1st KATRD Bronchoscopy and Thoracic Ultrasound
Hands on Program for Respiratory Disease

# Lung Ultrasound for Respiratory Diseases

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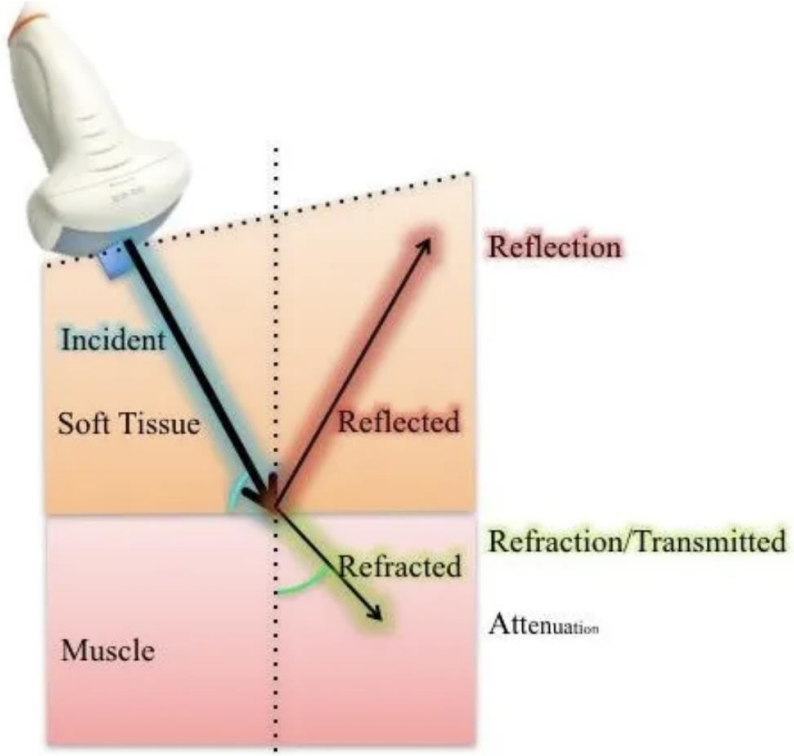
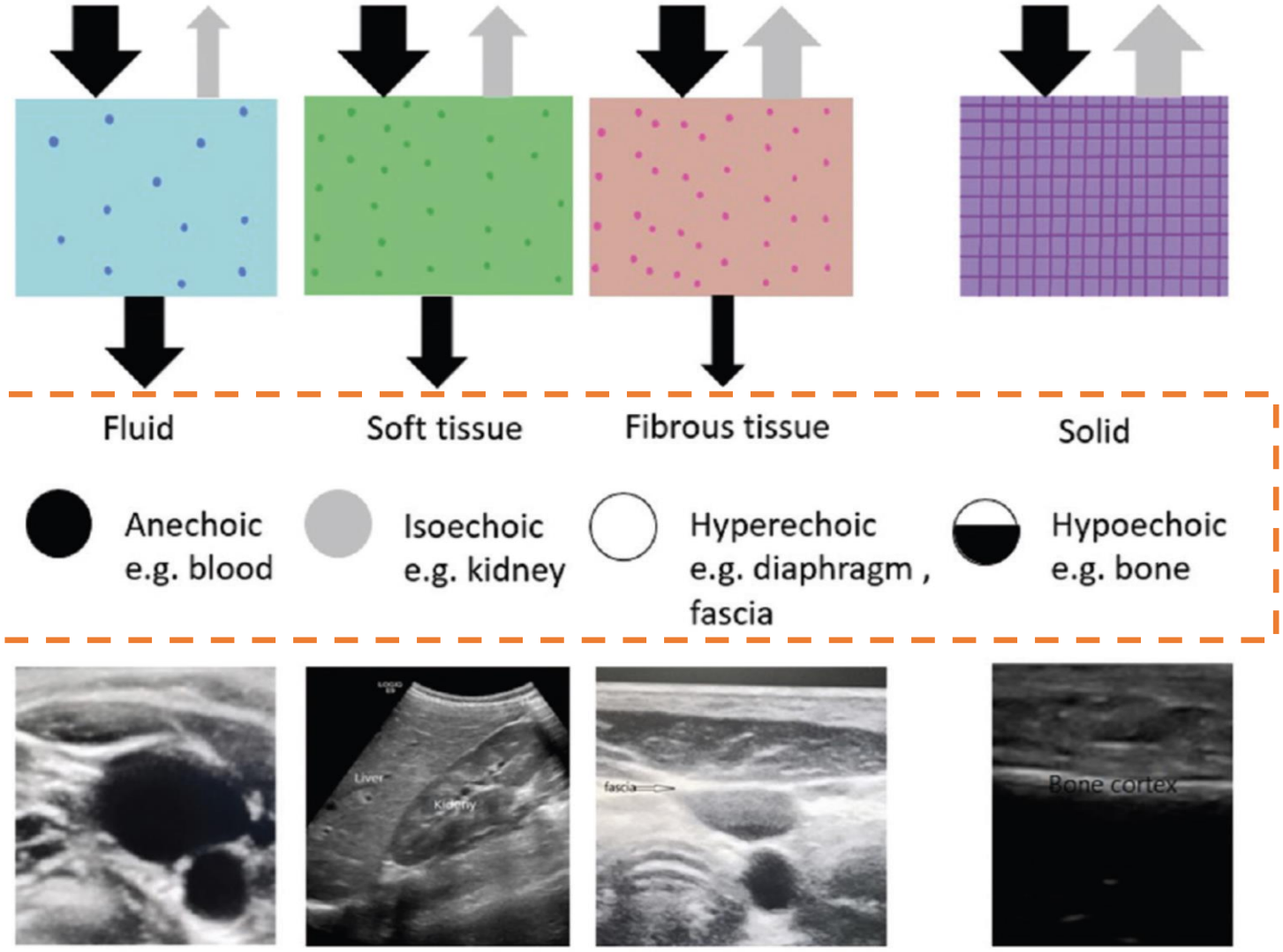
# Basic principles

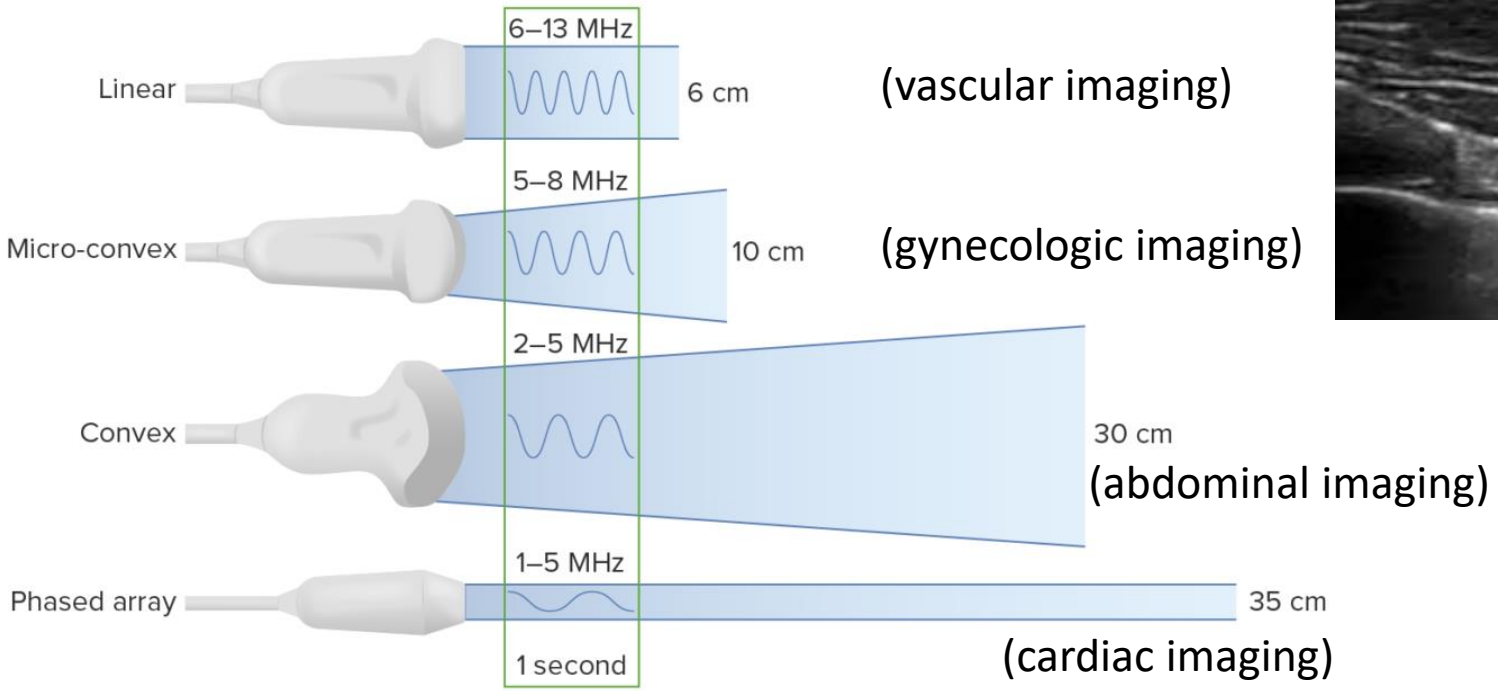
- Echogenicity



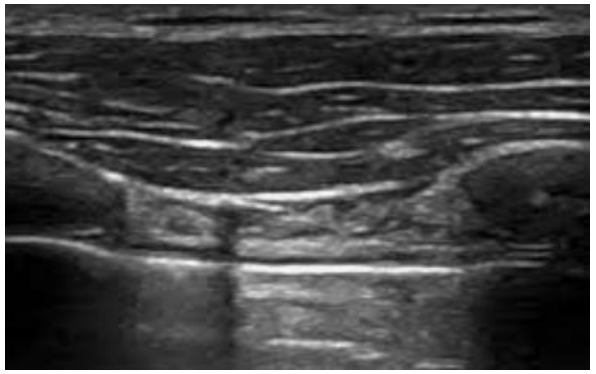



# Transducer (probe)

- Acts as an emitter and receptor of sound waves
- Types:



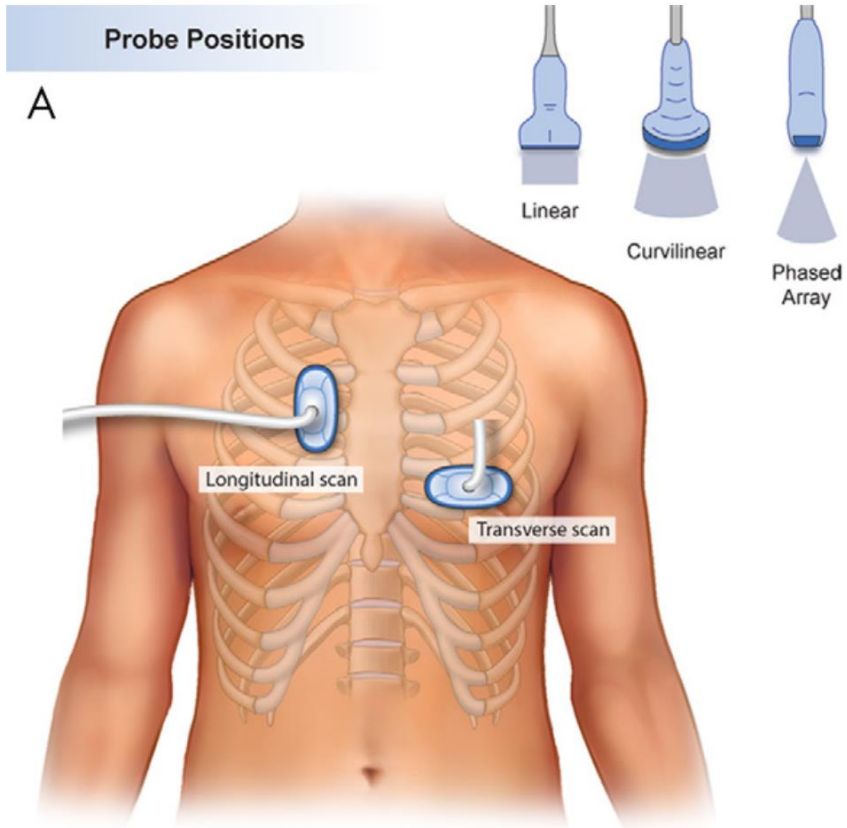

Low penetration
High resolution

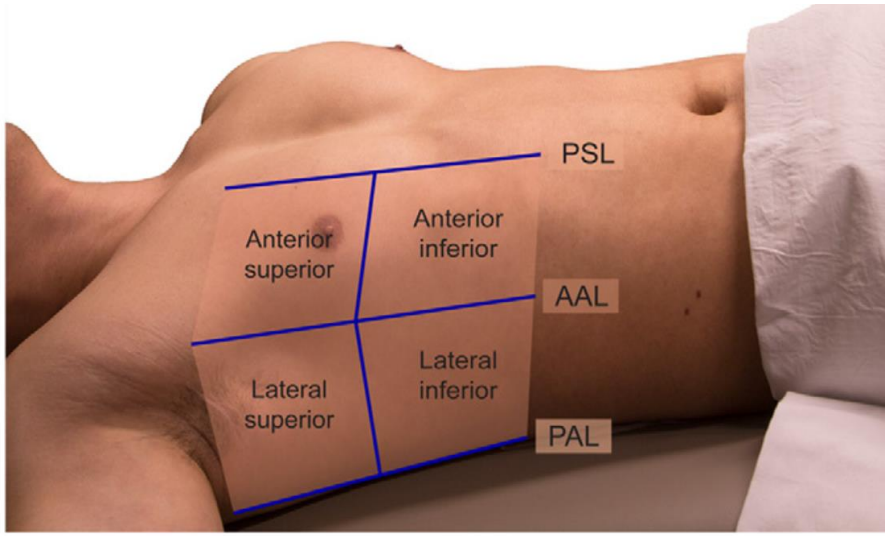


High penetration
Low resolution

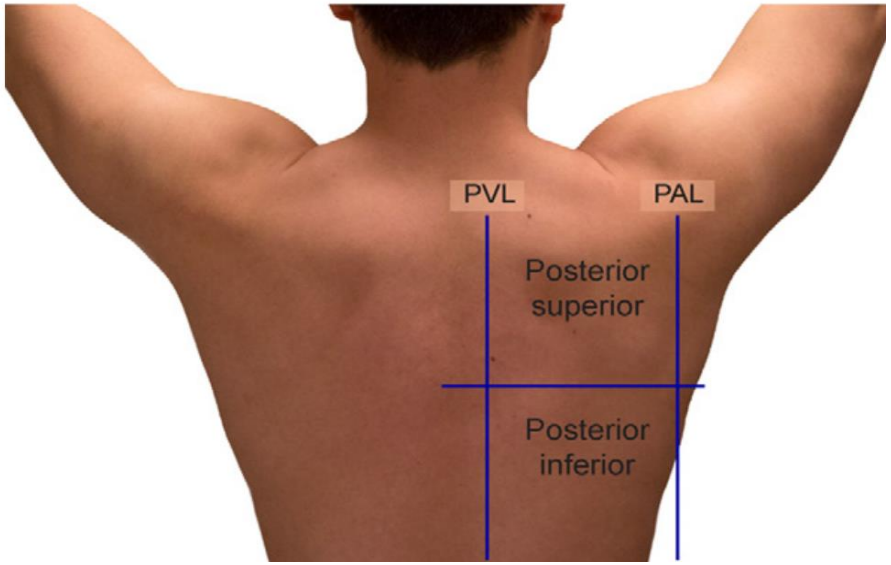
* Low *vs.* High frequency probe / Higher frequencies → detailed image

# Probe positions



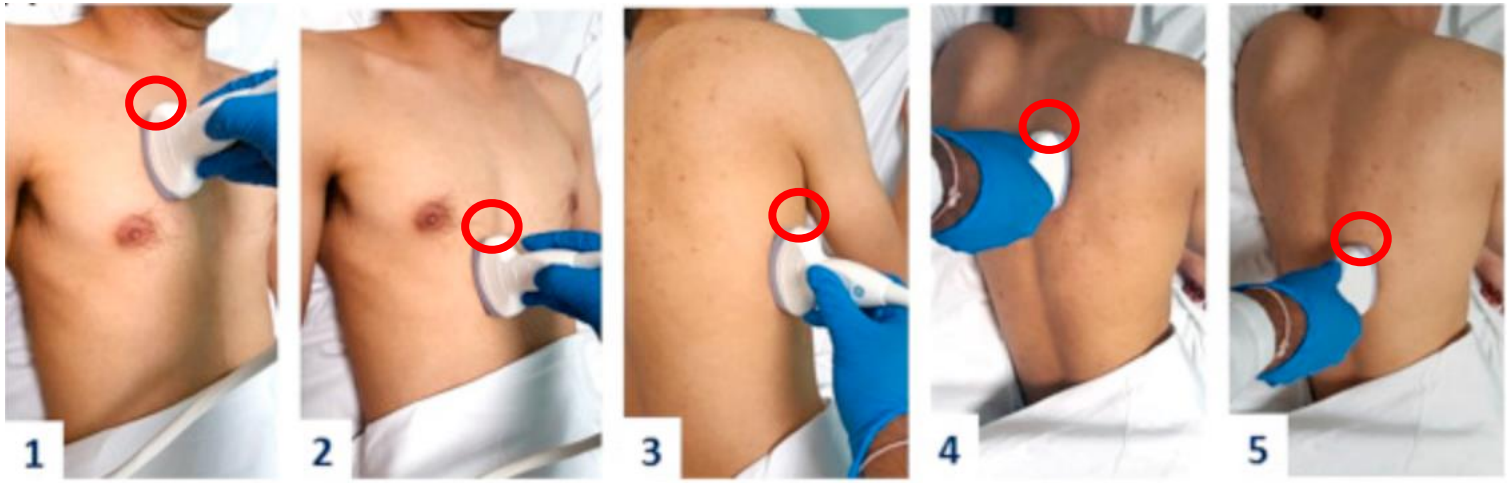

**Anterior**
: air (pneumothorax)



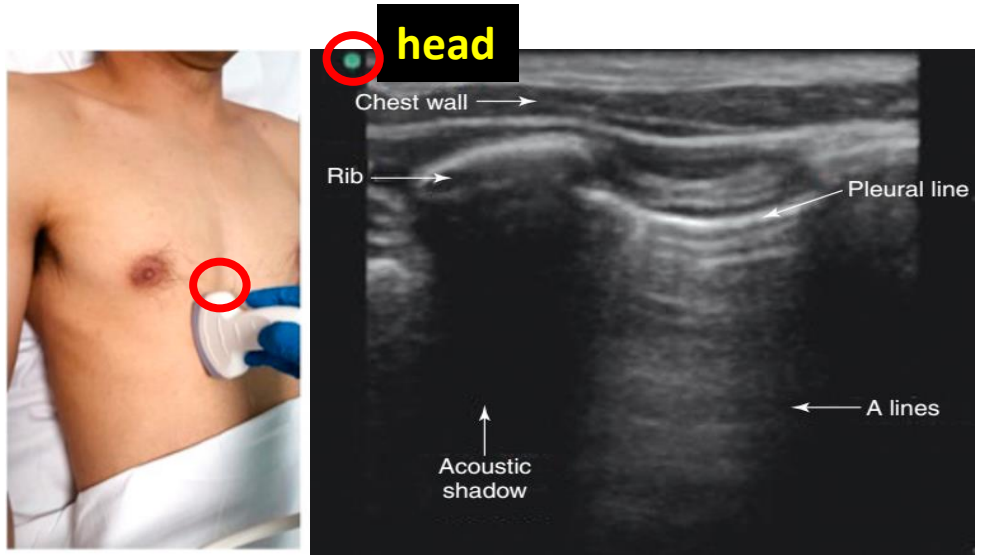

**Lateral / Posterior**
: consolidations and effusions

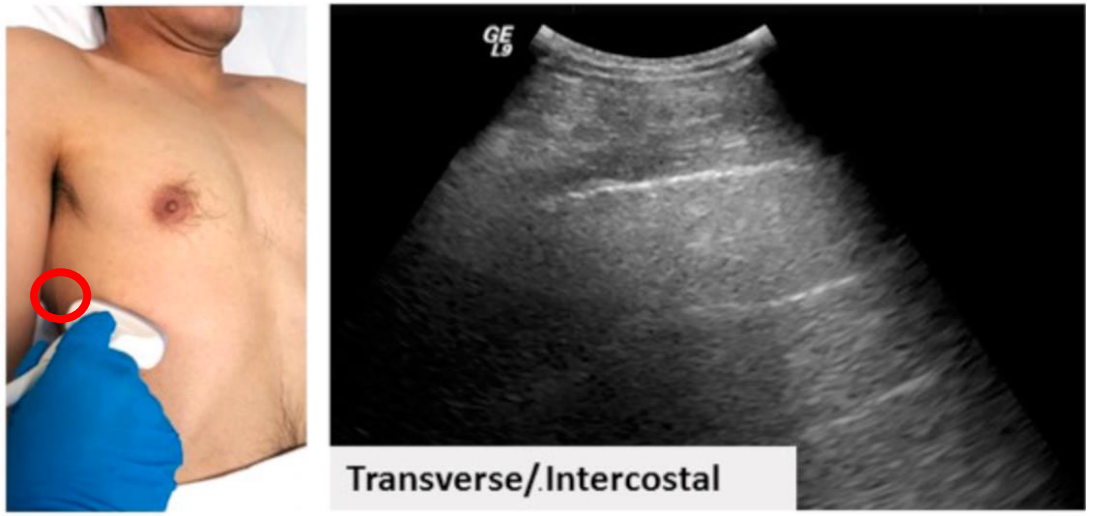
*Radiology: Cardiothoracic Imaging* 2021;3(2):e200564

# Probe positions




- Indicator cephalad
- Perpendicular to chest wall → “Rib shadows” confirm position and guide to pleura




*Current Problems in Diagnostic Radiology* 2017;46(4):305-316

# TUS vs Focused TUS

- TUS

  - to diagnose and exclude all conditions in the chest that potentially can be visualized using sonography.

- Focused TUS

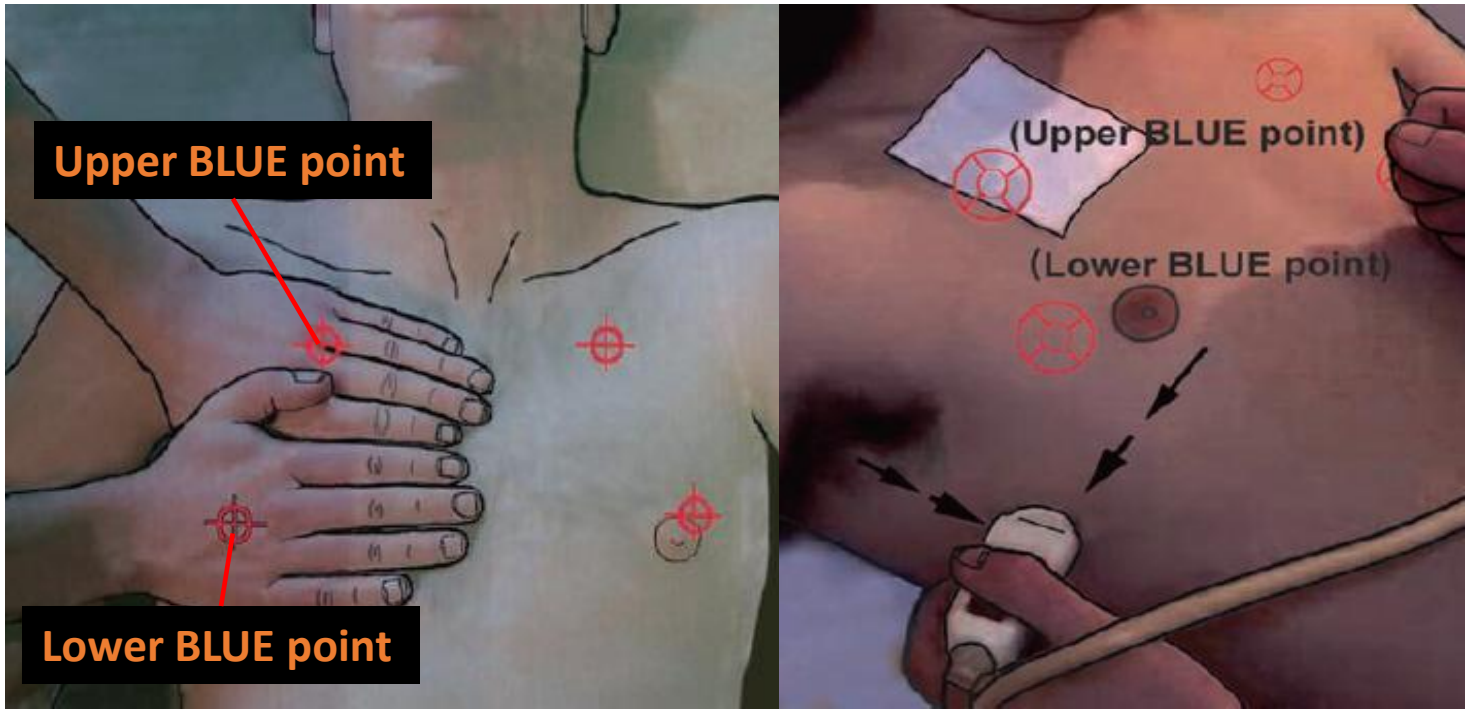
  - to diagnose or exclude acute, potentially life-threatening conditions

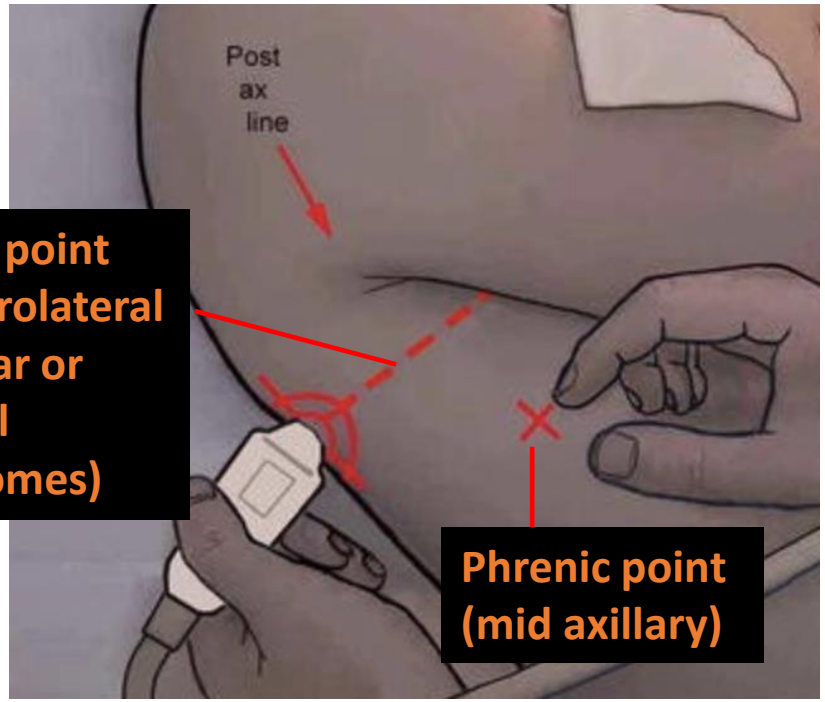
  → Yes/No questions

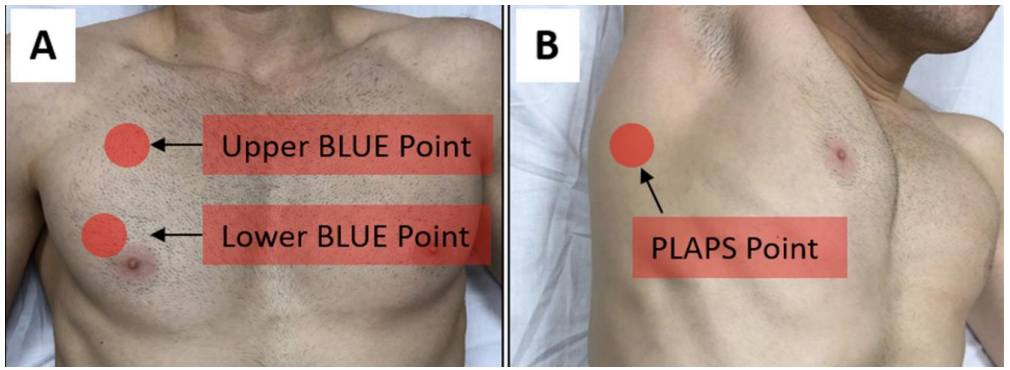
  1) Is a **PTX** present?
  2) Is a **pleural effusion** present?
  3) Is **interstitial syndrome** present?
  4) Is obvious pathology present?

# Probe positions: BLUE protocol

- BLUE (Bedside Lung US in Emergency)

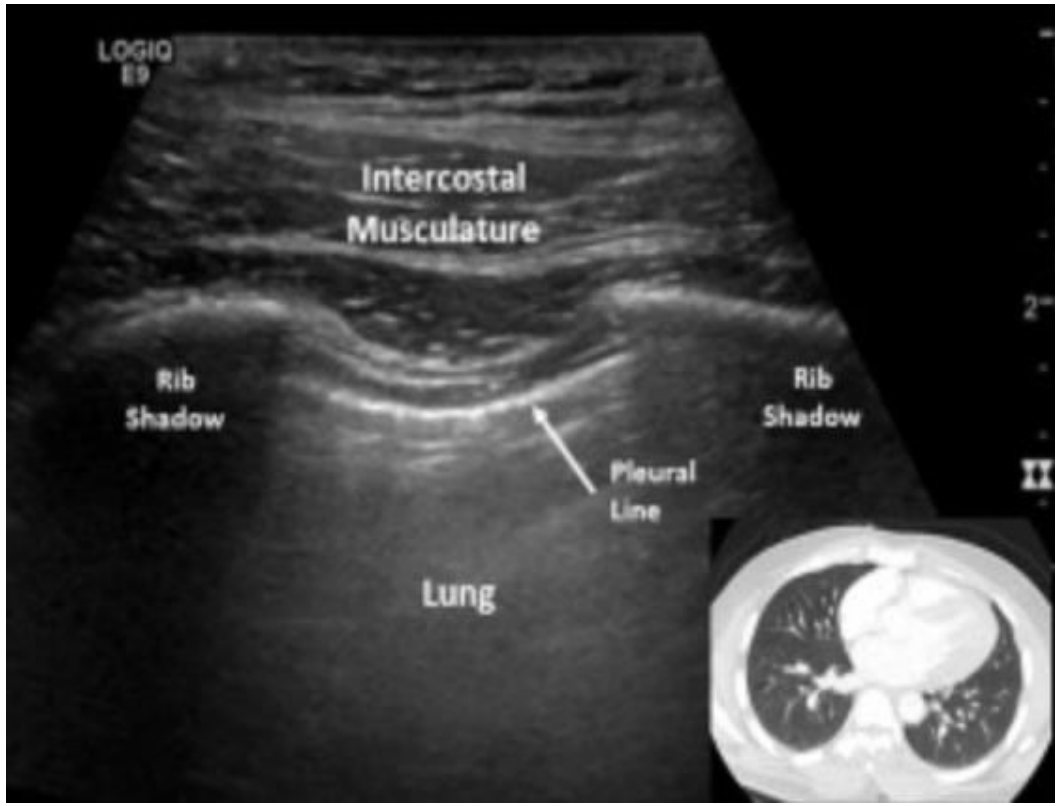


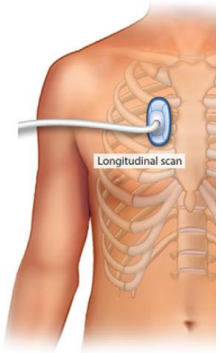



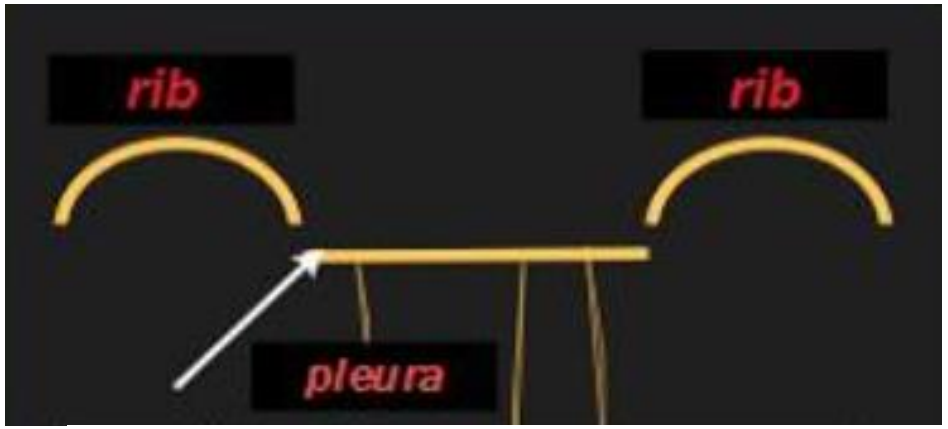



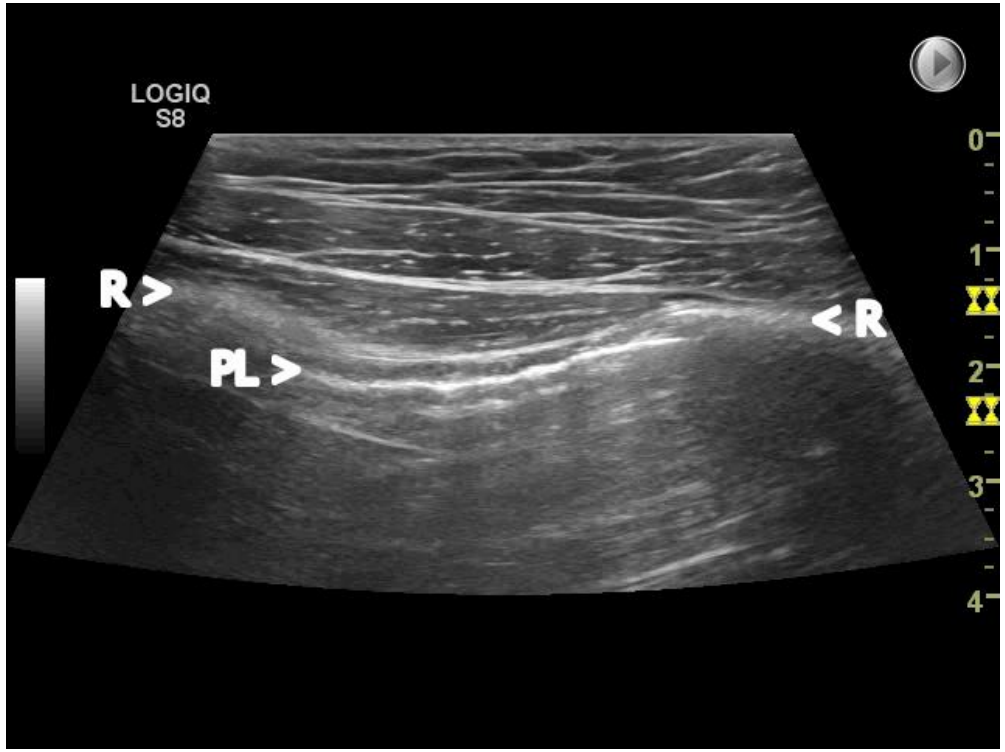

*Chest* 2008;134:117-125

# Basic principles



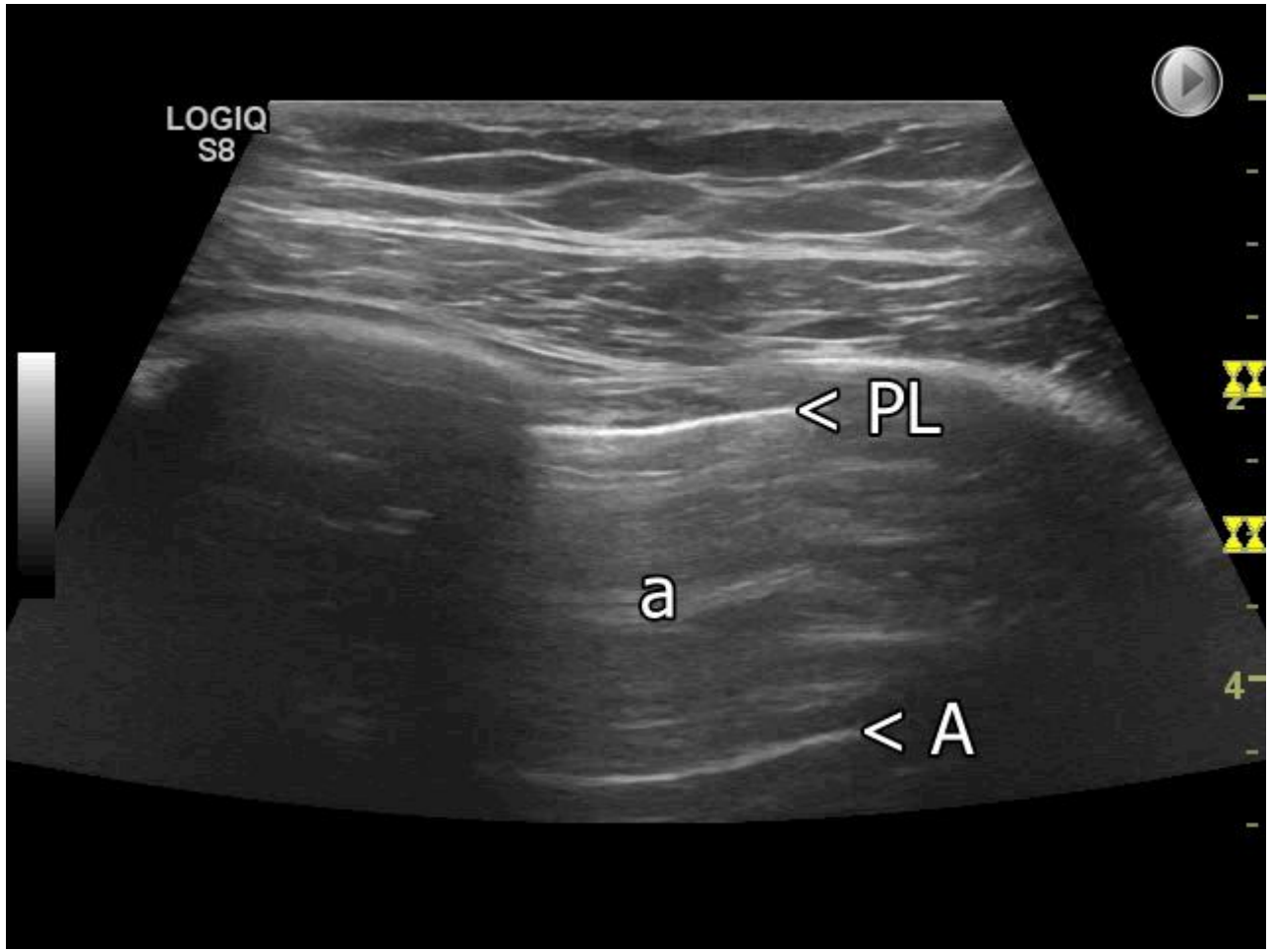




- Rib shadow (bat sign)

# Basic principles




- **Lung**

**The normal air filled lung**

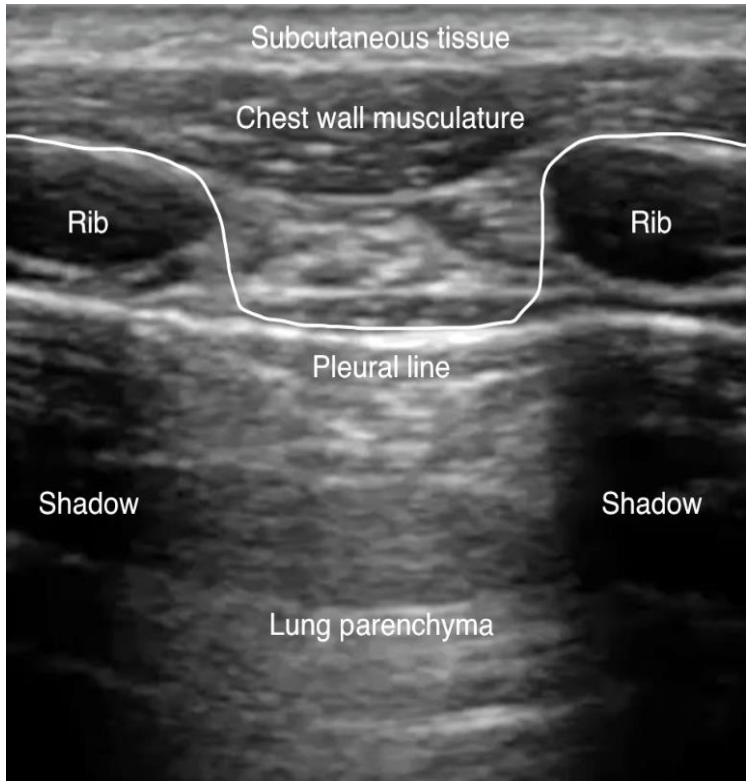
→ **<u>cannot be visualized</u>** using conventional 2D-mode US

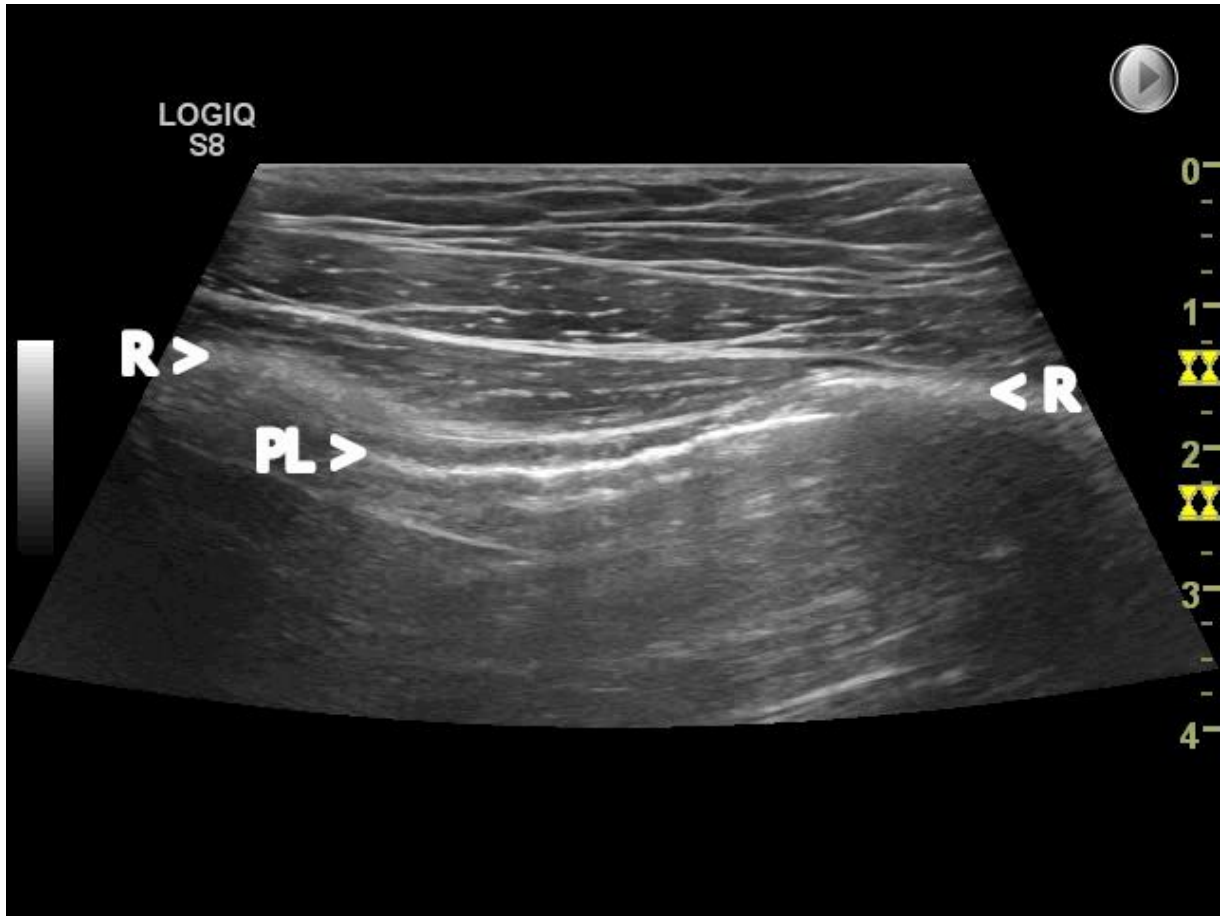
◀ The grey appearance of the area (a) and a hyperechoic line (A)

: **<u>artifact !!</u>**

# **Normal lung findings:** Lung sliding (1)

- Horizontal sliding movements of the visceral pleura with respiration along the parietal pleura

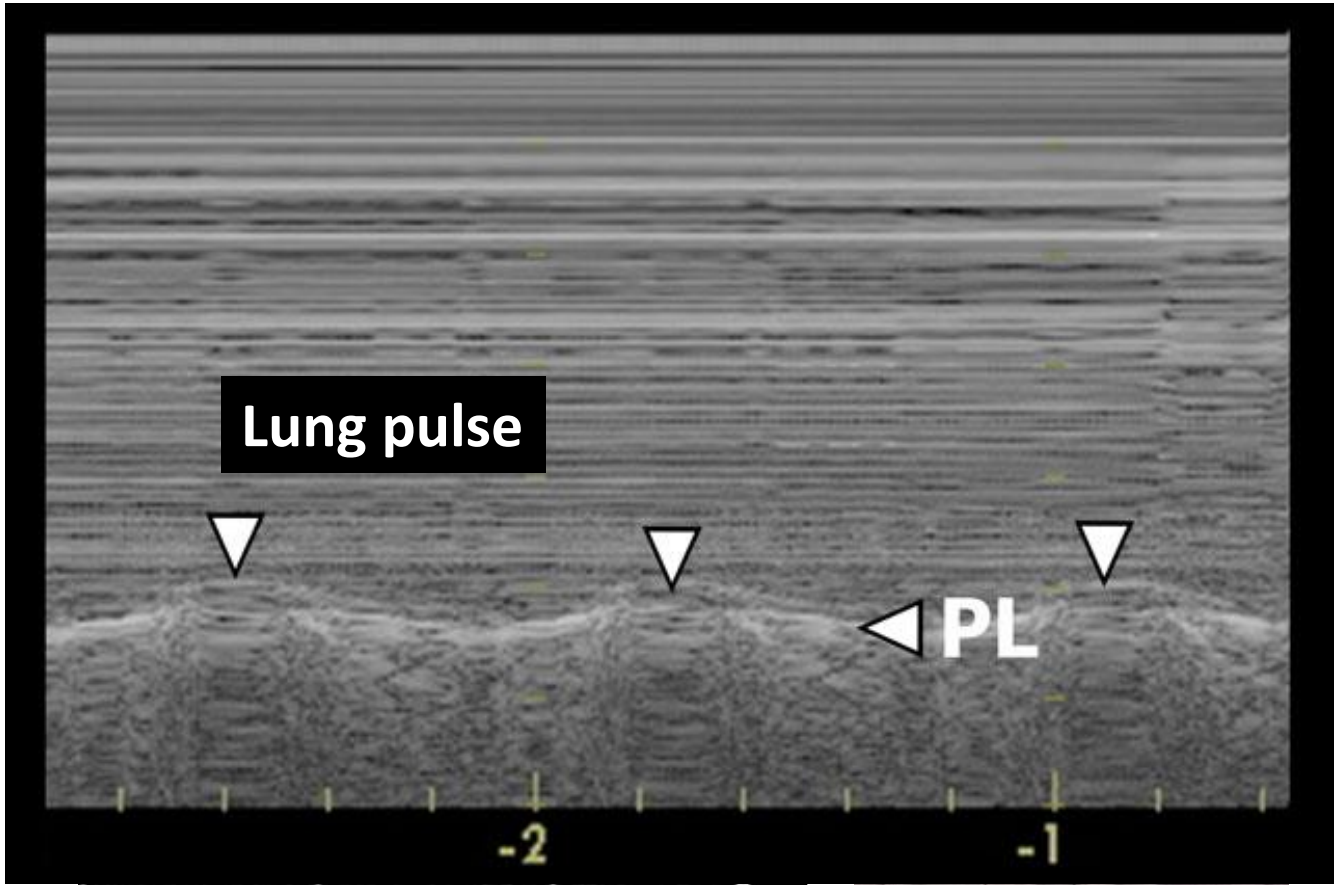



→ **Sliding = both the pleural (visceral and parietal) are in contact !!**

# **Normal lung findings:** Lung sliding (2)

- **Seashore sign** (M-mode)
  - superficial to the pleura
    : horizontal lines
  - deep to the pleura
    : the lung motion
    → **“sandy” pattern**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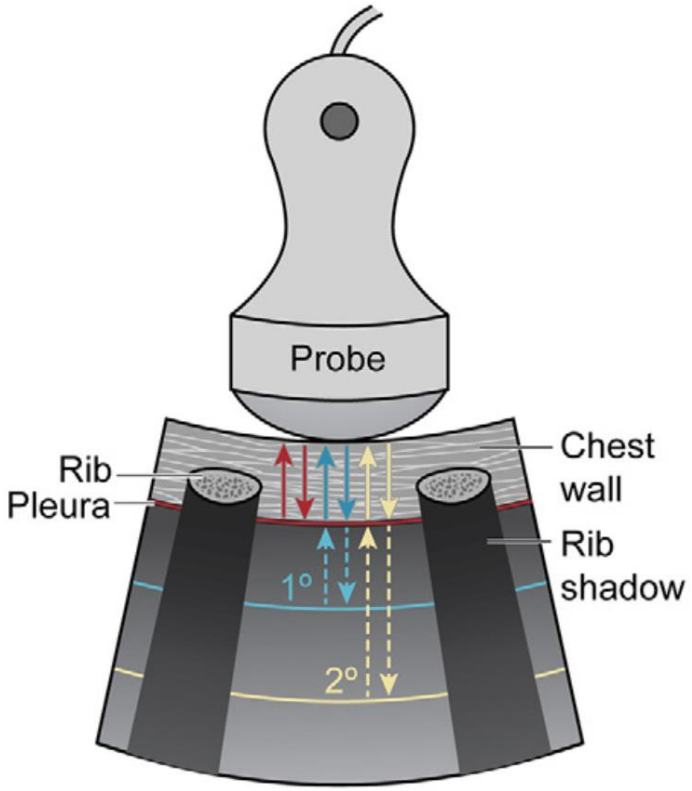
# **Normal lung findings:** A-lines

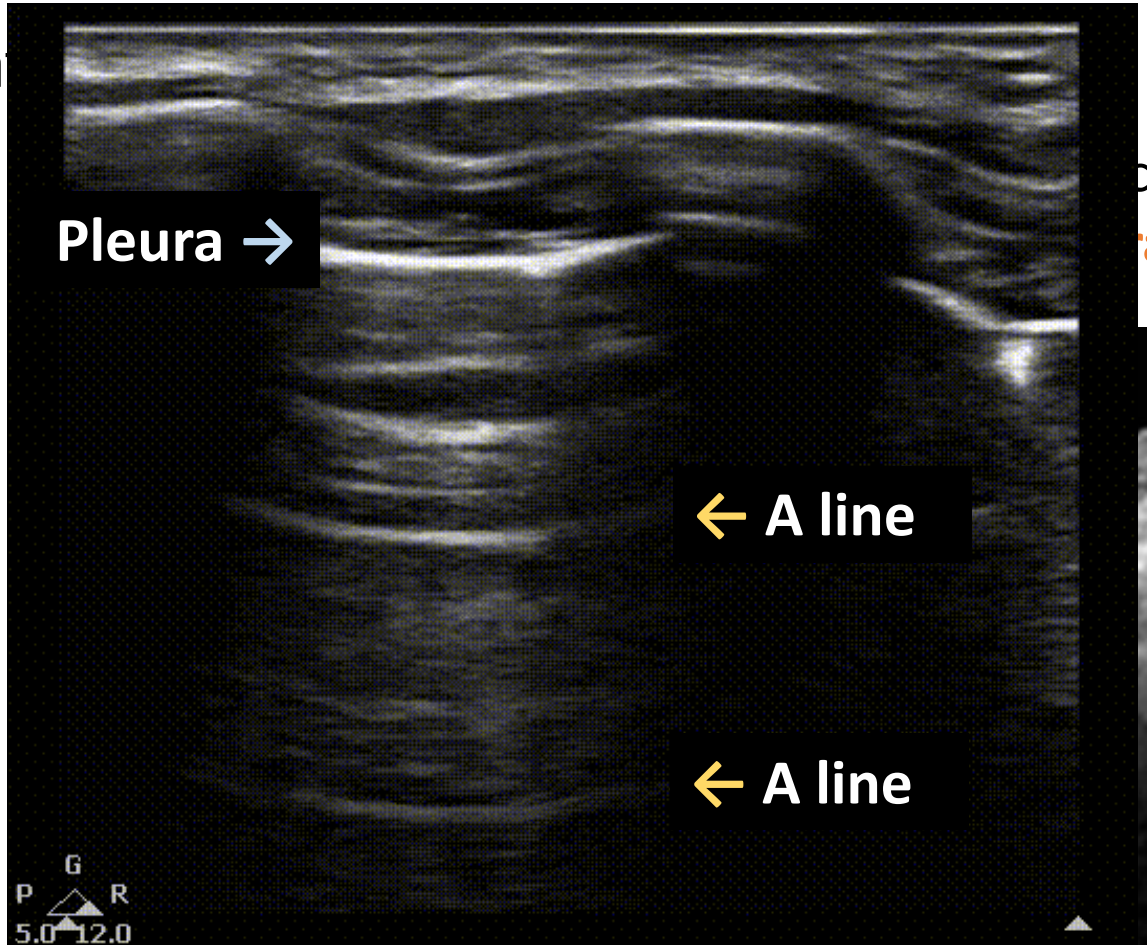
- Reverberation artifact

  : Hyperechoic horizon

ce from skin to pleura

**rated lung !!**





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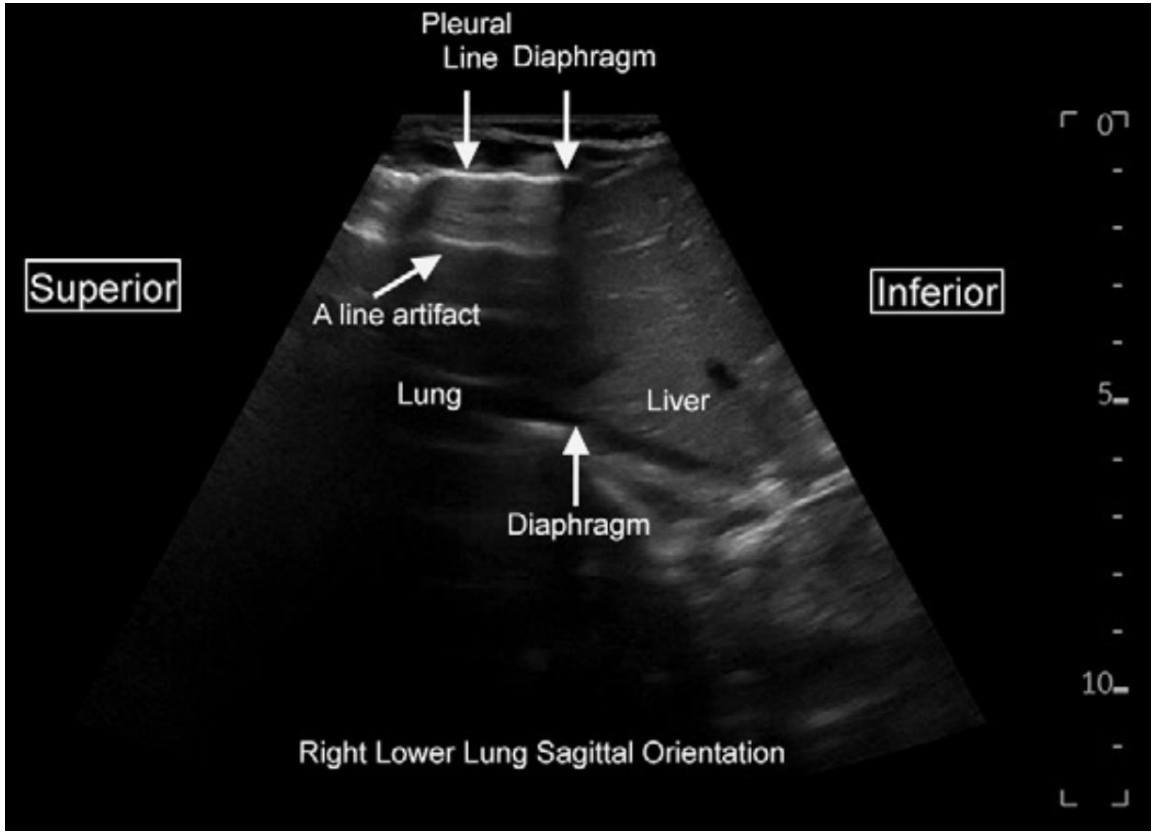
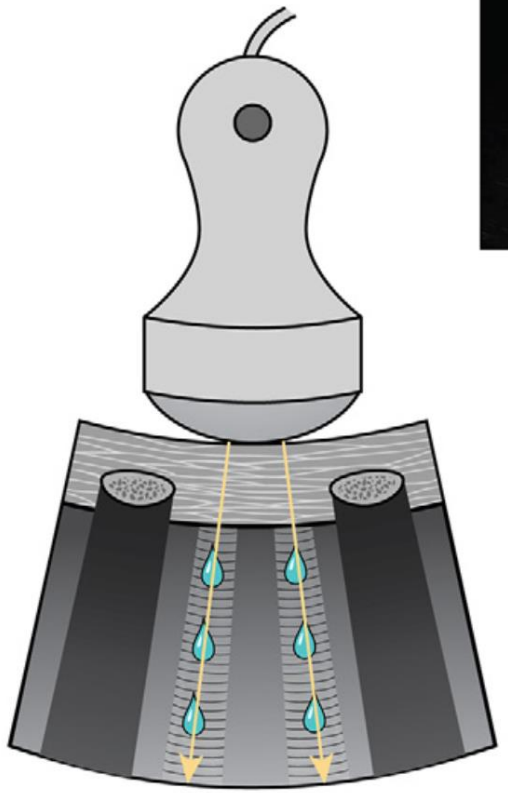
# **Normal lung findings:** Curtain sign

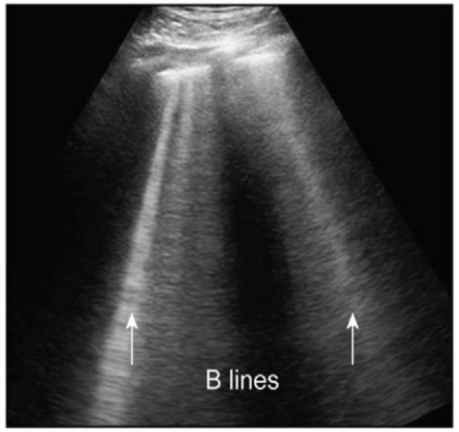
- the inferior aspect of the lung field,
  - the costophrenic recesses
  - the peripheral lung bases

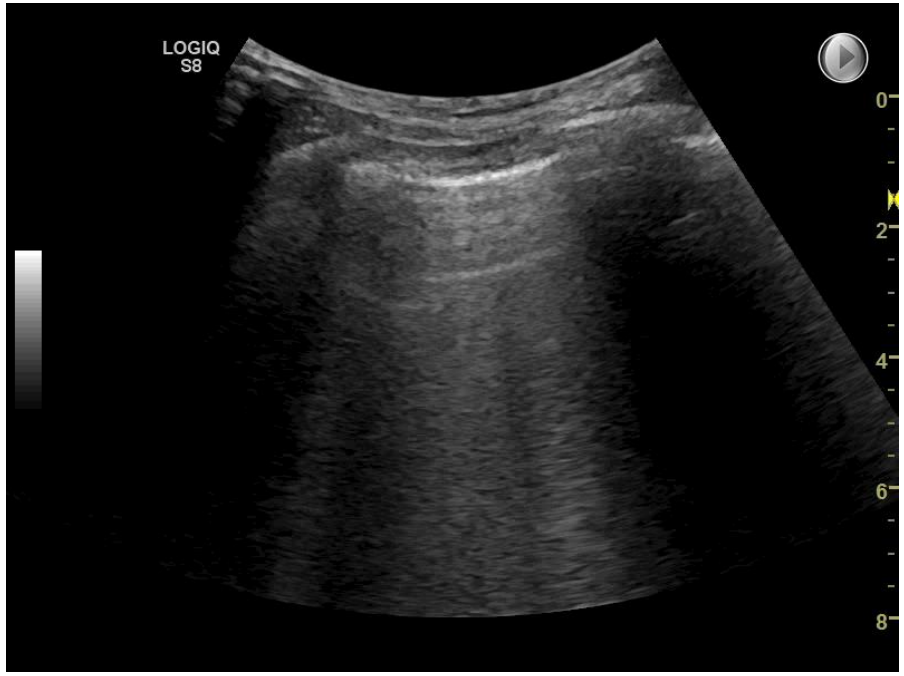



*Journal of Medical Ultrasound* 2017;25(2):101-104
*Radiology: Cardiothoracic Imaging* 2021;3(2):e200564

# **Normal & Abnormal lung findings:** B-lines (1)






- Arise from pleura
- Hyper-echoic vertical line
- Erases, or obliterates the A-lines
- Move with respiration

- **More than three B-lines** is indicative of increased density
  → **"B sign", "B pattern"**

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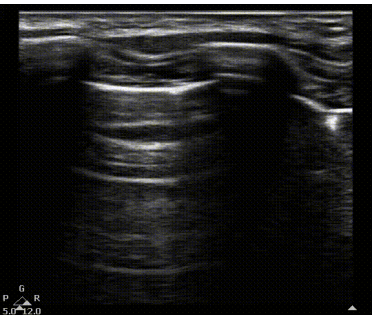
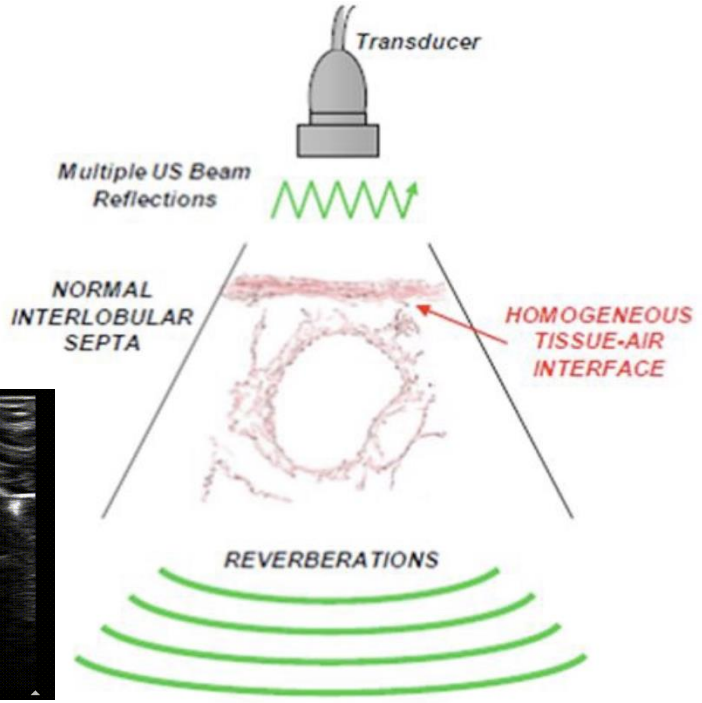
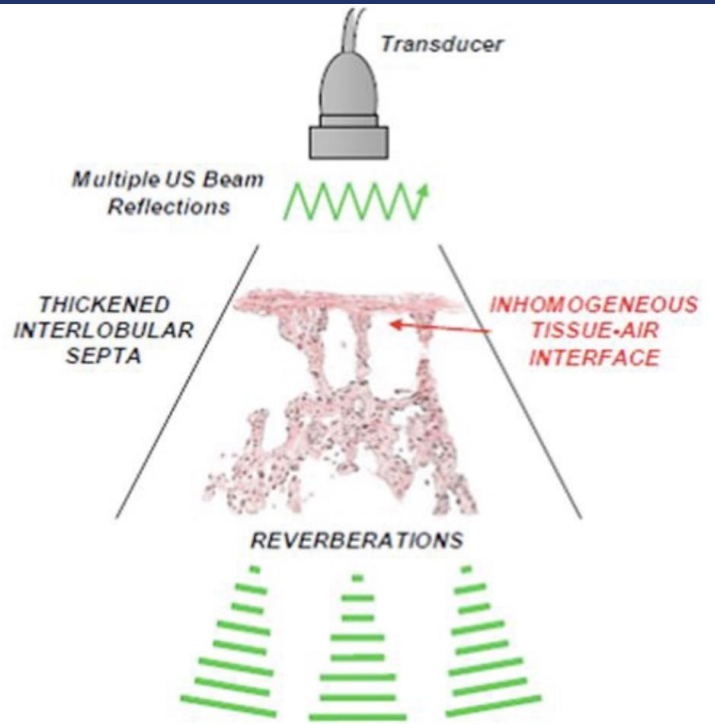
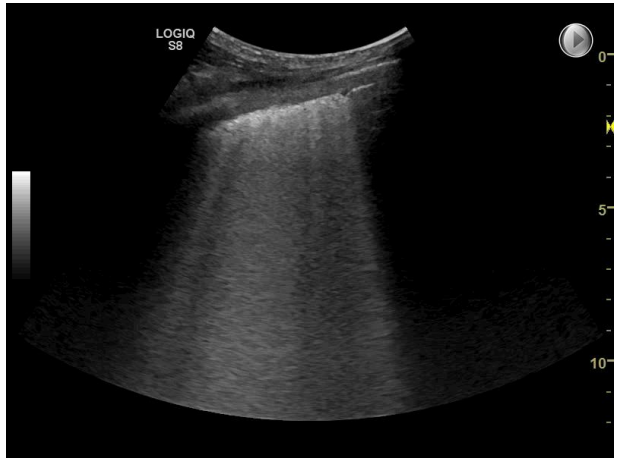
# Normal & Abnormal lung findings: B-lines (2)

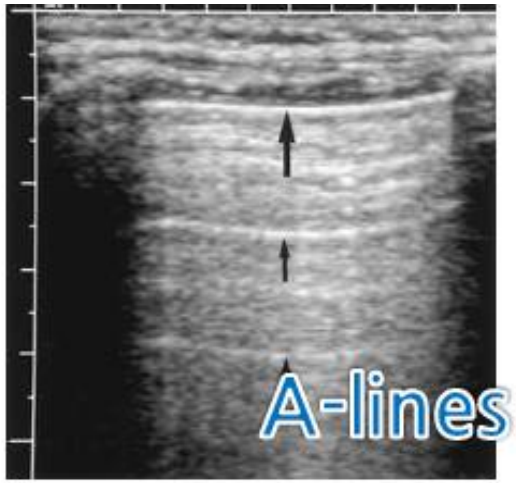


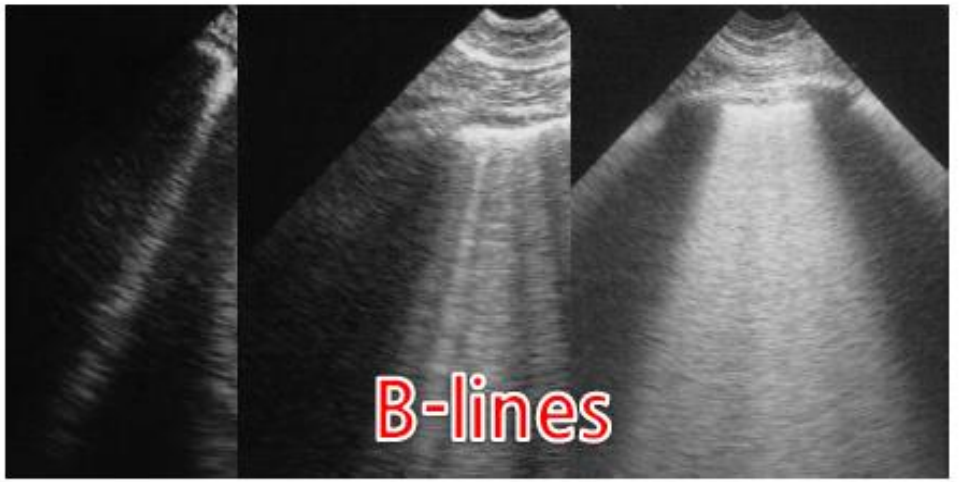



Healthy (well-aerated)



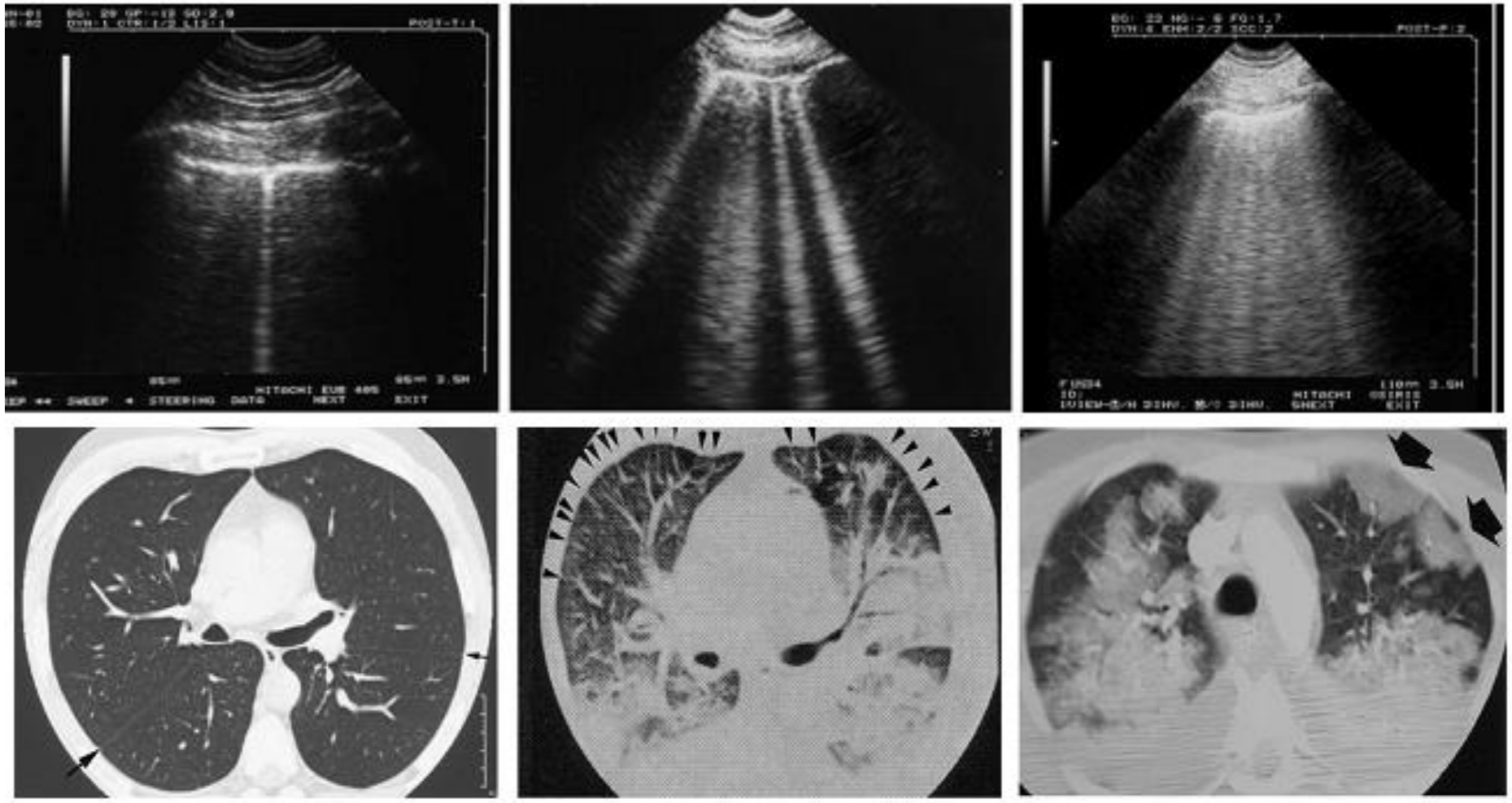




Pulmonary edema (fluid-filled)
Pneumonia (consolidated)

# B-lines (3)

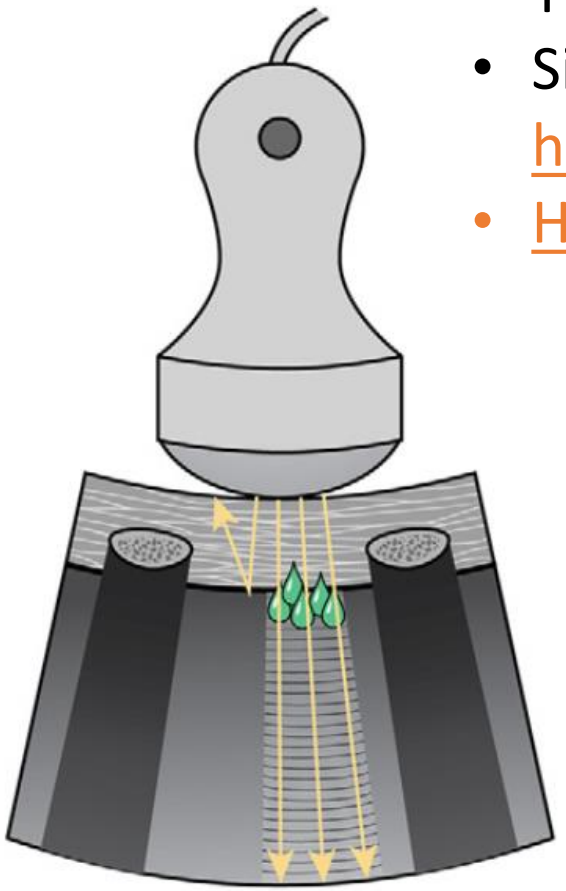
- Multiple B-lines can be seen in any disease with a localized increased density of the lung tissue

→ Pneumonia,
atelectasis,
pulmonary contusion,
pulmonary embolism,
pleural disease
and malignancy

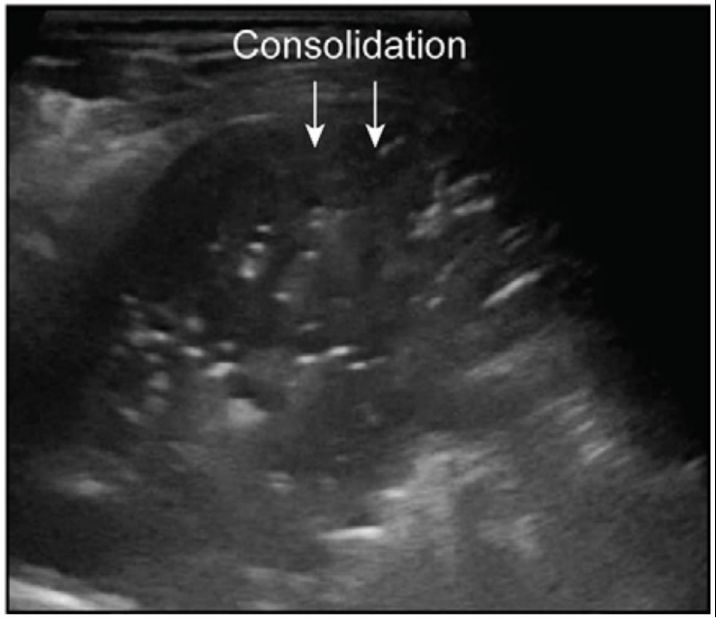


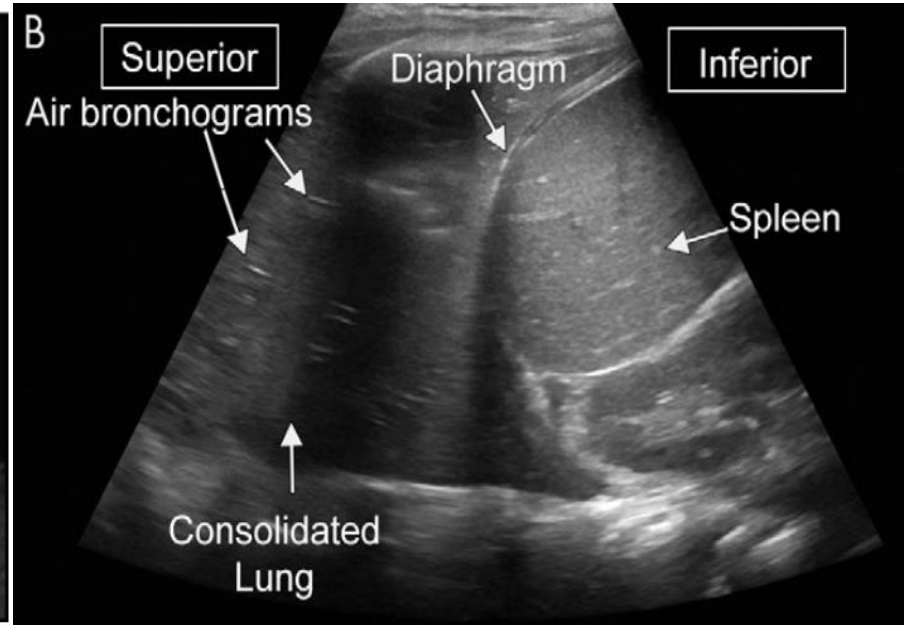
*Journal of Medical Ultrasound* 2017;25(2):101-104

# **Abnormal lung findings** : Consolidation (1)



- Tissue-like pattern, not artifact!
- Similar to the liver, representing so-called hepatization of the pulmonary parenchyma
- Hyper-echoic foci = air bronchograms

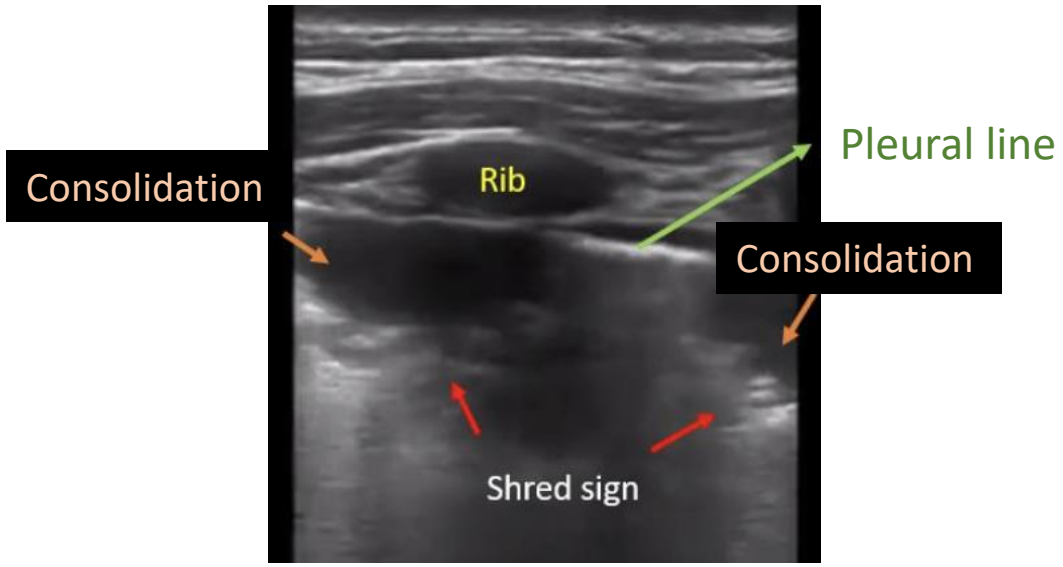



*Radiology: Cardiothoracic Imaging* 2021;3(2):e200564

# Abnormal lung findings: Consolidation (2)

- Shred sign
  - Typical alveolar consolidation,
  - Tissular pattern arising from the pl
    shredded border





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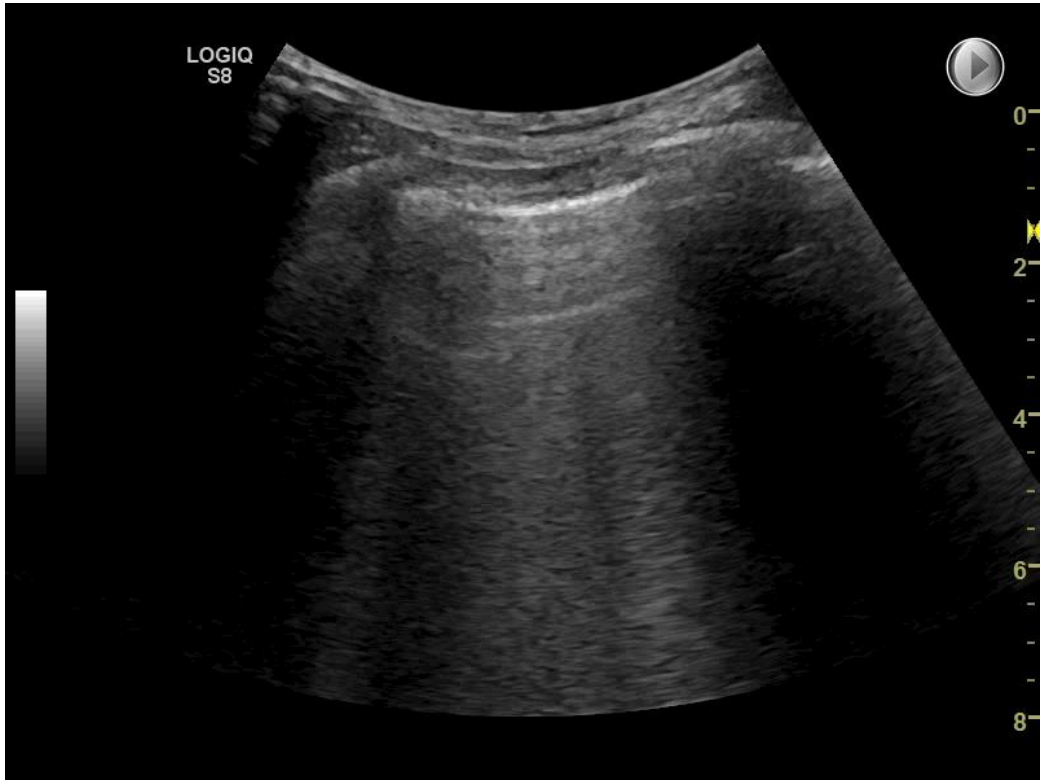
# Assessment

- The presence or absence of three findings is of importance

**(1) Lung sliding**

**(2) the lung pulse**

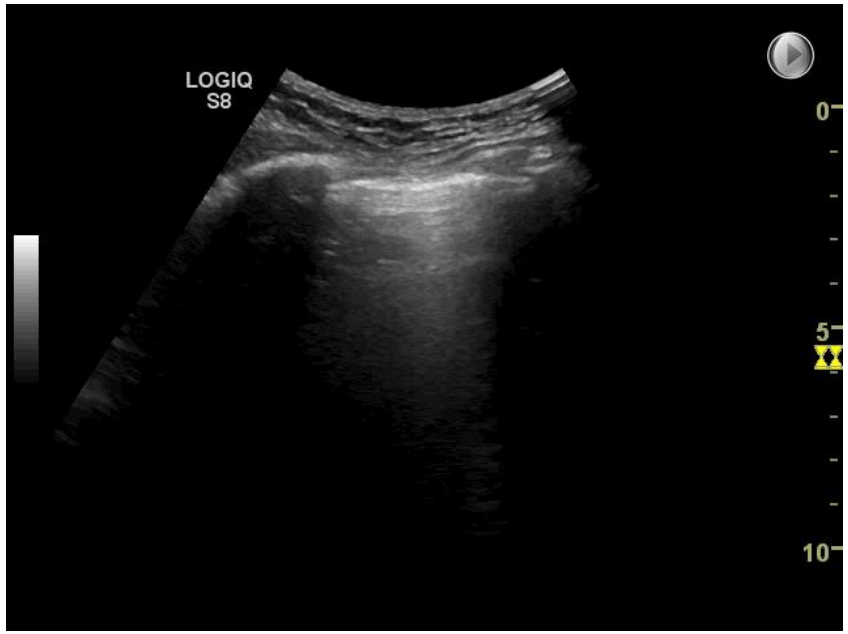
**(3) B-line(s)**



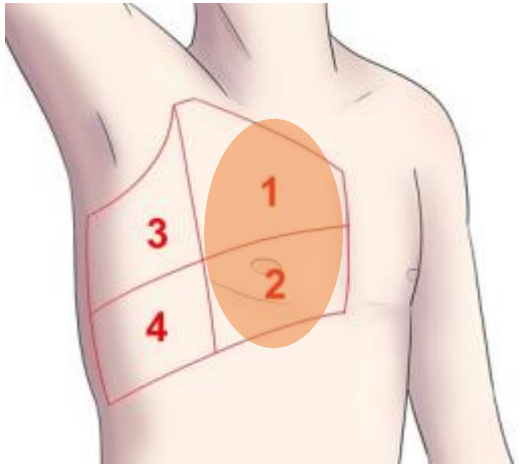
# Assessment

- Lung scanning (1)

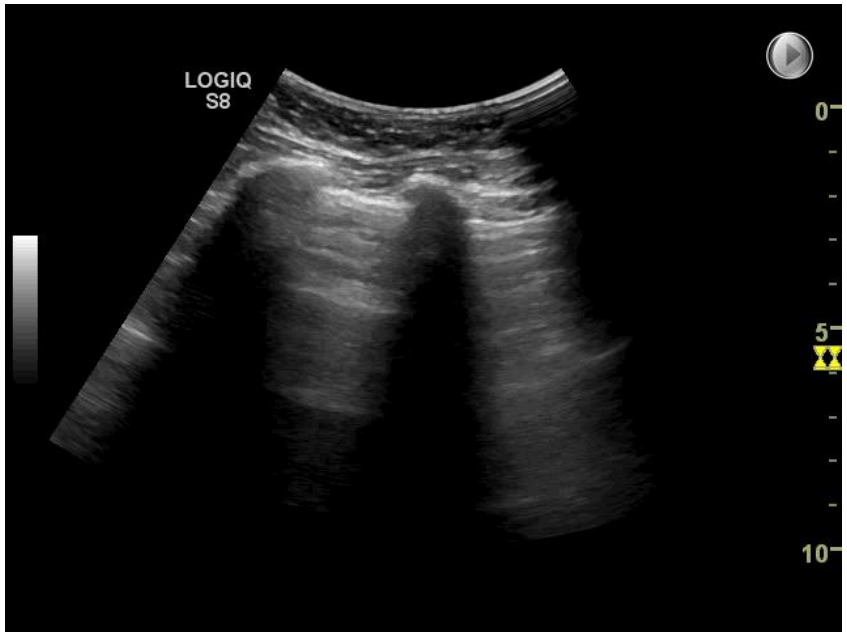
**Zone R1 / L1** ▶
(intercostal space 2)


▲ **Zone R2** (intercostal space 4)



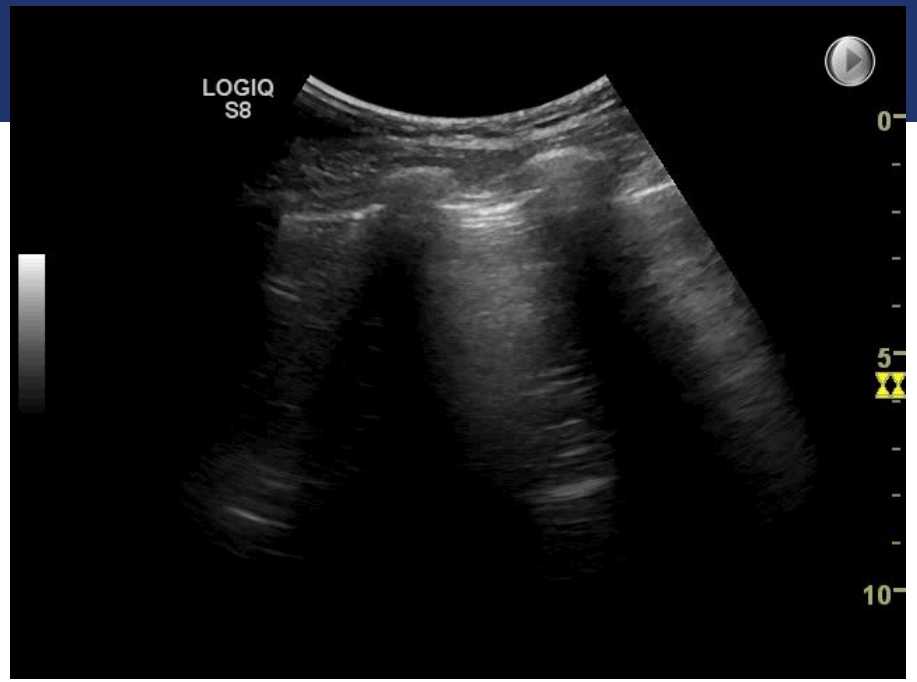

**Zone L2** ▶



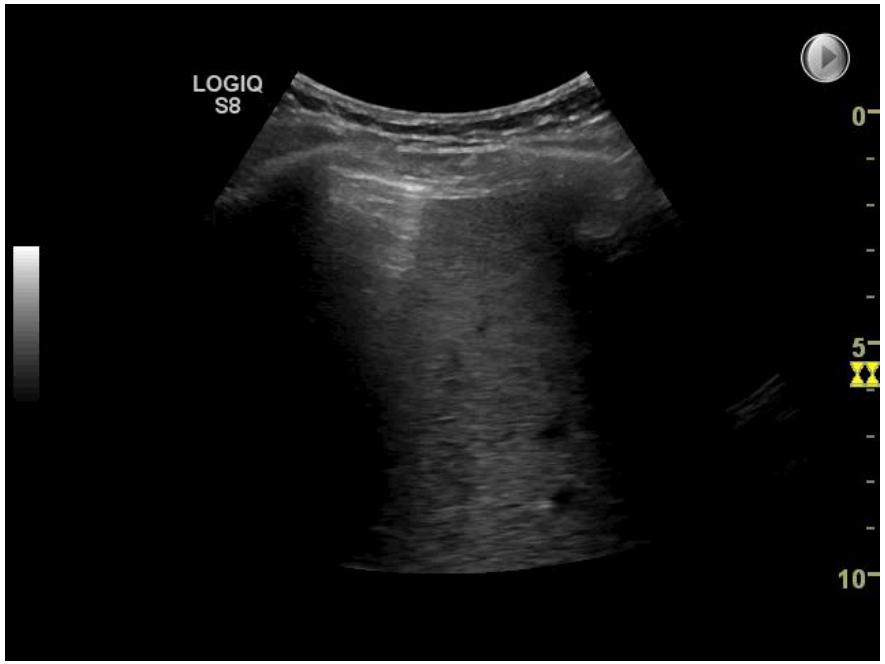
# Assessment

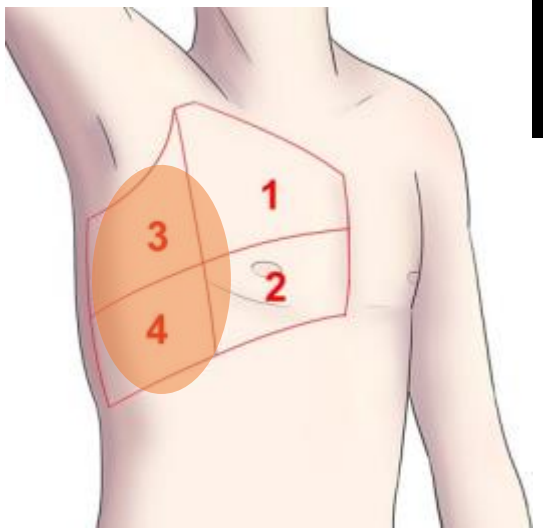
- Lung scanning (2)

**Zone R3 / L3** ▶
(intercostal space 3,
Midaxillary line)

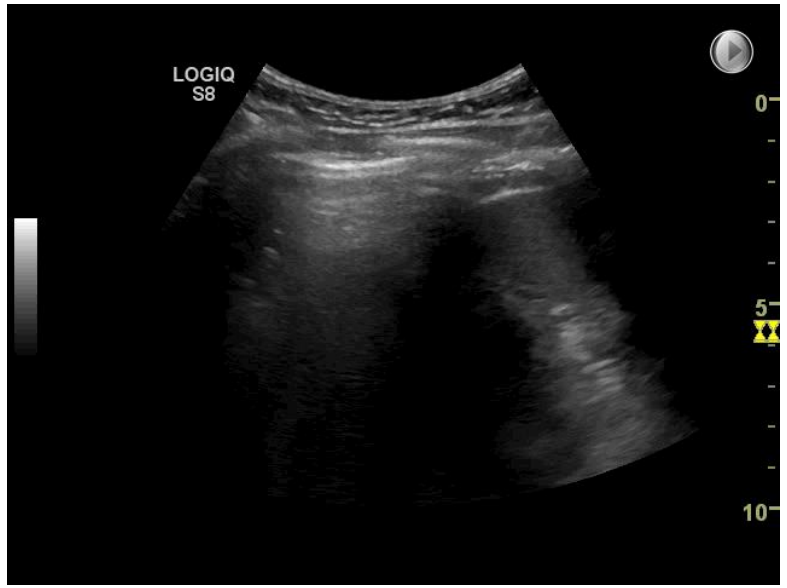



▼ **Zone R4** (midaxillary line)



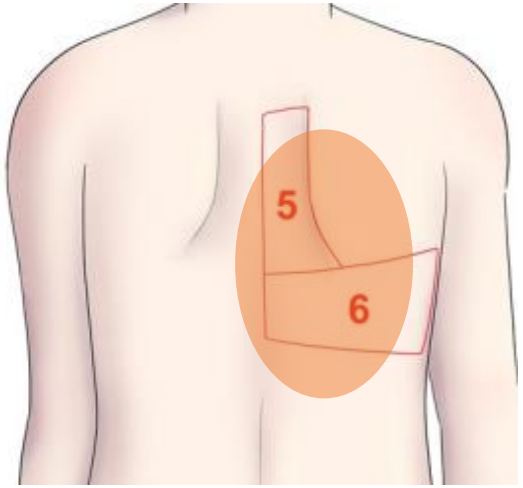

**Zone L4** ▶



# Assessment

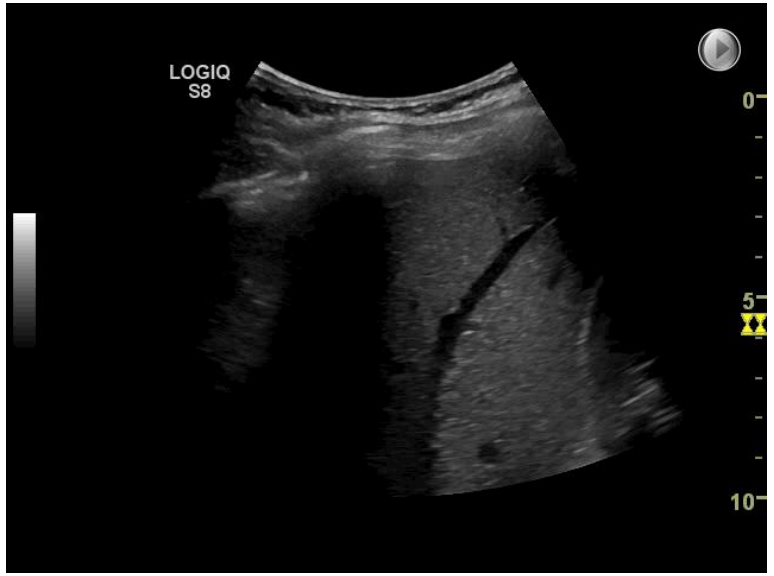

◀ **Zone L5**

**Zone R5** ▶
(the posterior midclavicular line,
the middle of the scapulae)


▼ **Zone L6** (the tip of the scapulae,
at the lower part of the chest)


**Zone R6** ▶
(the tip of the scapulae,
at the lower part of the chest)

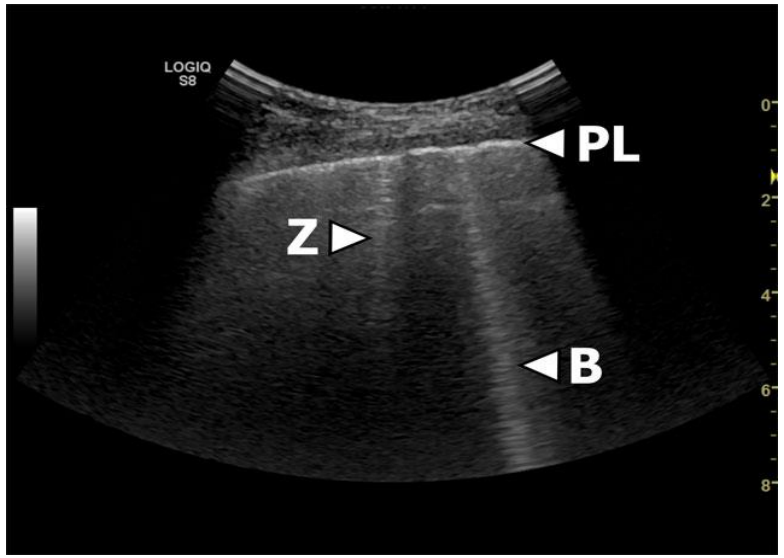


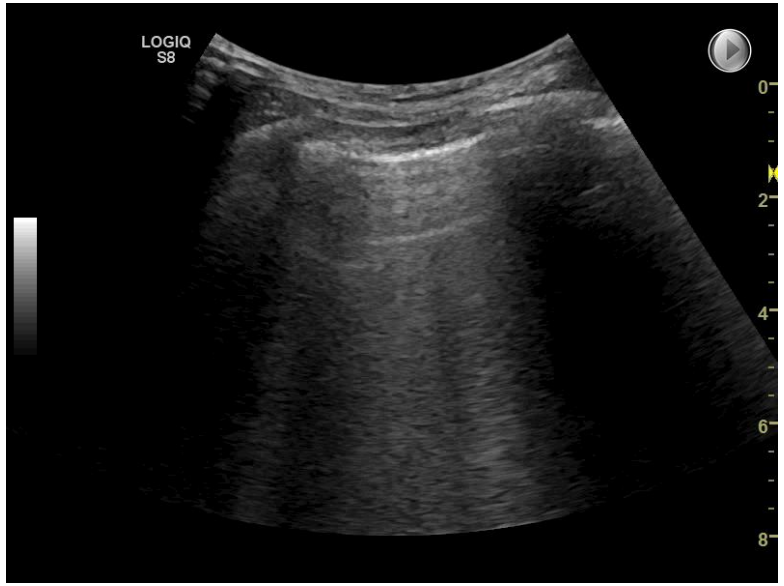
# Interstitial syndrome

- lung disease affecting the lung interstitium

- Sonographic signs: B-lines (cf. Z-line)

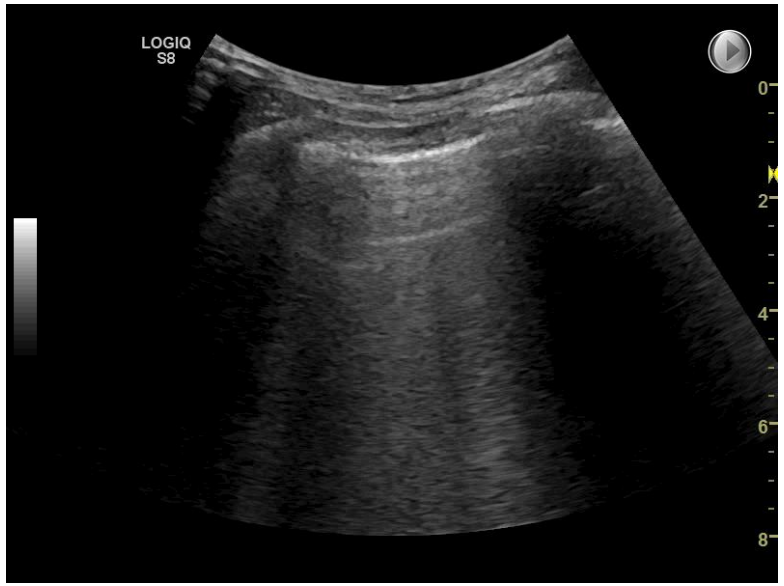
- Clinical applications
  - Cardiogenic pulmonary edema
  - Non-cardiogenic pulmonary edema (e.g. fluid overload, renal failure)
  - Viral pneumonia
  - Bacterial pneumonia
  - ARDS
  - Interstitial lung diseases
  - Drowning / near-drowning
  - Lung contusion

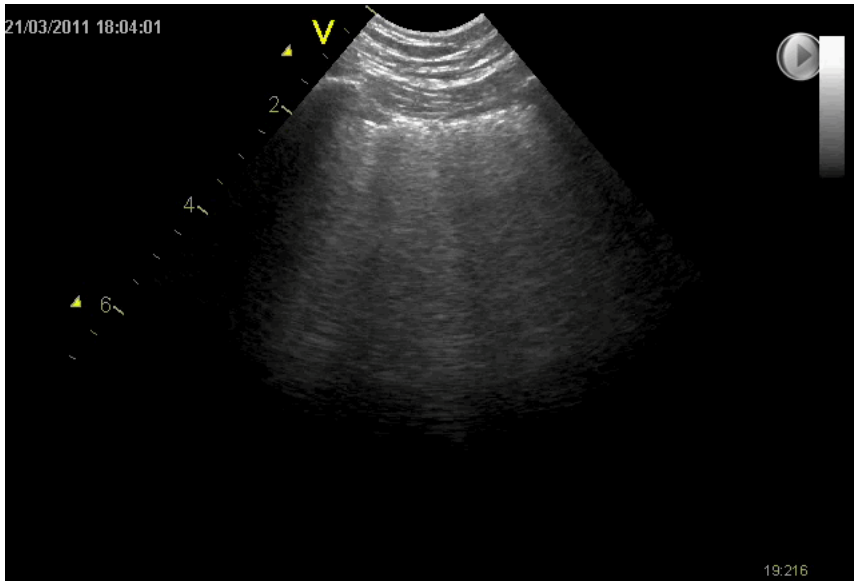


# Interstitial syndrome

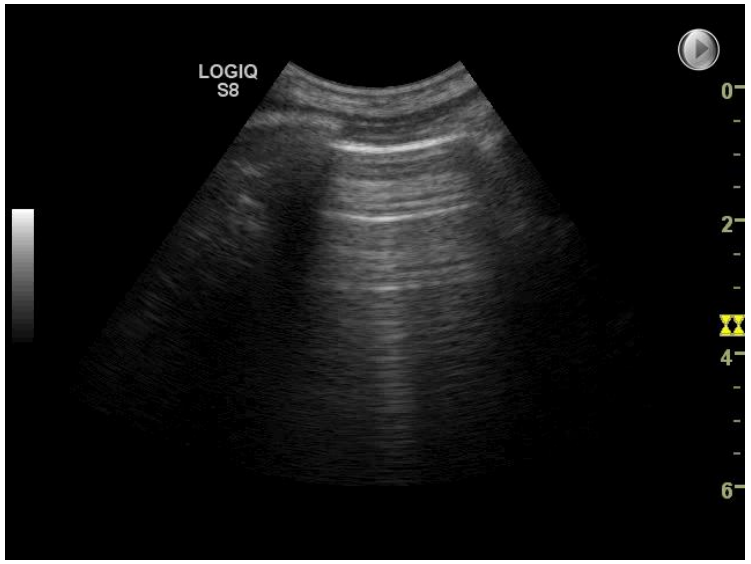
HF



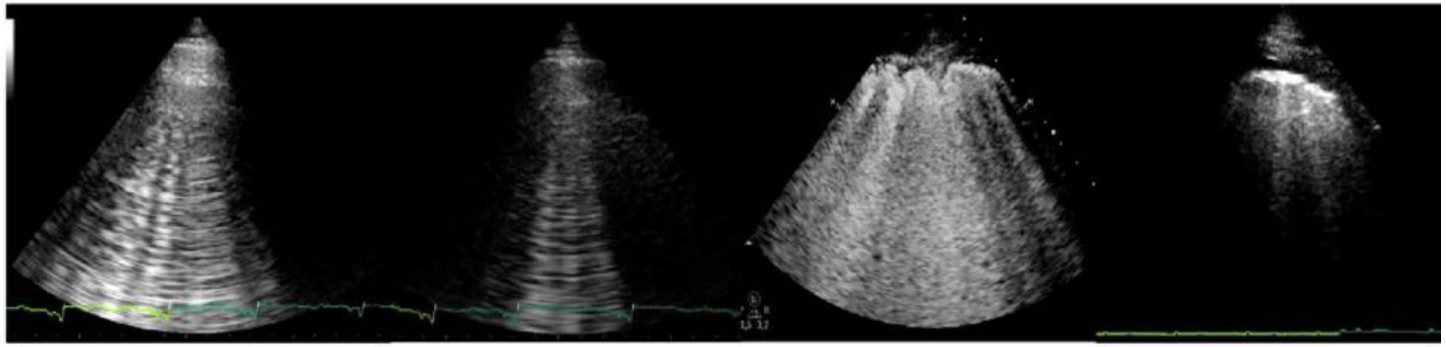

ARDS

Non-cardiogenic pulmonary edema (CKD)


Cf. COPD

# Interstitial syndrome (B pattern)



| | Acute cardiogenic pulmonary edema | Chronic heart failure | ALI/ARDS | Pulmonary fibrosis |
|---|---|---|---|---|
| **Clinical setting** | acute | chronic | acute | chronic |
| **B-lines number** | ++++ | +/++/+++ | ++++ | +/++/+++ |
| **B-lines distribution** | multiple, diffuse, bilateral (white lung) | multiple, diffuse, bilateral, following decubitant regions (black and white lung) | non-homogeneous distribution, presence of spared areas | more frequently posterior at lung basis |
| **Other LUS signs** | pleural effusion | pleural effusion | pleural effusion, pleural alterations, parenchymal consolidations of various size | pleural thickening |
| **Echocardiogram** | abnormal | abnormal | likely normal | likely normal |

*Cardiovascular Ultrasound* 2011;9:6

# Interstitial lung disease

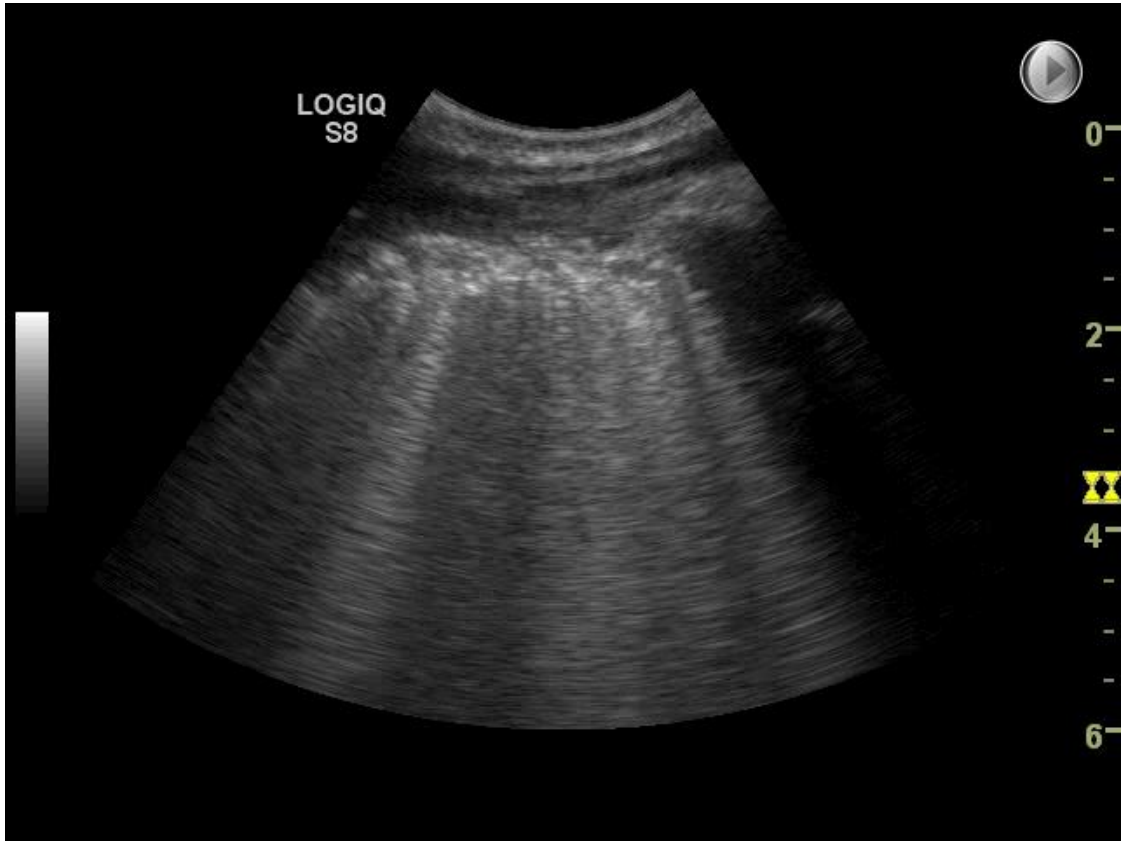
- Comprised of a variety of different diseases

- Sonographic signs

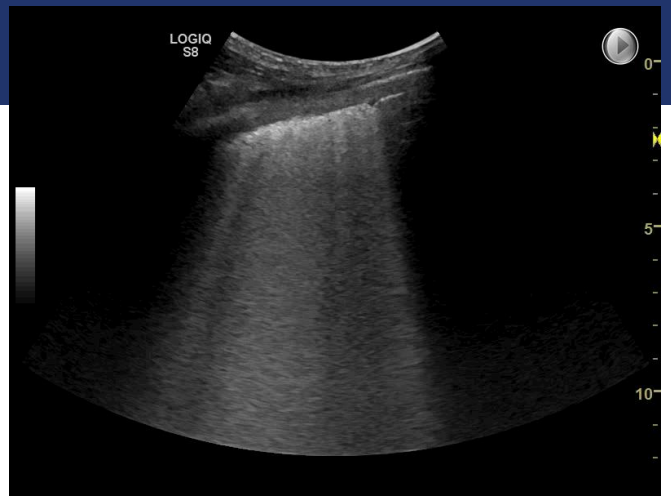
1) Ground glass opacity: B-lines in affected areas

2) Honeycombing: Abnormal visceral pleura,
B-lines may be present

3) Cystic changes: Normal visceral pleura,
no B-lines



# Pneumonia

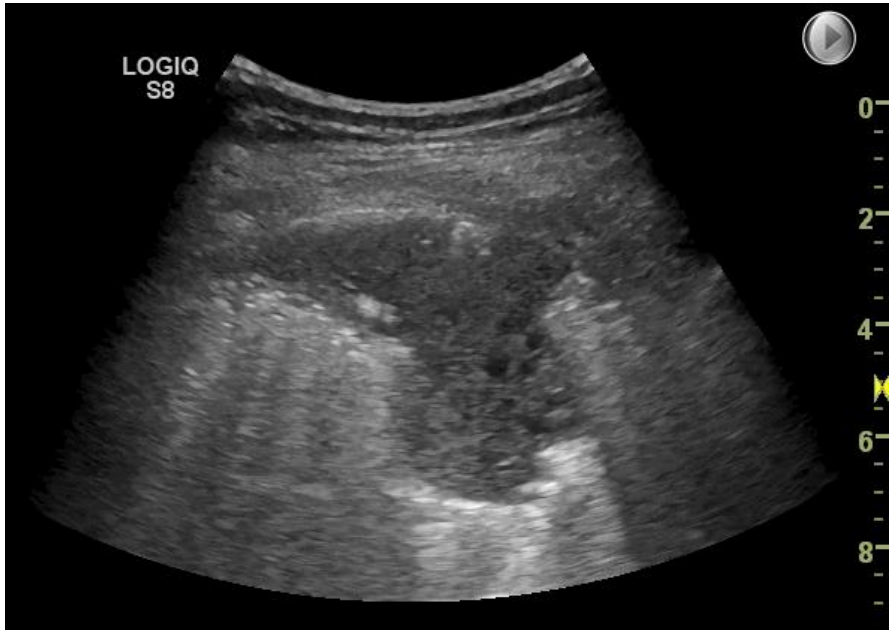


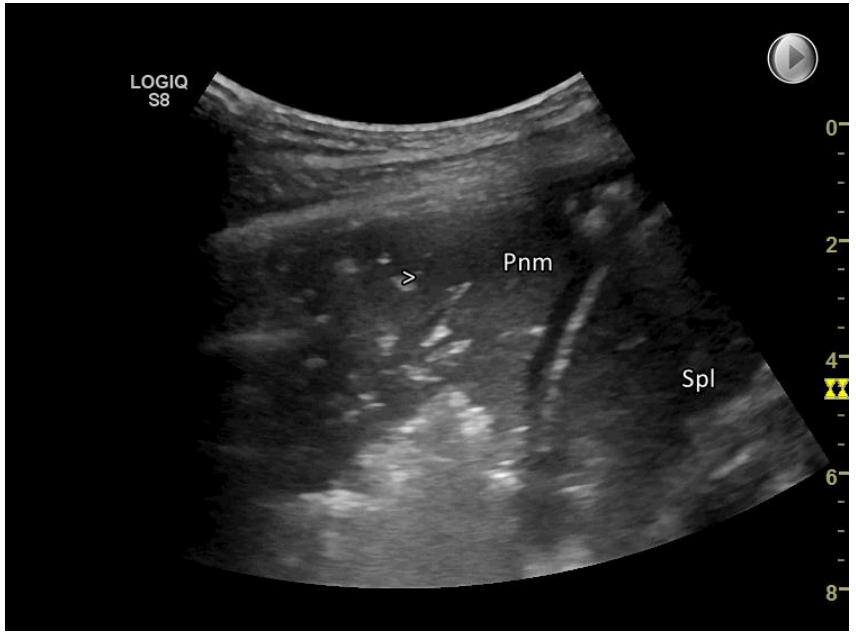

- Resulting increased density of the lobe

  → multiple B-lines

- The density further increases and the lung tissue is filled with fluid and secretions → the pattern will change to that of lung consolidation

- Air bronchogram
- Fluid bronchogram
- Vascularization



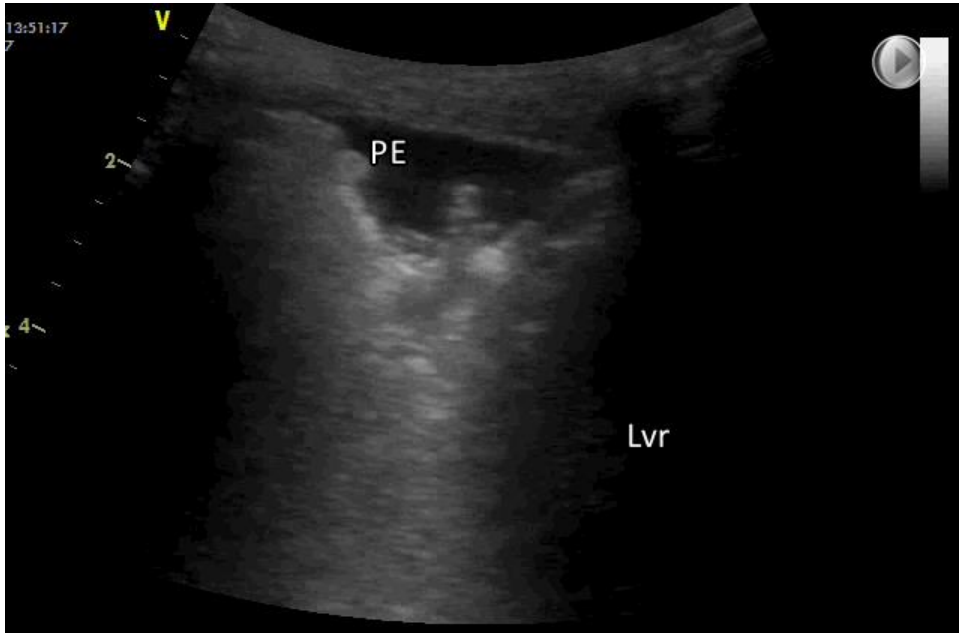
# Pulmonary embolism

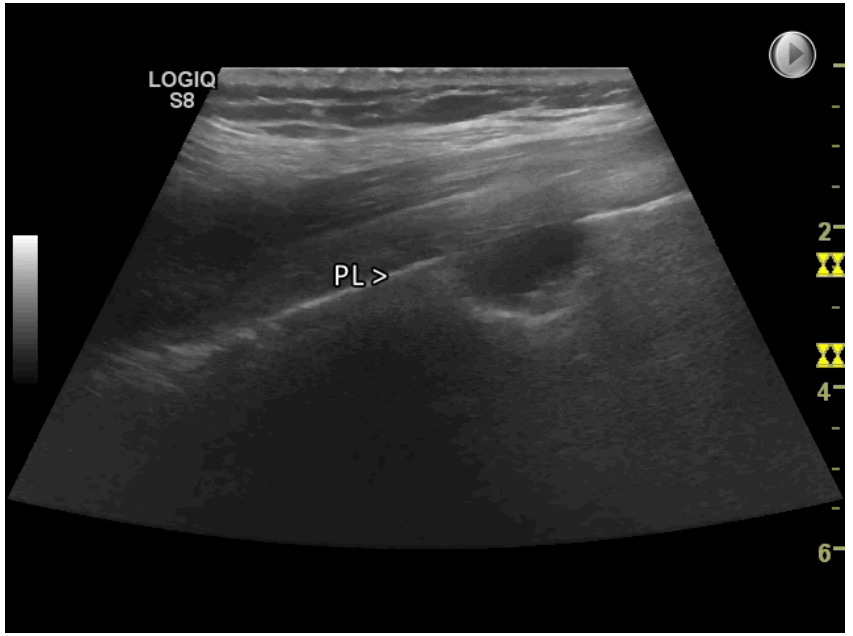
- Sonographic signs

1) The consolidation

: a hypoechoic, triangular/round, well demarcated

2) The average patient with PE has 2-3 visible lung consolidations and often a pleural effusion.



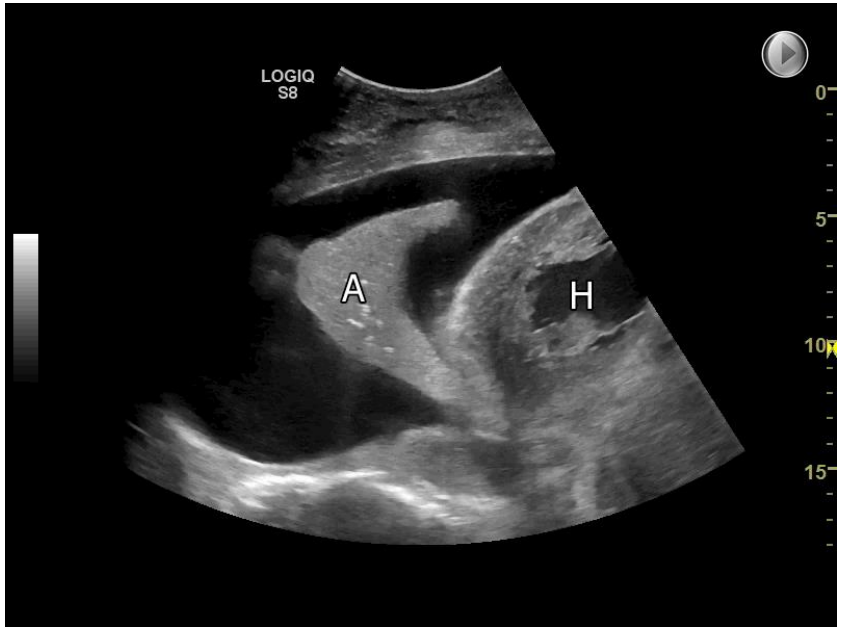
# Atelectasis

- The lung tissue is completely airless
- Sonographic signs

1) The consolidation

: a hypoechoic, homogenous, sharply demarcated

2) In comparison with pneumonia, no air bronchograms are visible.



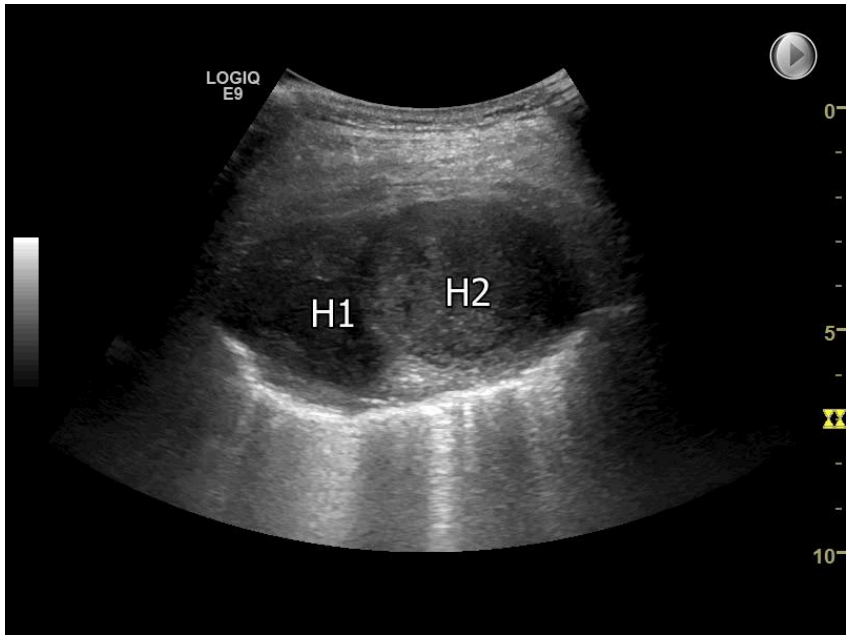

# Lung tumor

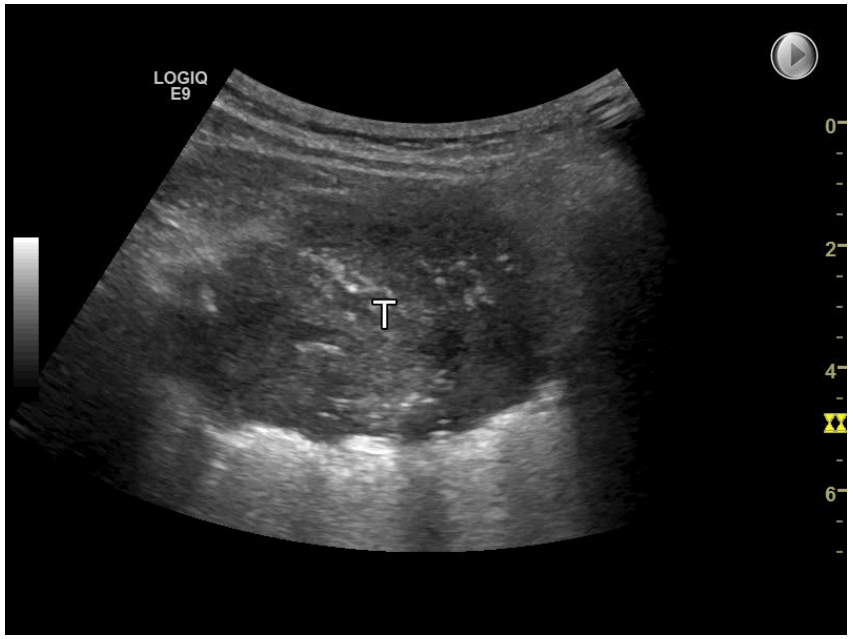
- Sonographic signs

1) hypoechoic / isoechoic / hyperechoic structure

2) an inhomogeneous appearance with a mixture of hypo-/ iso-/ hyperechoic

3) well demarcated / diffusely demarcated

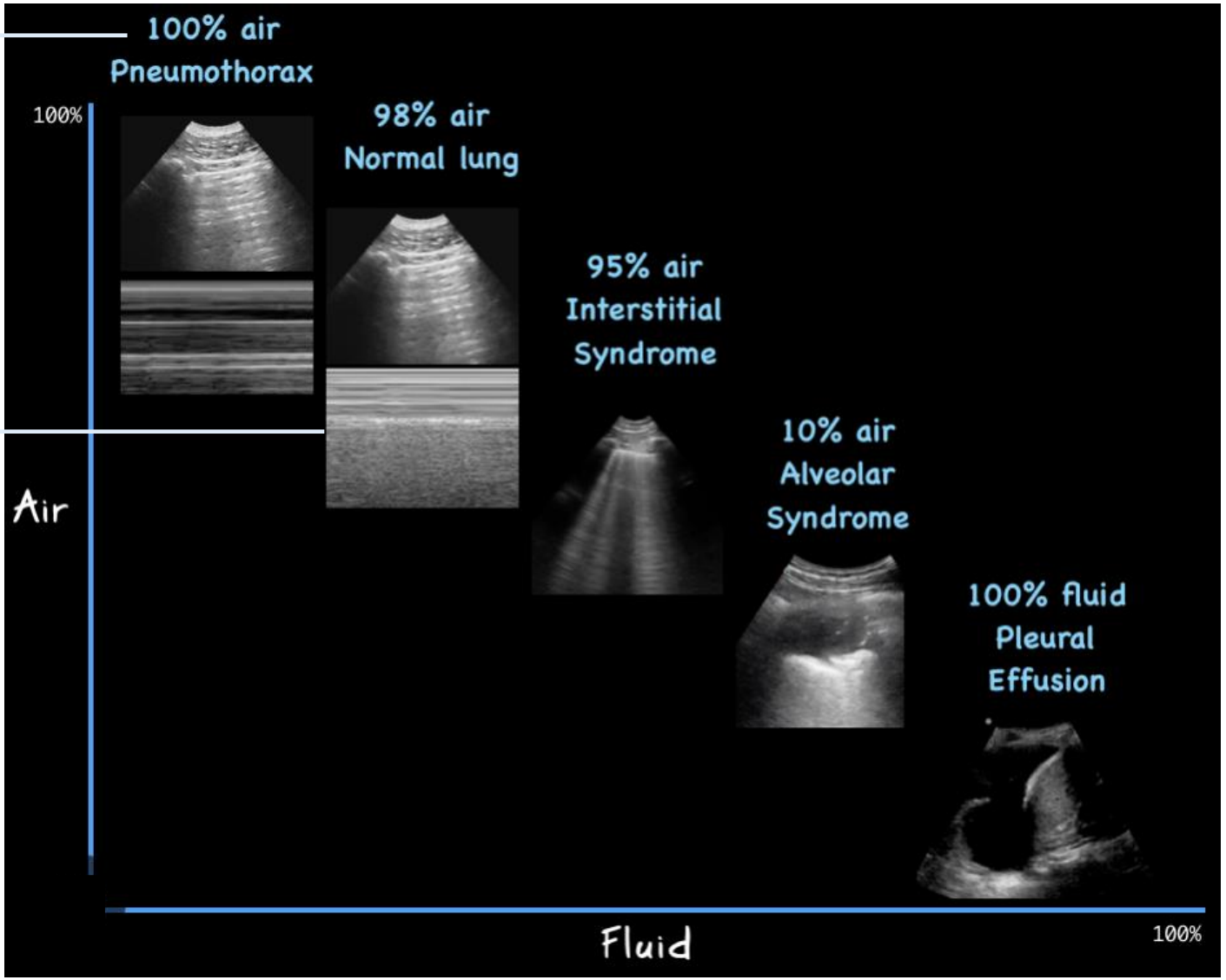


# Continuum of aeration in LUS

[ PNX ]
- No lung sliding
  : barcode sign
- Lung point (hard to find)
- A-lines

[ Normal lung ]
- Lung sliding
  : seashore sign
- A-lines
- Curtain sign

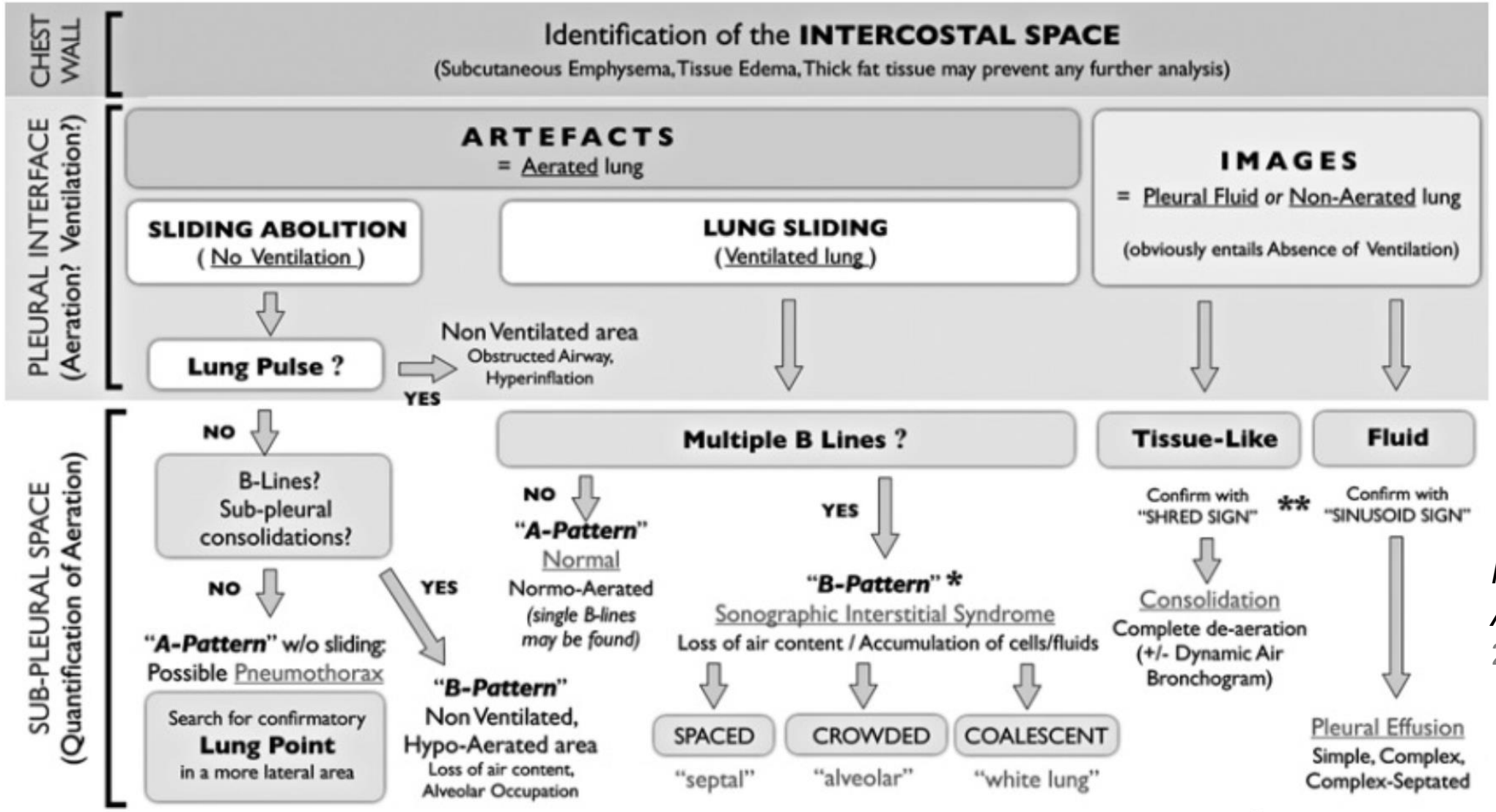



[ Pneumonia ]
- B-lines
- Hepatization of lung
- Shred sign
- Possible small pleural effusion

[ Cardiogenic pulmonary edema ]
- Widespread bilateral B-lines
- Normal lung sliding
- Possible bilateral pleural effusion

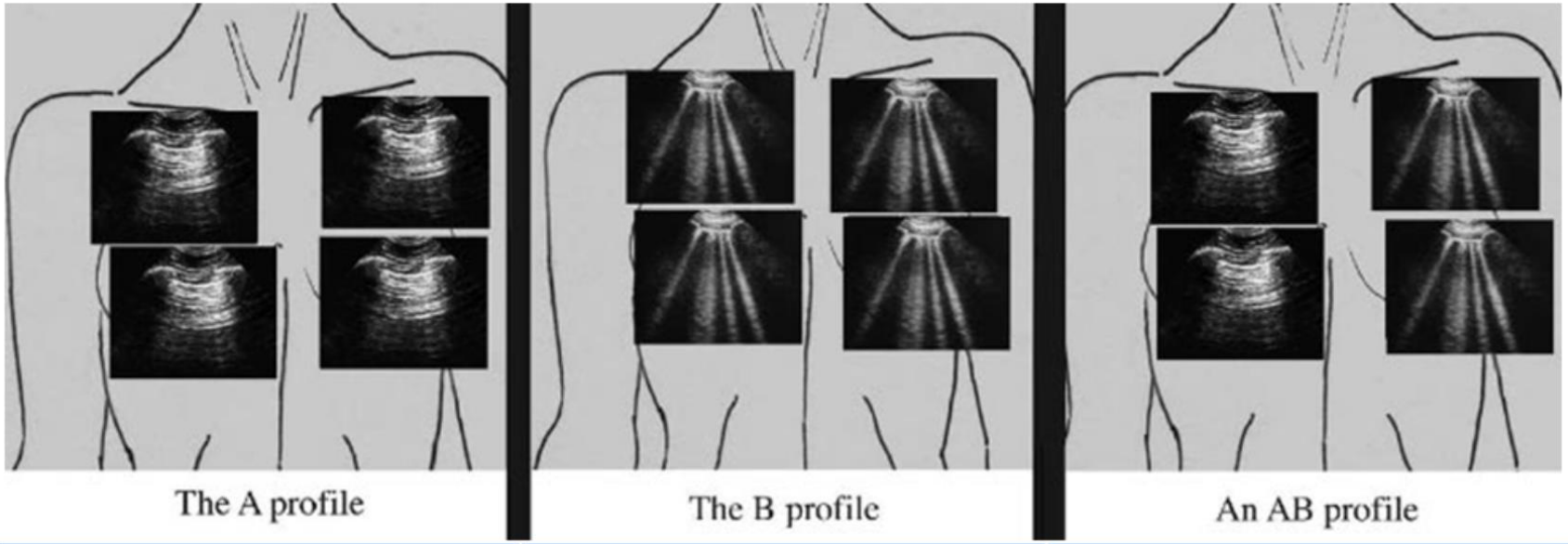
[ ARDS ]
- Bilateral or unilateral B-lines
- Normal lung sliding

# Interpretation of LUS




*Minerva Anestesiol* 2012;78(11):1282-96

# BLUE (Bedside Lung US in Emergency) protocol

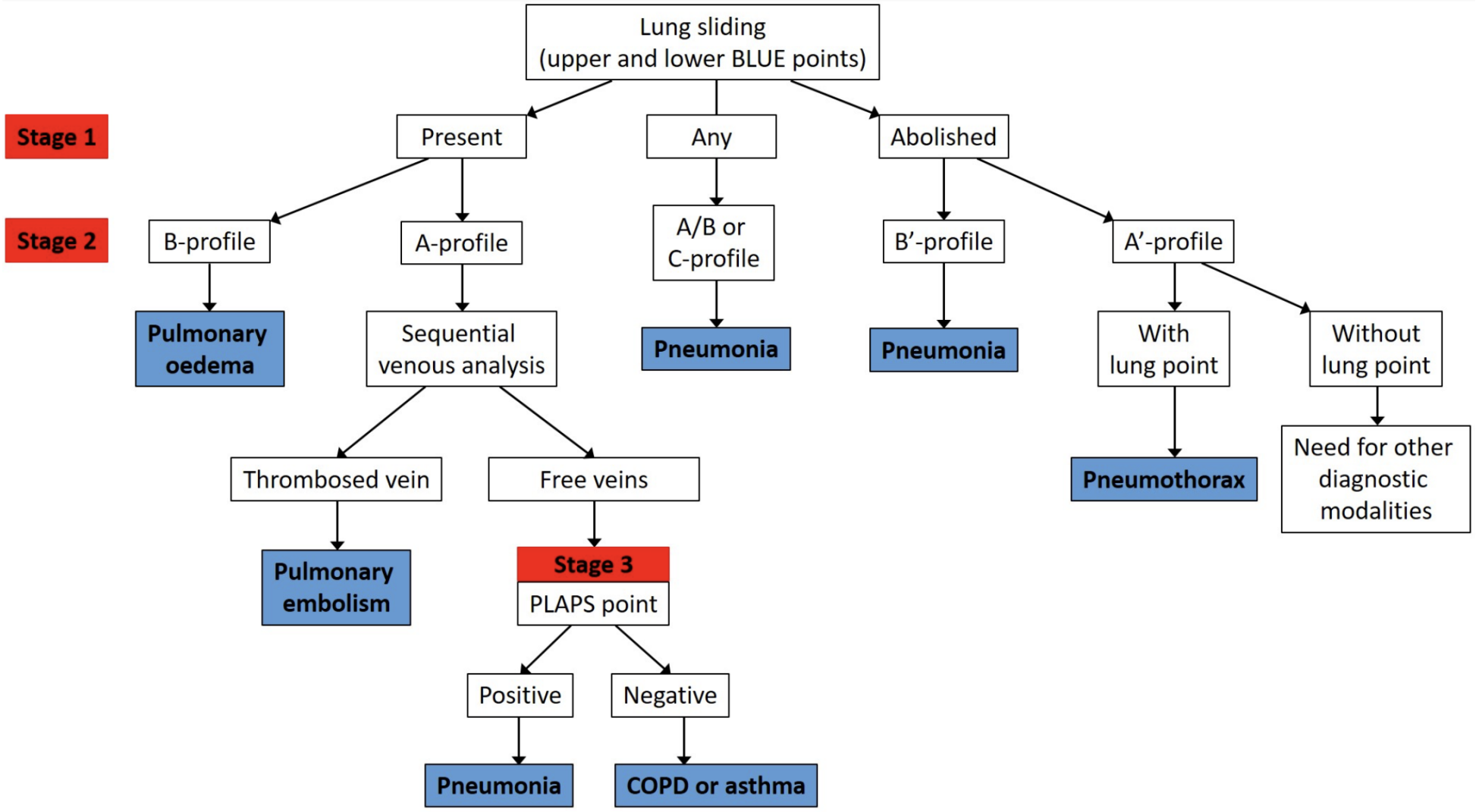



| A Profile (A lines + sliding) | B Profile (+ sliding) | AB Profile (+ sliding) |
|---|---|---|
| + COPD/asthma | + pulmonary oedema | + pneumonia |
| + PE | - COPD/asthma | - Pulmonary oedema |
| + Posterior pneumonia | - PE | - COPD/asthma |
| - Pulmonary oedema nearly ruled out | - pneumothorax | |

\+ : potential diagnosis
\- : diagnosis ruled out

*Chest* 2008;134:117-125

# BLUE (Bedside Lung US in Emergency) protocol

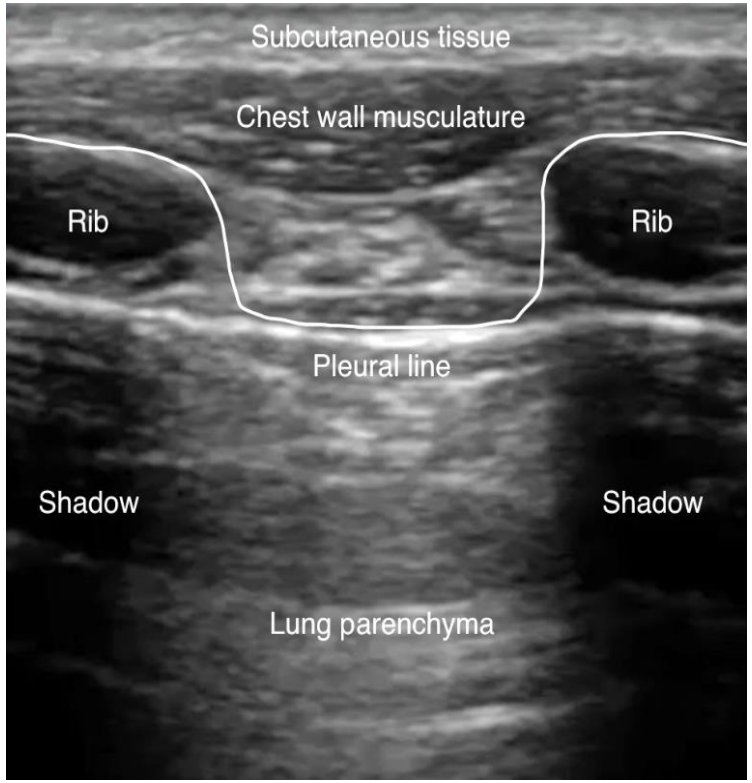


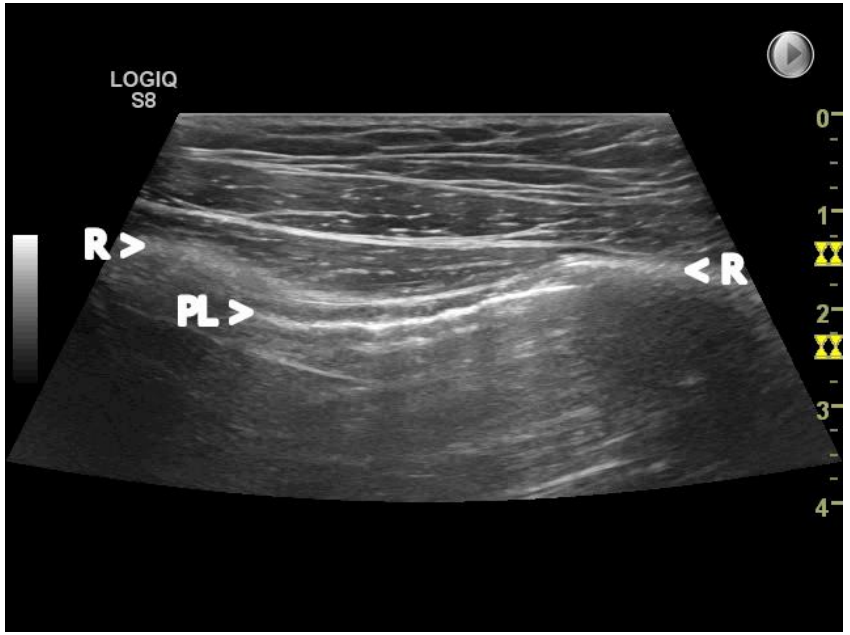

*Chest* 2008;134:117-125

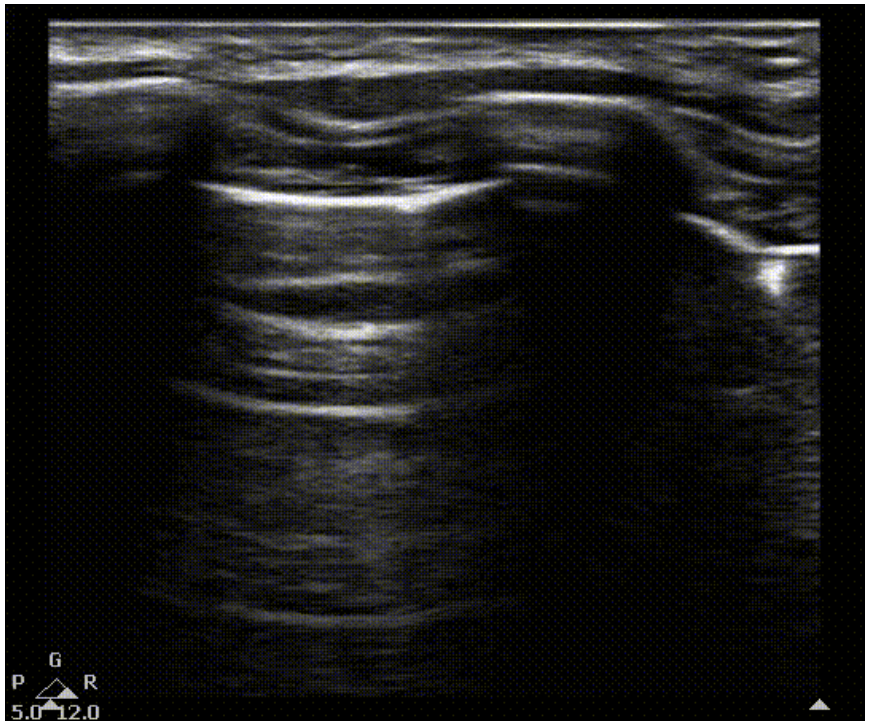
# Summary

- Basic principles: the lung tissue is seen as **artifacts**
- **Interpretation of Thoracic US**

  - Normal lung findings: Lung sliding (seashore sign), A-lines, curtain sign



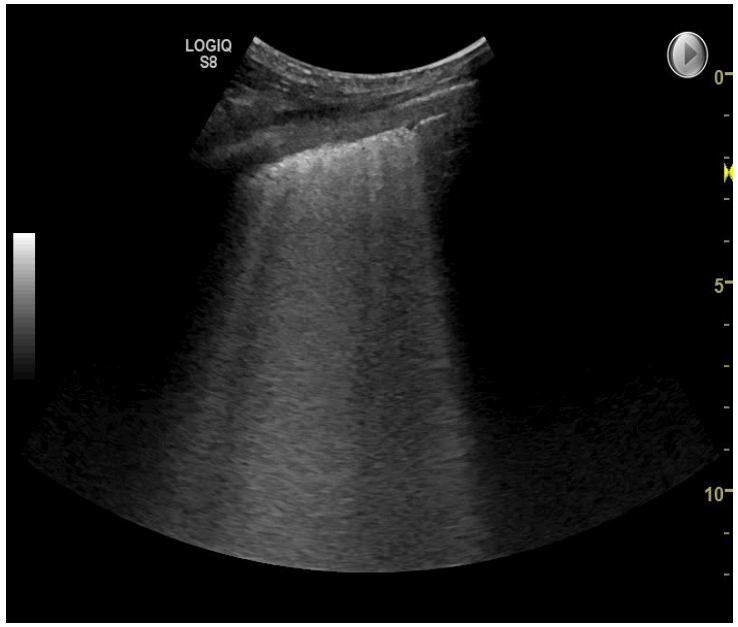



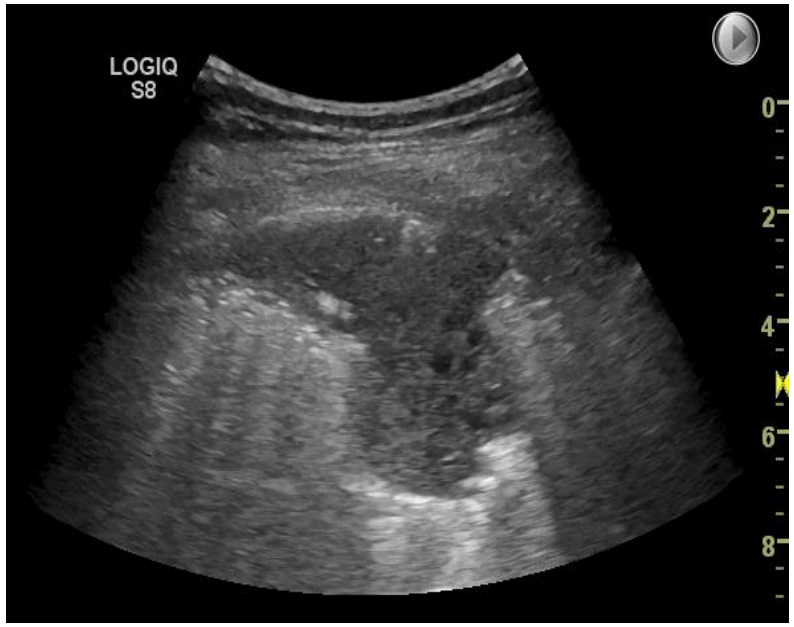



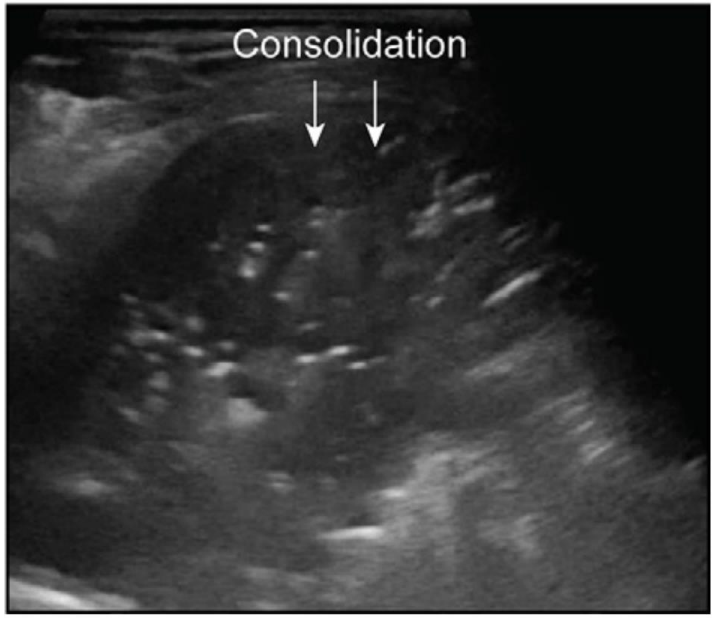
# Summary

- **Interpretation of Thoracic US**

- Injured lung findings: B-lines, interstitial syndrome (B-patterns), consolidation (tissue-like, shred sign),

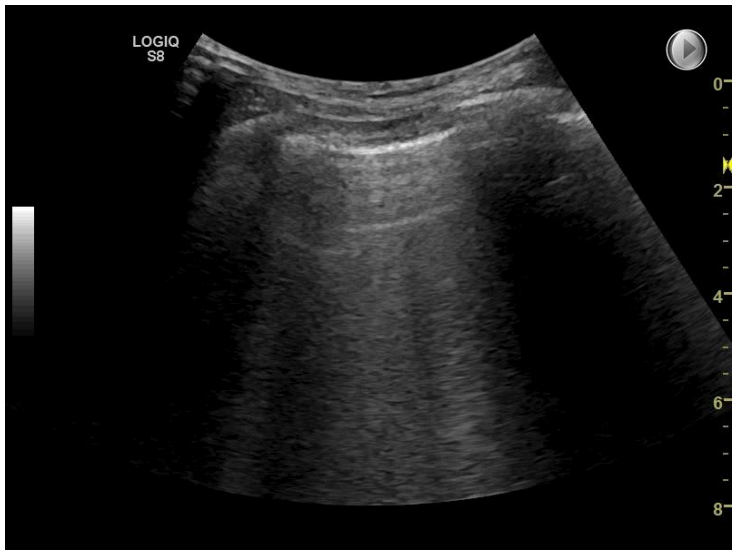


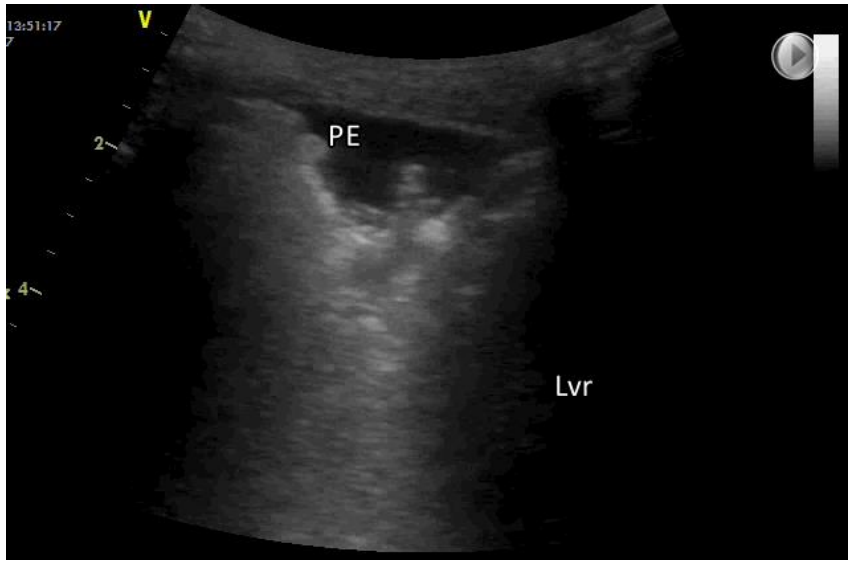



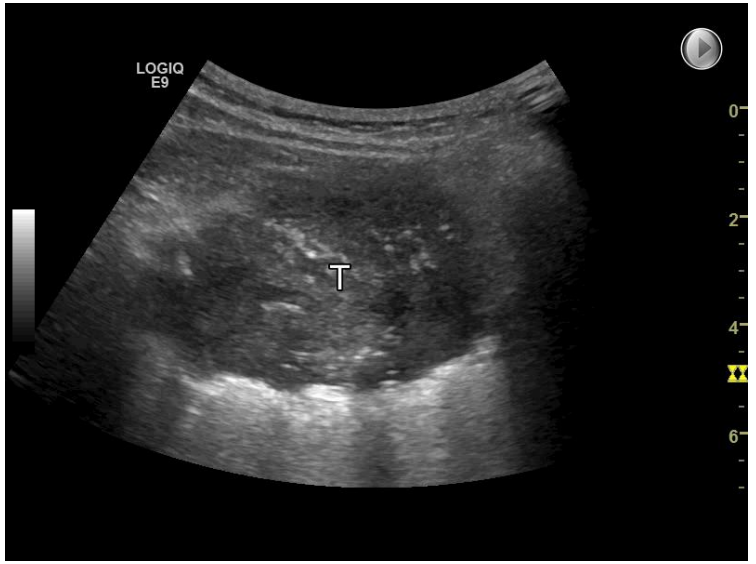



# Summary

- **Respiratory disease**




- **Technique and protocols:** BLUE protocol (Upper/lower points, PLAPS point)

- Thank you for your attention ☺