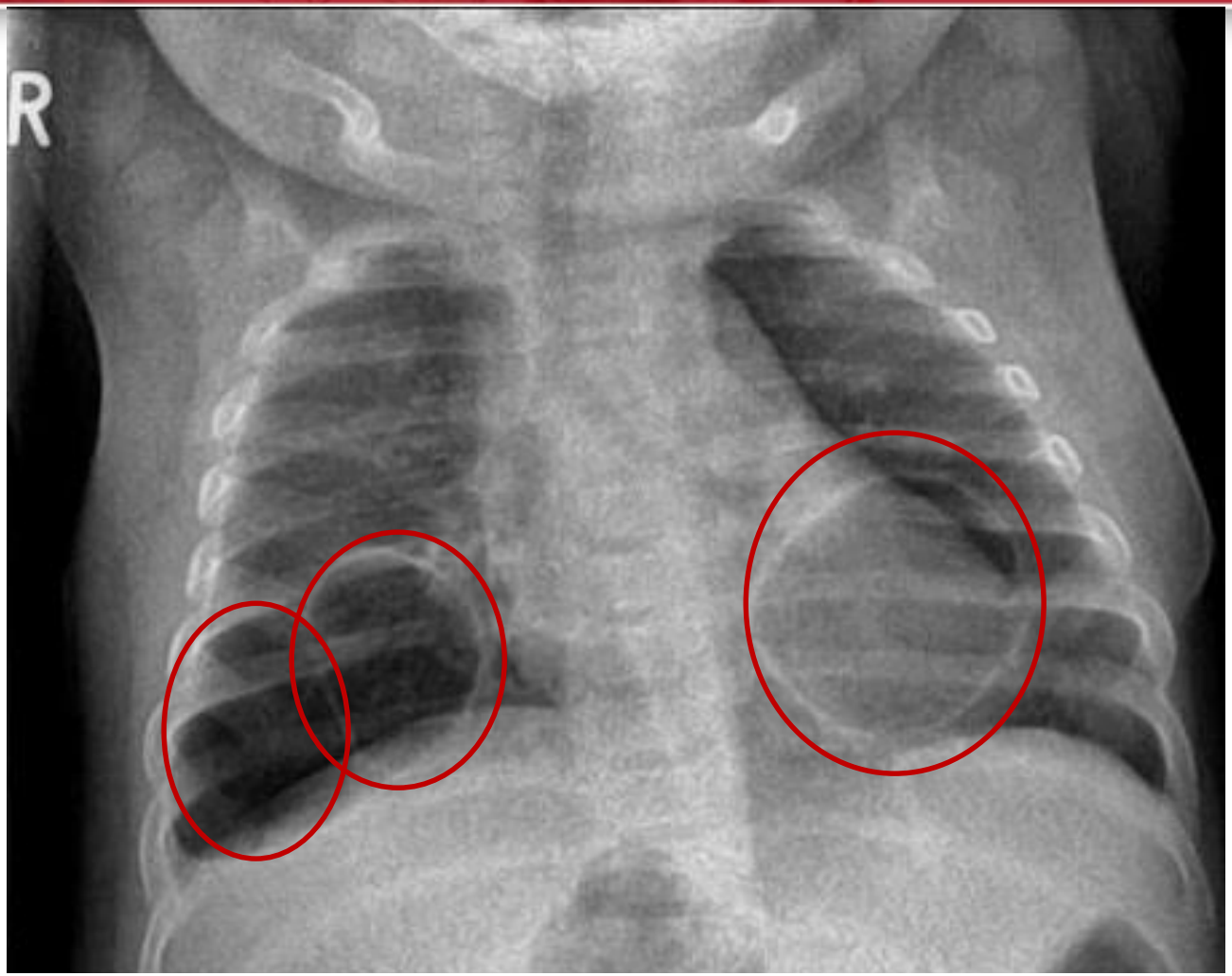


Ds: Cavitated squamous cell lung cancer (it forms a solid mass and then cavitates internally due to cell necrosis).

Sternal wires and clips – due to a previous history of coronary artery bypass graft (CABG) surgery.

Cyst

Cyst



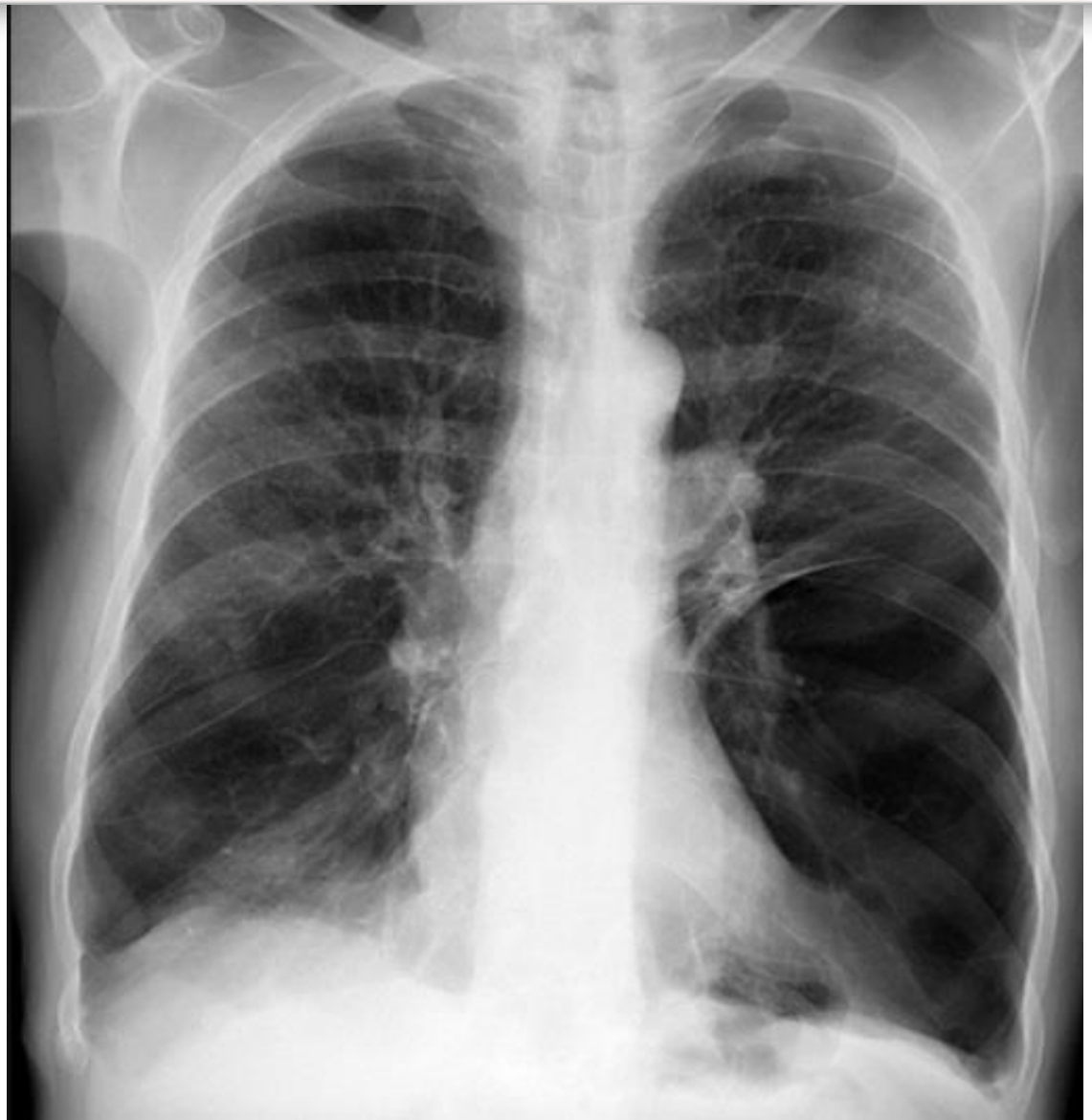
Ds: Bilateral post pneumonic pneumatoceles with cysts in 4 months old infant.

Draw your attention to thin wall, presence of air without liquid in cysts.

Translucency diff. diagnosis

Cavity - wall > 3mm	**Cyst** - wall ≤ 3mm	**Multiple**
Infection • Staphylococcus - Klebsiella • Gram negative • Anaerobe in aspiration • TB - Fungal (aspergillus) **Neoplasm** • Lungca - squamous cell - BAC • Metastases **Vascular** • Lunginfarction	**Congenital** • Bronchogenic cyst • CAM - cystic adenomatoid malformation **Bulla** **Pneumatocele** • posttraumatic	**Infection** • Staphylococcus - Klebsiella • Gram negative • ***PCP*** • Anaerobe in aspiration • TB - Fungal (aspergillus) **Neoplasm** • Lungca - squamous cell - BAC • Metastases **Collagen-vascular** • thrombo- and septic emboli • RA - Wegener's **Emphysema** **Cystic Lung disease** • Langerhans cell histiocytosis • Lymphangioleiomyomatosis • Honeycombing

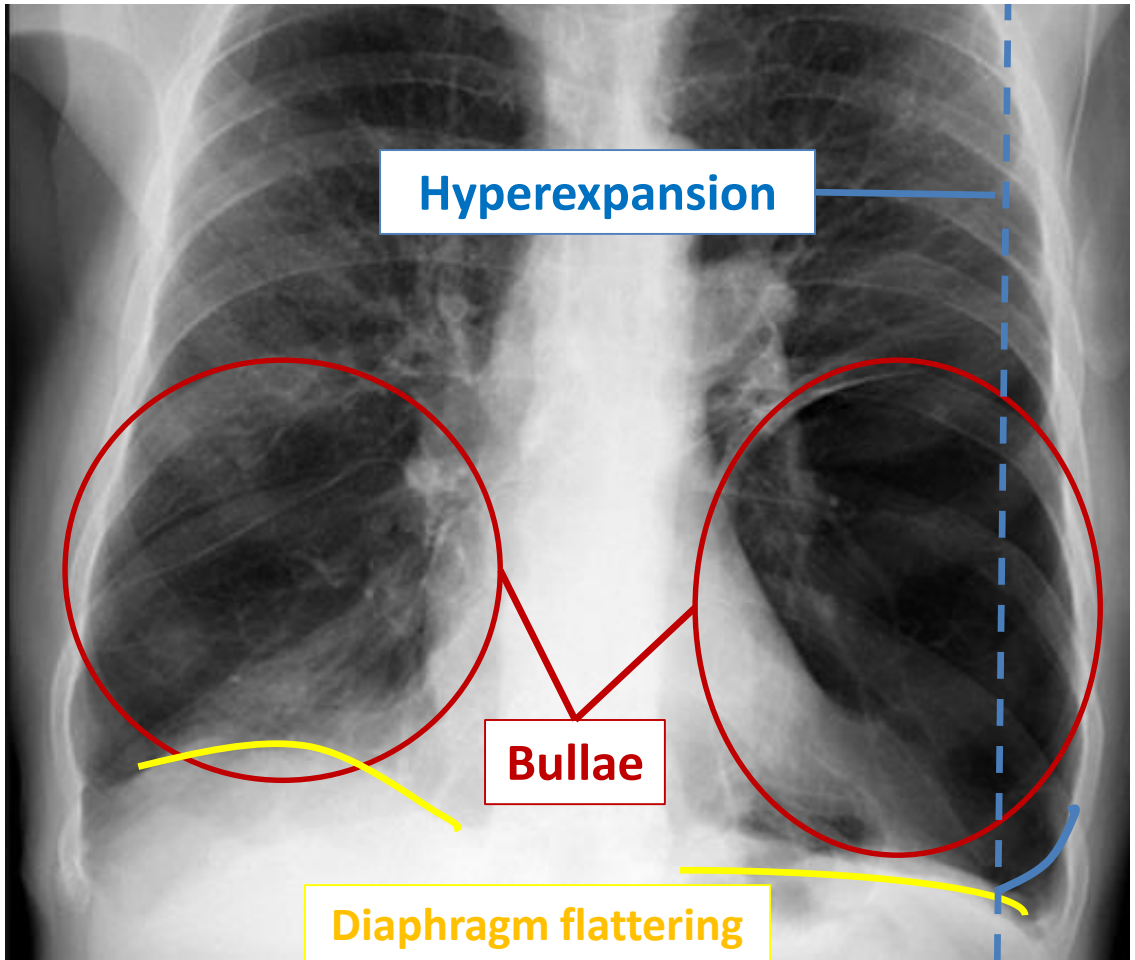
Emphysema



Emphysema

Ds: Bullous emphysema.

Bilateral diffuse hyperlucency of lung fields. Large bilateral bullae in lower zones. Flattering of diaphragm hemispheres. Hyperexpansion.



§5. Common pathologies review

- Pneumonia
- Pulmonary edema
- Hydrothorax (pleural effusion)
- Pneumothorax
- Pulmonary abscess
- Pulmonary gangrene
- COPD

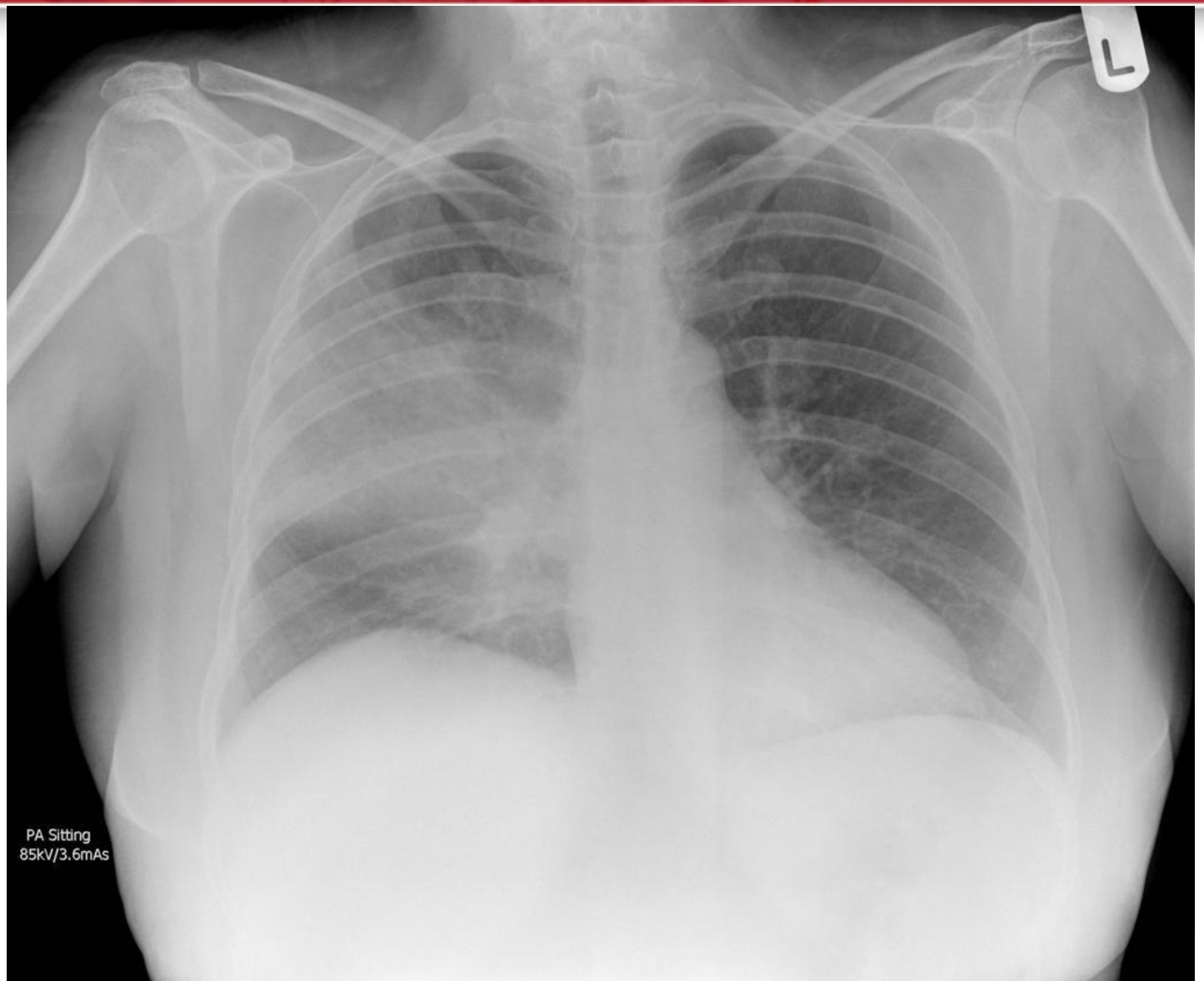
Pneumonia

Pneumonia

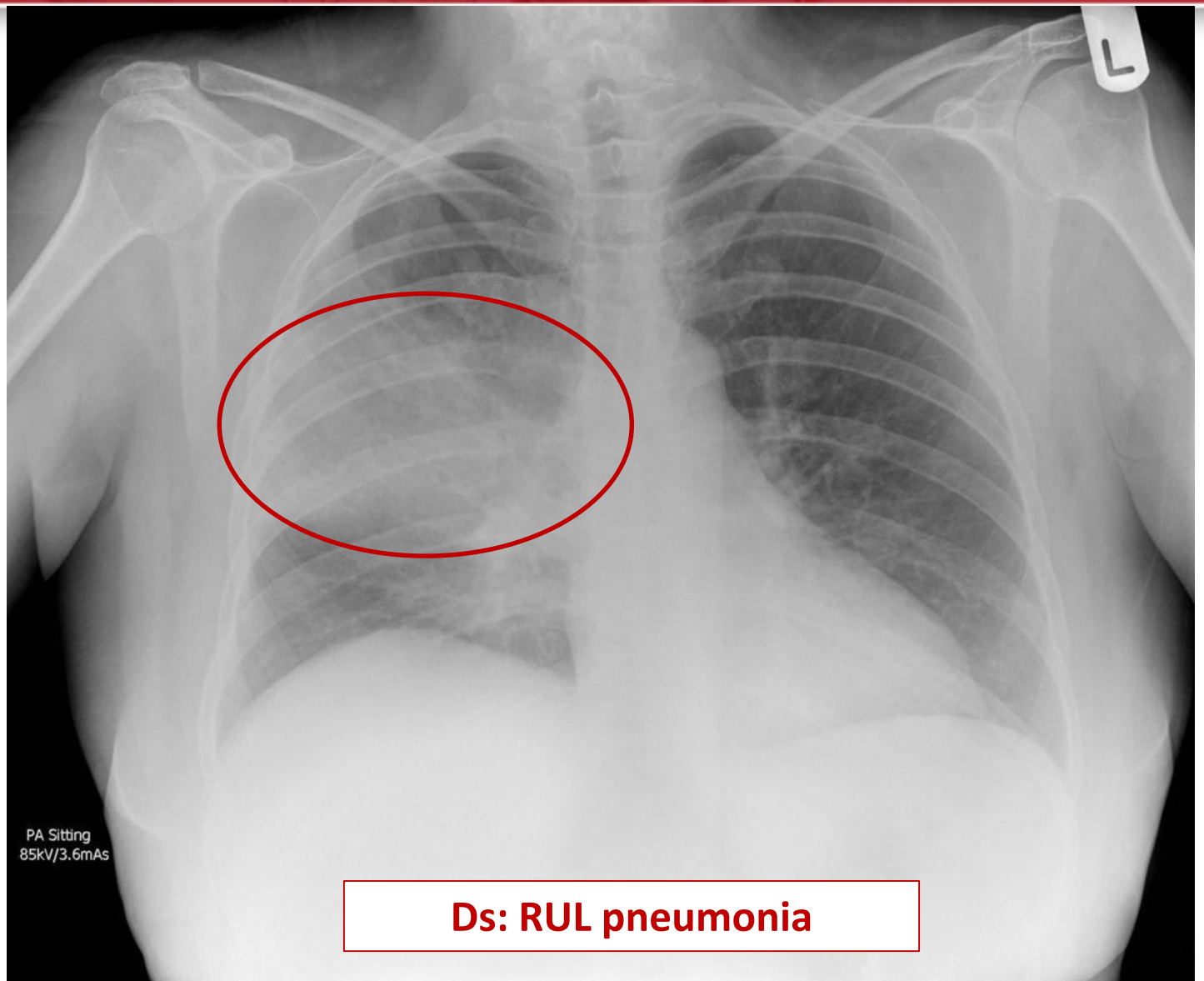
- **Pneumonia** is the lung inflammatory condition affecting primarily the alveoli that results in filling them with pus.
- Has infectious etiology, foremost – **bacterial**.
- **Characteristic on CXR:**

  - Consolidation
  - Air bronchogram
  - Not centered at hilum
  - No volume loss
  - Usually unilateral

Pneumonia

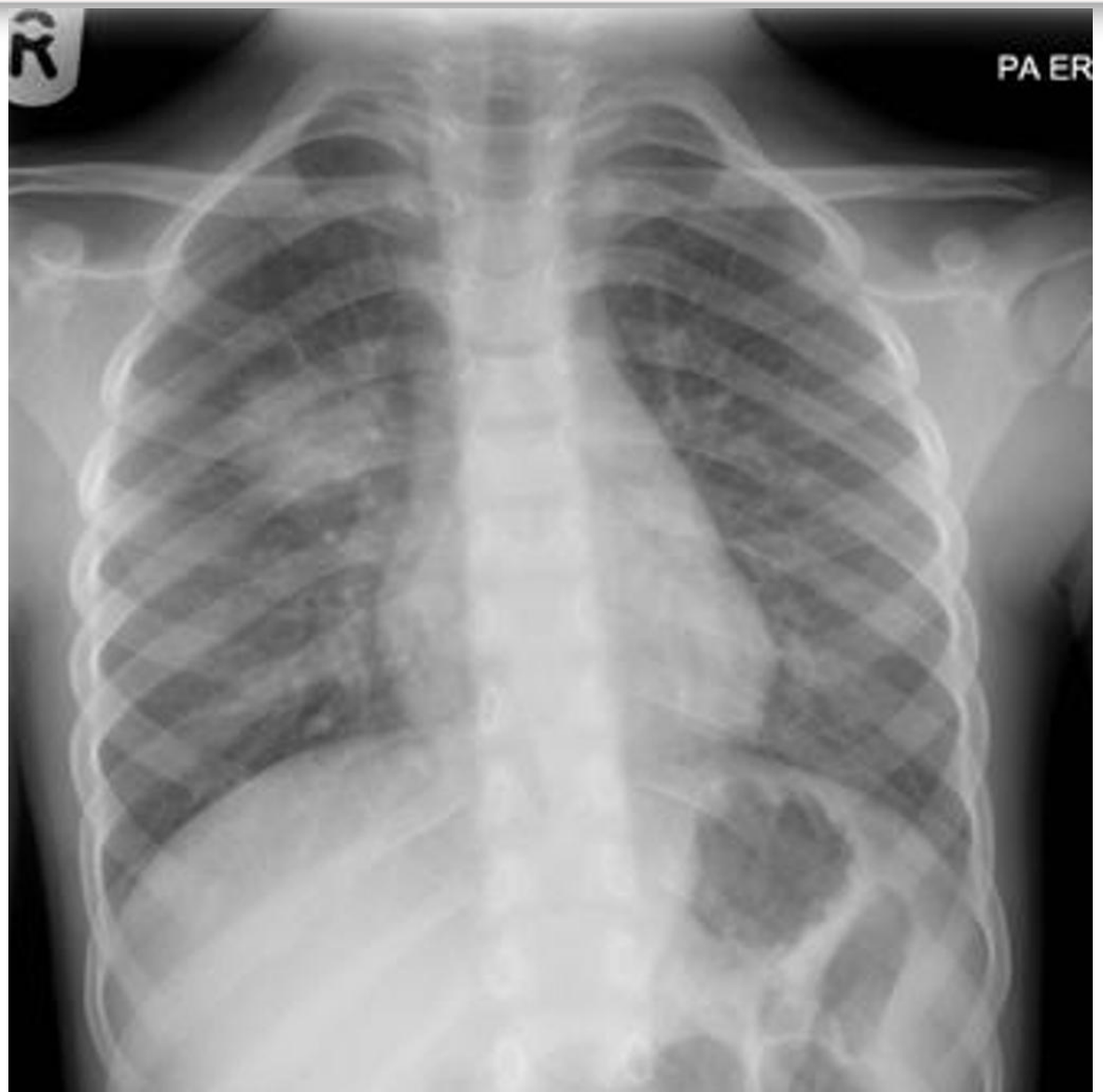


Pneumonia

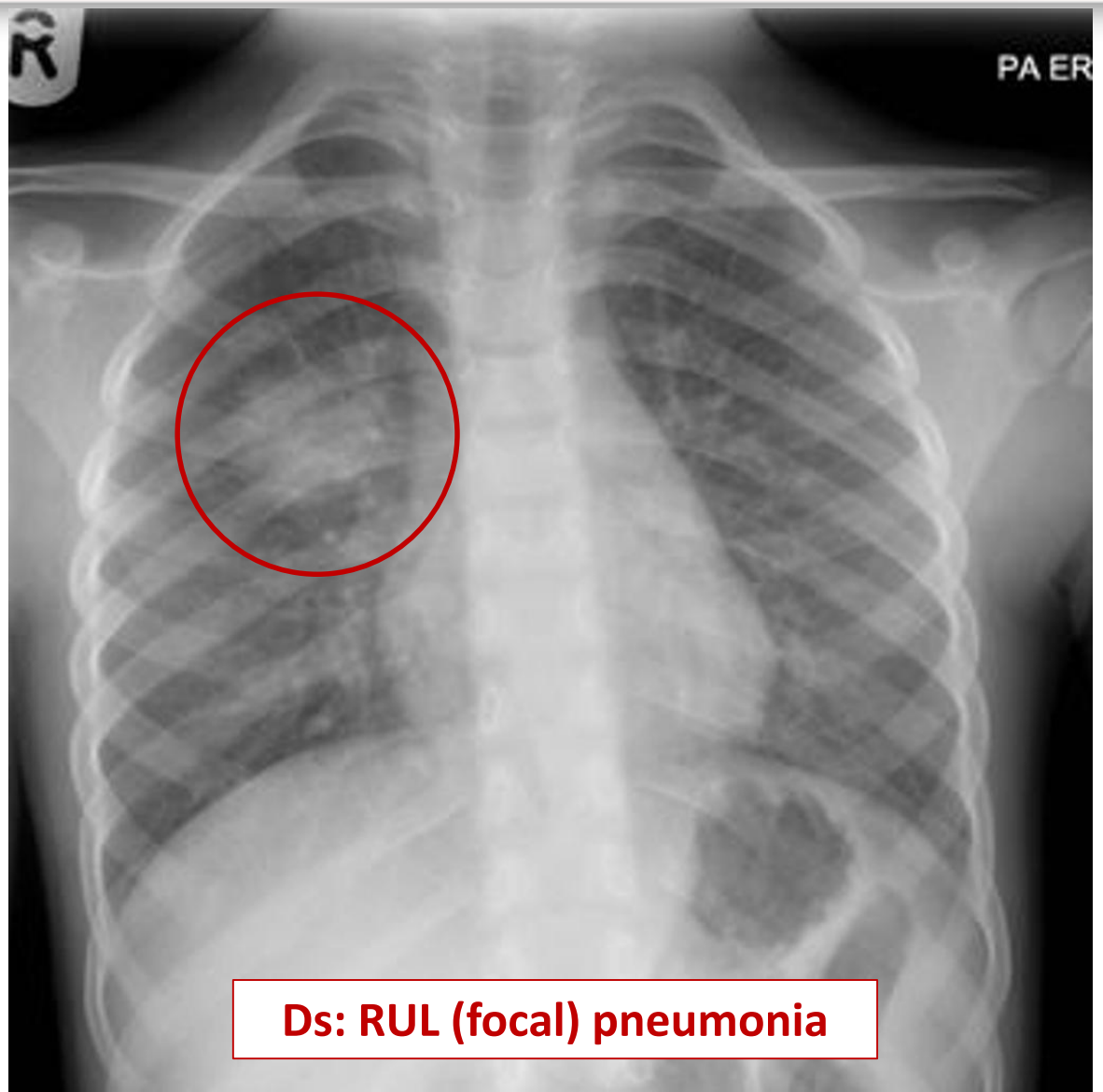


Ds: RUL pneumonia

Pneumonia

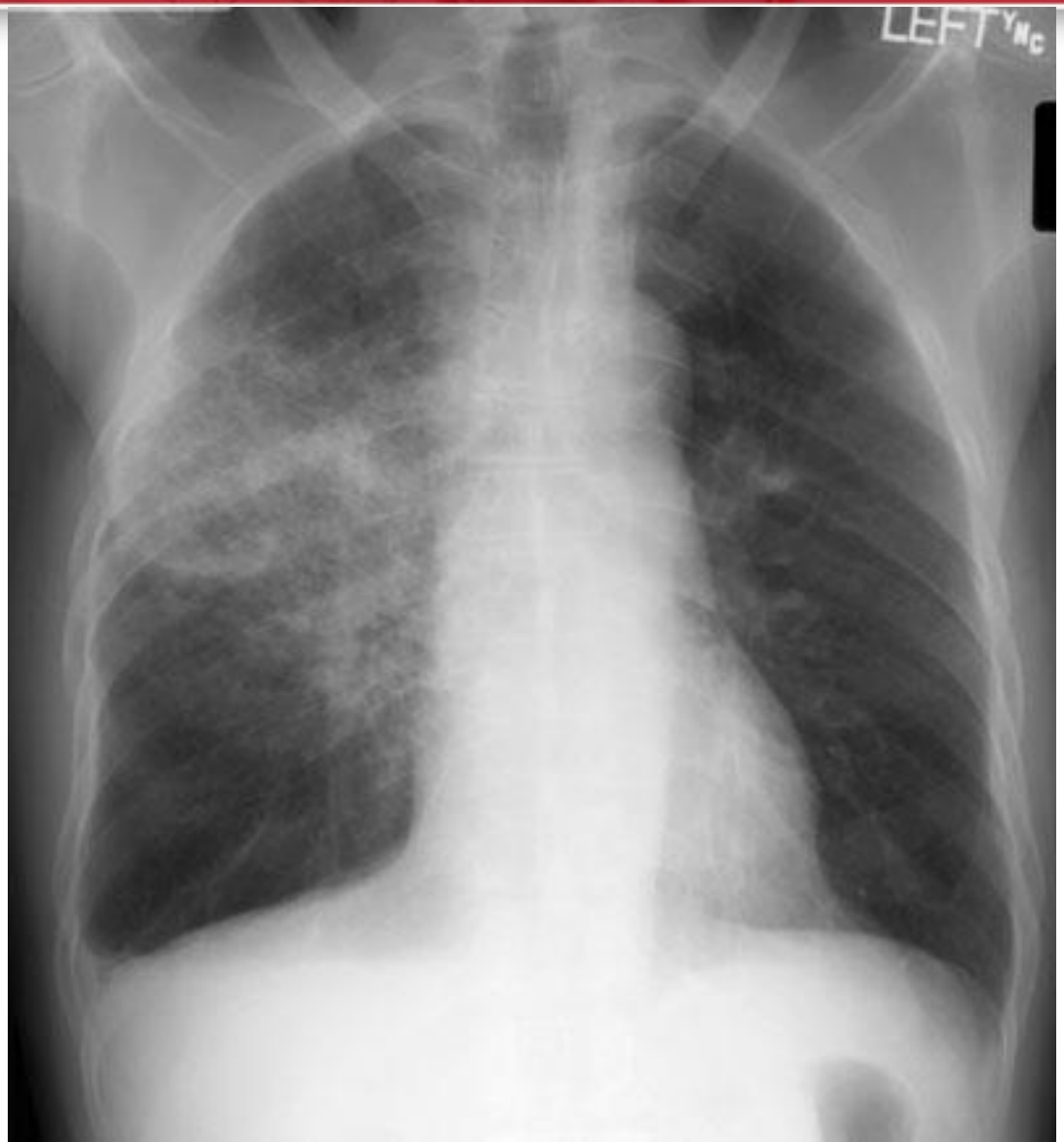


Pneumonia

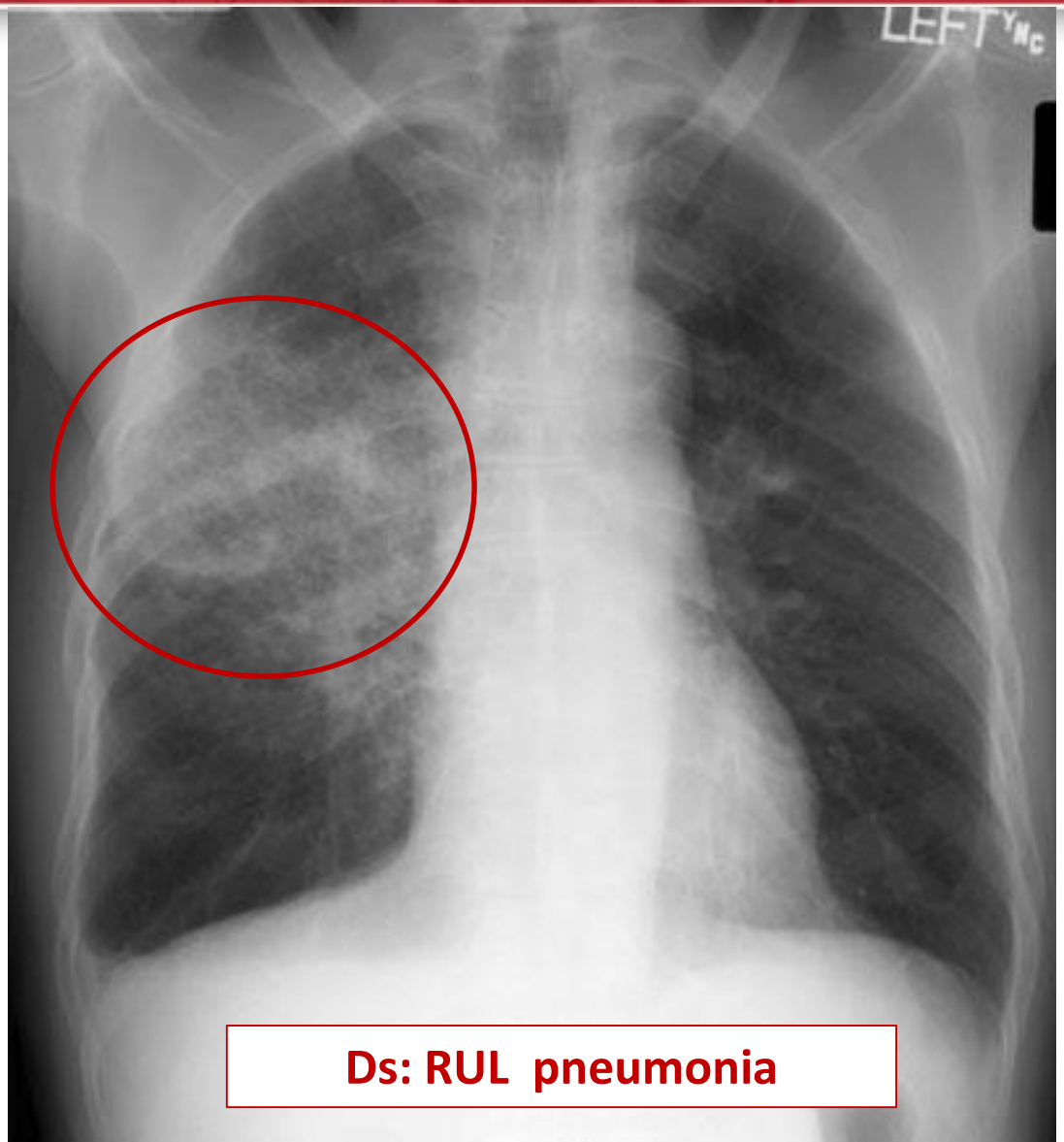


Ds: RUL (focal) pneumonia

Pneumonia



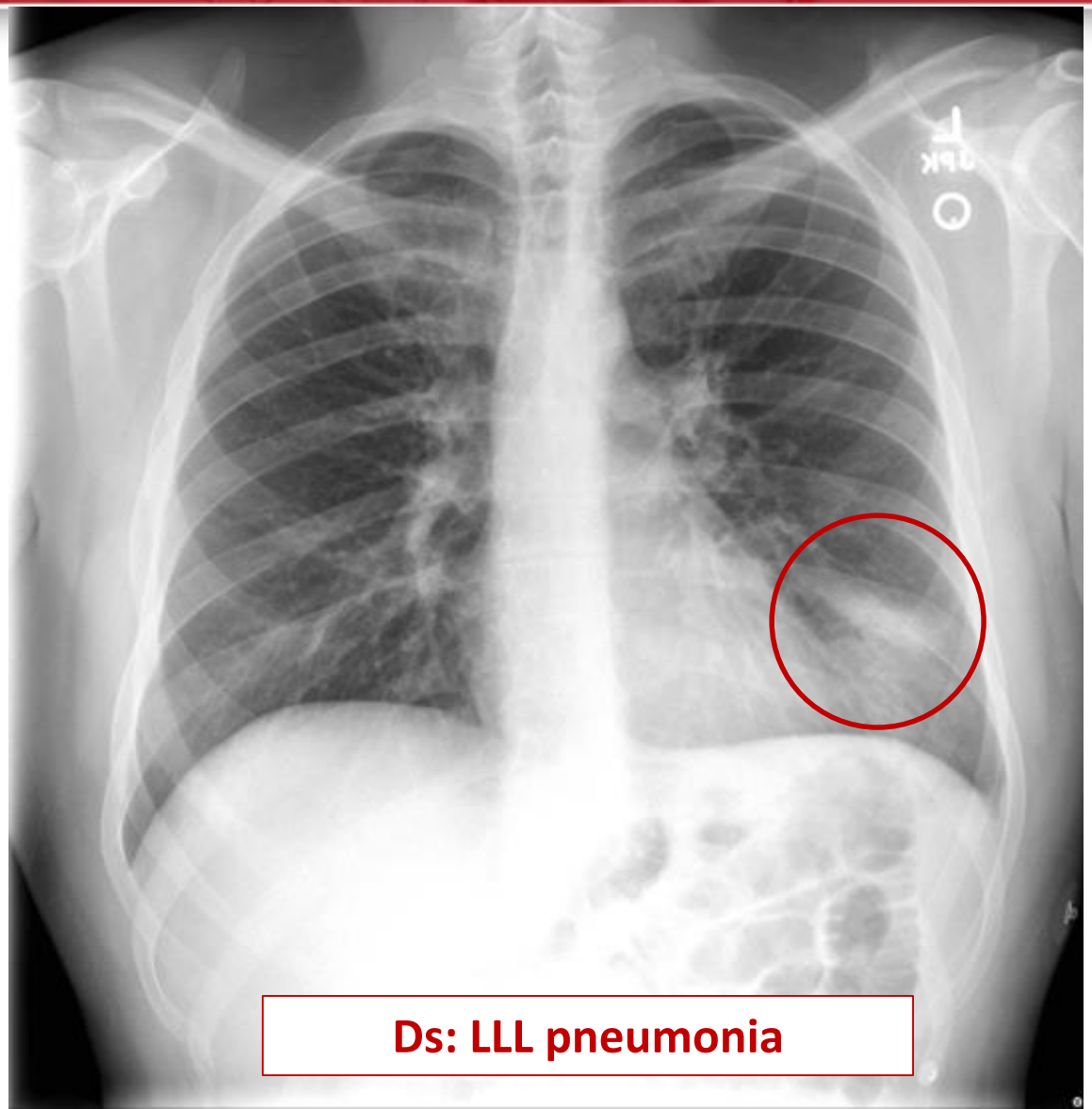
Pneumonia



Ds: RUL pneumonia

Pneumonia

Pneumonia



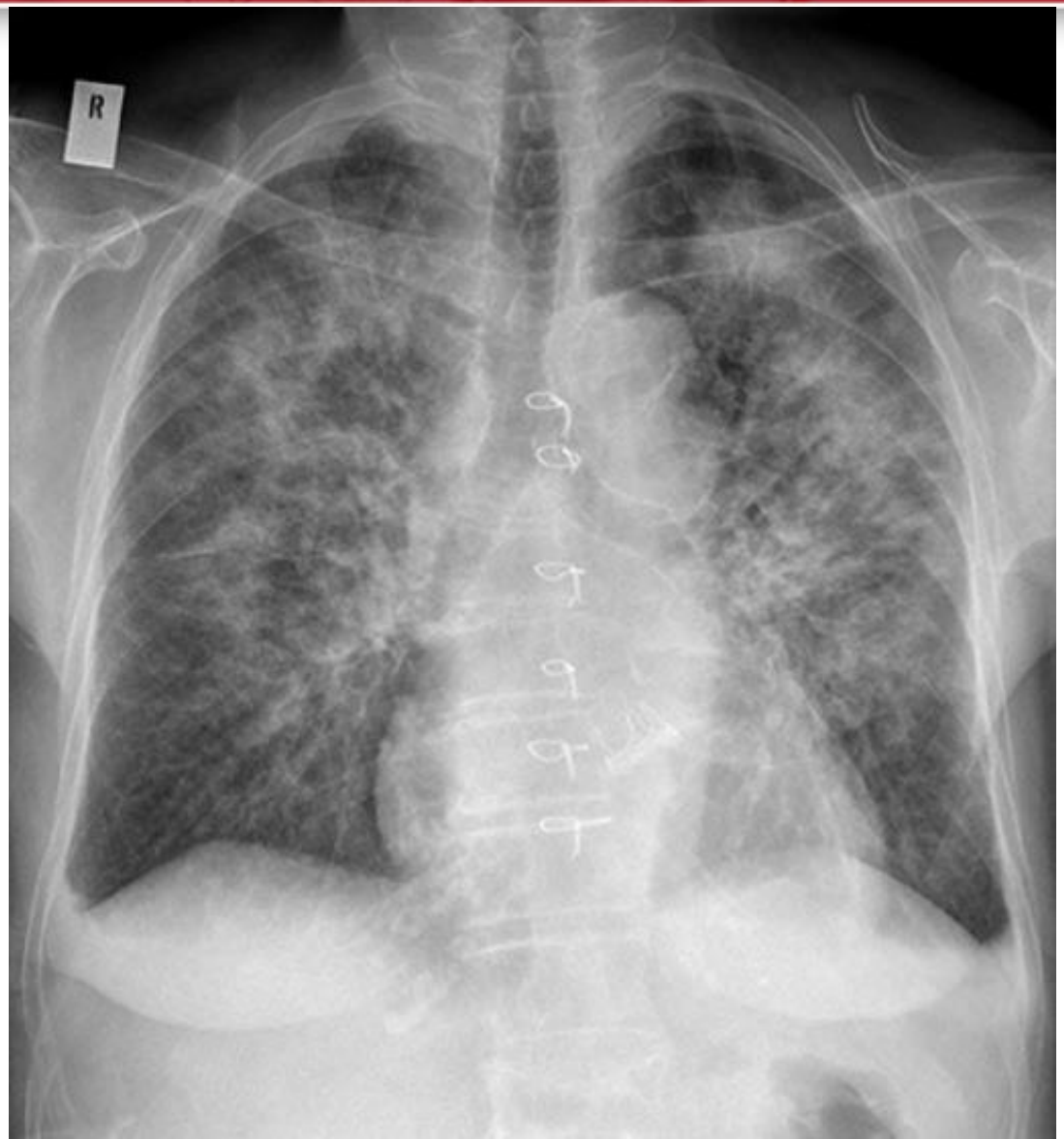
Ds: LLL pneumonia

Pulmonary edema

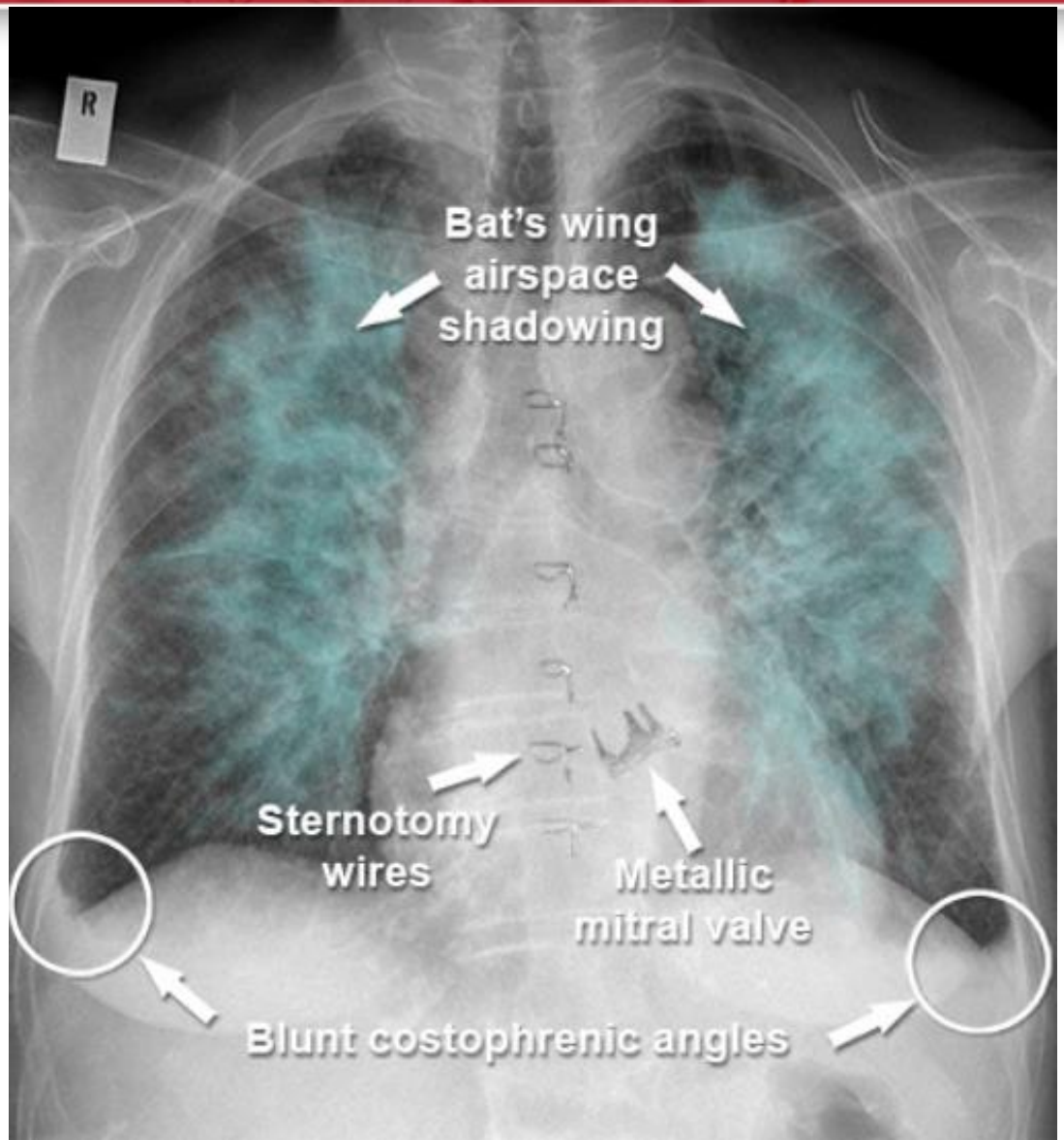
Pulmonary edema

- **Pulmonary edema** is fluid accumulation in the tissue and air spaces of the lungs. Leads to impaired gas exchange and causes respiratory failure.
- Divided on **cardiogenic** (which is more common) and **non-cardiogenic**.
- **Characteristic on CXR:**
  - **Kerley B (septlal) lines**
  - **Patchy opacification with air bronchograms**
  - **Batwing pattern**
  - **Increased cardiac size**
  - **Bilateral abnormalities, rarely - assymetrical**
  - **May be accompanied with pleural effusion**

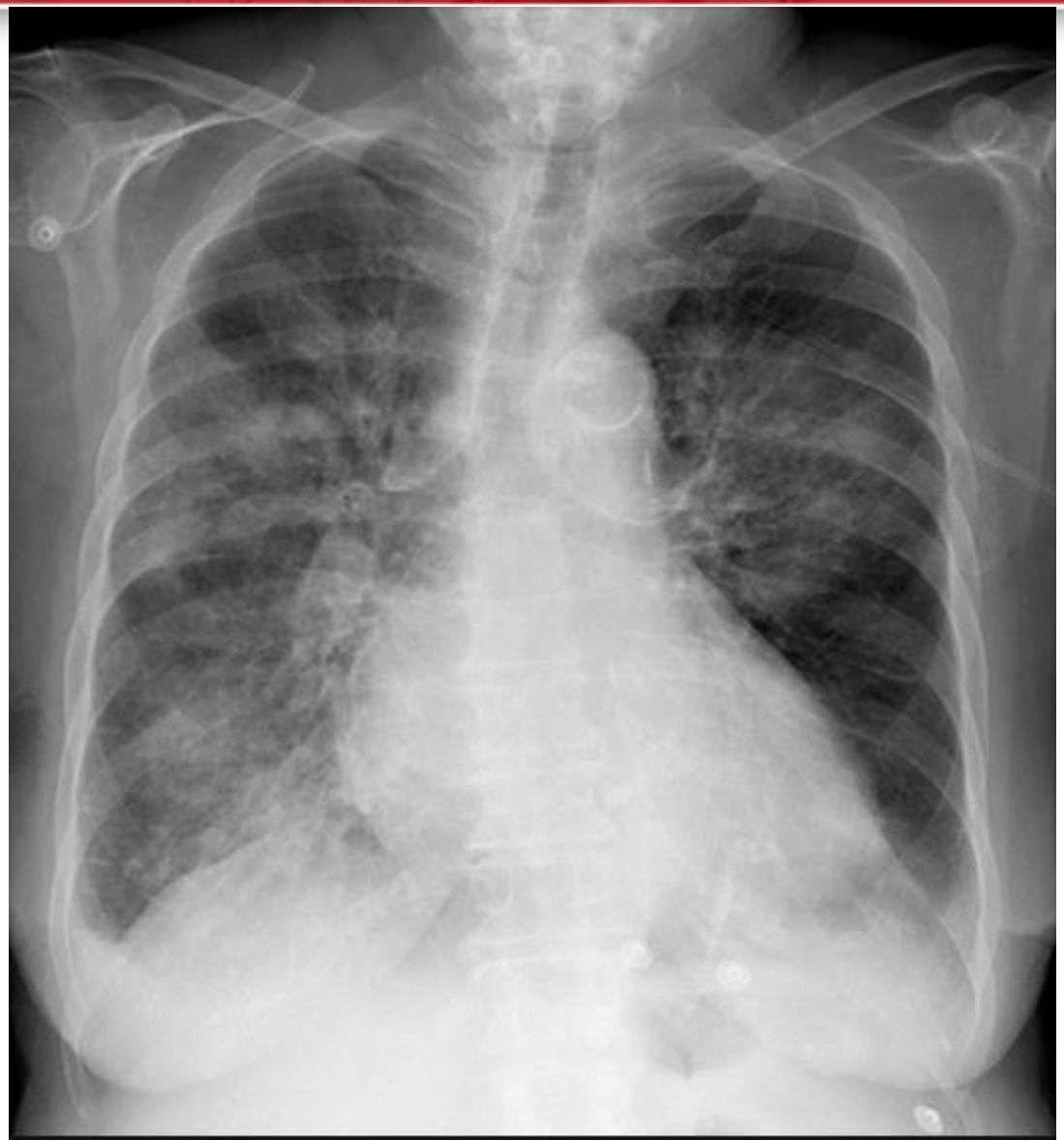
Pulmonary edema



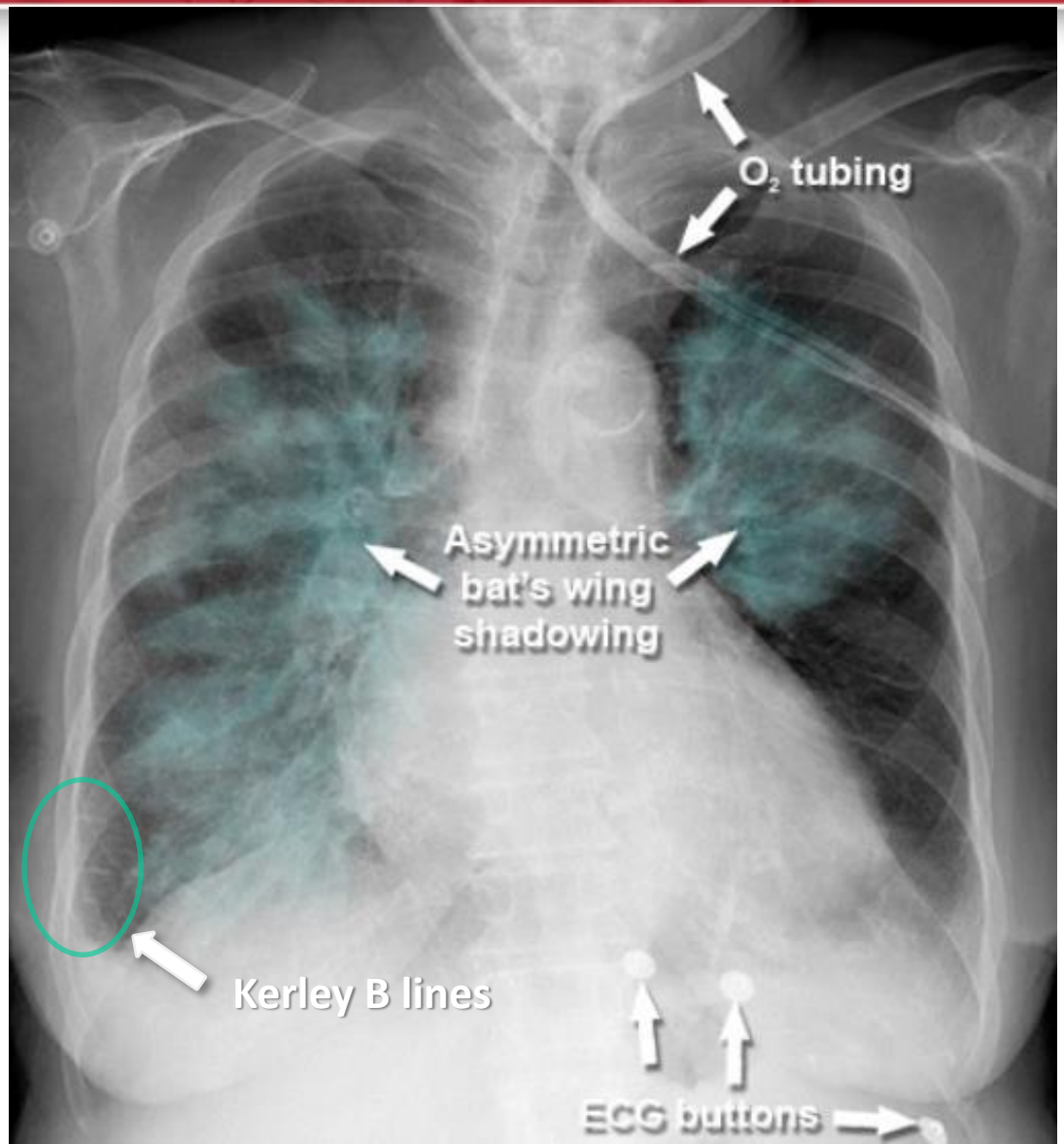
Pulmonary edema



Pulmonary edema



Pulmonary edema

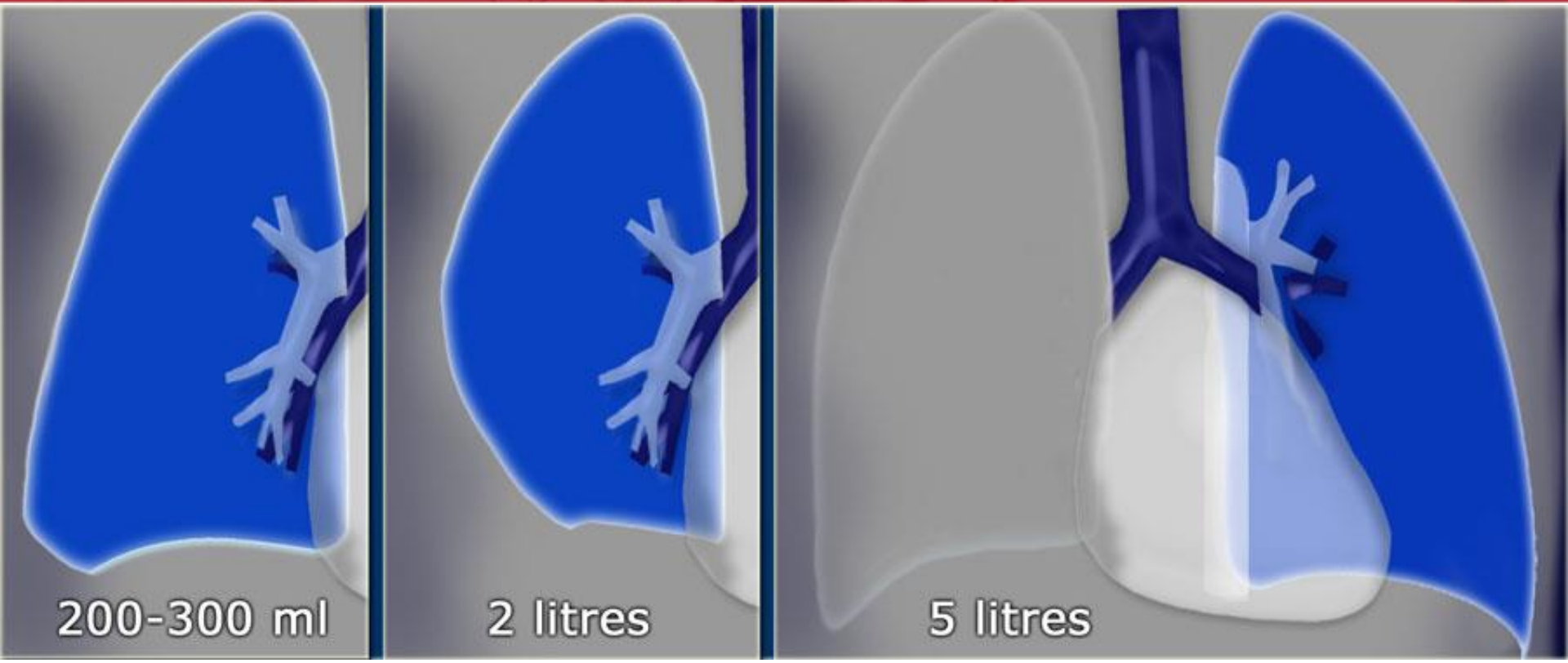


Pleural effusion

Pleural effusion

- **Pleural effusion** is excess **fluid** that accumulates **in the pleural cavity**.
- Depending on the nature of the fluid pleural effusion may be called ***hydrothorax*** (serous fluid), ***hemothorax*** (blood), ***urinothorax*** (urine), ***chylothorax*** (chyle), or ***pyothorax*** (pus).
- **Big volume** of pleural effusion usually refers to **transudative pathophysiology *(congestive heart failure, liver cirrhosis, nephrotic syndrome, malignancy).***

Pleural effusion



- It takes about **200-300 ml** of fluid before it comes visible on an CXR.
- About **5 liters** of pleural fluid are present when there is total opacification of the hemithorax.

Pleural effusion

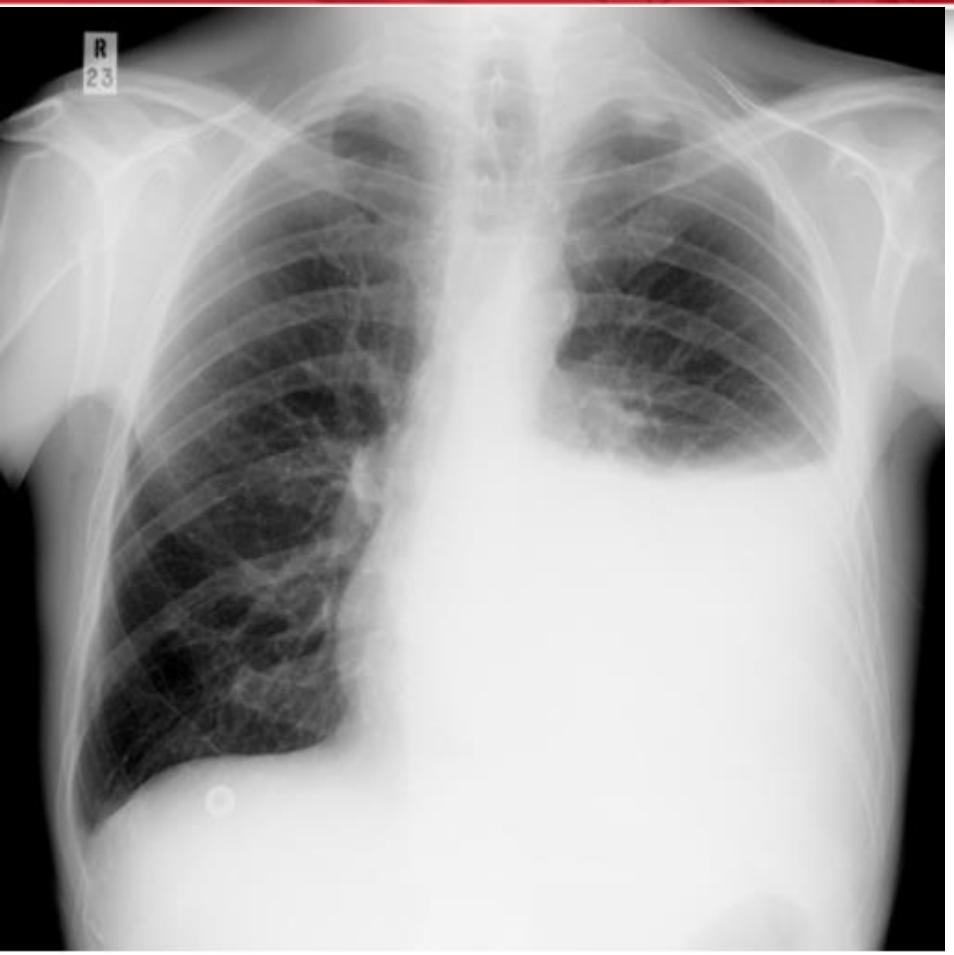
- **Effusion size** is measured by counting **intercostal spaces (ICS)** from **costophrenic angle**:
  - ***Small*- localized to 1 ICS (<500 mL)**
  - ***Moderate* 2–3 ICS (500–1000 mL)**
  - ***Large* ≥4 ICS (>1000 mL)**

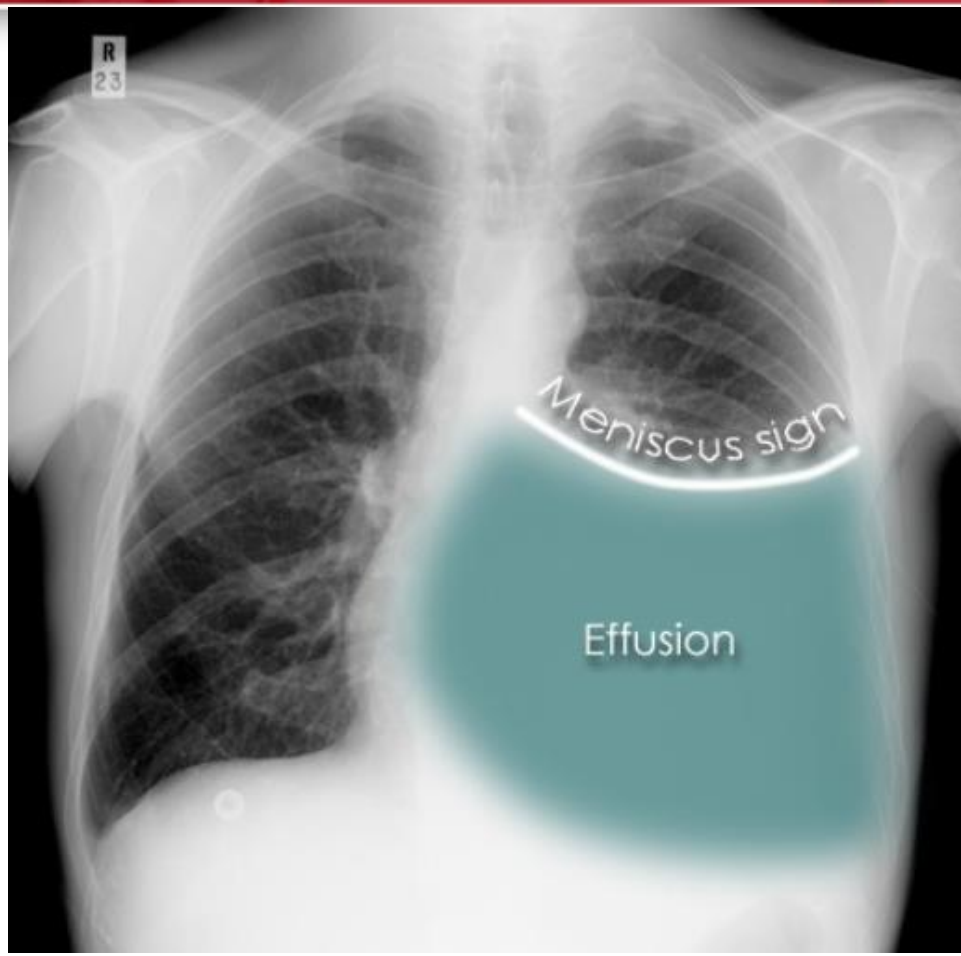
Pleural effusion

- **Characteristic on CXR:**

- Blunting of the **costophrenic angle**
- **Obscured hemidiaphragm**
- **Homogenous opacity**
- Positive **silhouette sign**
- **Meniscus sign** (absent in case of hydropneumothorax)
- **Volume loss** (due to atelectasis)
- **Contralateral mediastinal shift** (in case of large effusion)
- Can be **unilateral or bilateral**

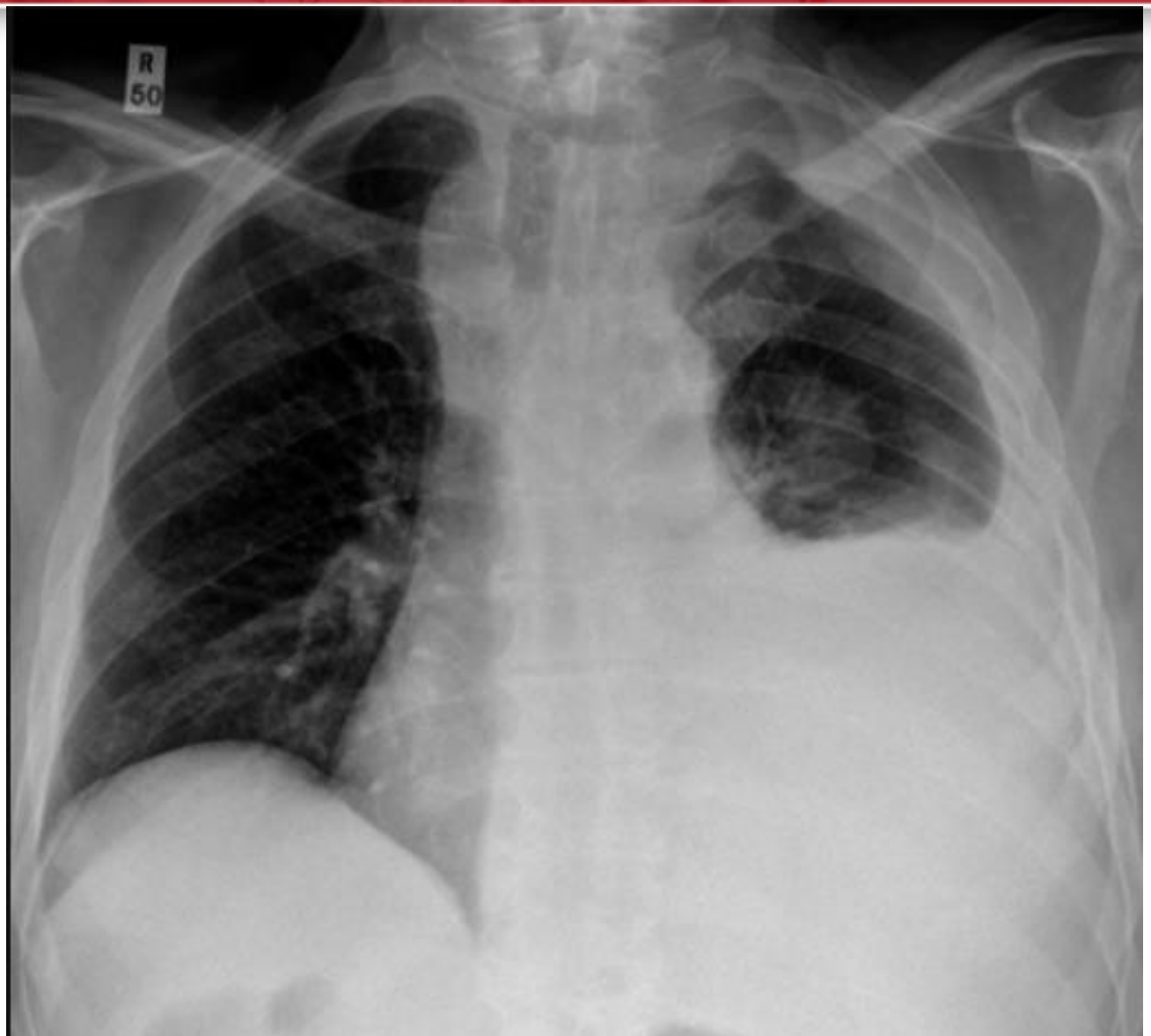
Meniscus sign



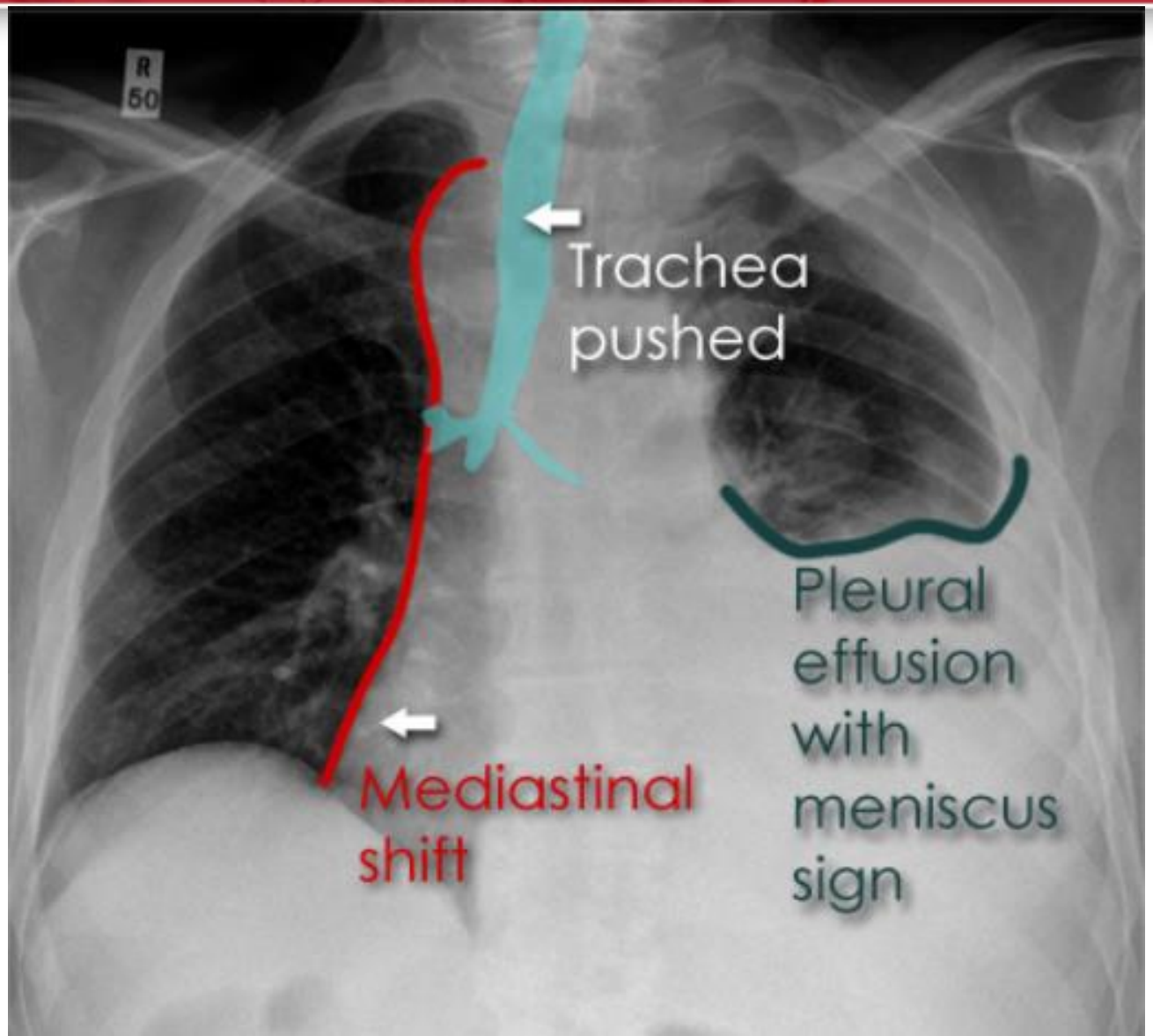


- **Ds: Large left-sided pleural effusion. Underlying bronchogenic carcinoma.**
- **Meniscus sign –** a concave line obscuring the costophrenic angle and part or all of the hemidiaphragm **(fluid level gets a shape of half moon).**

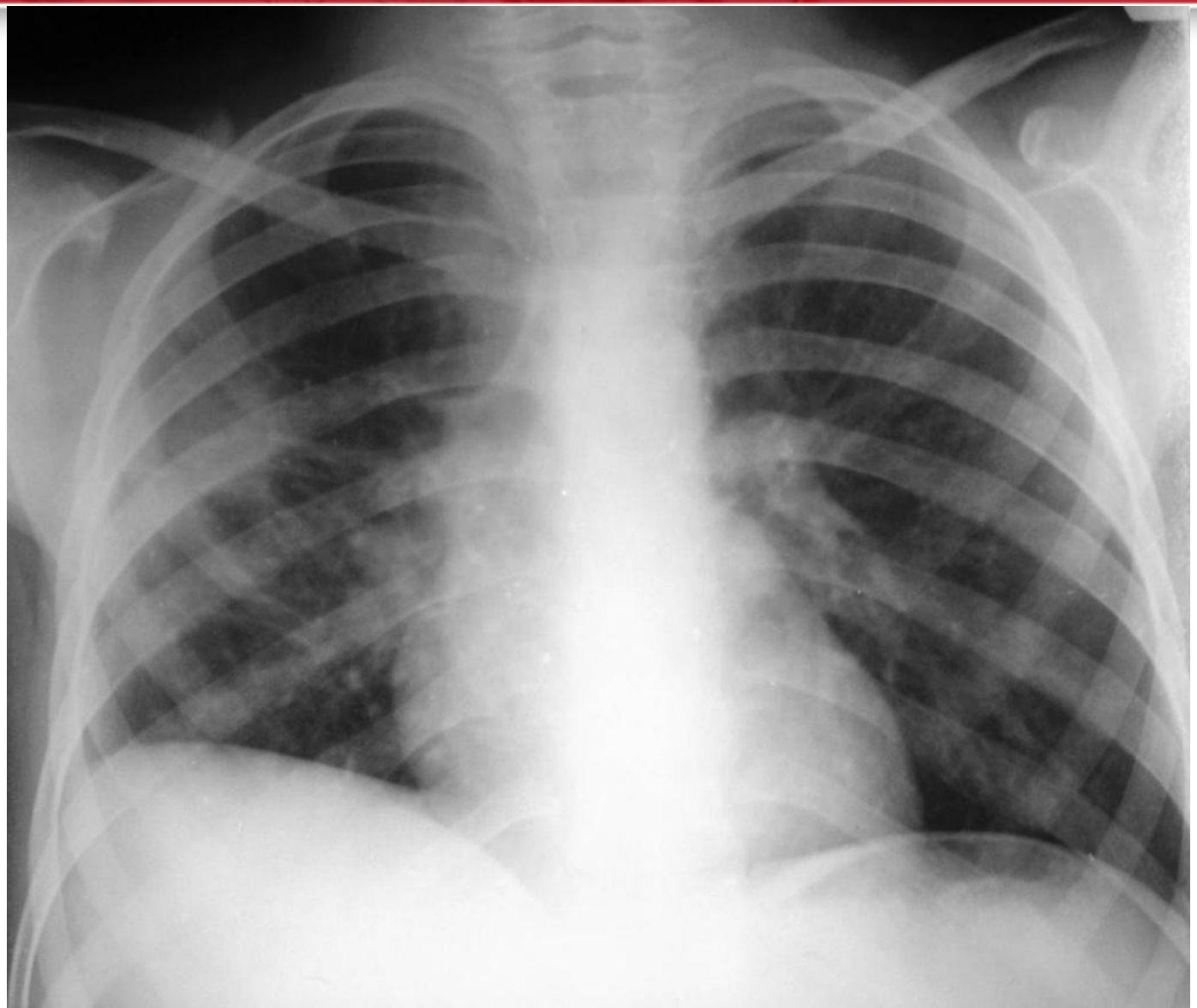
Pleural effusion



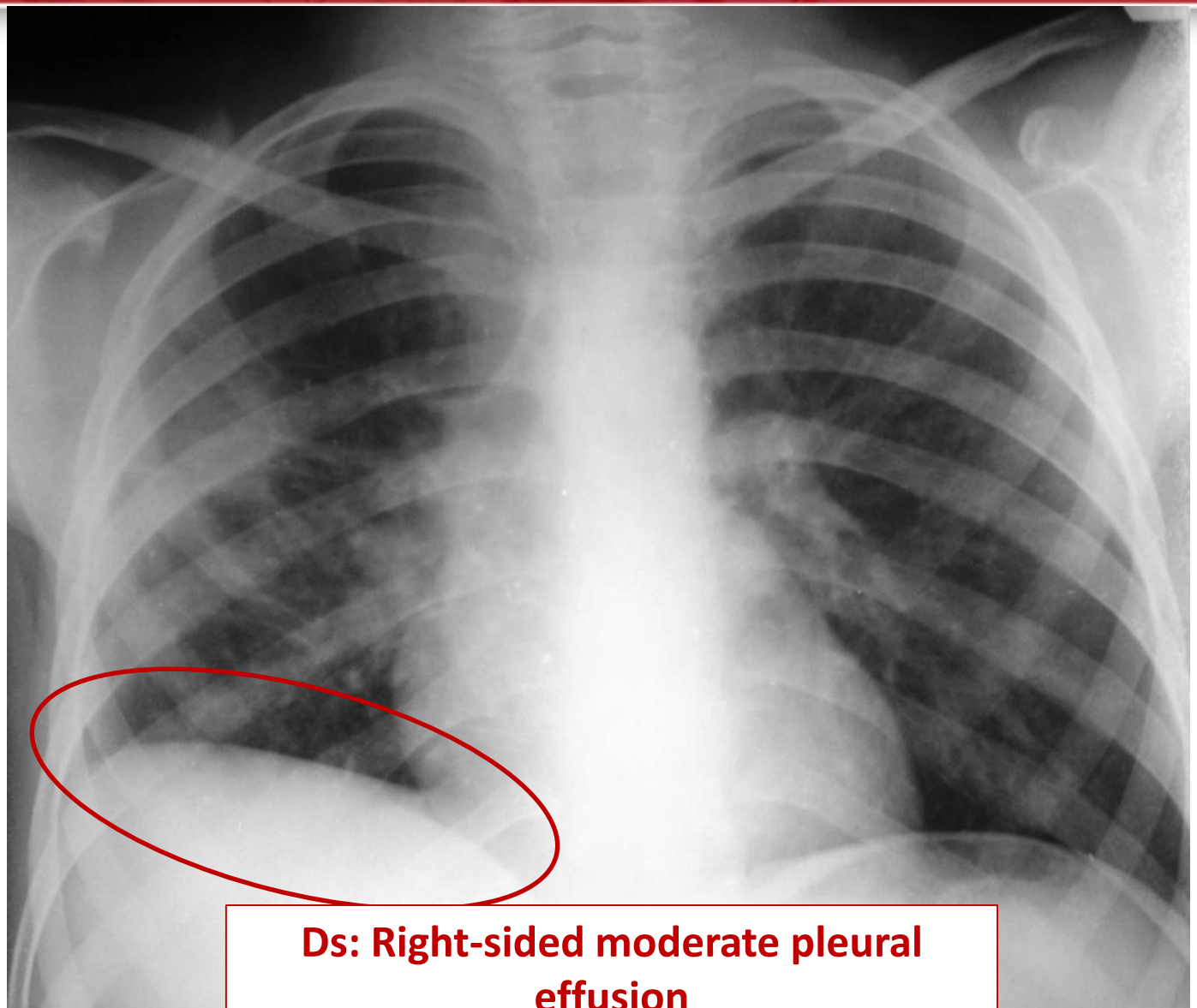
Pleural effusion



Pleural effusion



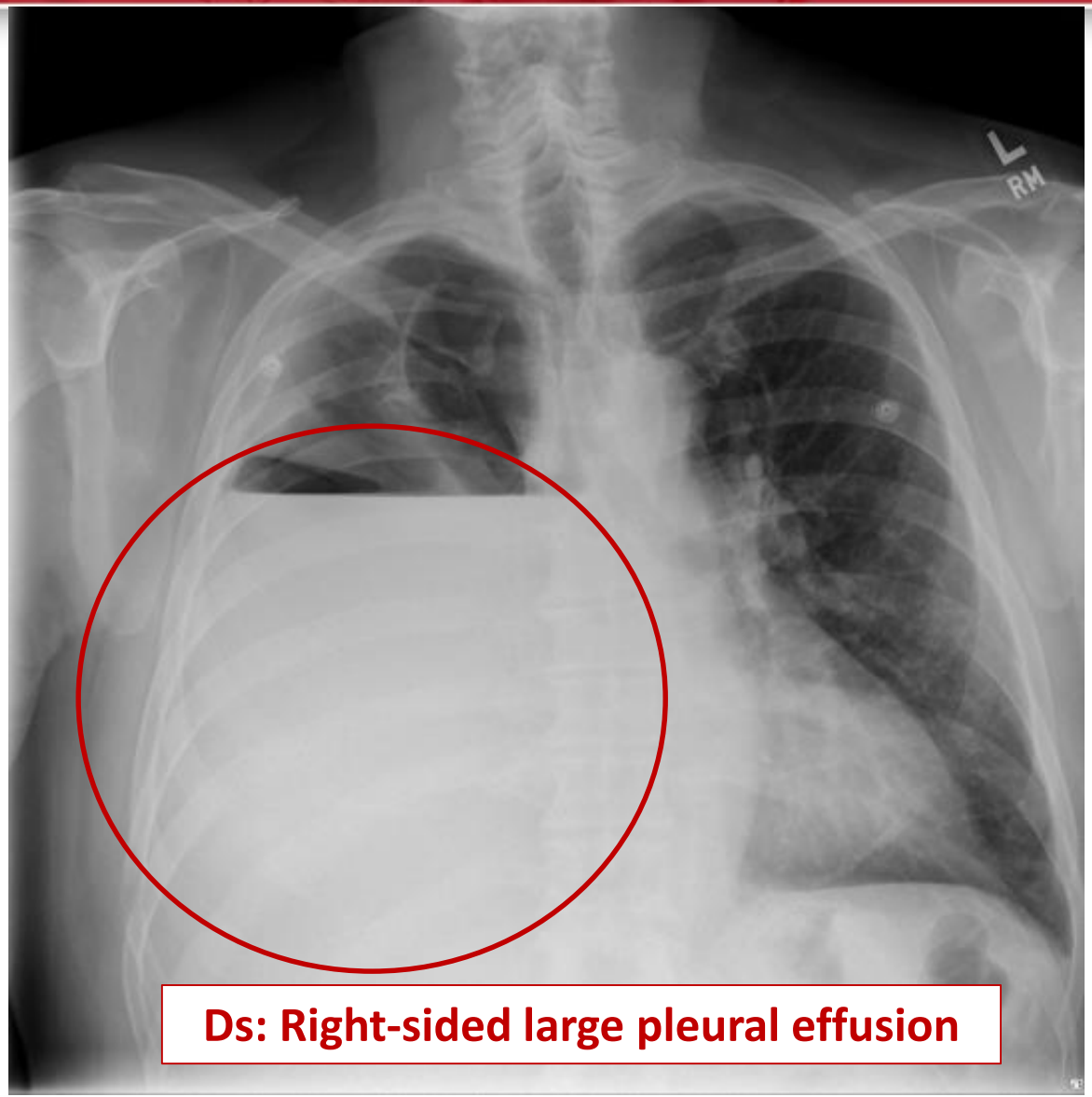
Pleural effusion



Ds: Right-sided moderate pleural effusion

Pleural effusion

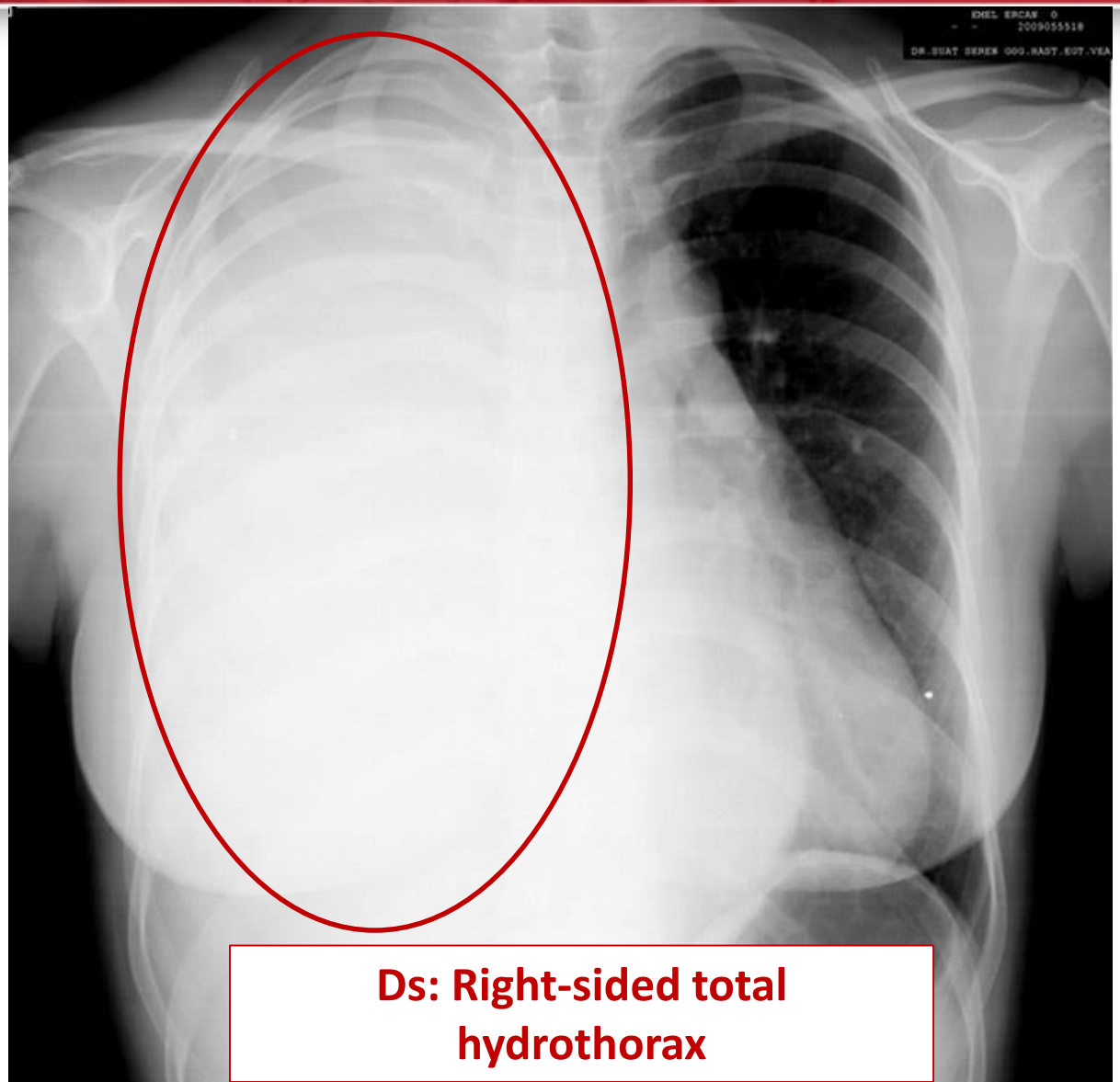
Pleural effusion



Ds: Right-sided large pleural effusion

Pleural effusion

Pleural effusion

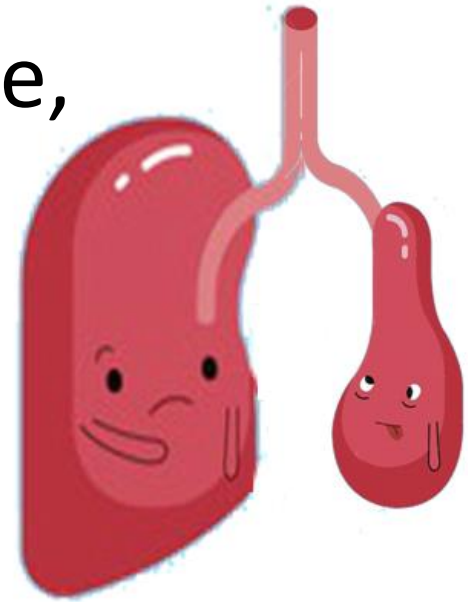


Ds: Right-sided total hydrothorax

Pneumothorax

Pneumothorax

- **Pneumothorax** - the presence of **air** or gas **in the pleural cavity**, causing collapse of the lung.
- It is classified as **spontaneous** (primary – no underlying disease, secondary – underlying disease is present), **traumatic** and **iatrogenic.**



Pneumothorax

- **Characteristic on CXR:**

  - Visible **visceral pleural edge/lung margin** (seen as a very thin, sharp white line)

  - **No lung markings** are seen peripheral to this line

  - Peripheral space is **radiolucent** compared to the adjacent lung

  - Lung may completely **collapse**

  - Volume loss (due to atelectasis)

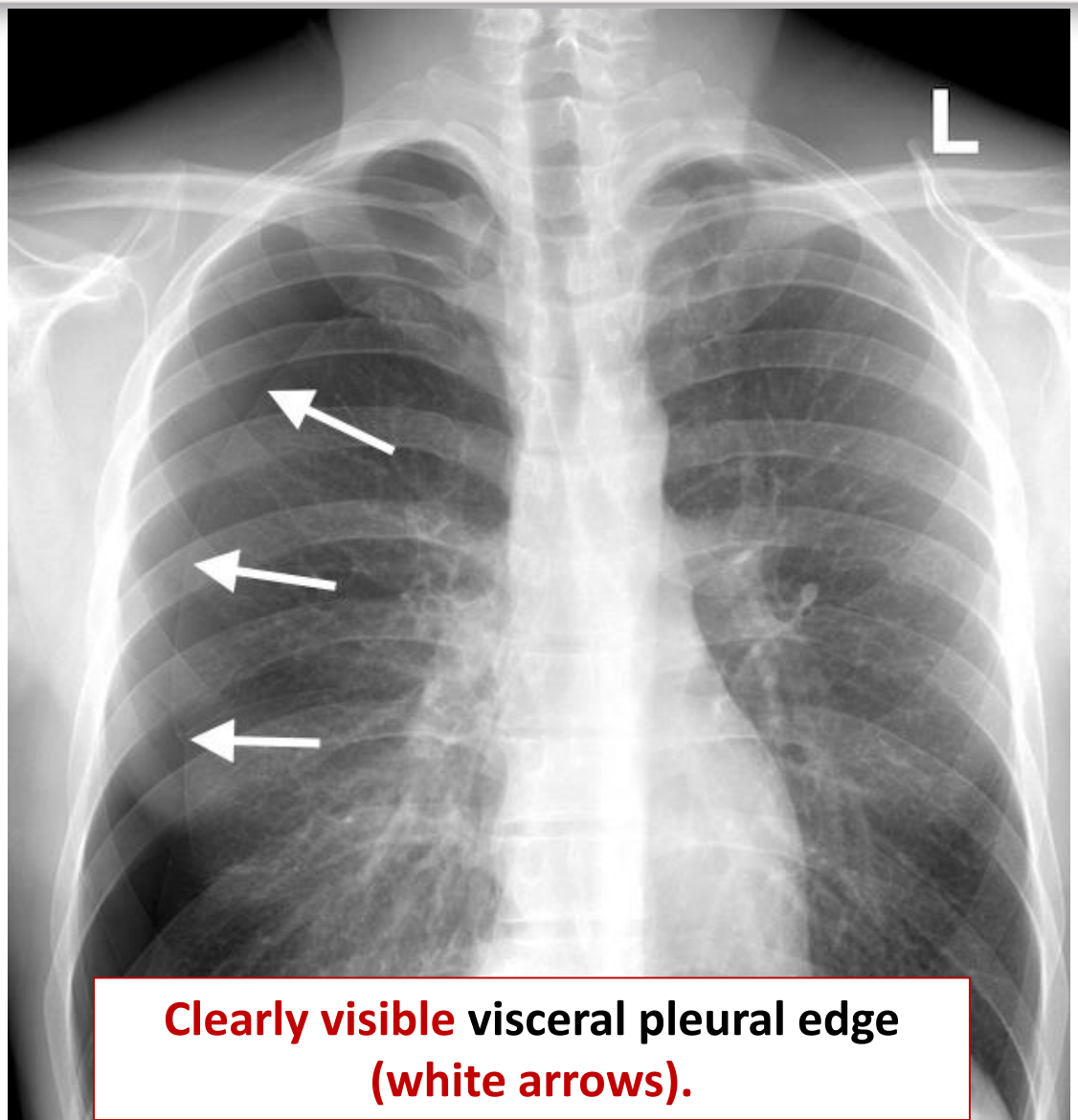
  - **Contralateral mediastinal shift** (in case of a large tense pneumothorax)*

  - Commonly **unilateral**

Pneumothorax

- ***Attention!**
  Lung collapse **without pneumothorax** leeds to volume loss and **pulling** of mediastunum towards the affected side.

Pneumothorax



Clearly visible visceral pleural edge (white arrows).

Pneumothorax

- **Pneumothorax size** estimation helps to determine **management** of the patient.

- **Small pneumothorax** will typically resolve without treatment and requires only monitoring.
- **Large pneumothorax** requires pleural drainage.

Pleural drainage kit

NB!

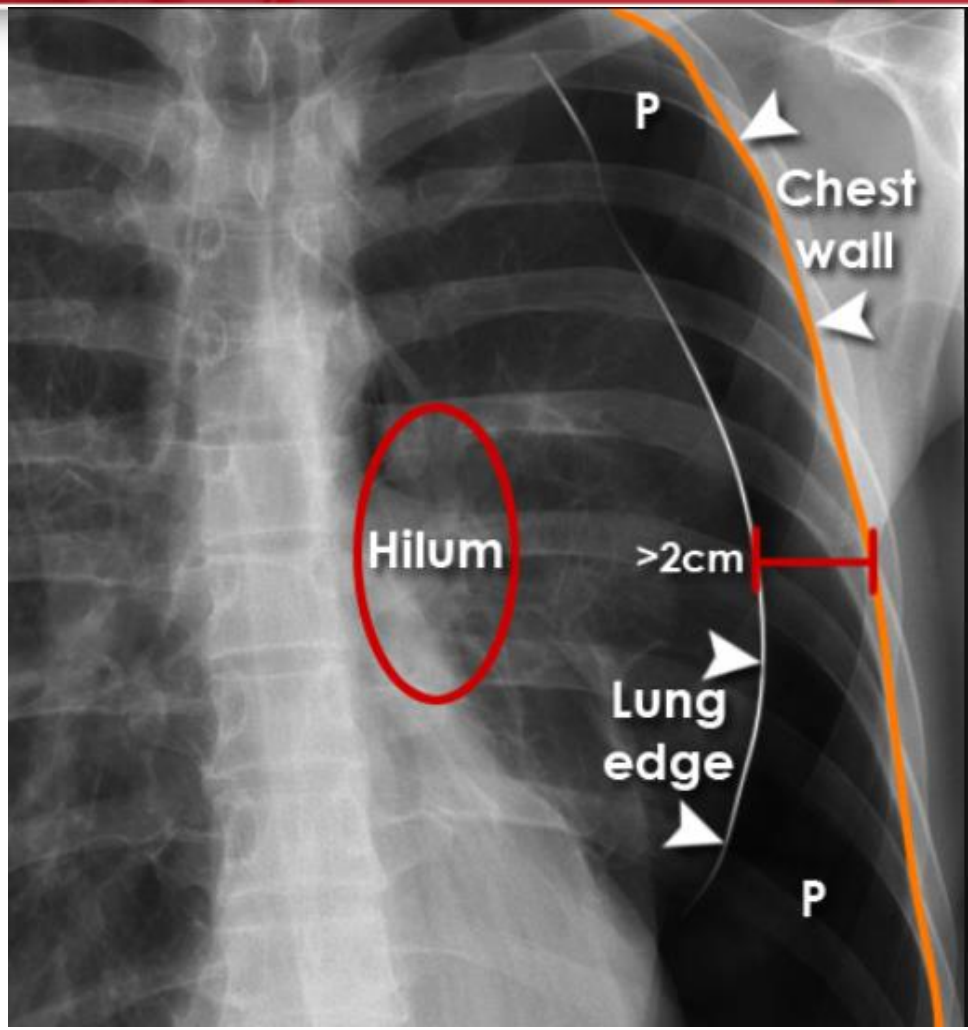
Although size is an important factor, the clinical features are also considered.

Pneumothorax

- **Size of pneumothorax** is established by measuring the **distance between the chest wall and the lung**.
- Measurement should be performed:
  - at the level of the hilum (GB; small <2 cm, large ≥2cm)
  - at the apex (USA; small <3cm, large ≥3 cm)

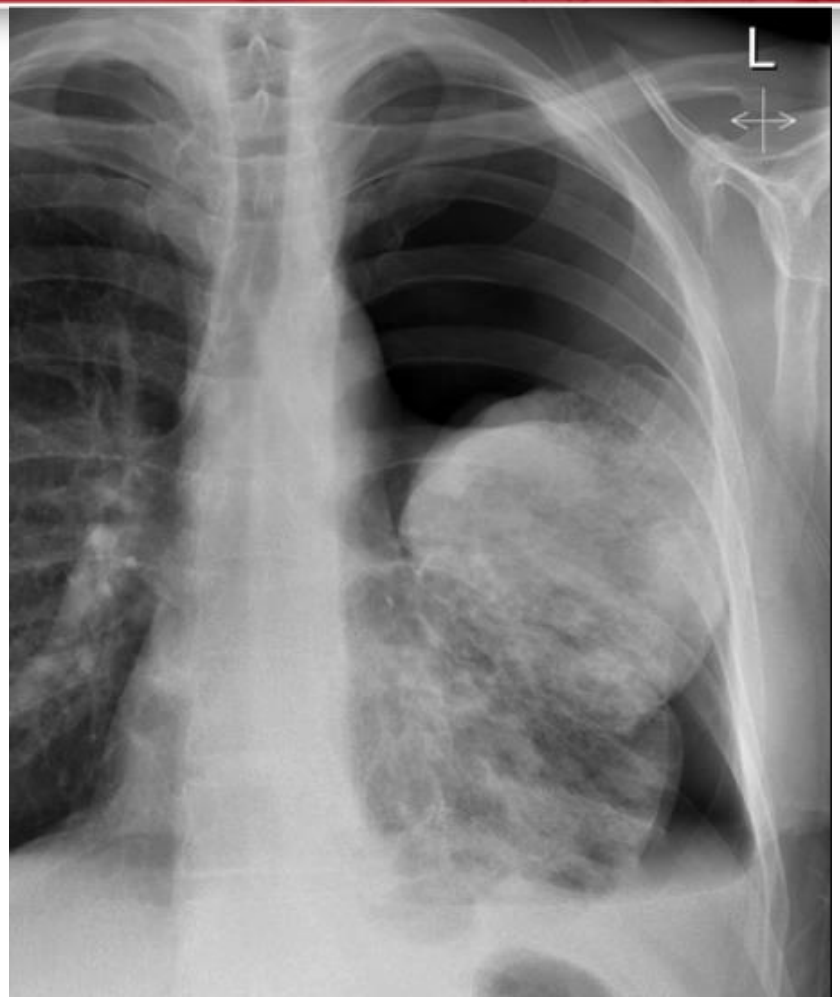
NB! **Air rim of 2 cm at the level of hilum means that the pneumothorax occupies about 50% of the hemithorax.**

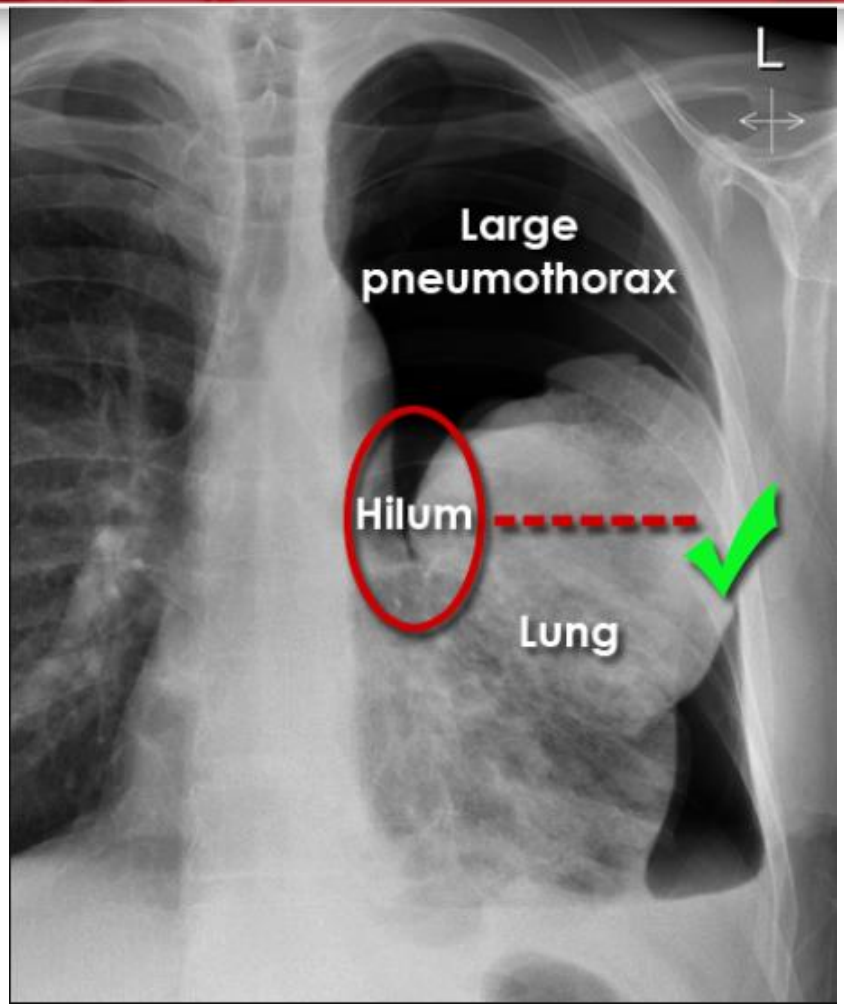
Pneumothorax



Large pneumothorax (P) which is >2 cm depth at the level of the hilum.

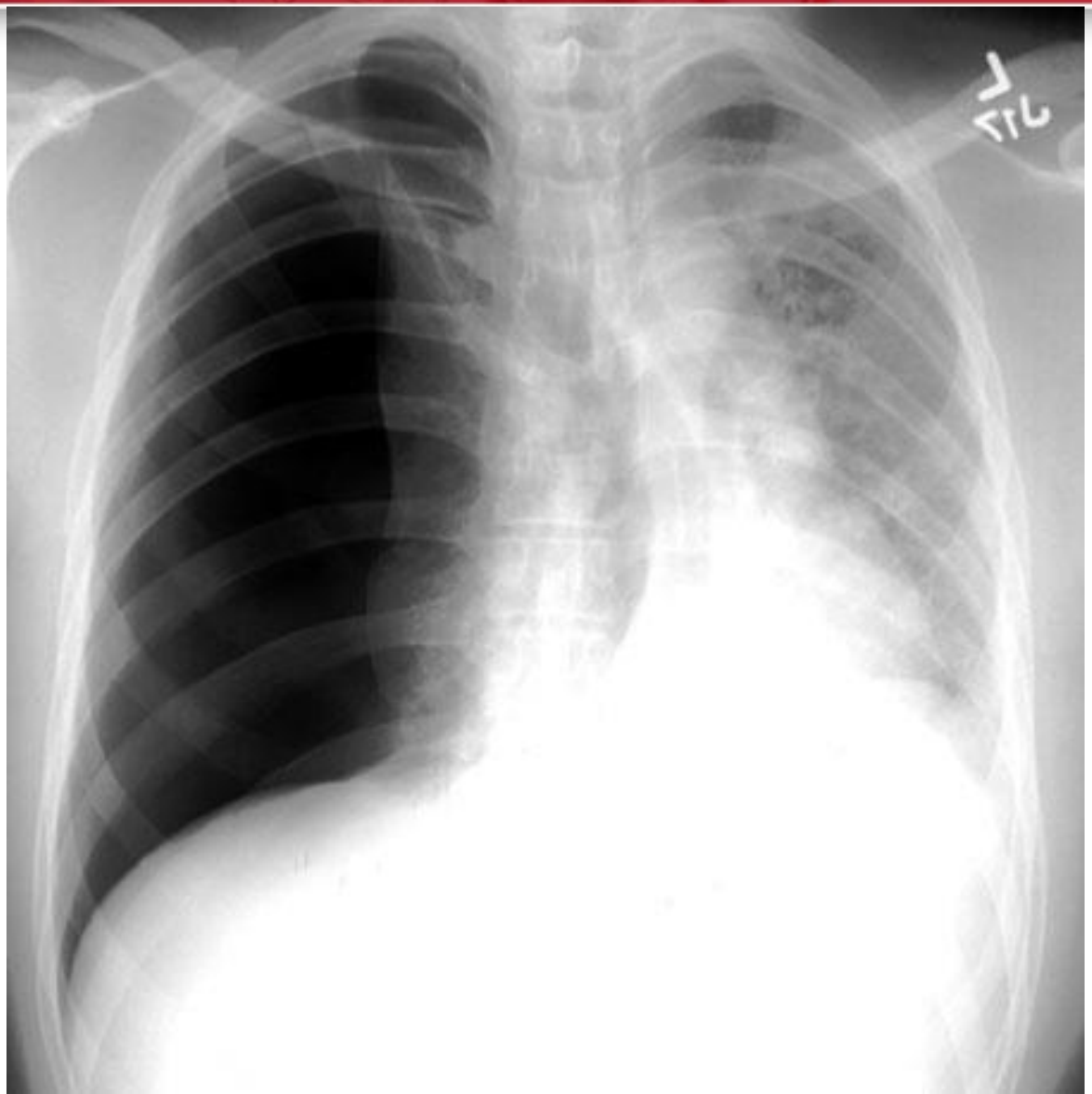
Pneumothorax



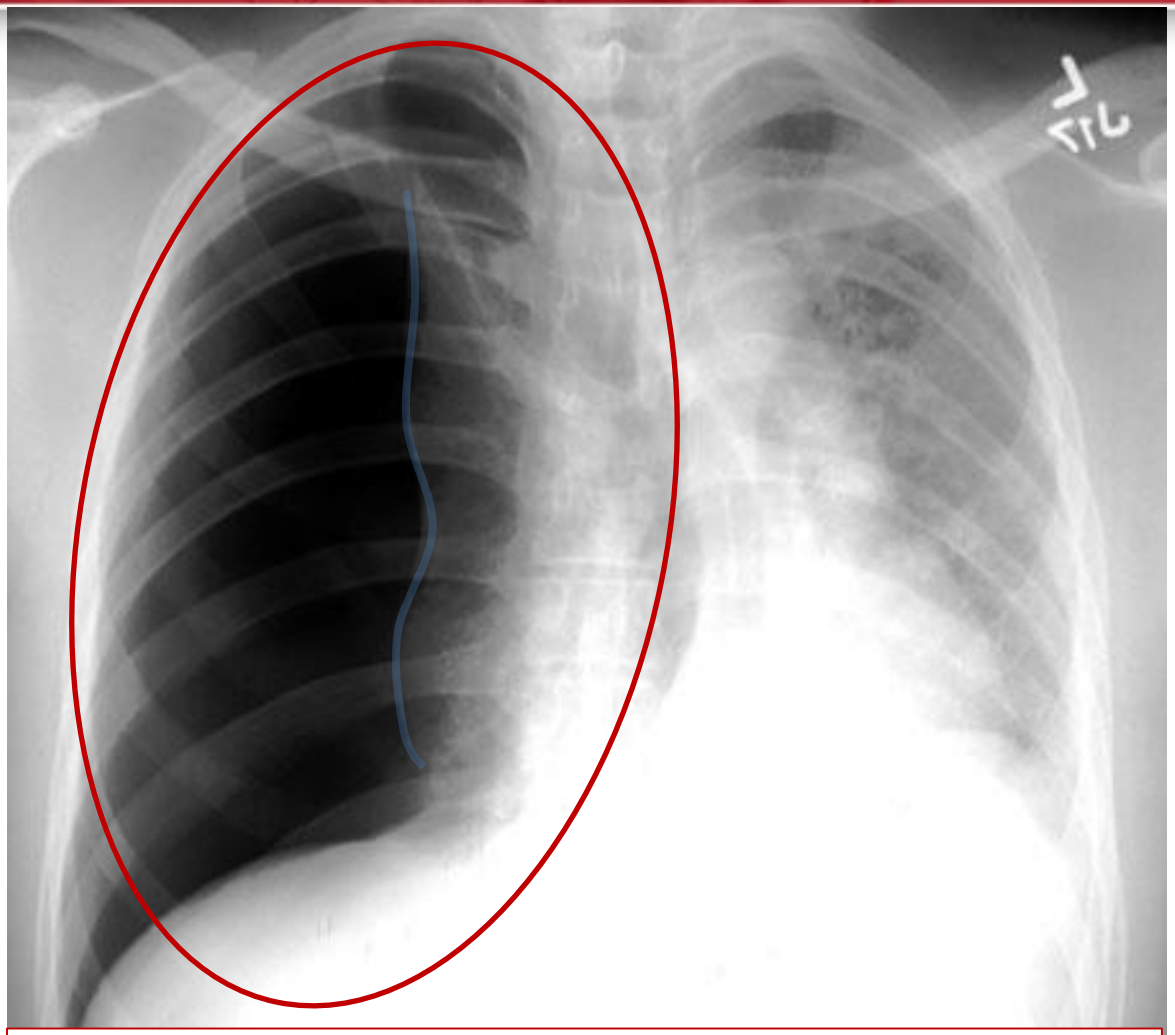


This image doesn't respond British guidelines "large pneumothorax" requirements, but fits American guidelines requirements.

Pneumothorax

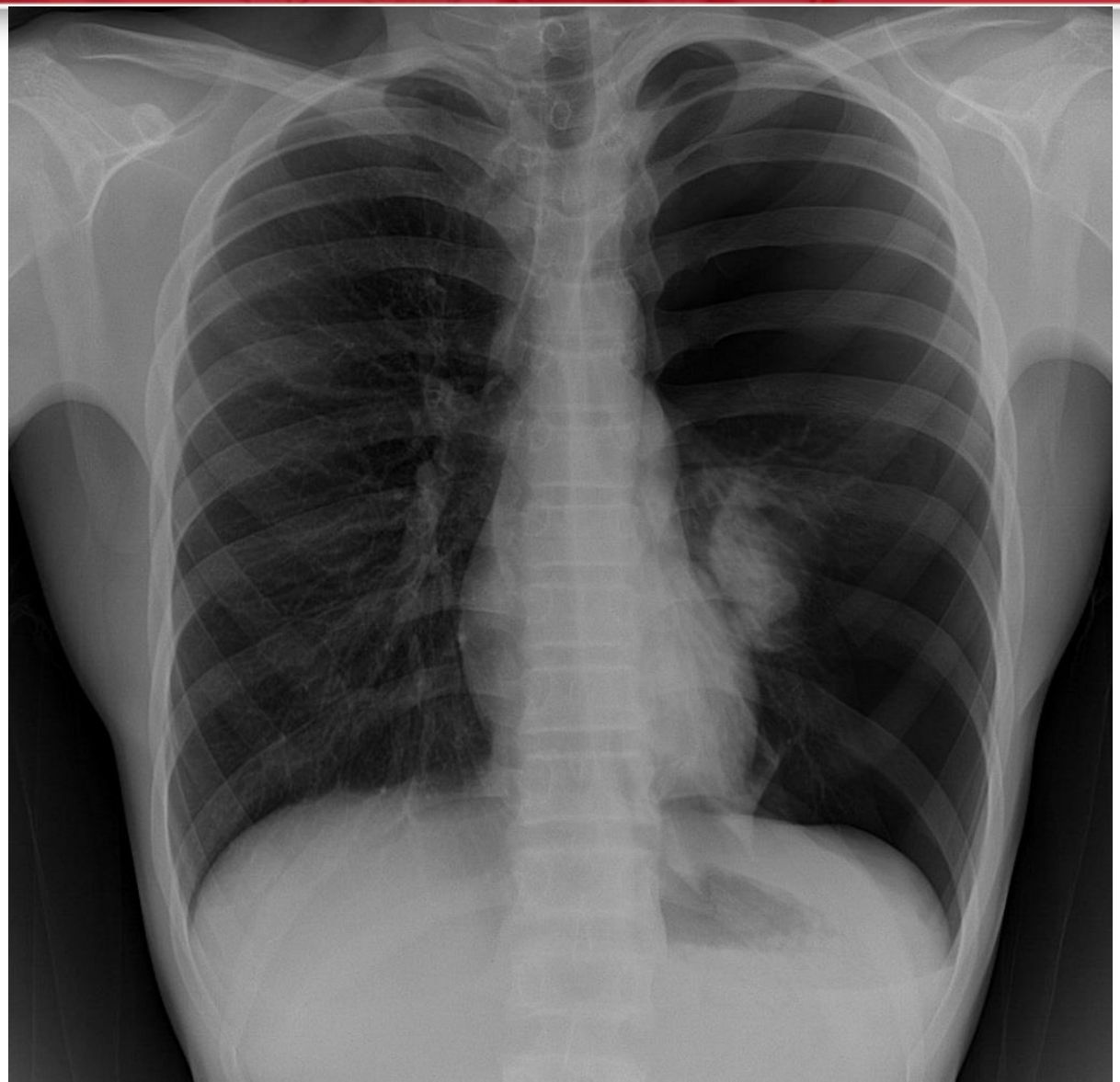


Pneumothorax

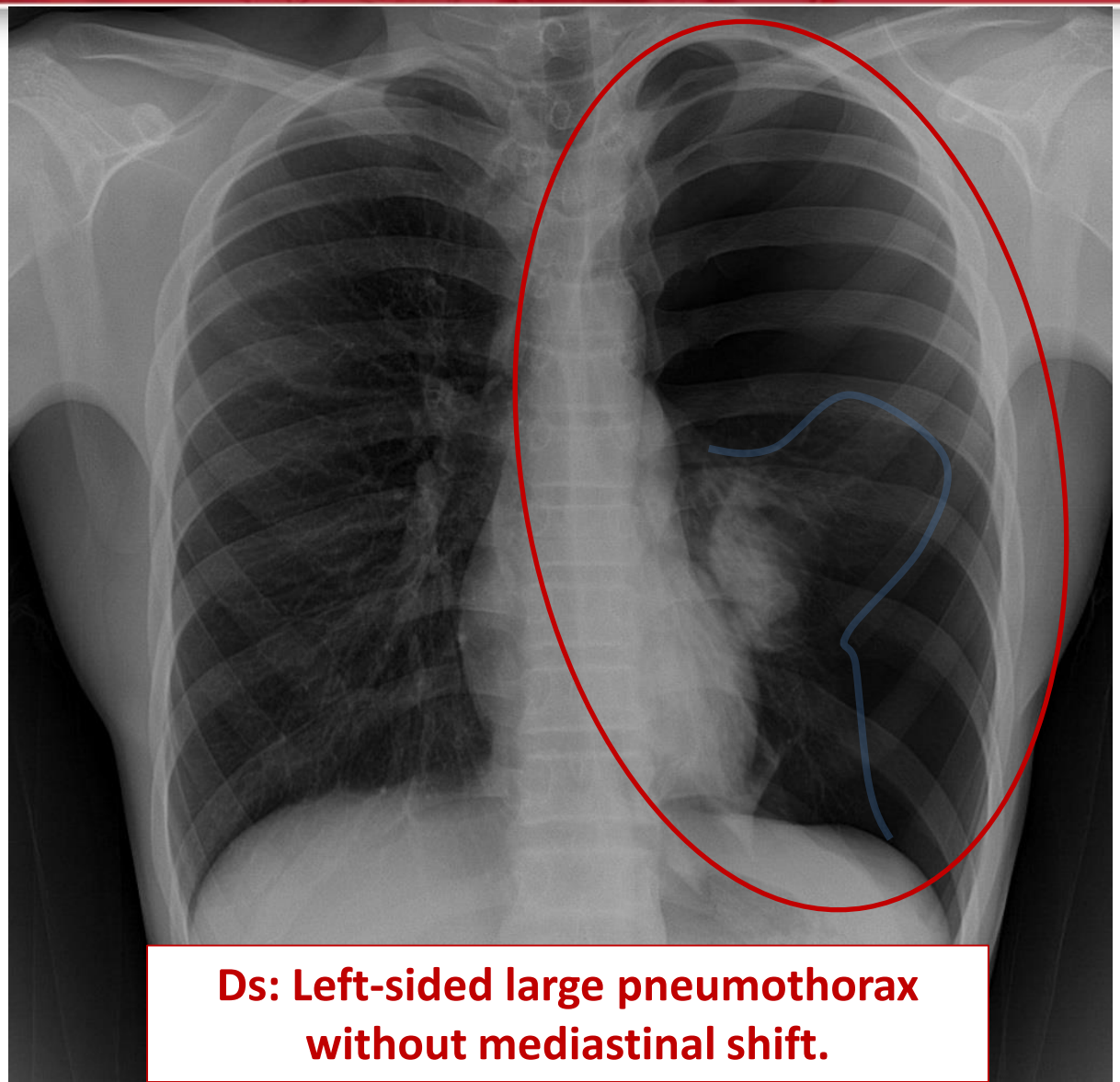


Ds: Right-sided large pneumothorax. Mediastinal shift to the left.

Pneumothorax



Pneumothorax

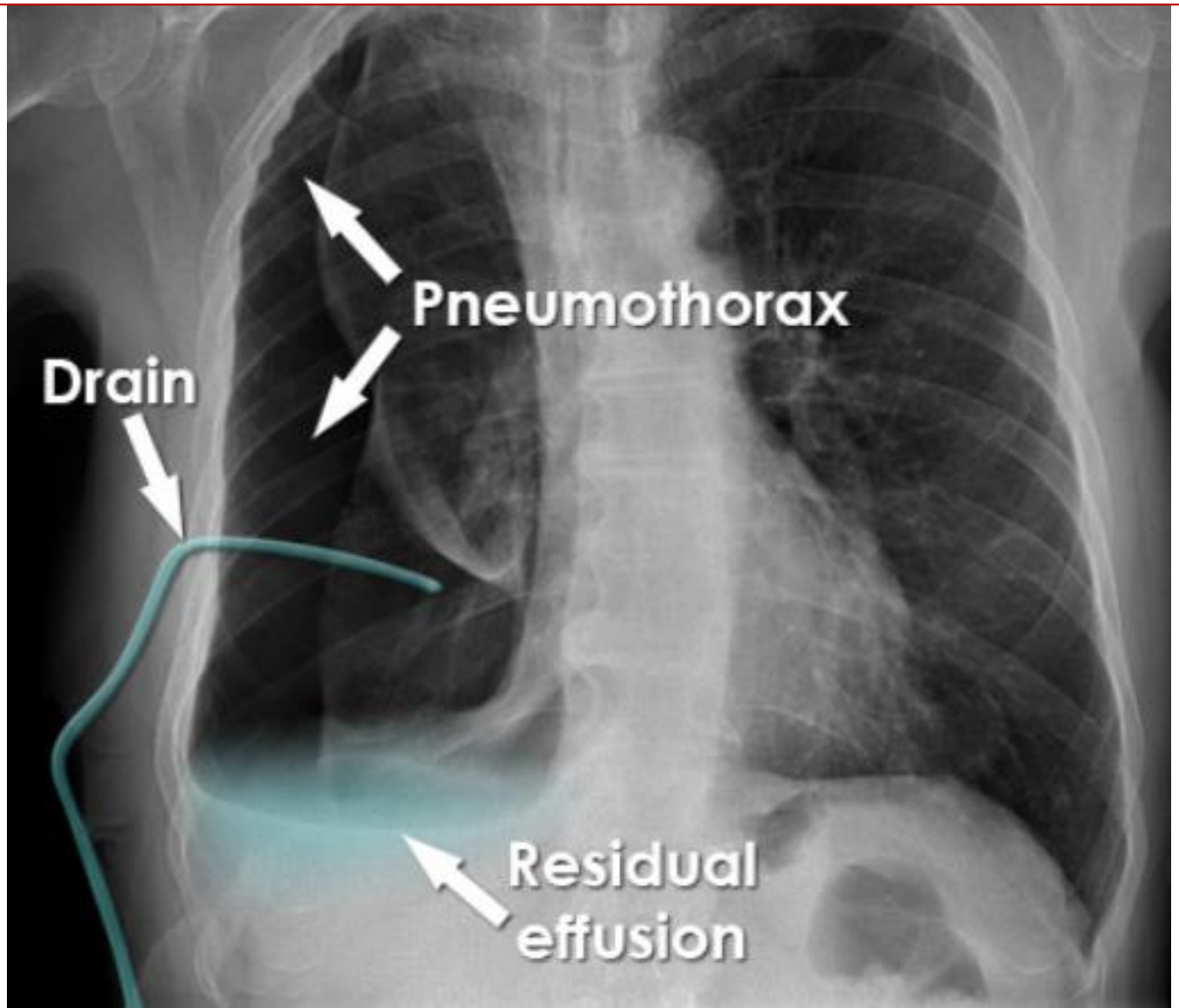


Ds: Left-sided large pneumothorax without mediastinal shift.

Pneumothorax

Pneumothorax

Ds: Iatrogenic right-sided large pneumothorax with mediastinal shift. Small right-sided pleural effusion.



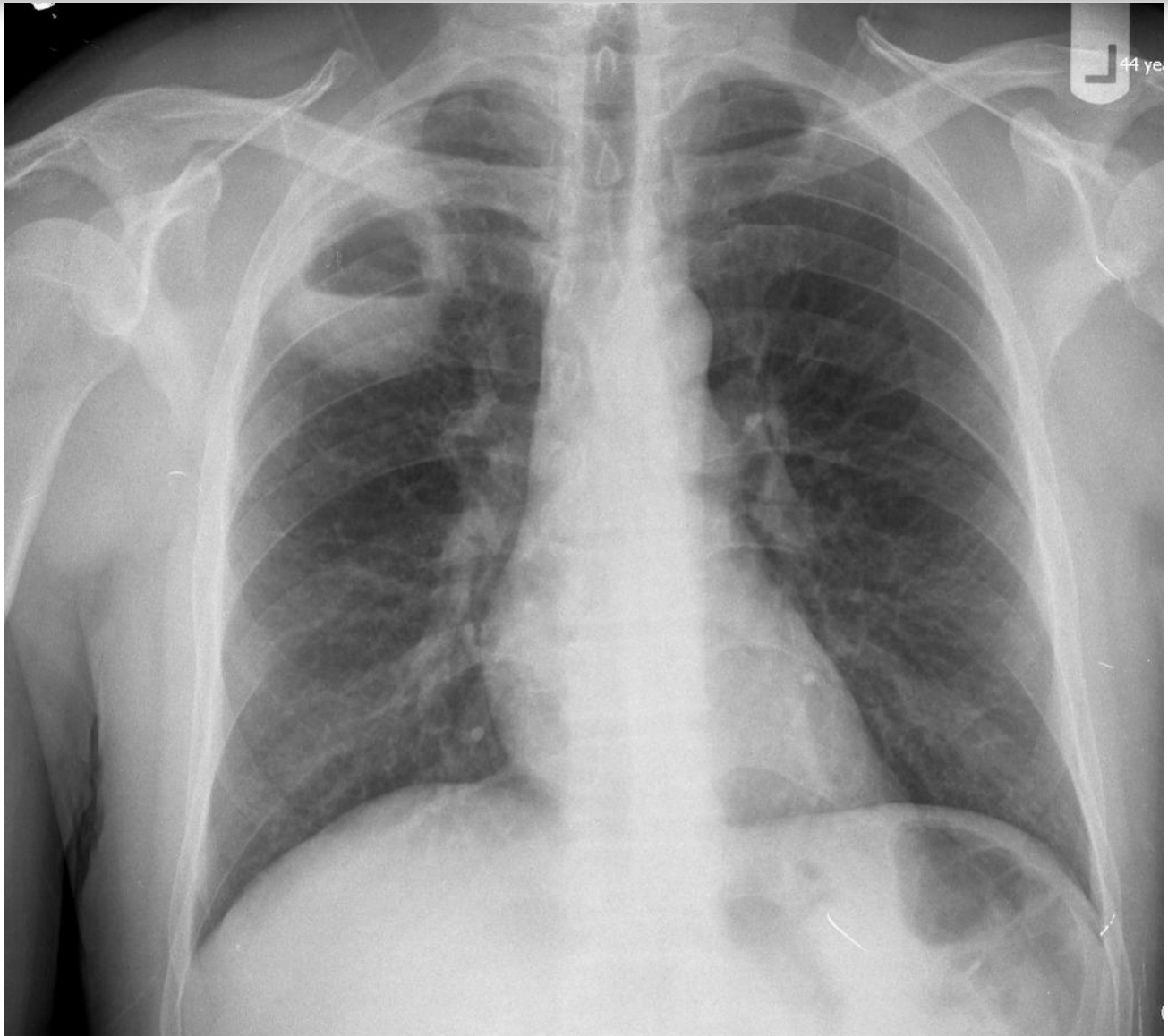
Abscess

Abscess

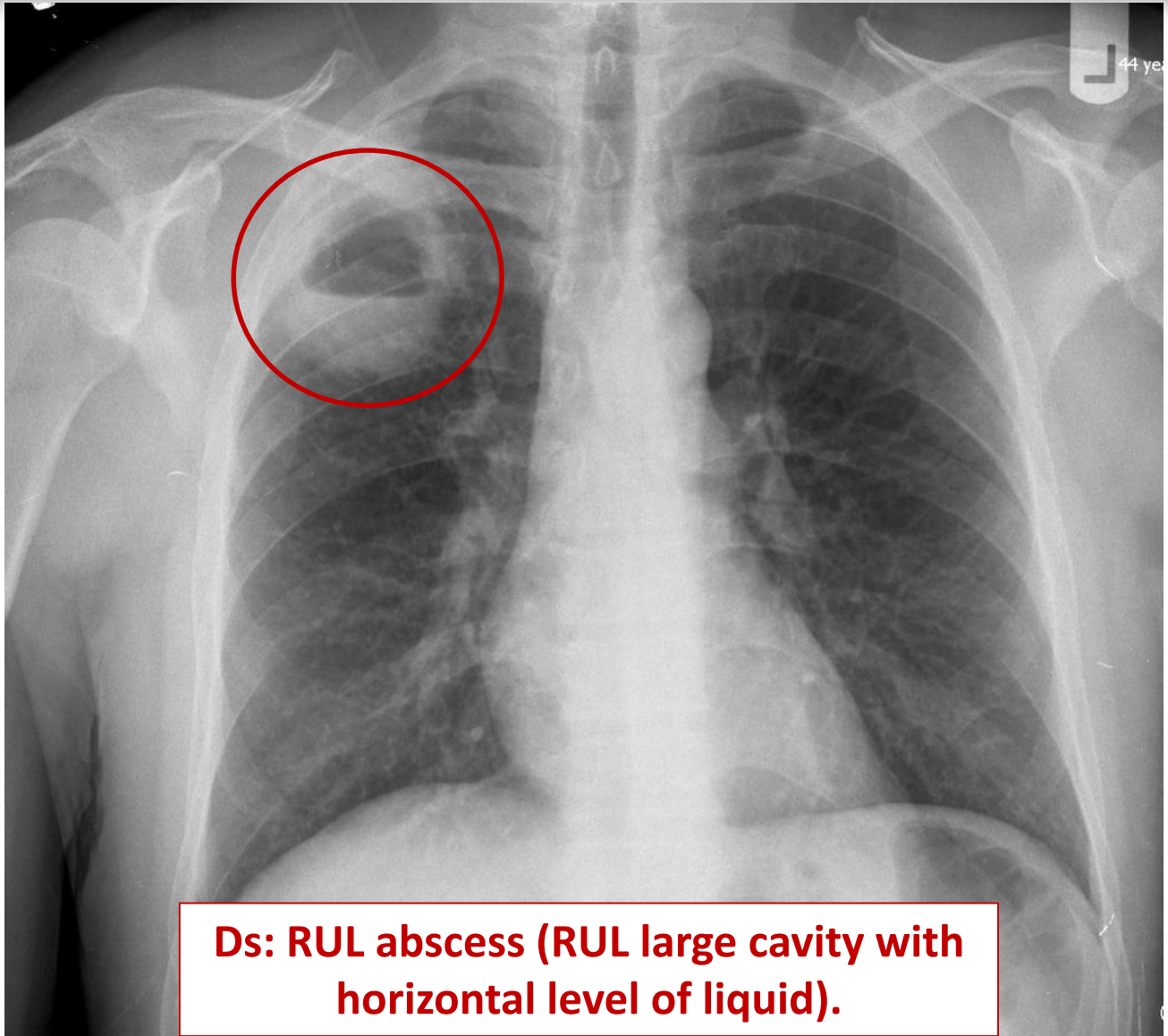
- **Lung abscess** is a type of liquefactive necrosis of the lung tissue and formation of cavities with necrotic debris or fluid caused by microbial infection.

- **Characteristic on CXR:**
  - Cavity containing a gas-fluid level
  - Irregularly shaped or round/oval
  - May form an acute angle with the costal surface / chest wall
  - Most frequently occurs in the posterior segments of the upper lobes or the superior segments of the lower lobes
  - All margins are equally well seen
  - Usually unilateral

Abscess

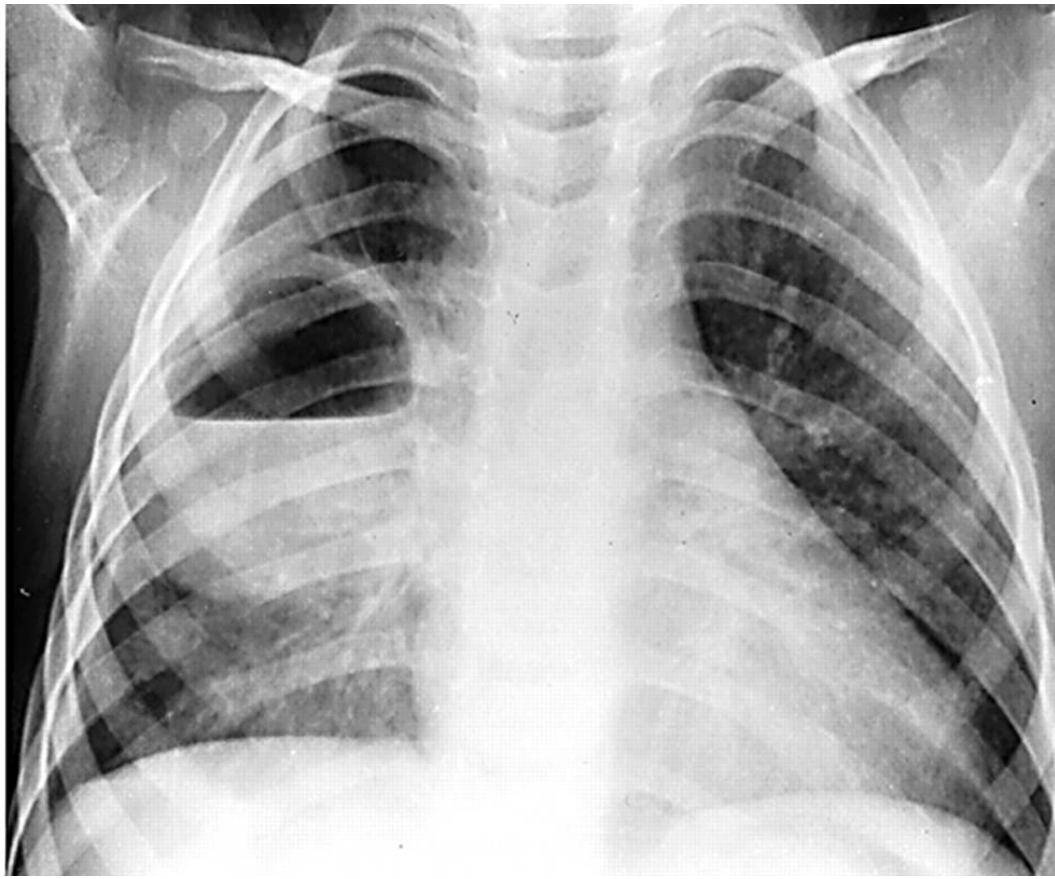


Abscess

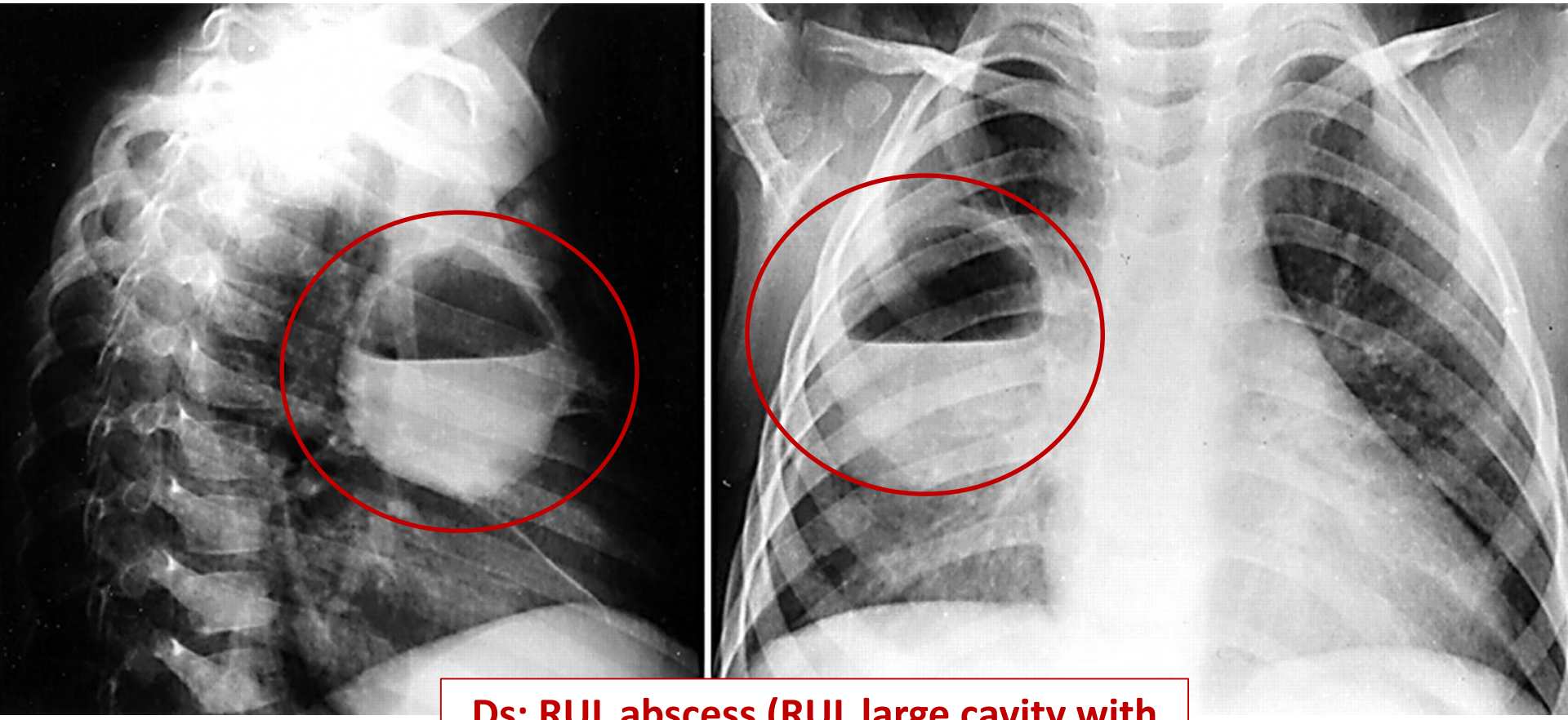


Ds: RUL abscess (RUL large cavity with horizontal level of liquid).

Abscess



Abscess



Ds: RUL abscess (RUL large cavity with horizontal level of liquid).

Gangrene

Gangrene

- **Pulmonary gangrene** is pyogenic destruction of a large area of lung (lobe, several lobes, whole lung) with tendency to further development.
- It refers to **necrotizing pneumonia** and **cavitation**.
- In fact – it's a complication of **anaerobic pneumonia** (mainly caused by **Klebsiella pneumoniae**).
- **Therefore, on X-ray its presented with opacifications and cavitations (with level of liquid).**

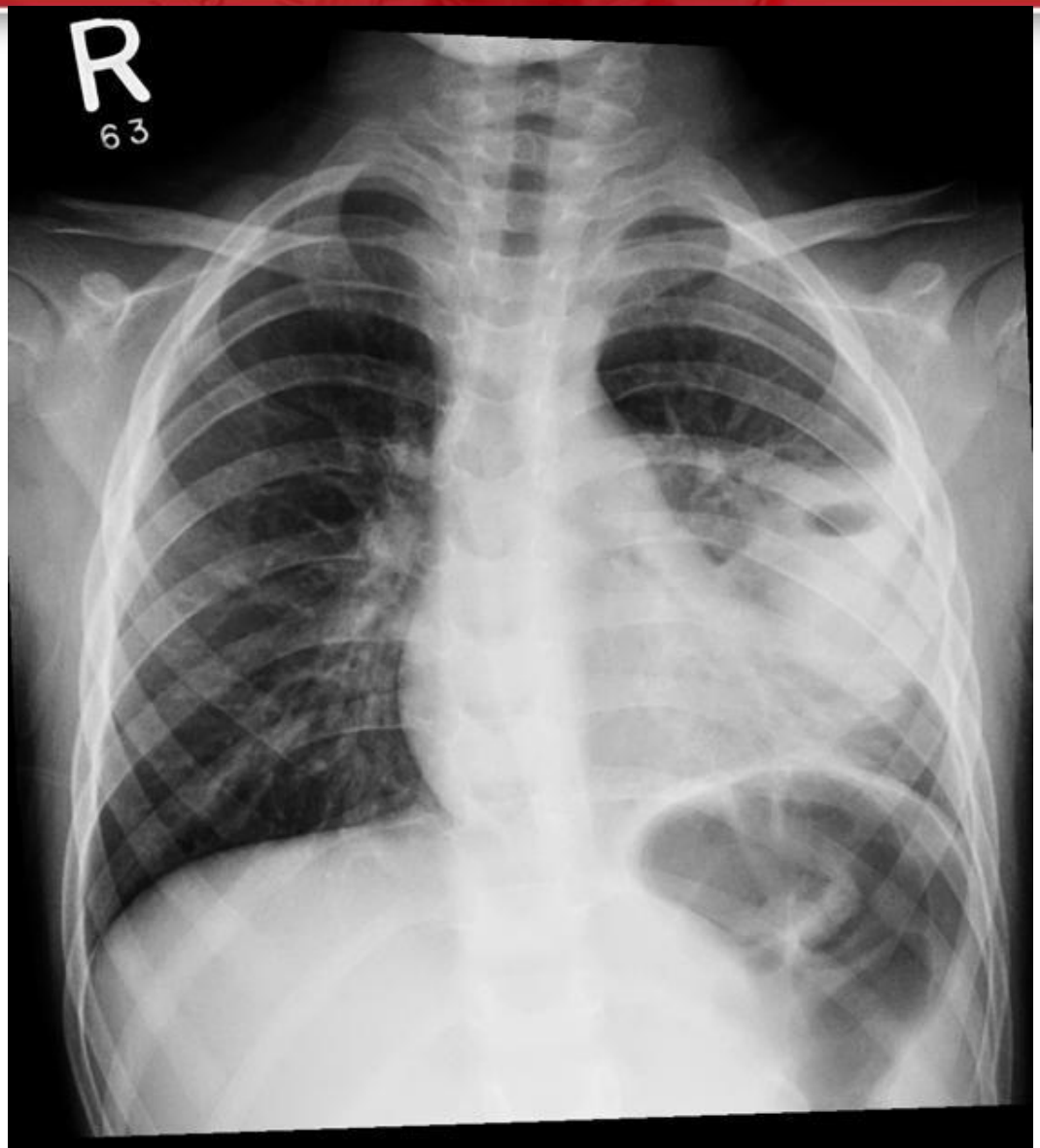
Gangrene

- Pulmonary gangrene needs to be **differentiated** with **abscess** and **pneumonia**.
- **X-ray doesn’t allow to make a reliable conclusion** in diagnostic of pulmonary gangrene.
- Diagnostics includes **sputum microscopy/culture** and **specific clinical signs** (along with laboratory and imaging methods).

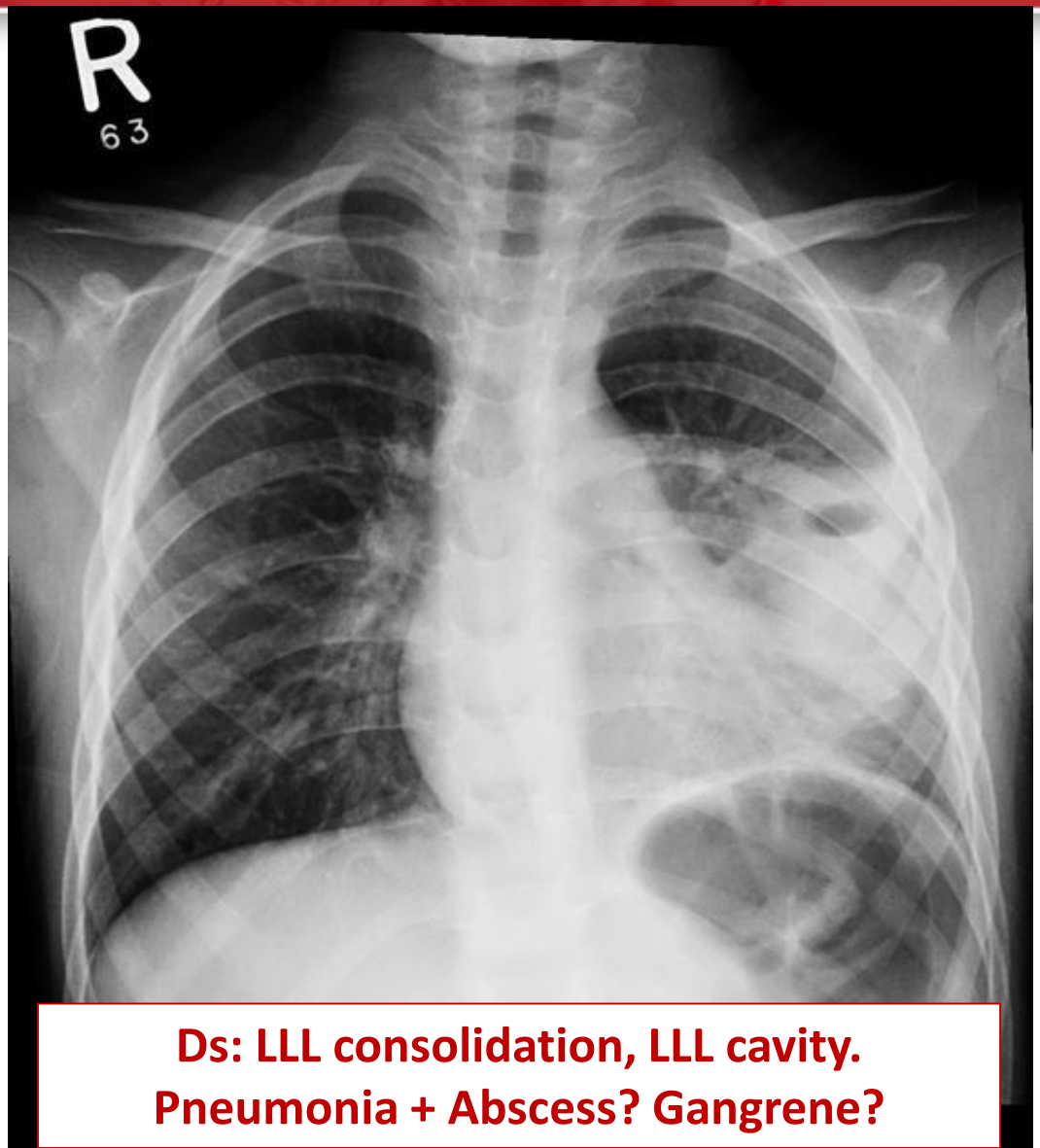
Gangrene vs. Abscess

- **Abscess** – a cavity with pus formed as a result of a decay of necrotized areas of lung, that is **limited** with granulation wall and perifocal infiltration zone **(=> thick distinct wall)**.
- **Gangrene** – necrosis of a significant area of lung **without limitation (=> no distinct wall)** with tendency to develop
  + lab and clinical features.

Gangrene



Gangrene



Ds: LLL consolidation, LLL cavity.
Pneumonia + Abscess? Gangrene?

COPD

COPD

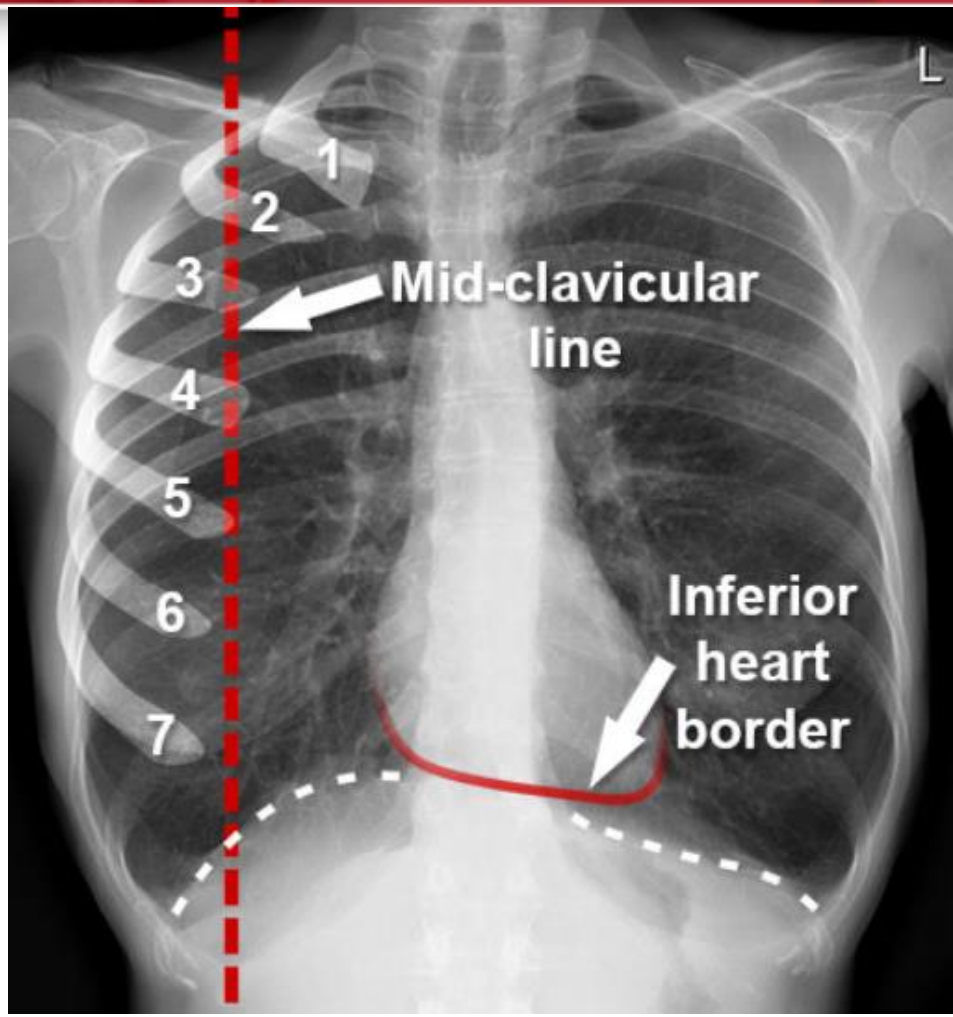
- **Chronic Obstructive Pulmonary Disease (COPD)** is a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases (foremost – smoking).
- Has two components - **chronic bronchitis and emphysema.**
- **Spirometry** is the gold standard of diagnostic for COPD, **CXR is an accessory investigation**.

COPD

- **Characteristic on CXR (refers to emphysema):**

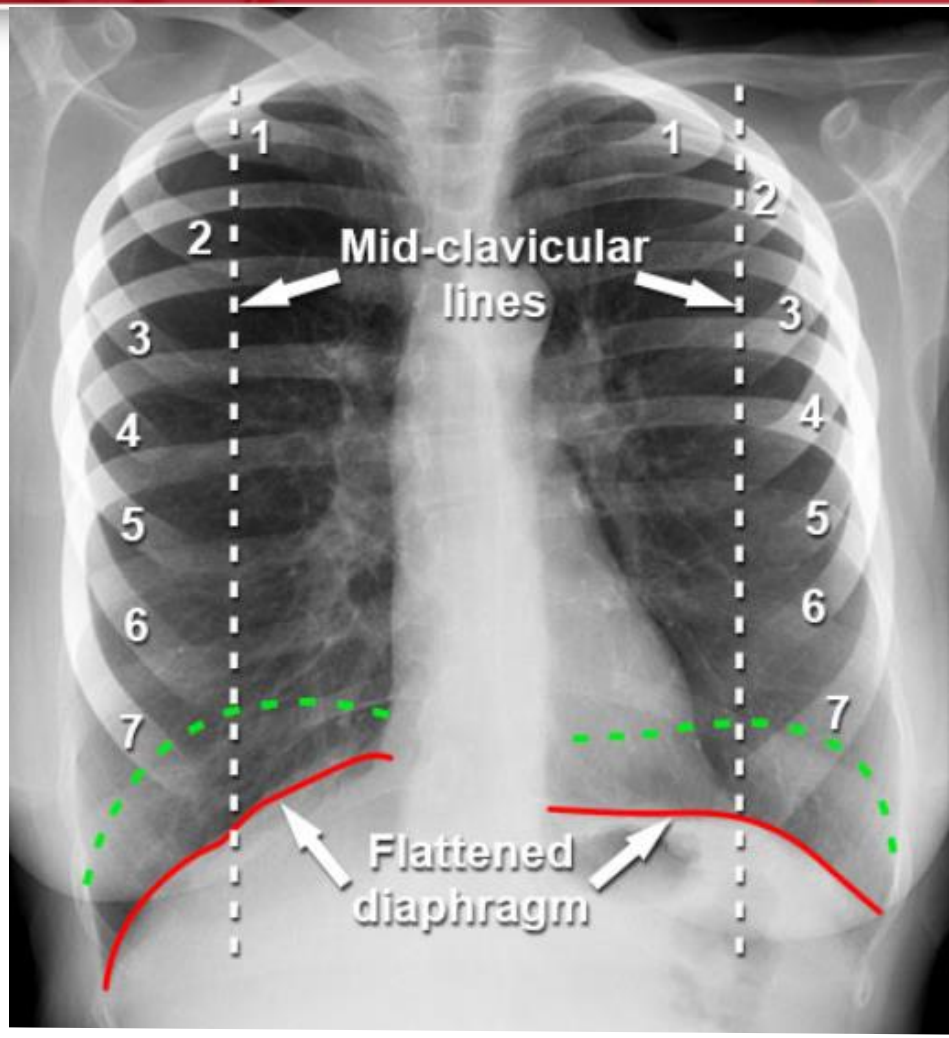
- Hyperexpansion
- Flattened diaphragm
- Floating heart sign
- Decreased peripheral bronchovascular markings
- Increased lung lucency (parenchymal loss)
- Bulla (round focal lucency over 1 cm)
- Prominence of the hilar vessels in pulmonary hypertension

Floating heart sign



- **Floating heart sign** - visibility of the inferior border of the heart (**heart appears to float above the diaphragm**); refers to **hyperexpansion.**

COPD

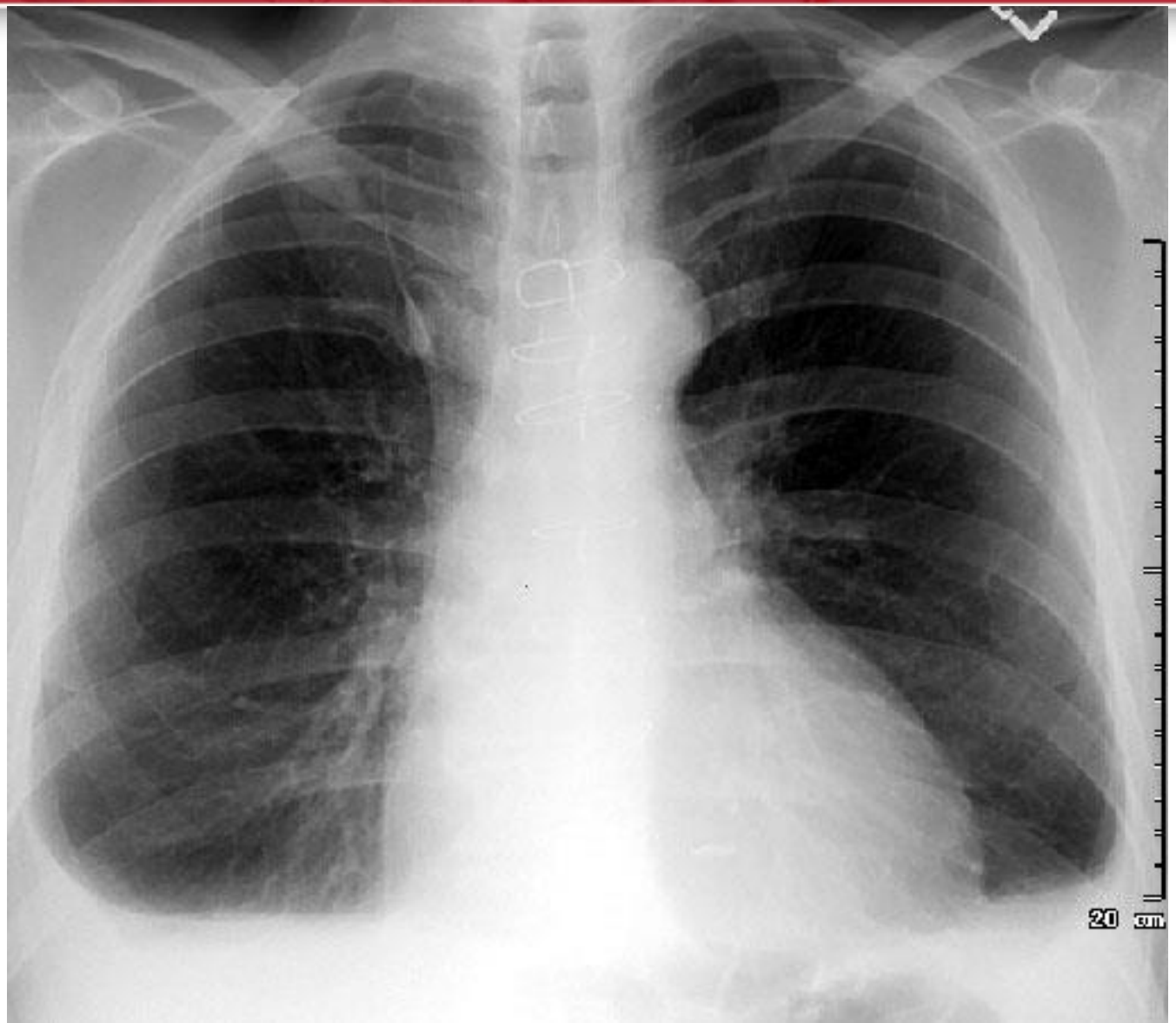


Ds: Emphysema (hyperexpansion, flattened diaphragm, hyperlucency of lung fields)

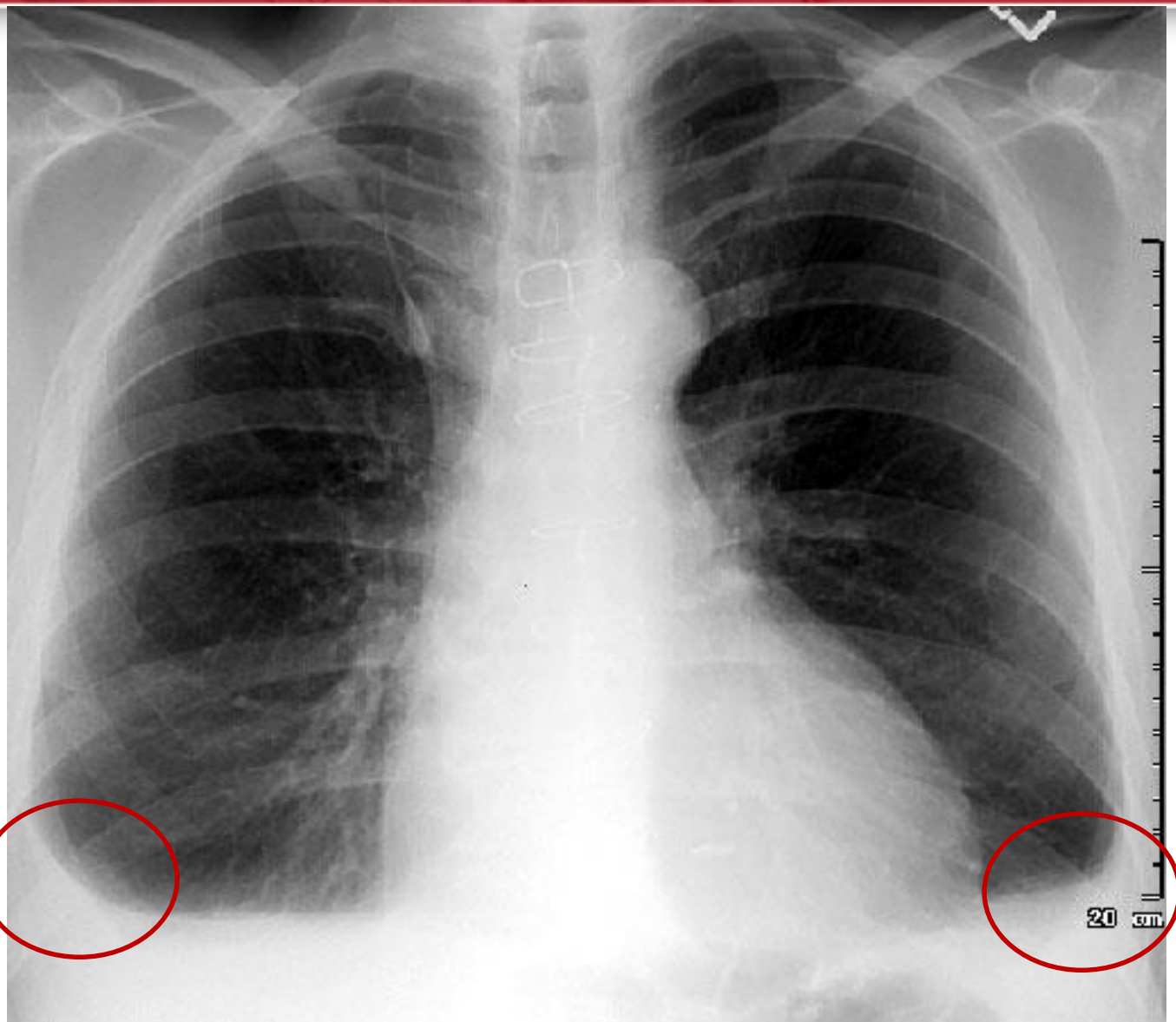
COPD

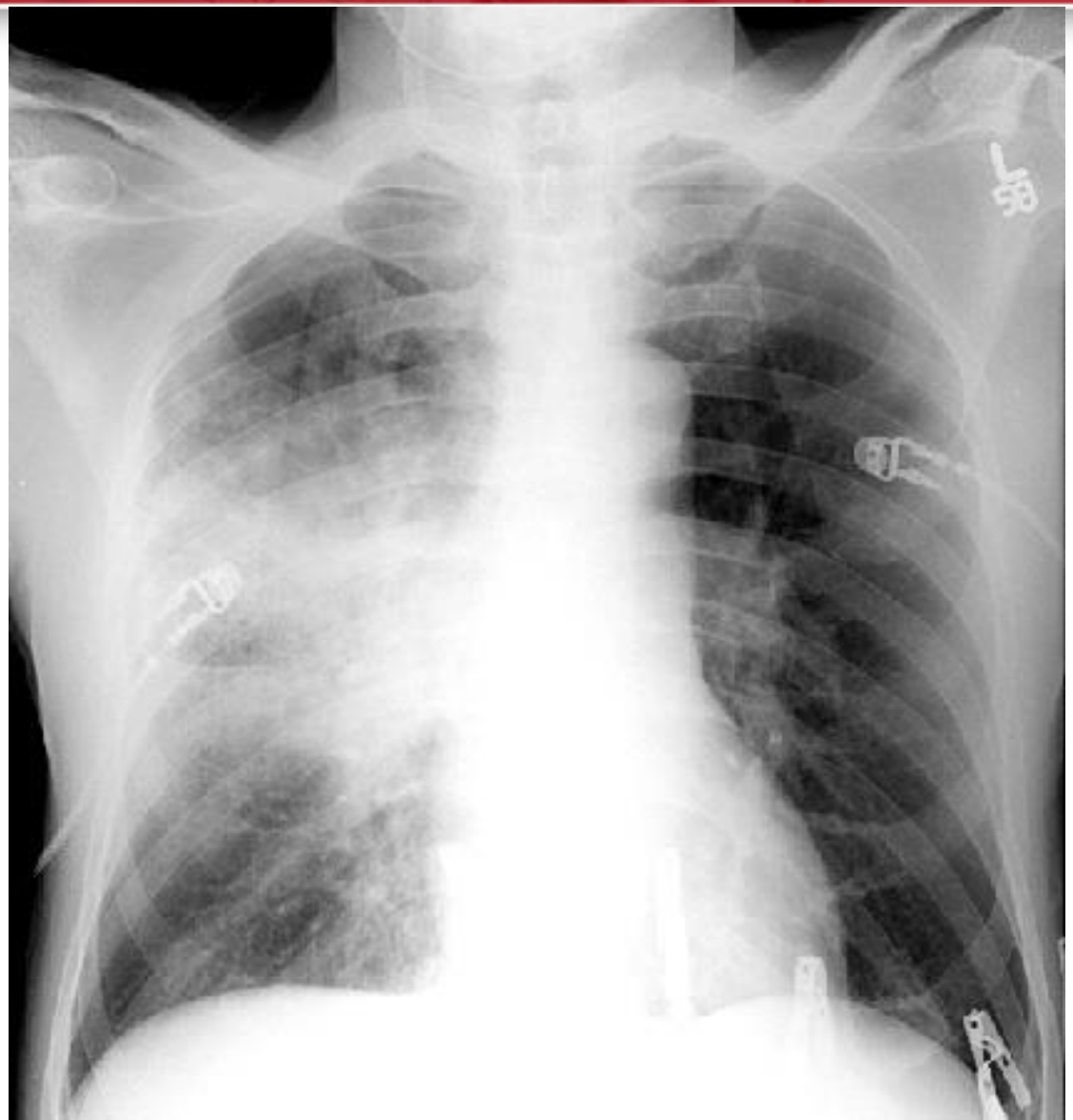
Ds: Emphysema (hyperexpansion, flattened diaphragm, hyperlucency of lung fields, floating heart sign), cardiomegaly (CTR>0.5)

§6. Test

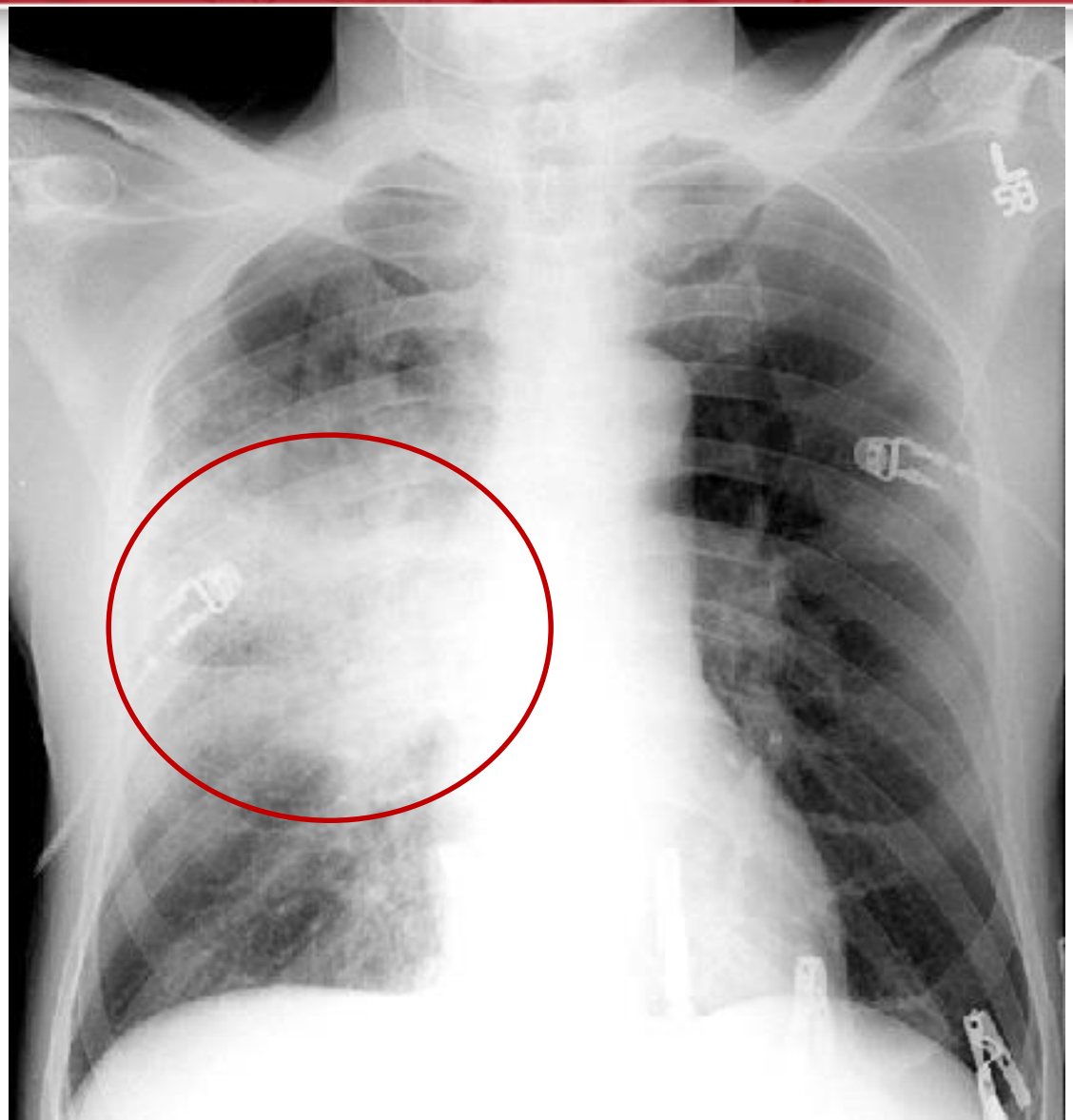


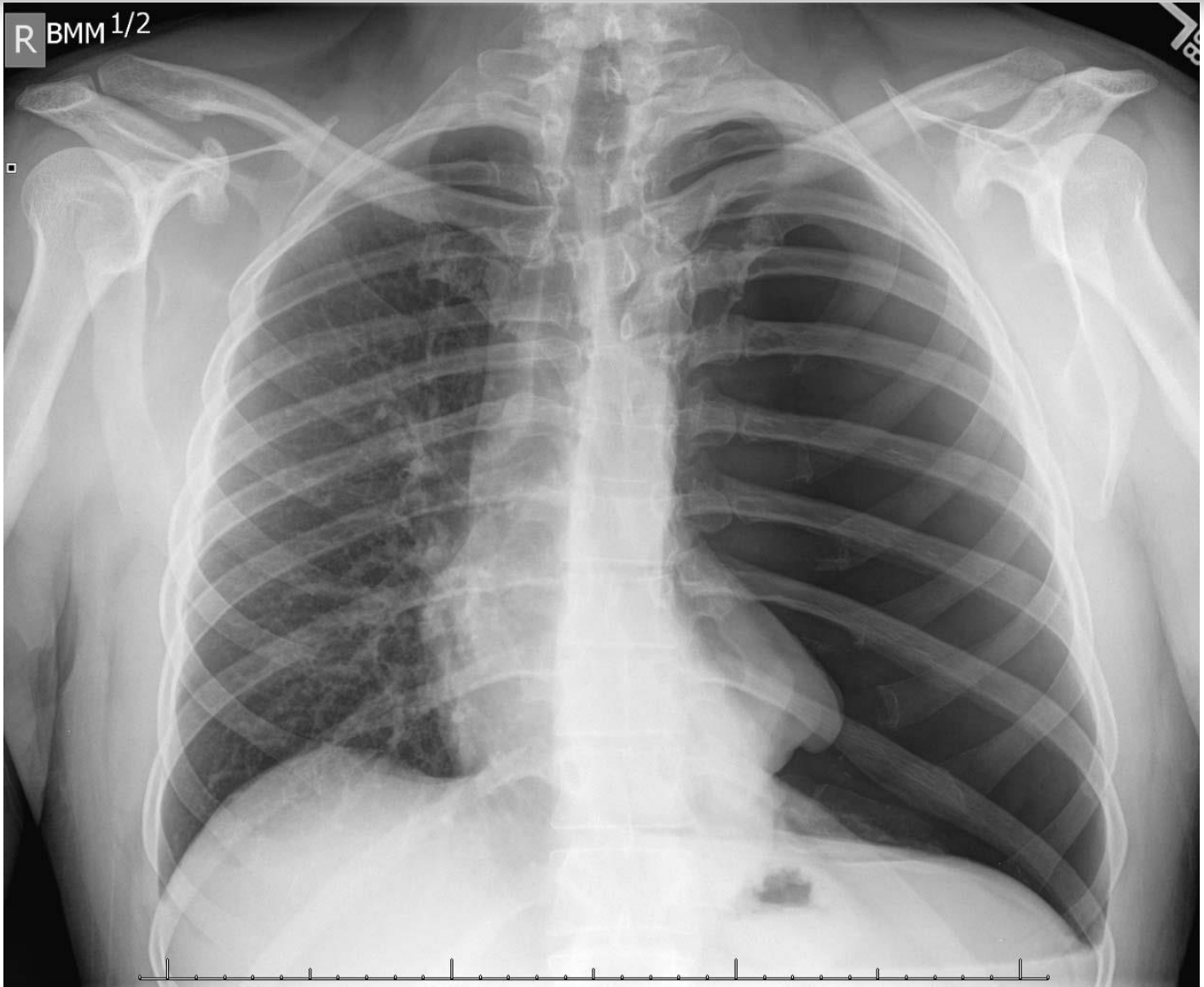
Bilateral small pleural effusion



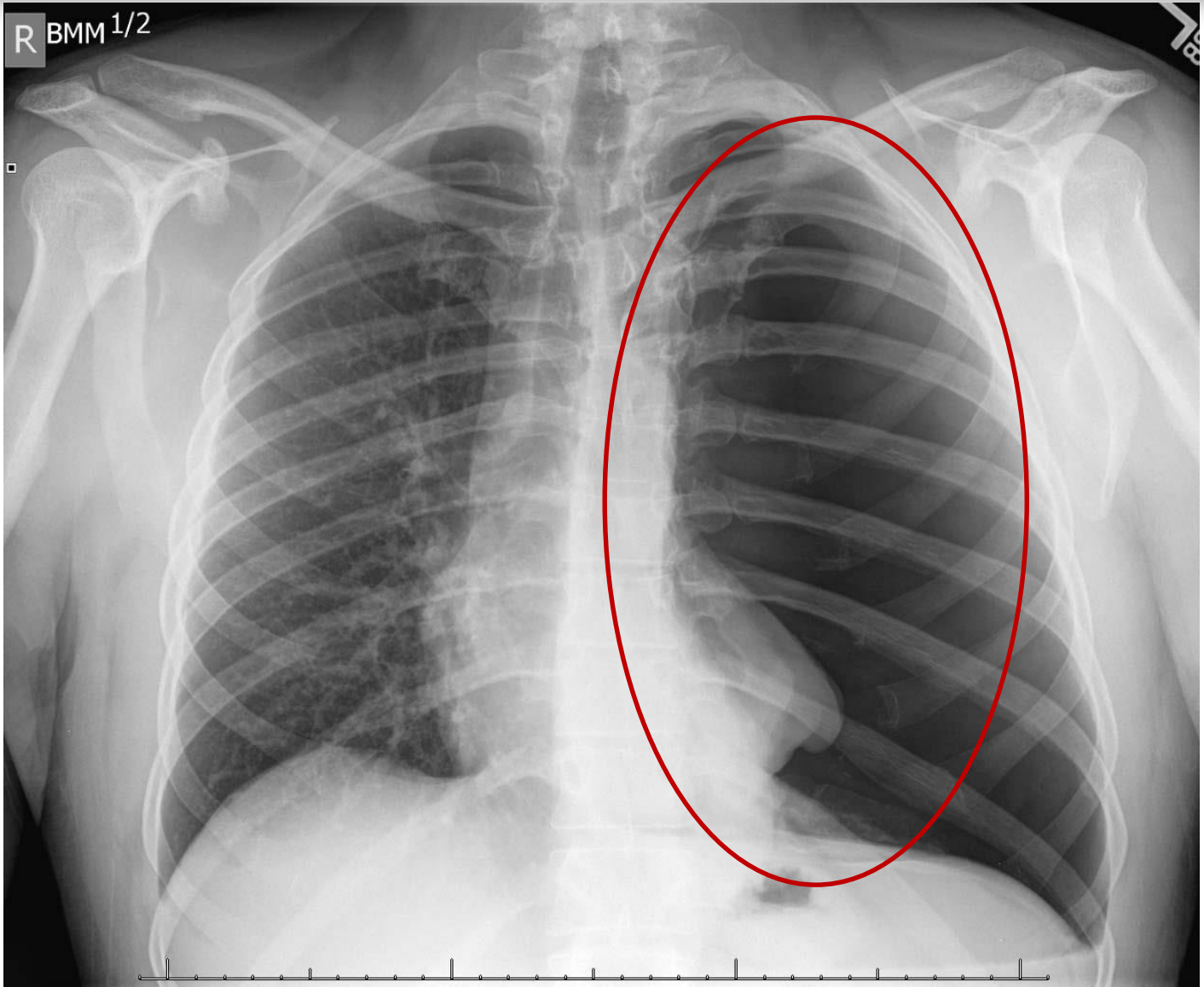


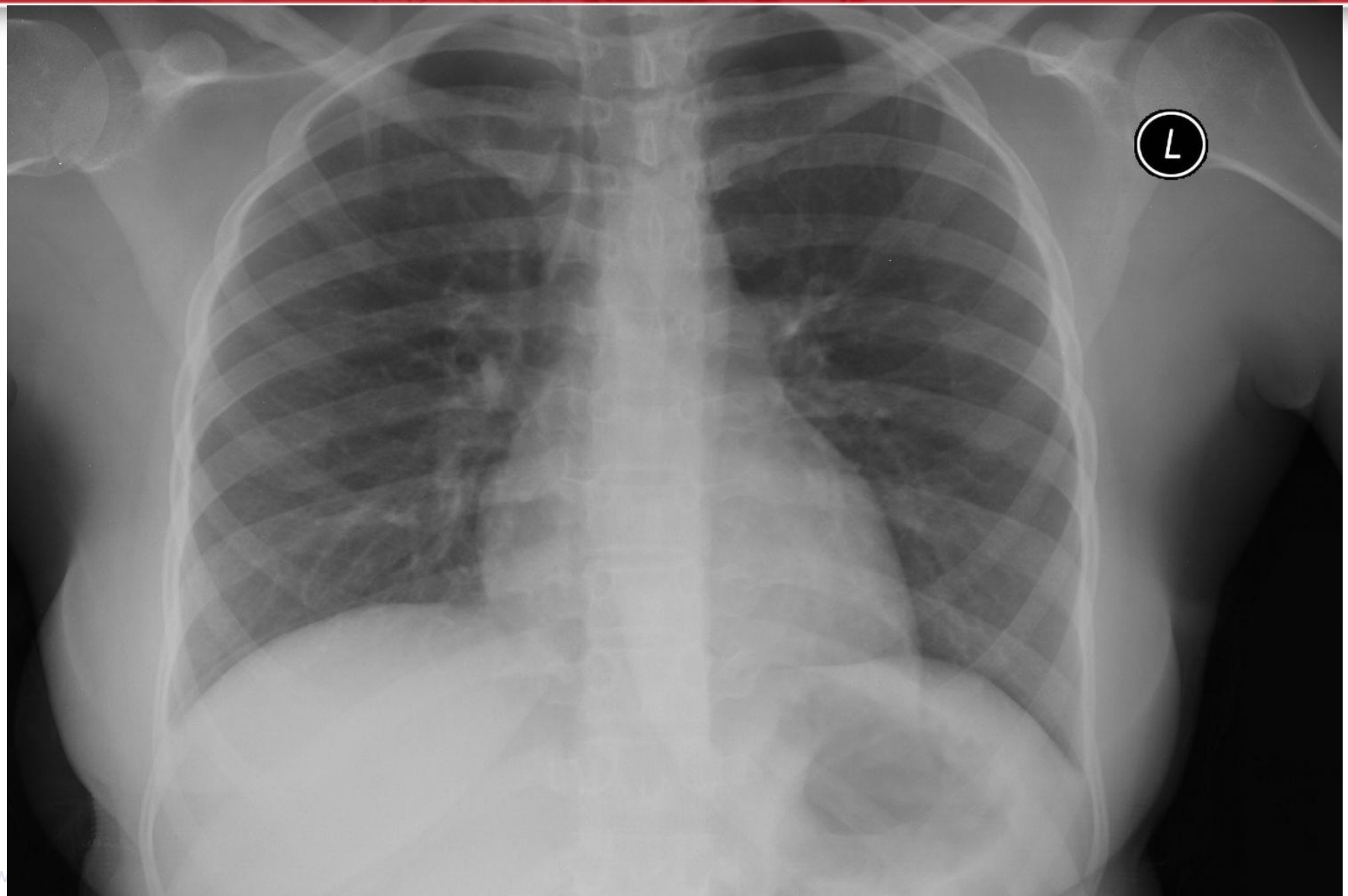
RUL pneumonia



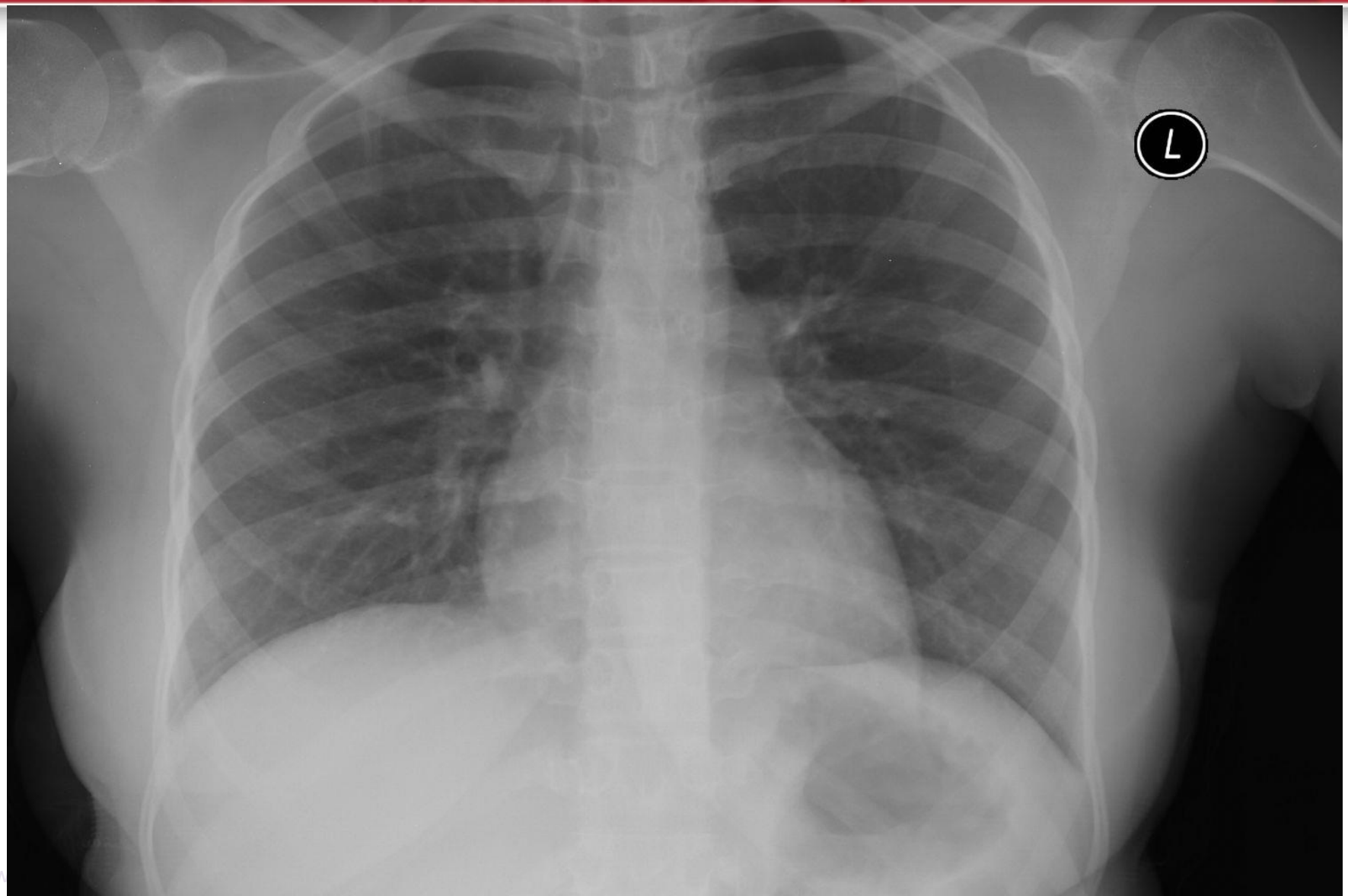


Left-sided pneumothorax

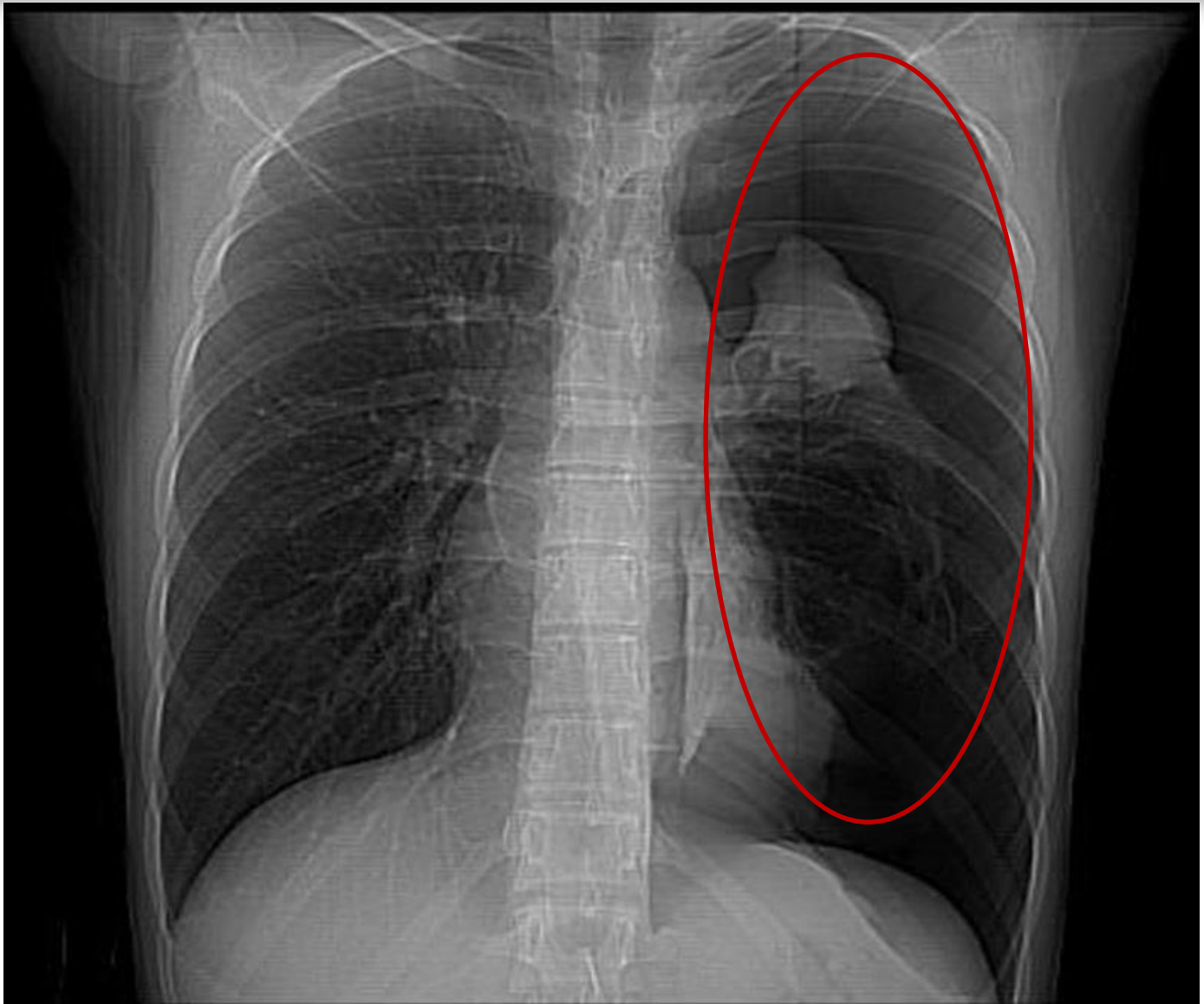


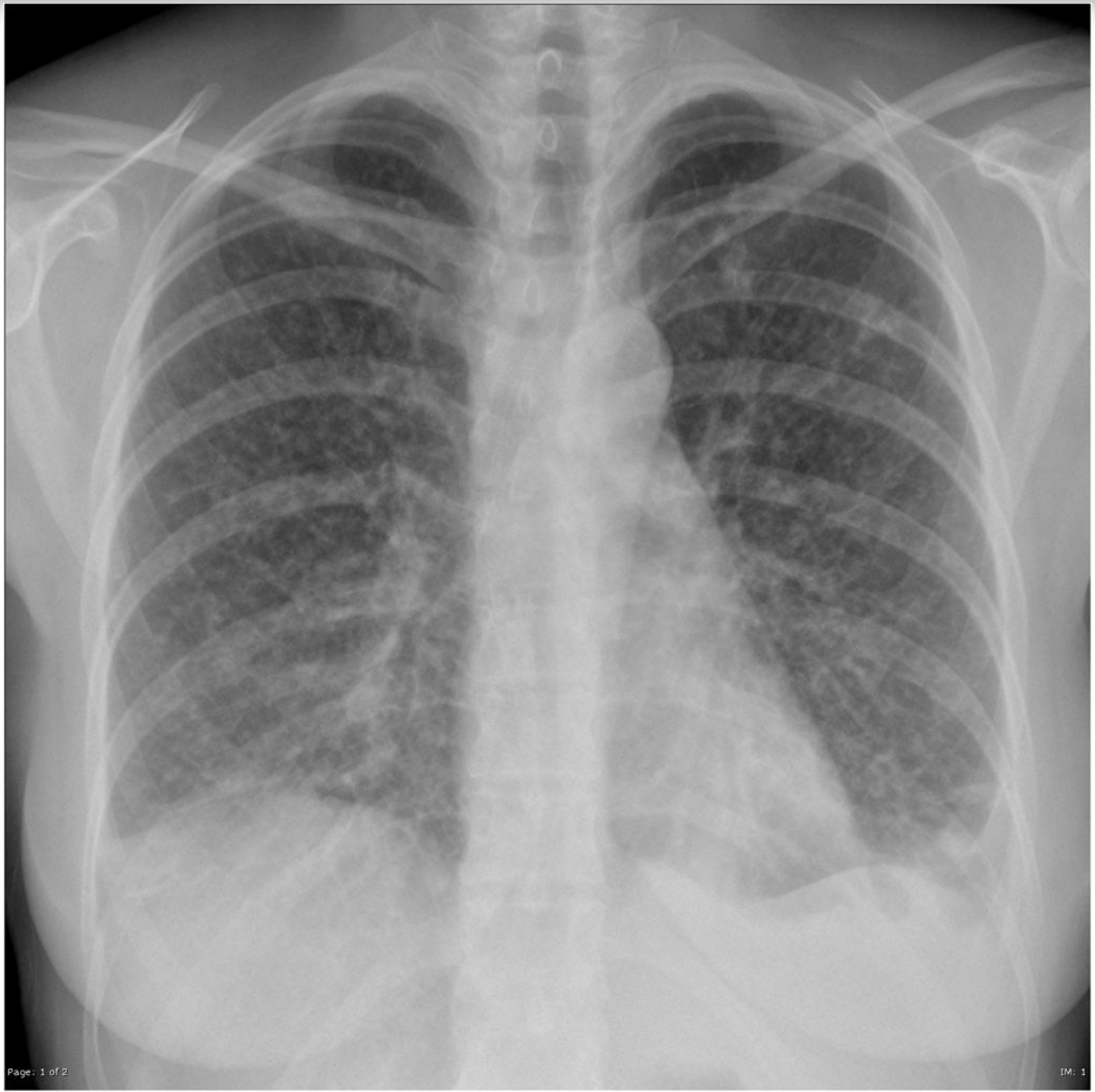

L

Normal CXR

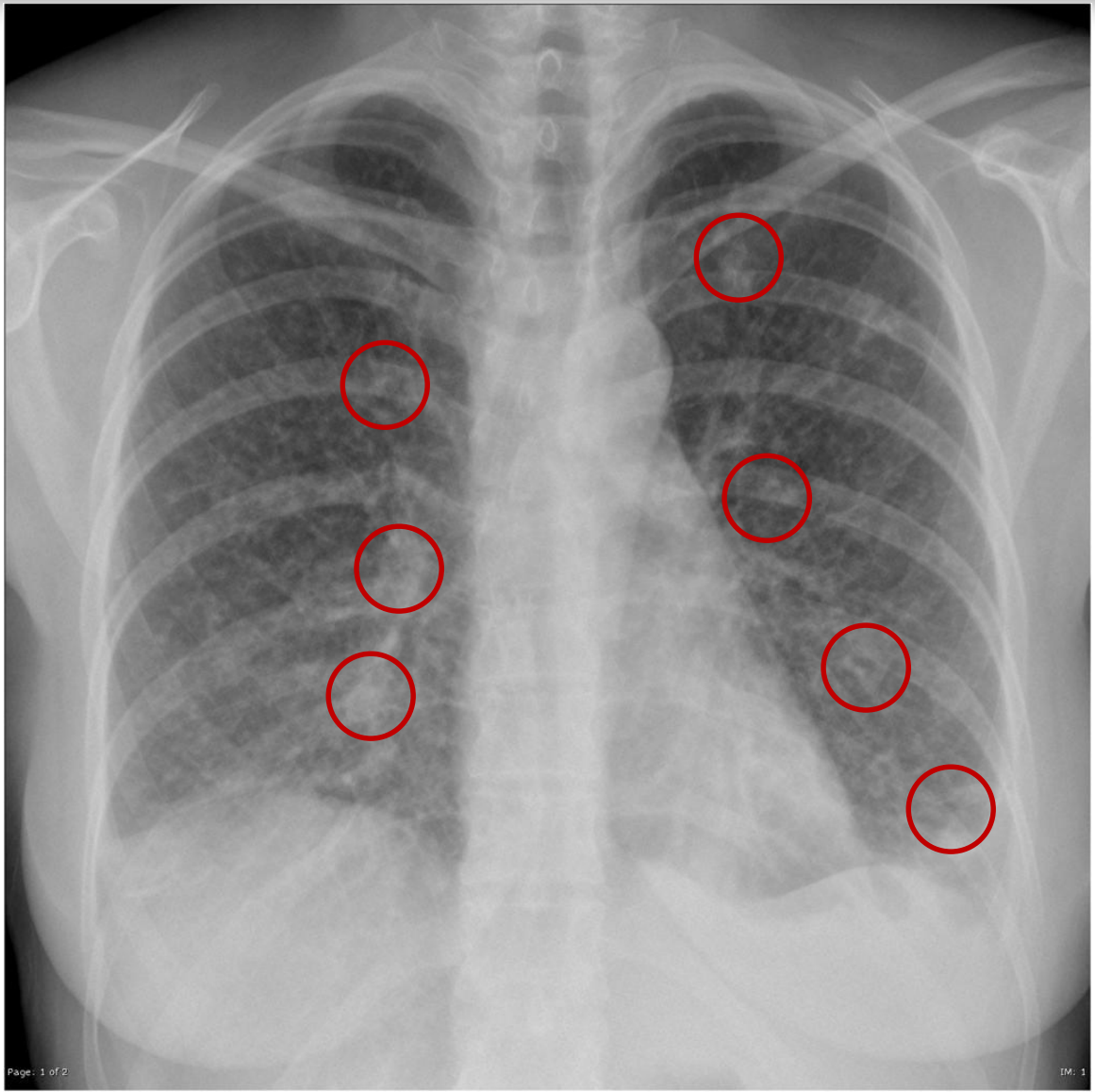


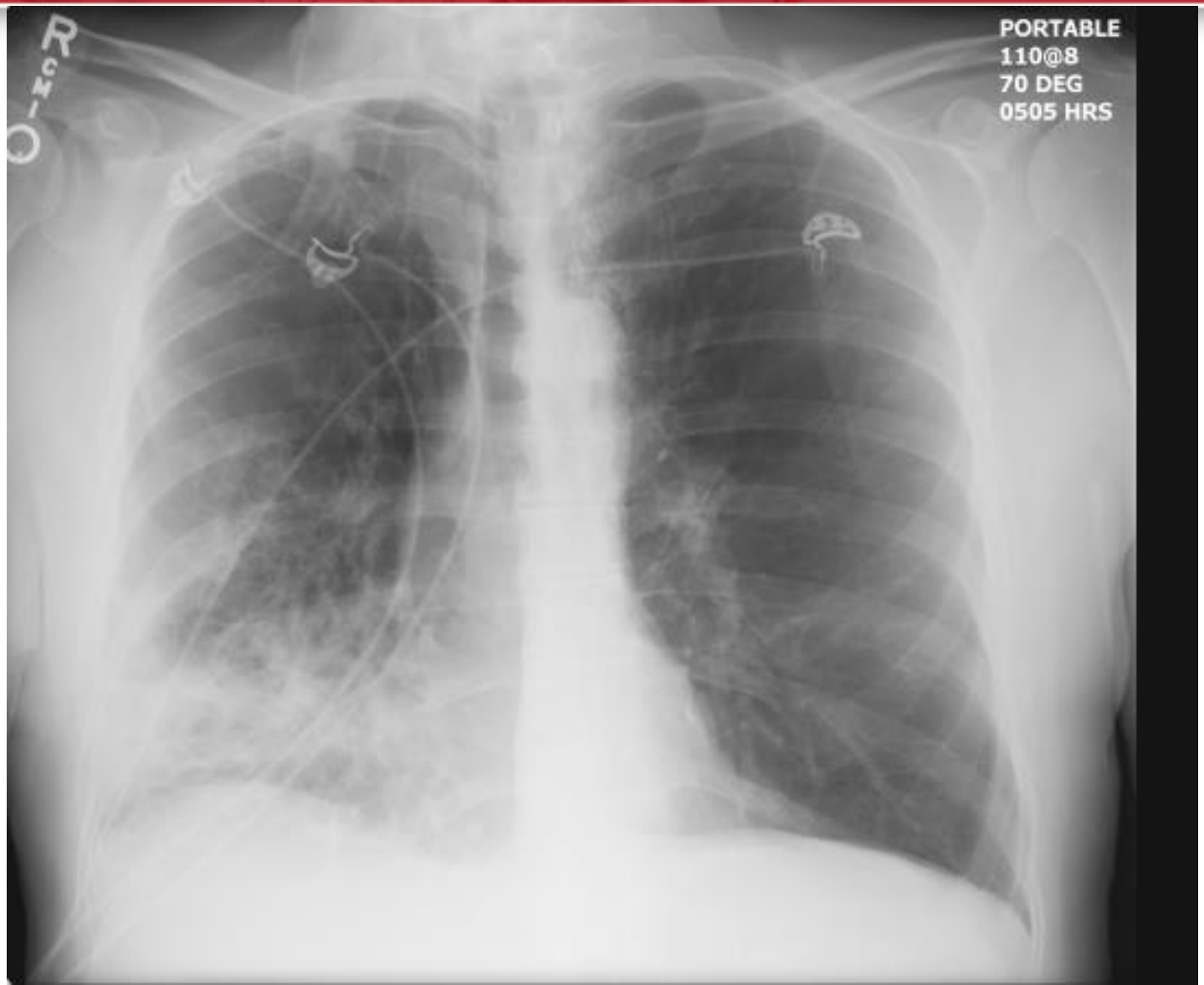
Left-sided pneumothorax



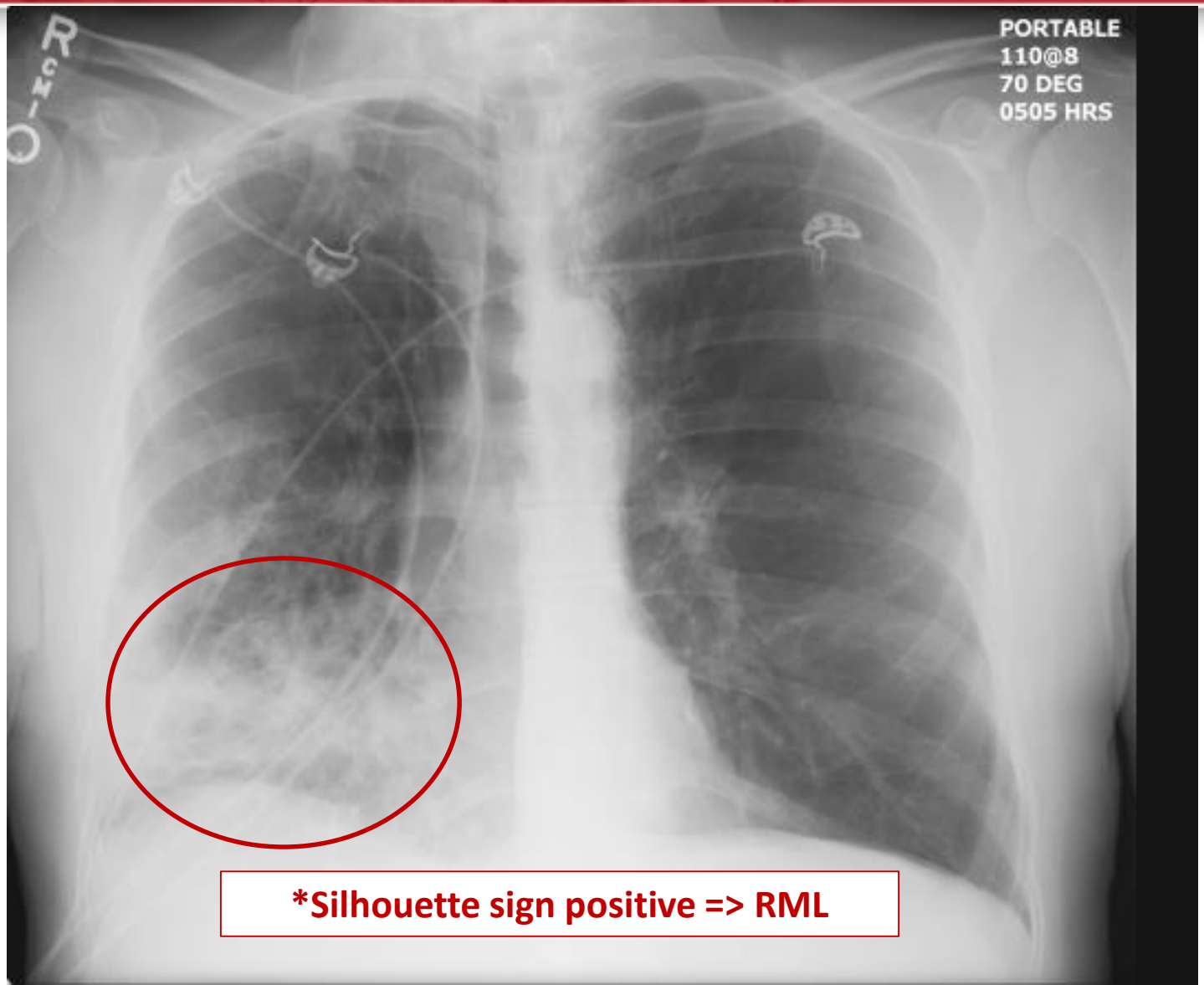


Disseminated nodular TB

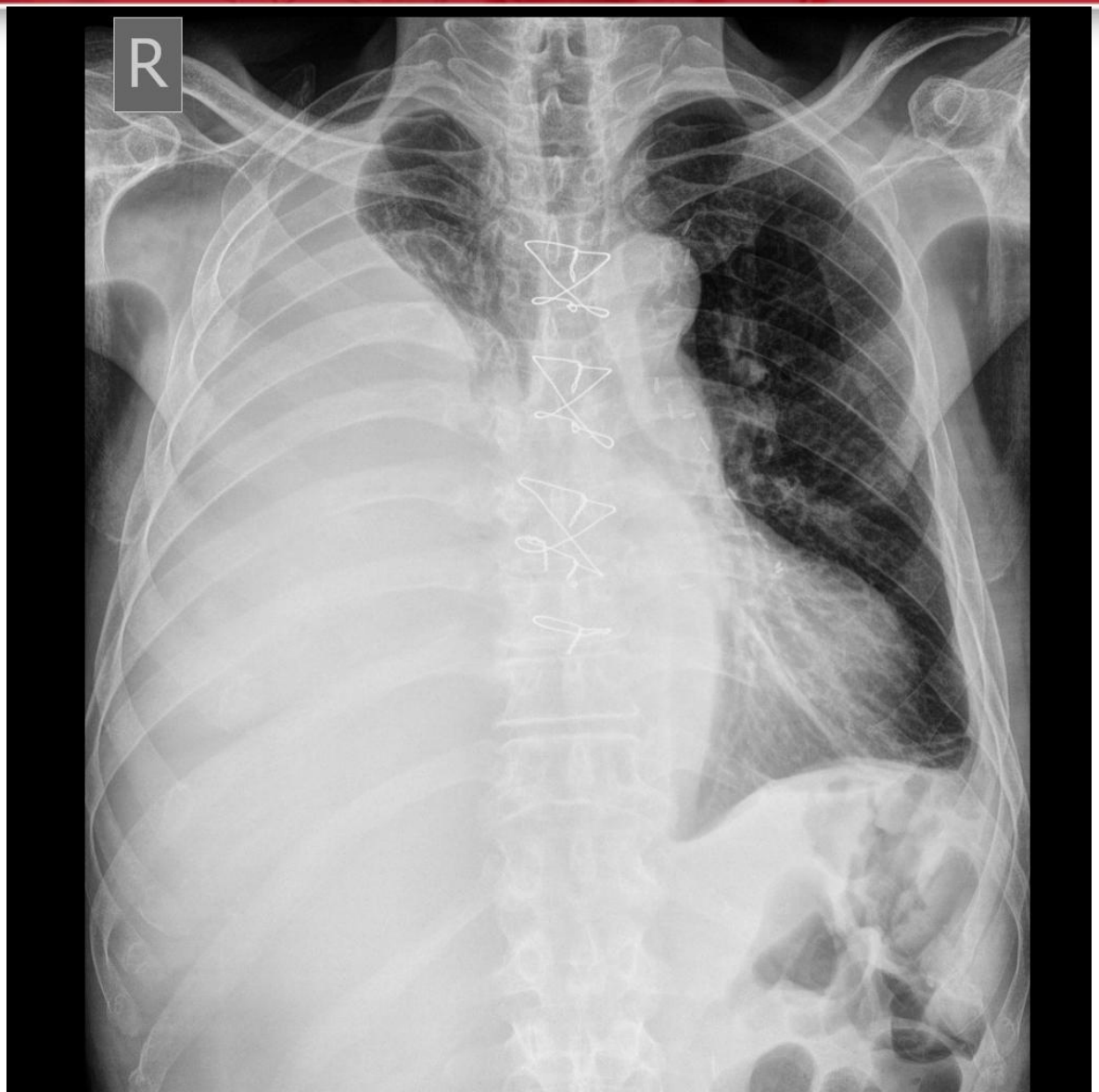




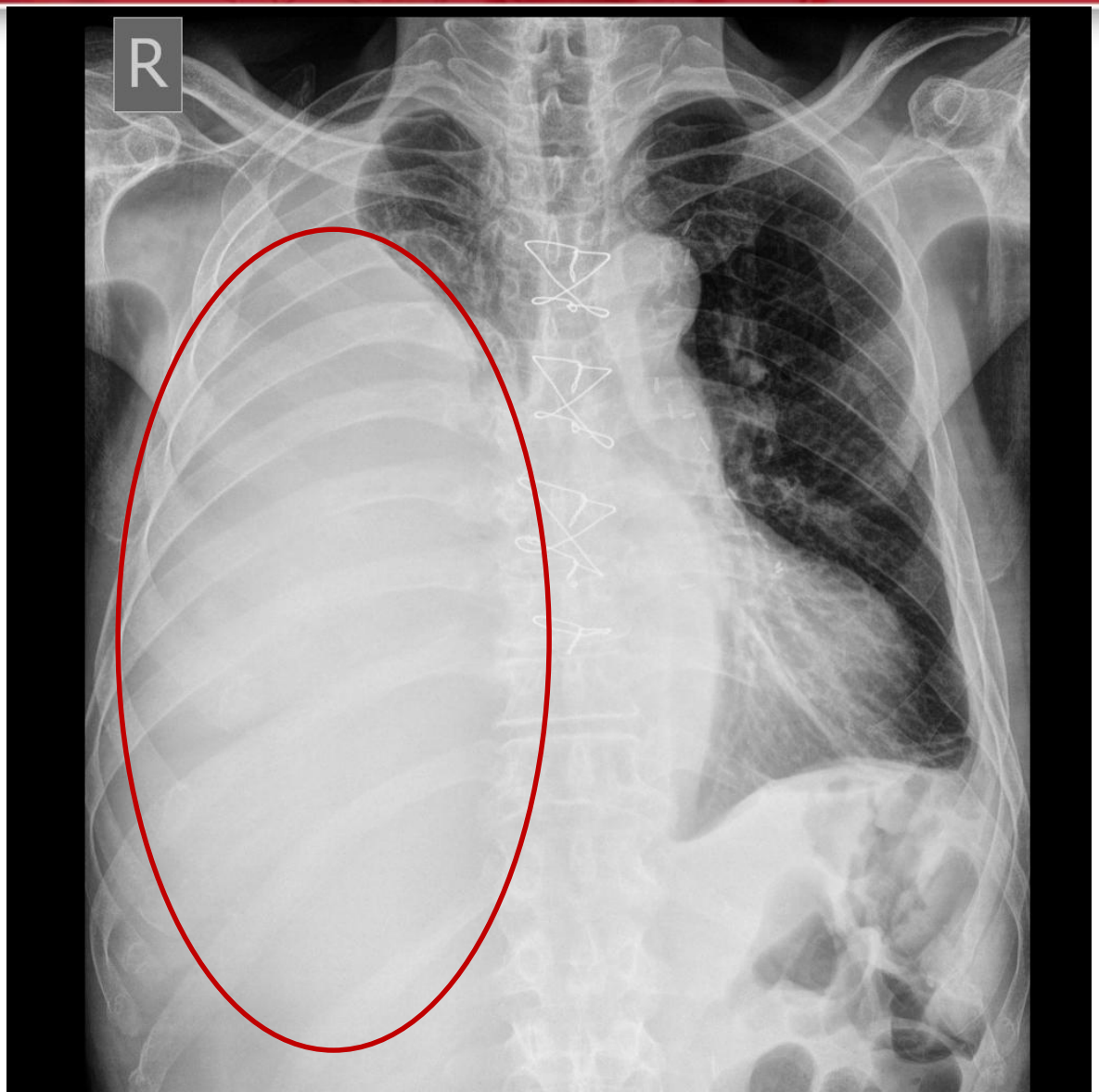
RML pneumonia*



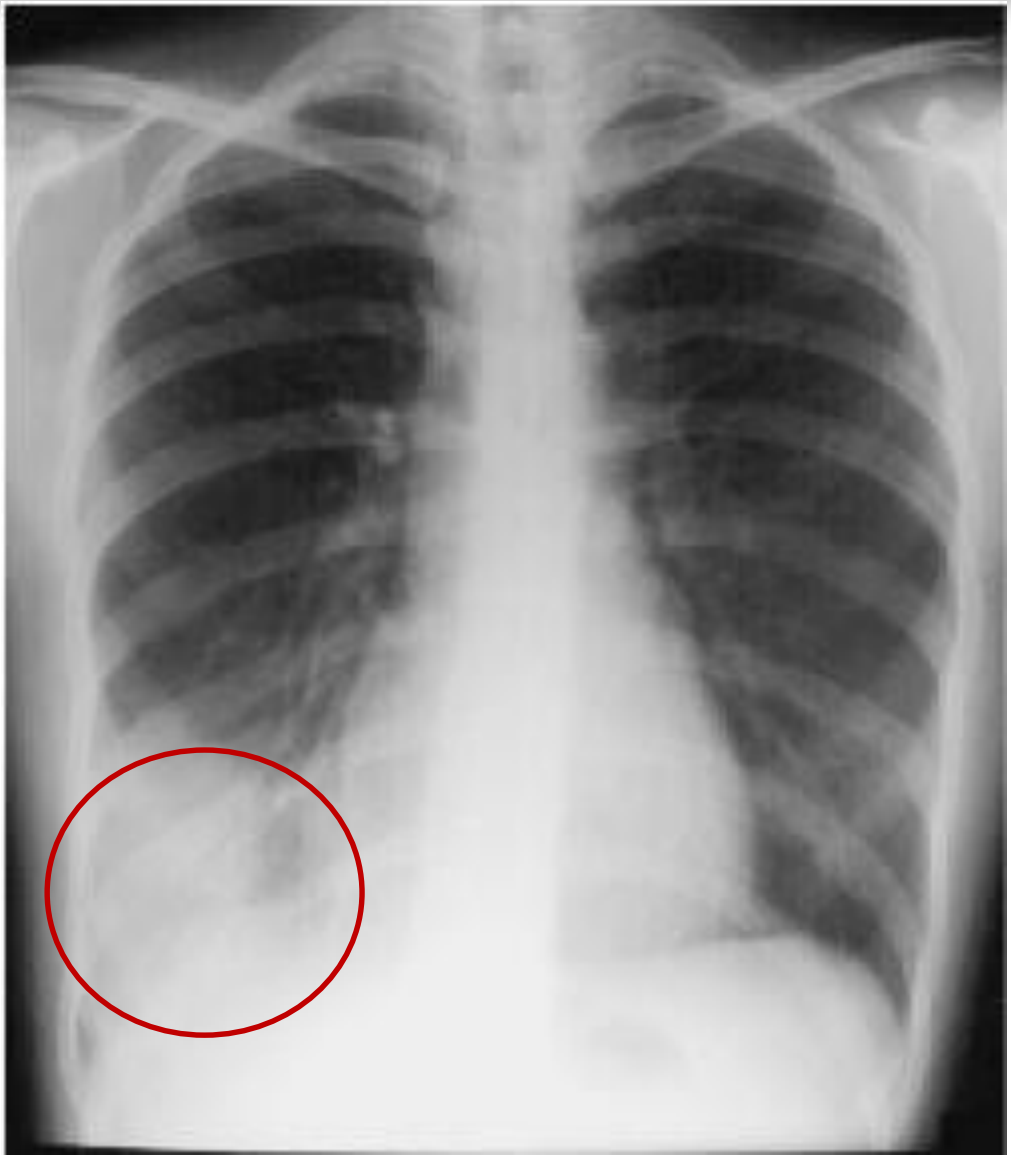
*Silhouette sign positive => RML

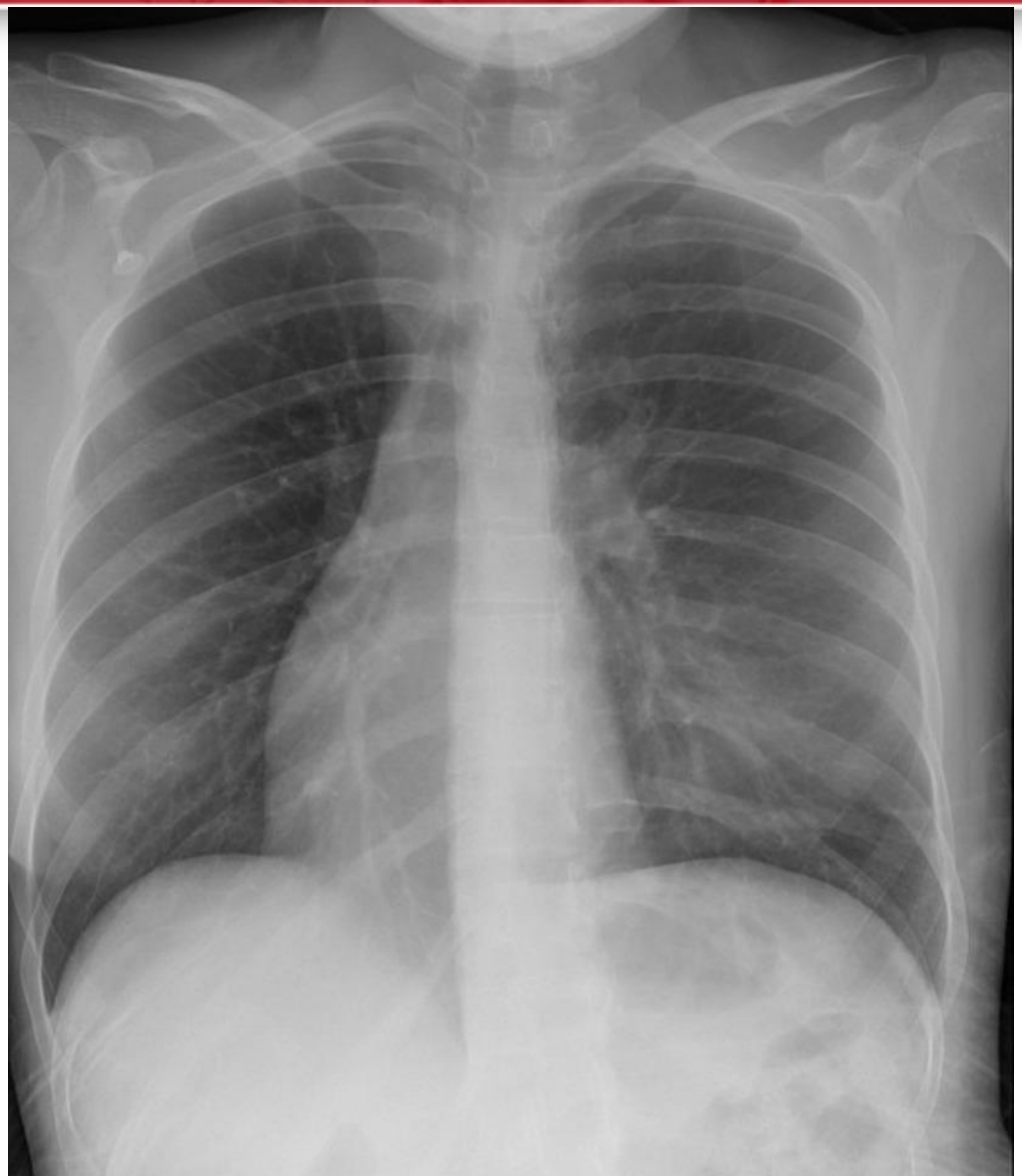


Right-sided pleural effusion

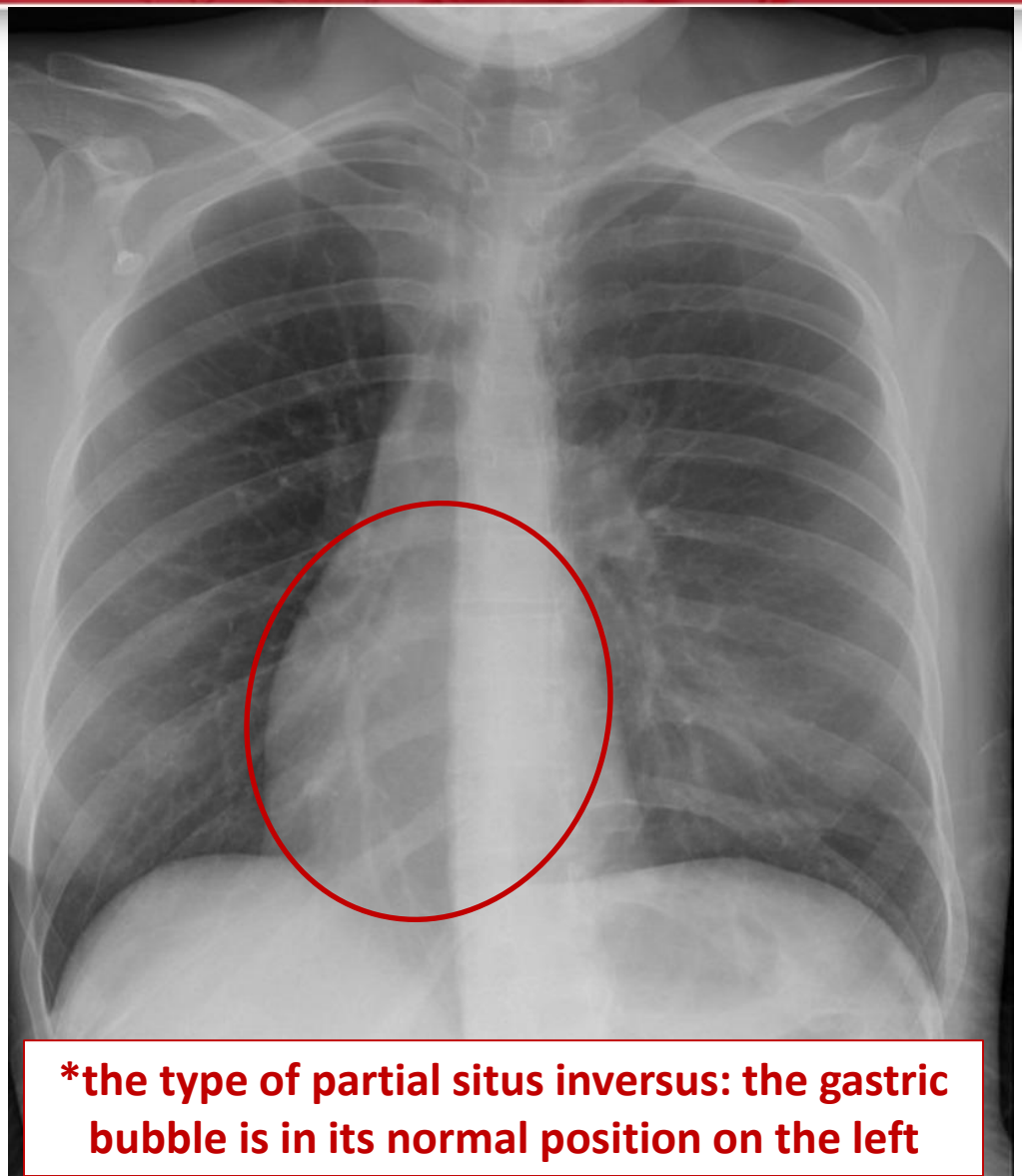


RLL pneumonia



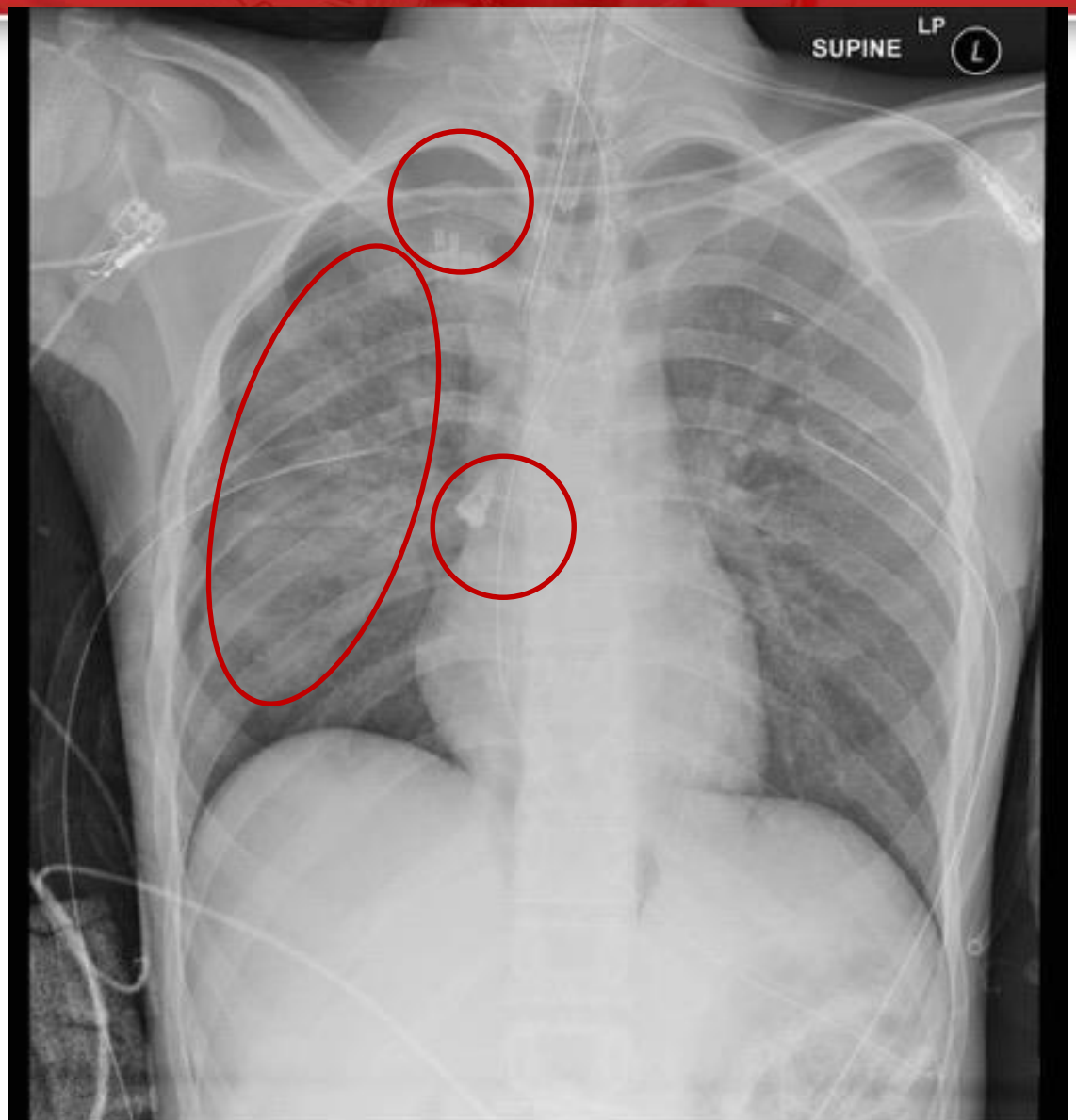


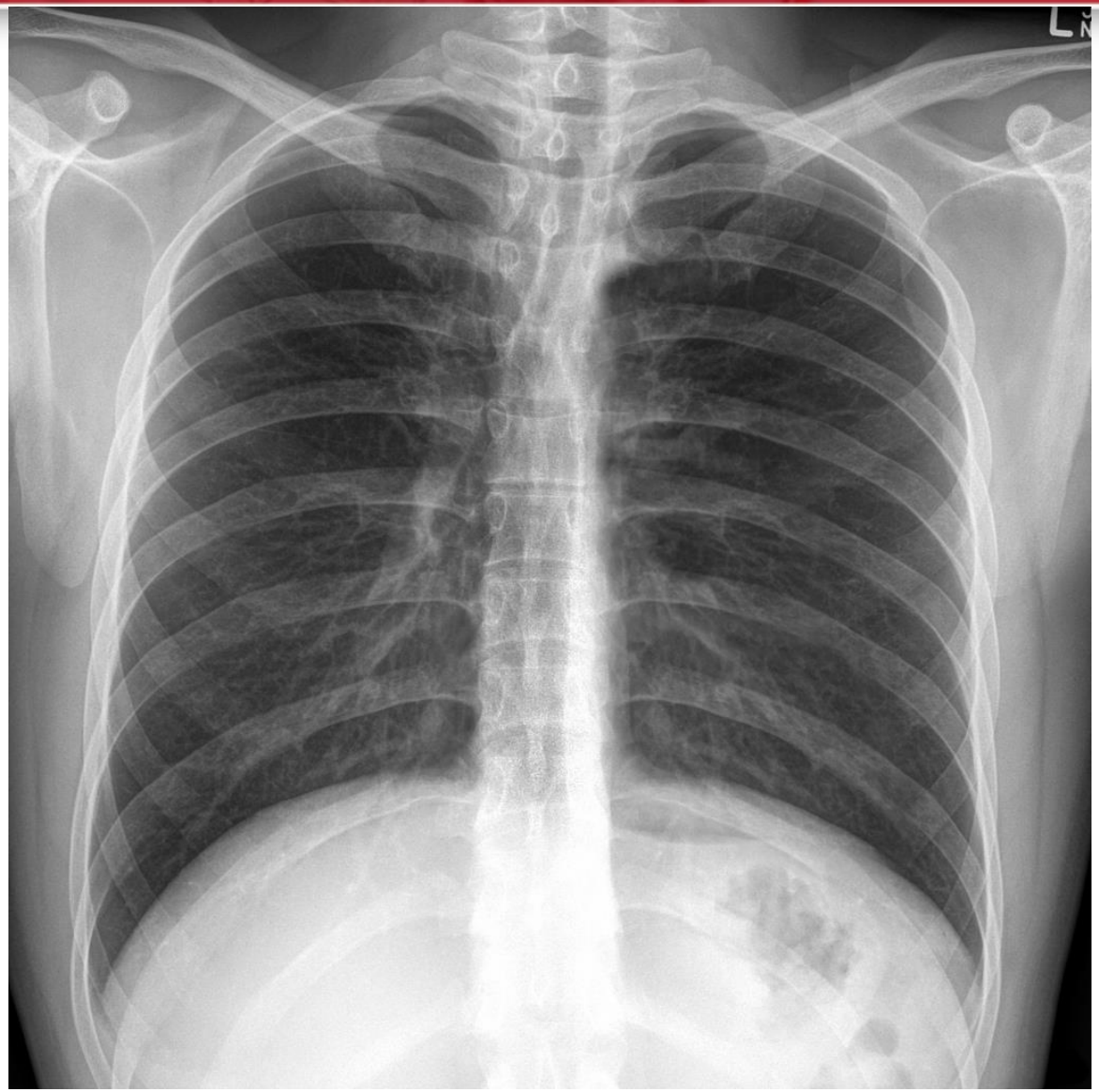
Dextrocardia*



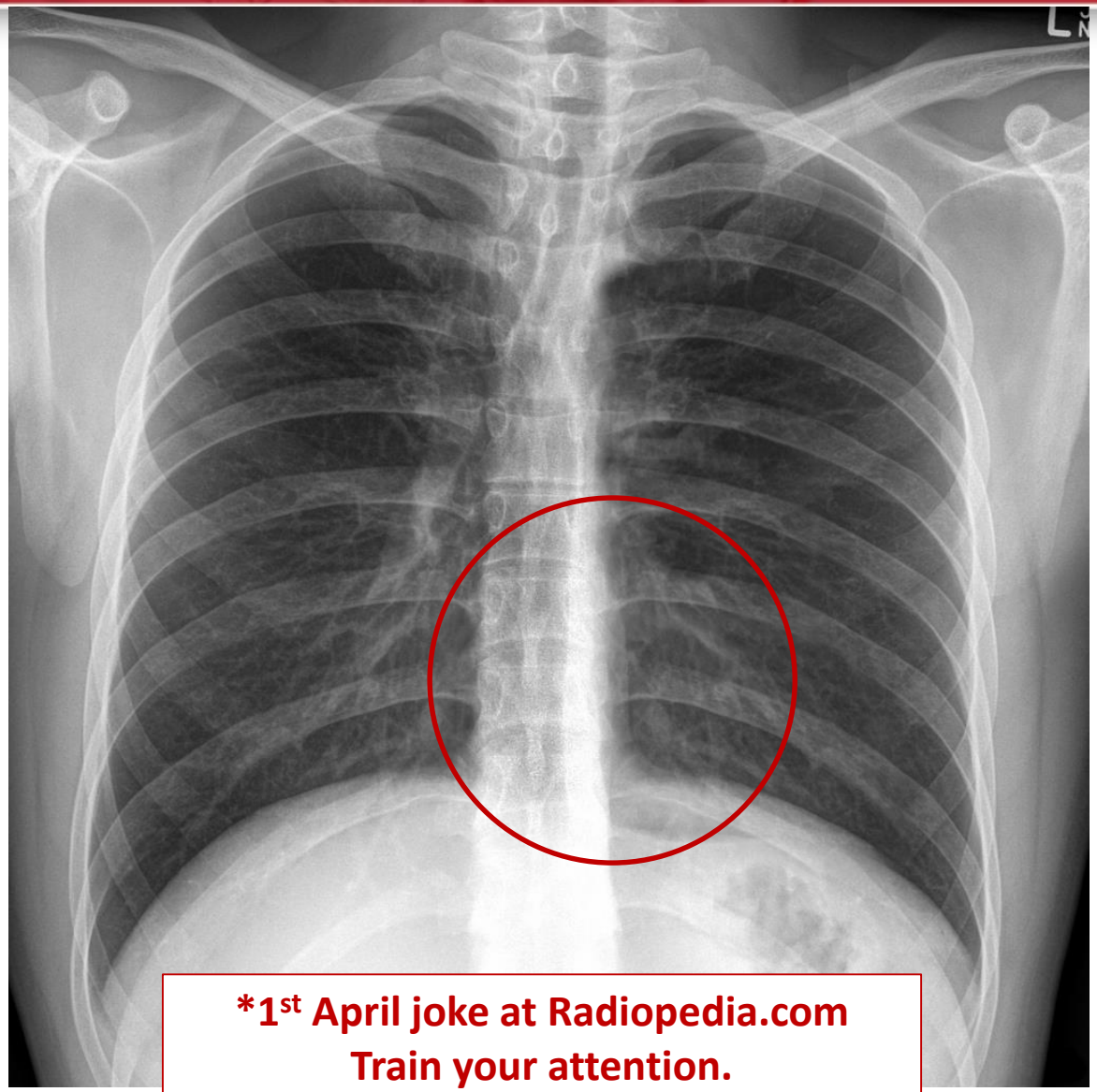
*the type of partial situs inversus: the gastric bubble is in its normal position on the left

Right-sided pneumothorax. 2nd right rib fracture. Foreign body of right primary bronchus (tooth).





Ectopia cordis*



*1st April joke at Radiopedia.com
Train your attention.

References*

Radiopaedia

https://radiopaedia.org/

RADIOLOGY masterclass

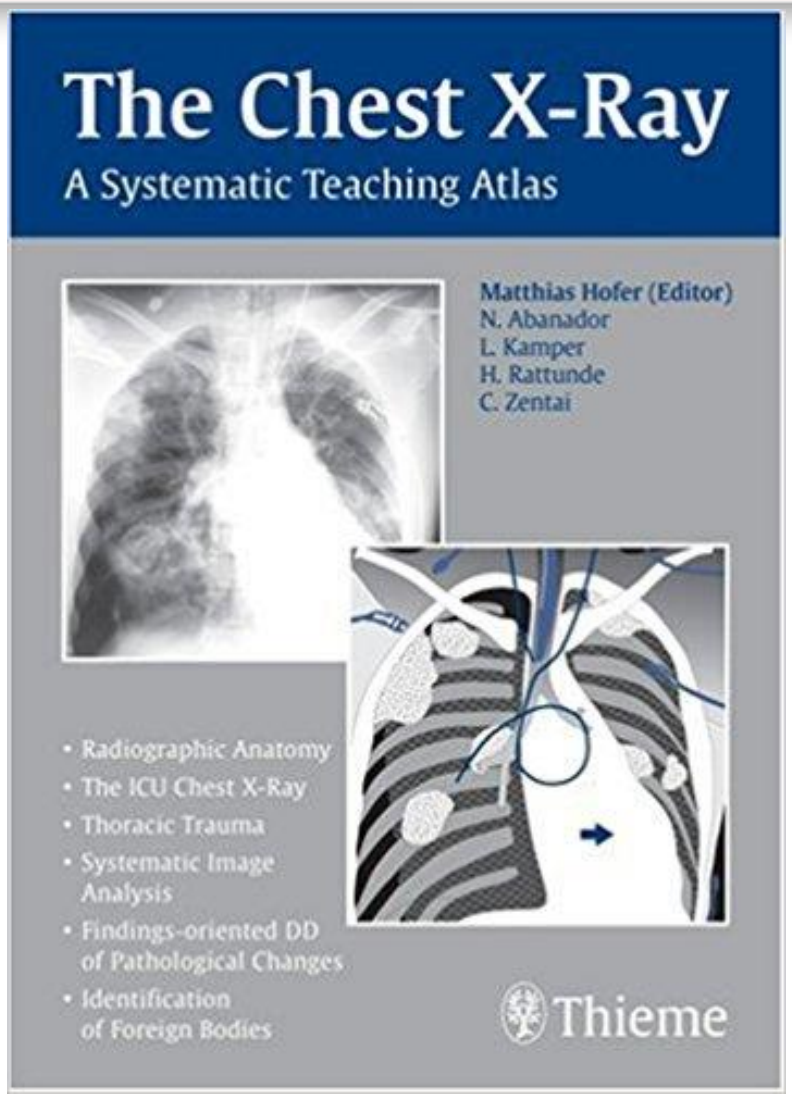
http://www.radiologymasterclass.co.uk/tutorials/tutorials/

wiki RADIOGRAPHY
world's largest radiography encyclopedia

http://www.wikiradiography.net/

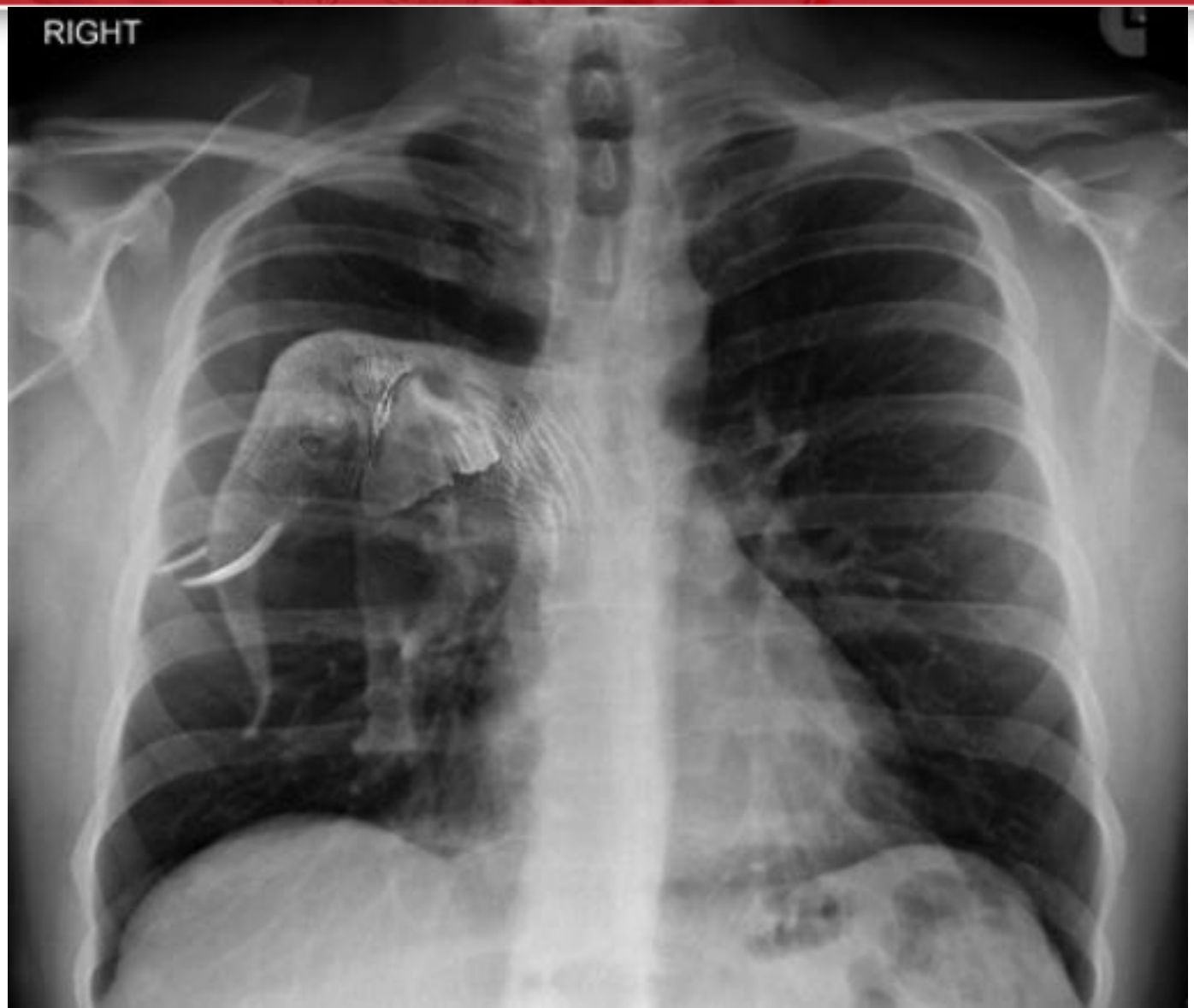
Radiology Assistant

http://www.radiologyassistant.nl/



*strongly recommended to medical students and young doctors.

Don’t miss an elephant while looking for a fly!



Thank you!

KEEP
CALM
AND
STUDY
MEDICINE