Point of Care Ultrasound for the Inpatient Provider

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I have no financial disclosures.

Objectives

1. Describe a framework for use of Point-of-Care lung ultrasound for the inpatient provider.

2. Consider the data for use of lung ultrasound in differentiating clinical syndromes.

3. Consider challenges in integrating POCUS into your clinical care.

Diagnostic Point-of-Care Ultrasound

Dichotamous

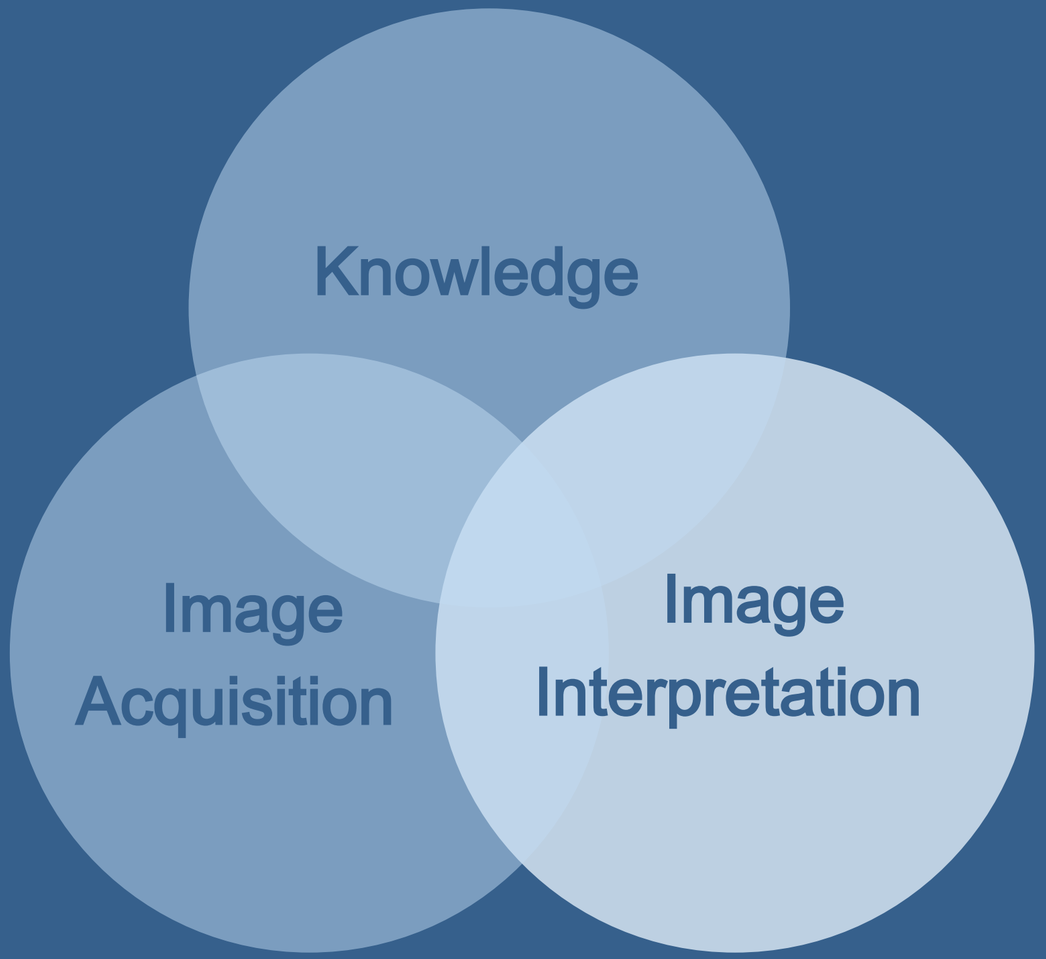
Use of Point-of-Care Ultrasound to answer a yes/no question.

- Does this patient have ascites?
- Does this patient have an abscess?
- Does this patient have hydronephrosis?

Trend

Use of Point-of-Care Ultrasound to follow the impact of a treatment decision:

- Does the density of lung B-lines decrease with diuresis?
- Does this patient's lung consolidation improve with bronchopulmonary hygene?

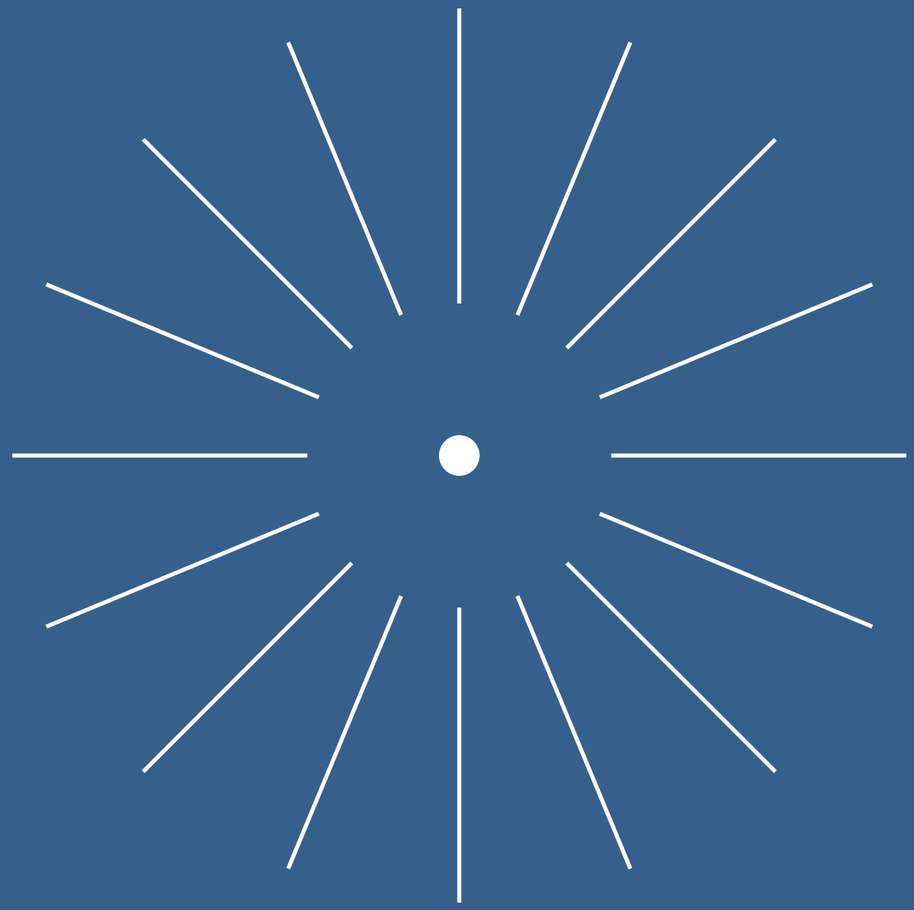


Point-of-Care Ultrasound

Soni, et al. Certification of Point -of-Care Ultrasound Competency. JHM. Vol12; 9. Sept 2017.

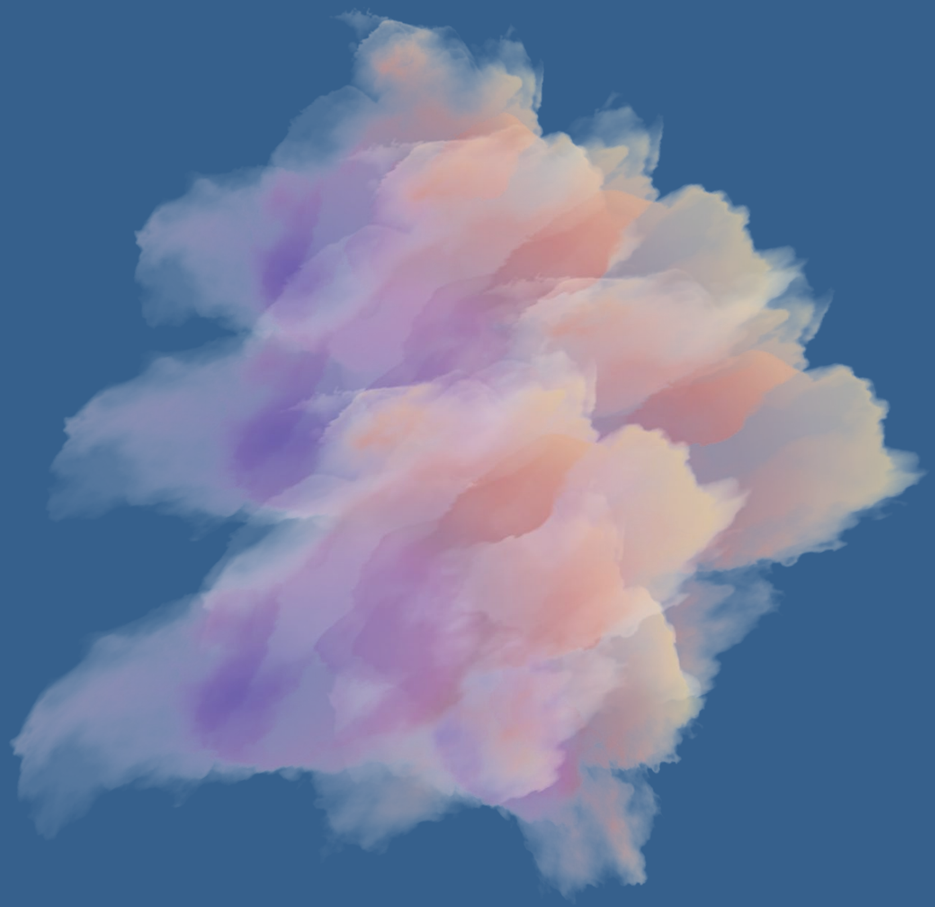
POCUS- First Approach

- Reduce time to treatment
- Improve patient safety
- Reduce cost
- Reduce radiation exposure



Case: Dyspnea

Dyspnea



76 y/o presenting with 3 days of worsening dyspnea on exertion.

- GOLD Stage III COPD
- HFrEF with EF 25%
- CKD 3b

He reports known sick contacts, reduction in urine out put to his typical diuretic, and increased cough with sputum.

Admitted for care for COPD vs. HFpEF exacerbation.

Dyspnea

HR 101, T 37.2, RR 24, O2 sat 86% on AA, 92% on 4L. BMI 33
General: Mild increased work of breathing
CV: Tachycardic, distant sounds. No m/r/g. JVP not visible due to anatomy. 1+ pitting edema to mid shins.
Chest: Enlarged thoracic volume. Mild increase in intercostal muscle use. Decreased air movement throughout. Scant wheezing on end expiration.

Labs:
BMP: Sodium 132, Bicarb 28, Creatinine 2.8 (baseline).
CBC: WBC 11
BNP: 102 pg/mL (upper limit of normal)

CXR: Diffuse streaky opacities, greater at the R base. Consider atelectasis, aspiration or pneumonia. Correlate clinically.

Lung Ultrasound

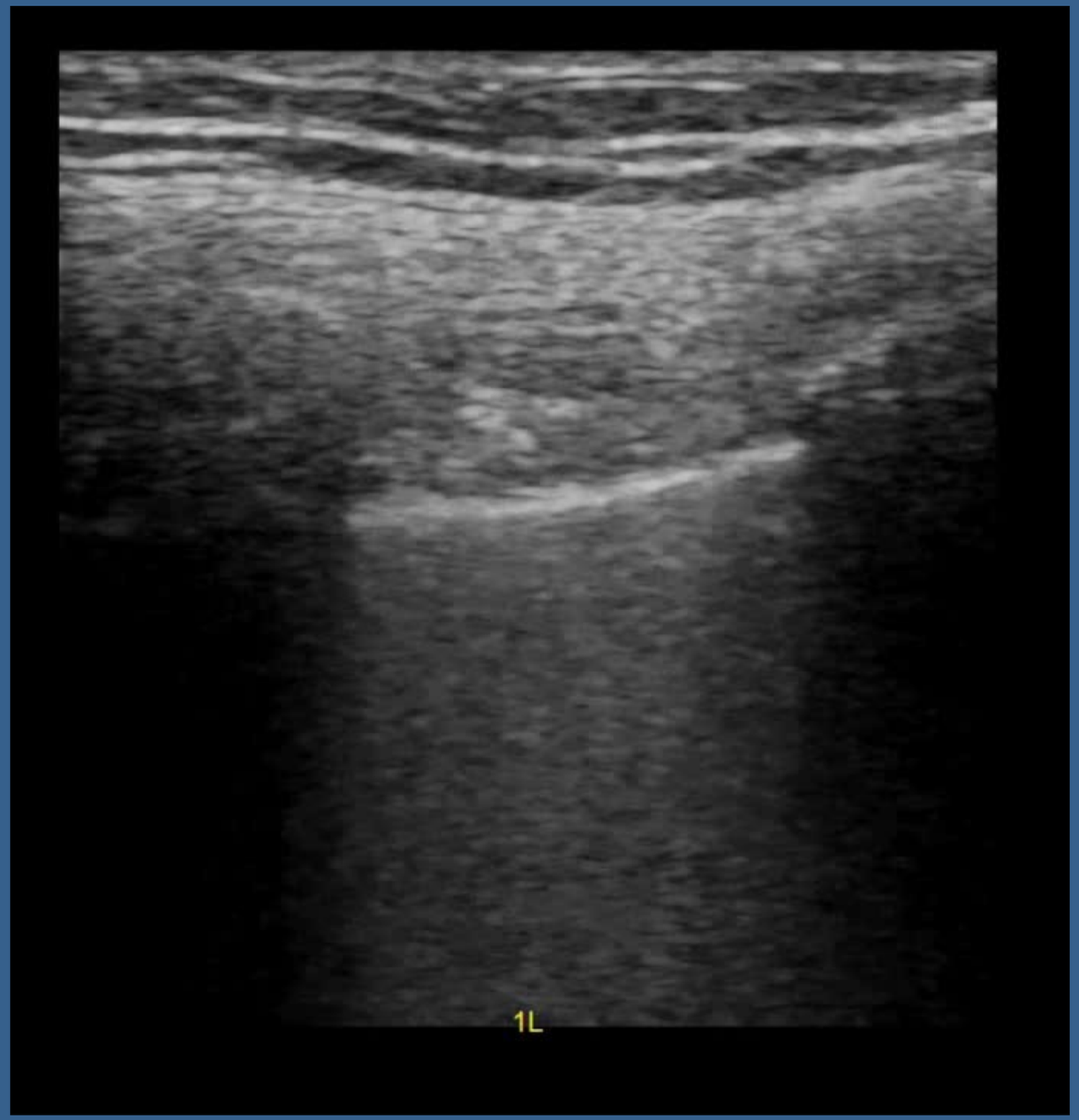
1. Evaluate the Pleura
2. Evaluate the Interstitial Pattern
3. Evaluate the Supradiaphragmatic Space

1

Evaluate the Pleura

In the normal state :

- Visceral and parietal pleura are apposed
- Freely move during respiratory cycle

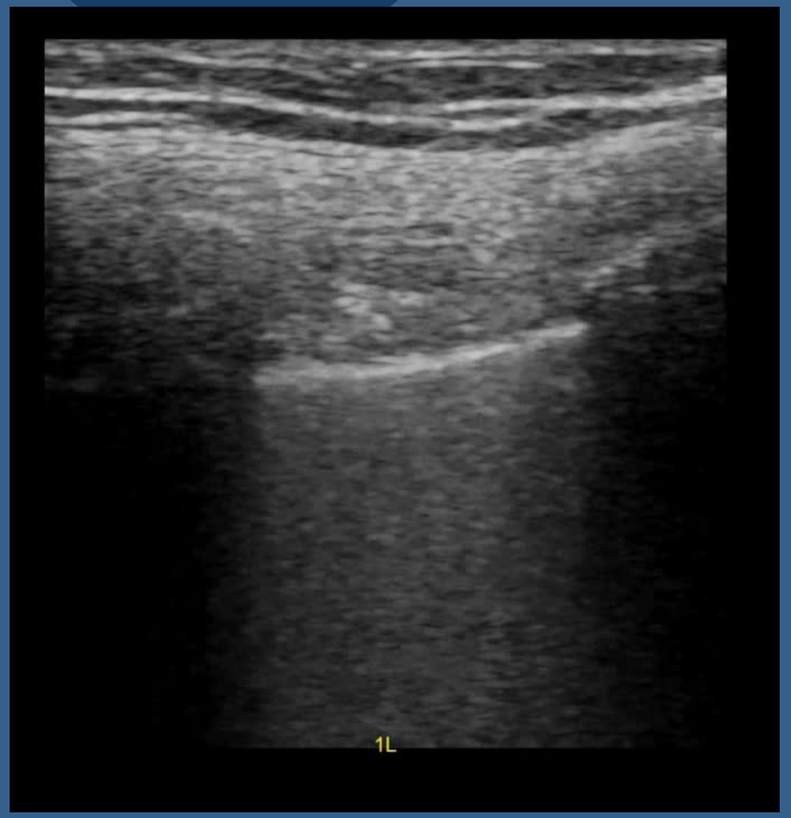


1

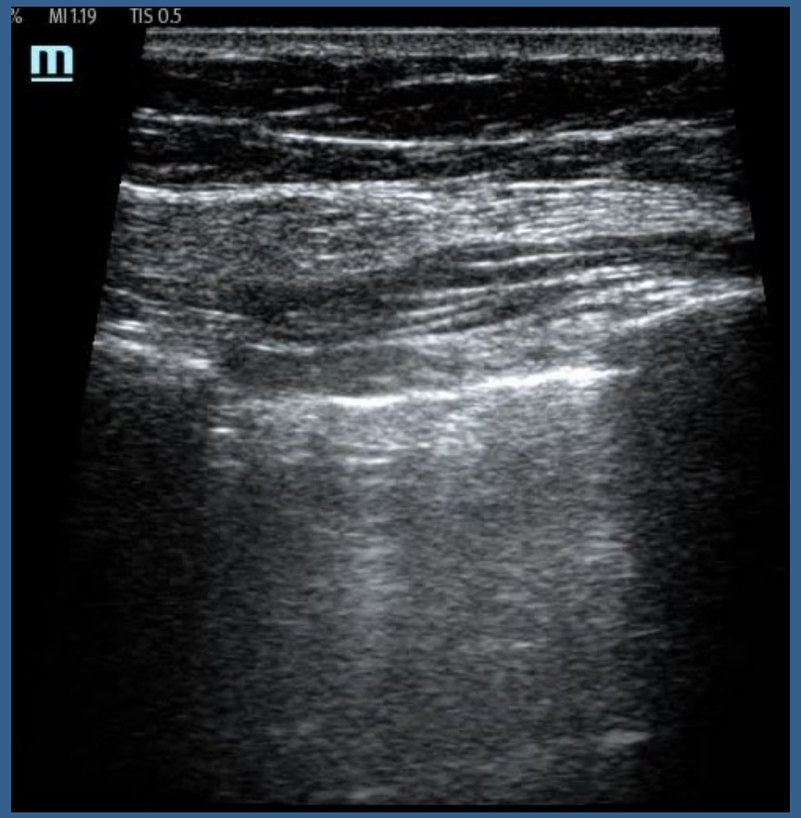
Evaluate the Pleura

- Ultrasound is positioned between two ribs to evaluate the rib space.
- Pleural line is identified just deep to ribs
- Assessment for movement about the pleural line.

1 Evaluate the Pleura



Normal Lung Sliding



Absent Lung Sliding

Lung Pulse

1 Evaluate the Pleura

Normal Lung Sliding: Parietal layers are apposed and freely moving.

Absent Lung Sliding:

- Parietal layers are not opposed: Pneumothorax, pleural effusion
- Parietal layers are not freely moving:
  - Pneumothorax
  - Pleurodesis (surgical, chemical or inflammatory)
  - Hyperinflation
  - Airway obstruction (mainstem intubation)

1 Evaluate the Pleura

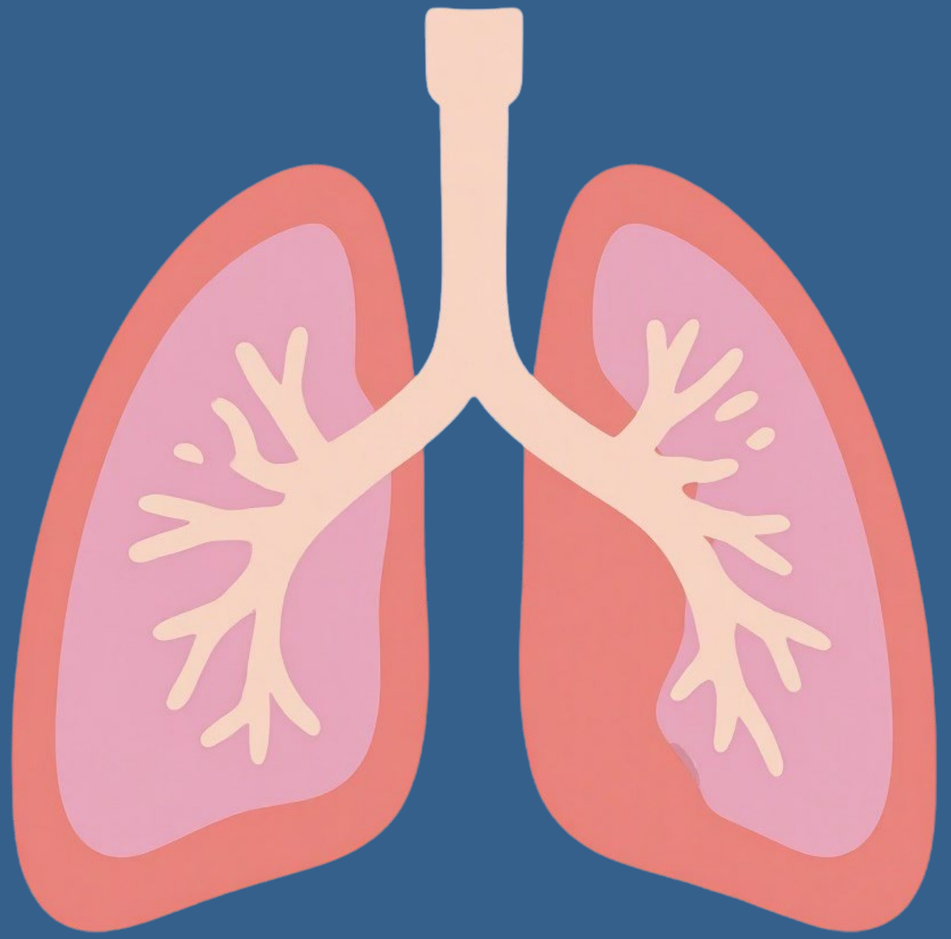
Evaluate for lung sliding in the most gravity independent positions:

- Above and below the clavicle when fully upright
- Just below the clavicle when semi recumbent
- Below the clavicle and an additional 1-2 rib spaces caudad when fully supine

2 Evaluate the Interstitial Profile

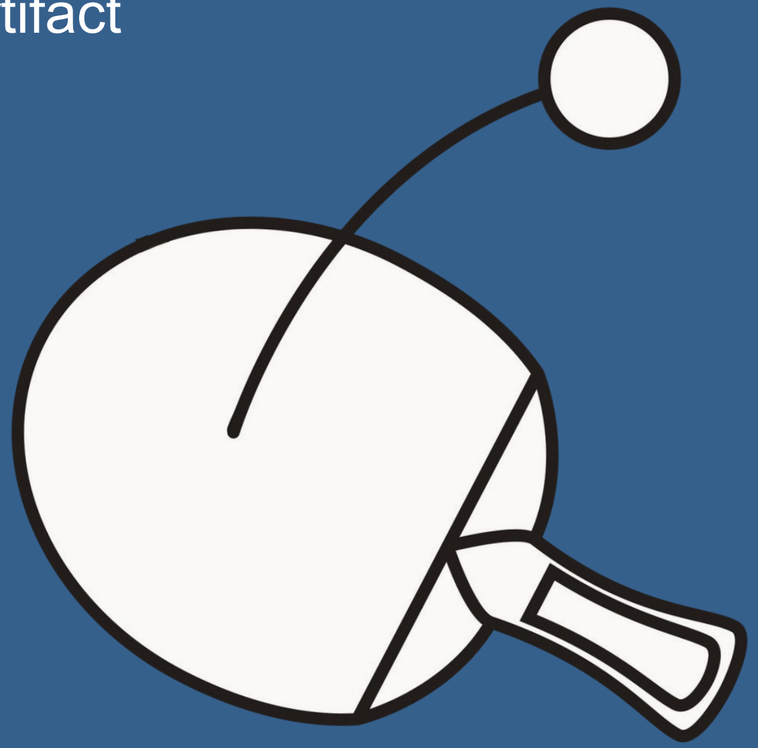
Lung density at the outermost layer of the ultrasounded lung determines the dominant artifact:

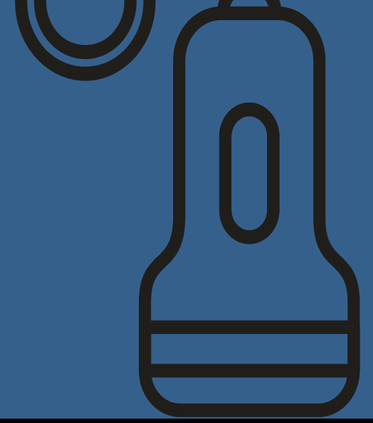
- A Lines: Normal Reverberation Artifact
- B Lines: Partially Increased Density
- Consolidation : Minimal Air Density

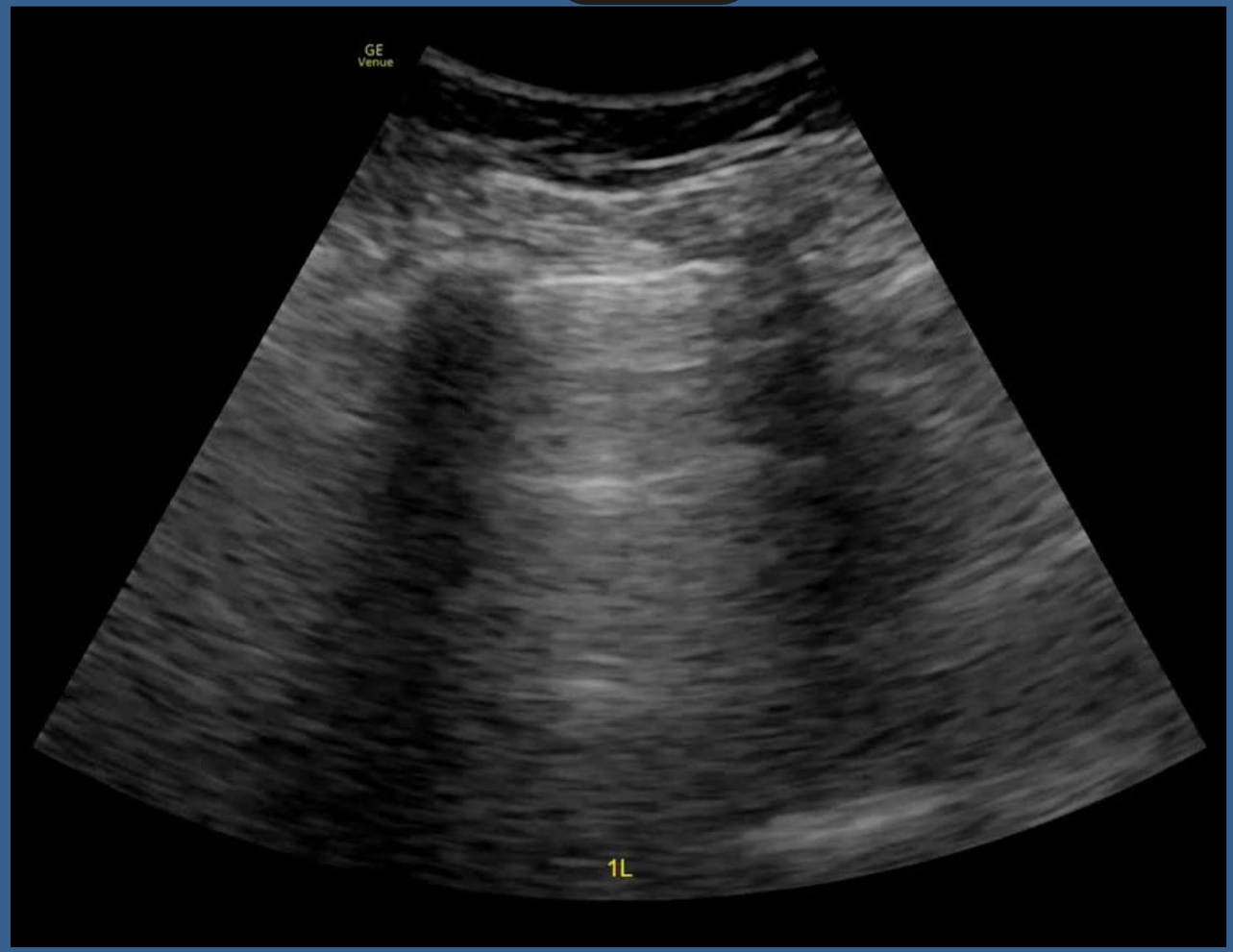


2 Evaluate the Interstitial Profile

- A Lines: Normal Reverberation Artifact

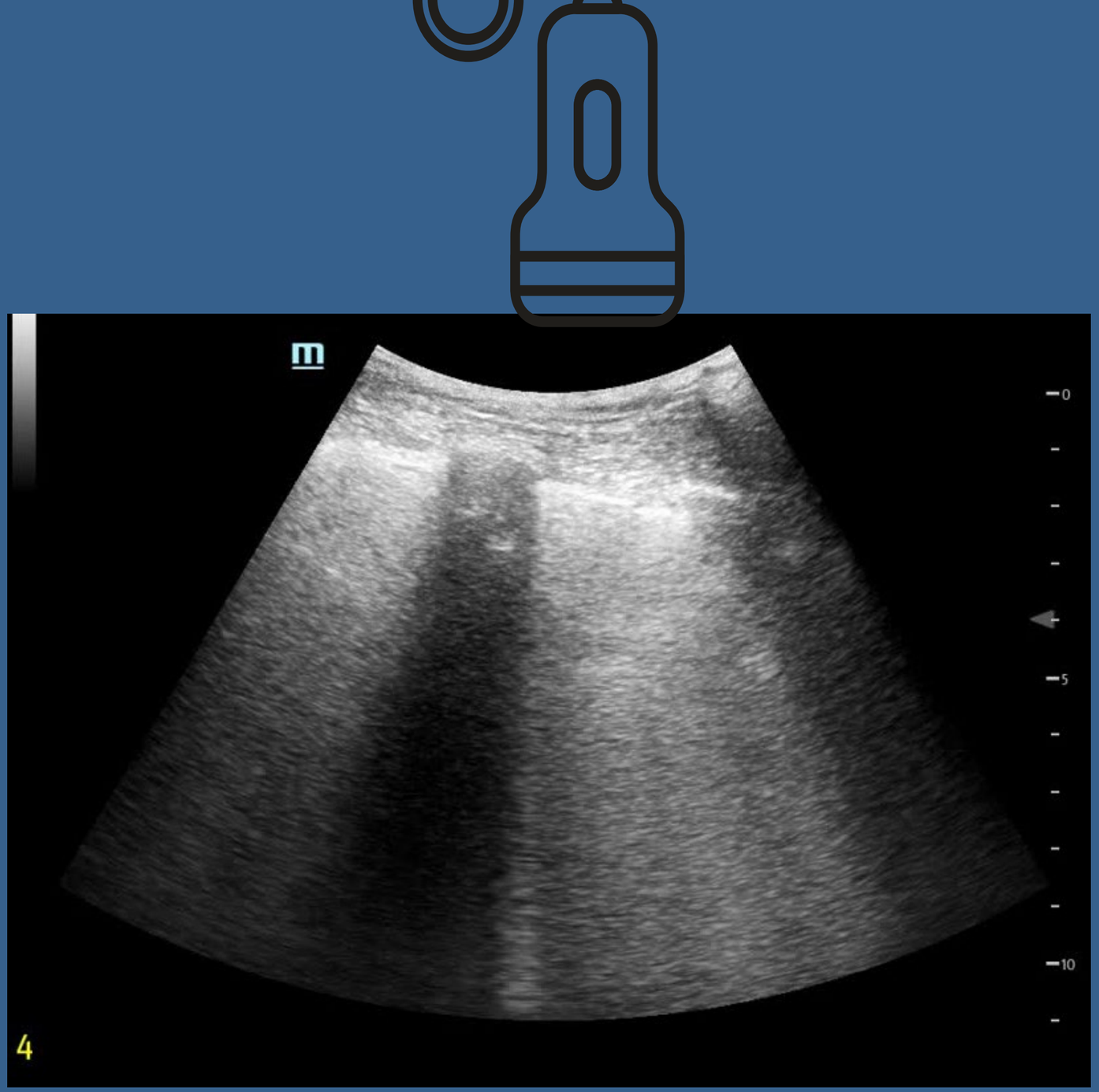






2 Evaluate the Interstitium

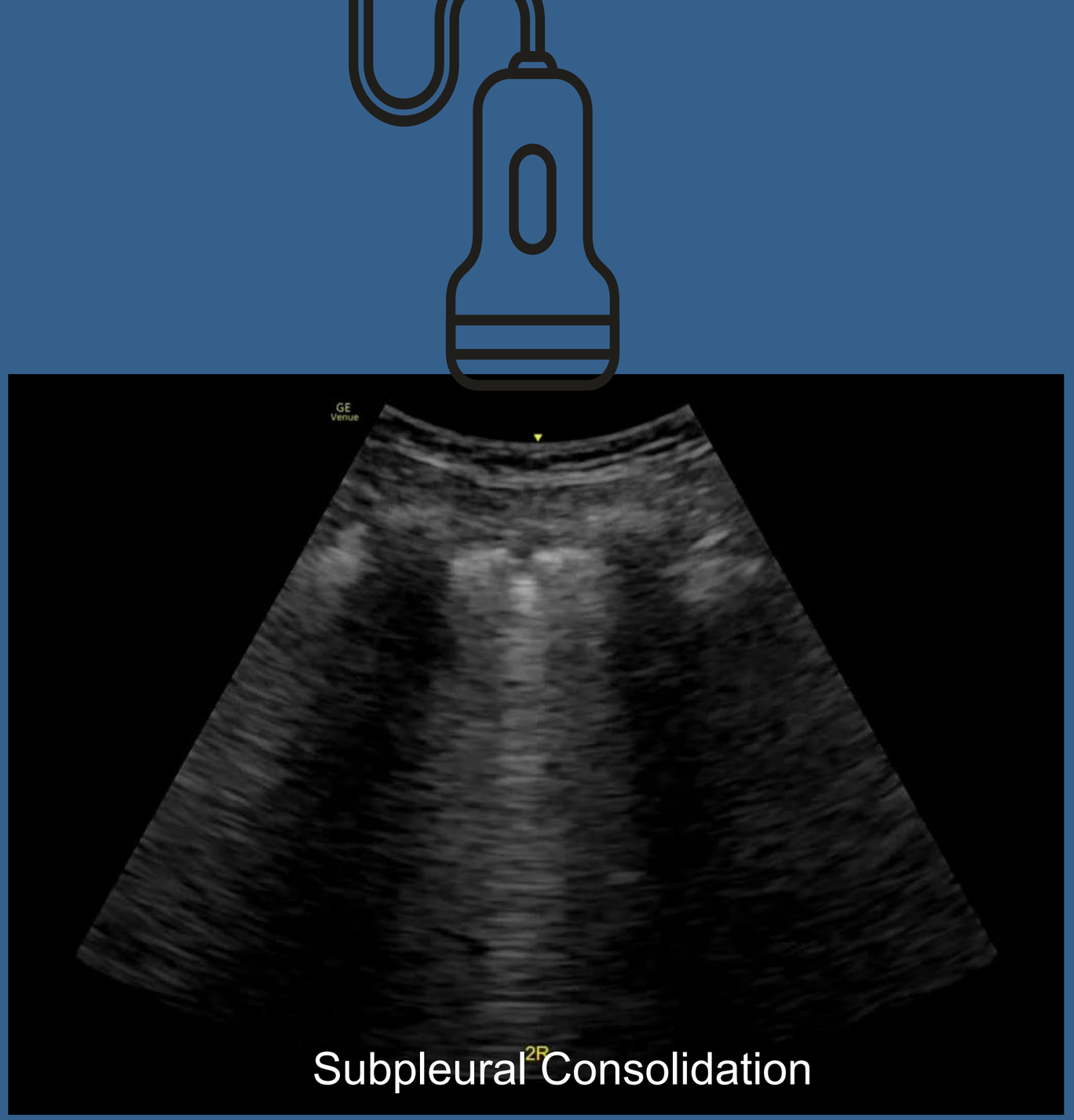
- **B-Lines:** Ring-down artifact indicating increased lung density (subnormal aeration)
- **B-Pattern:** 3 or more B-Lines in an intercostal space
  - Hydrostatic Edema
  - Alveolar filling processes
  - Atelectasis
  - ARDS
  - Inflammatory lung disease



2 Evaluate the Interstitial Profile

Consolidation: C - Pattern

- Density is further increased so that ultrasound penetrates through lung tissue and return to the transducer

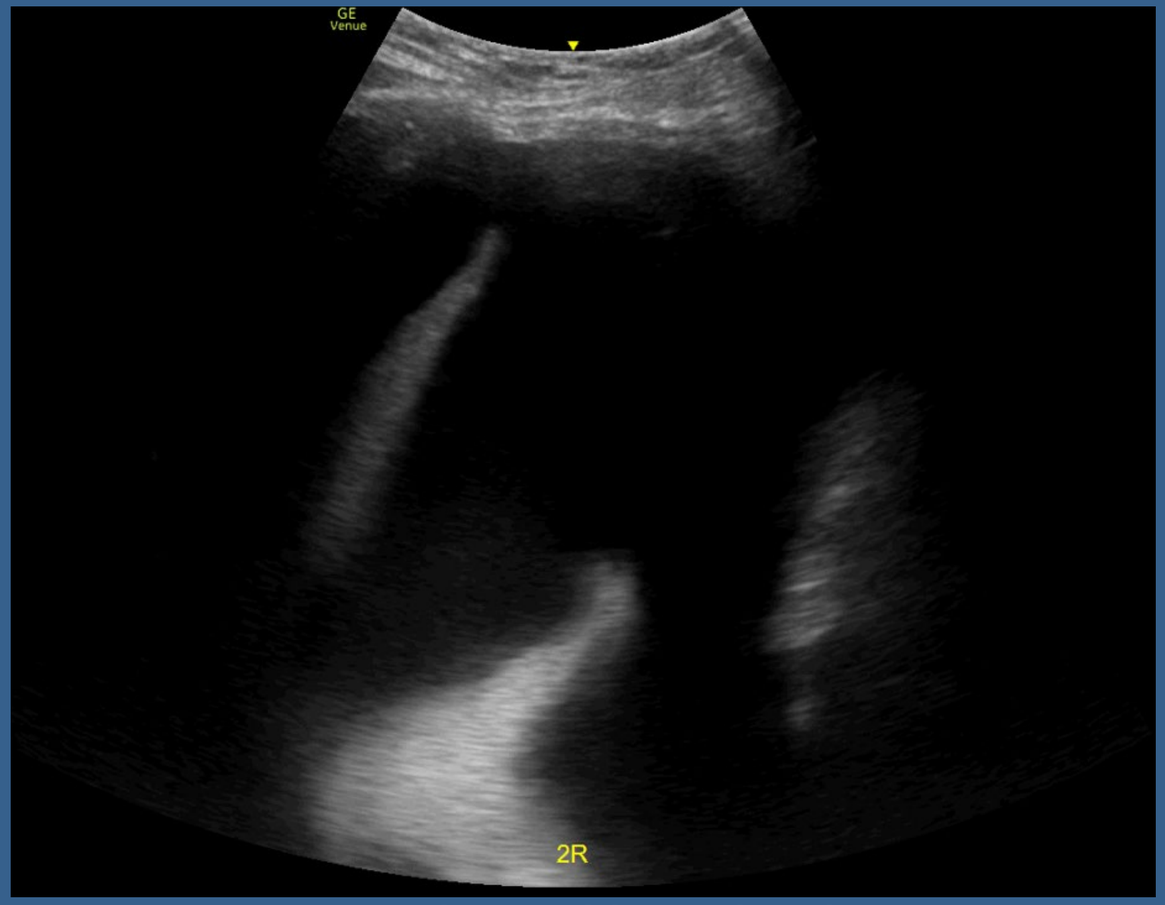


Subpleural Consolidation

2 Evaluate the Interstitial Profile

Consolidation: C - Pattern

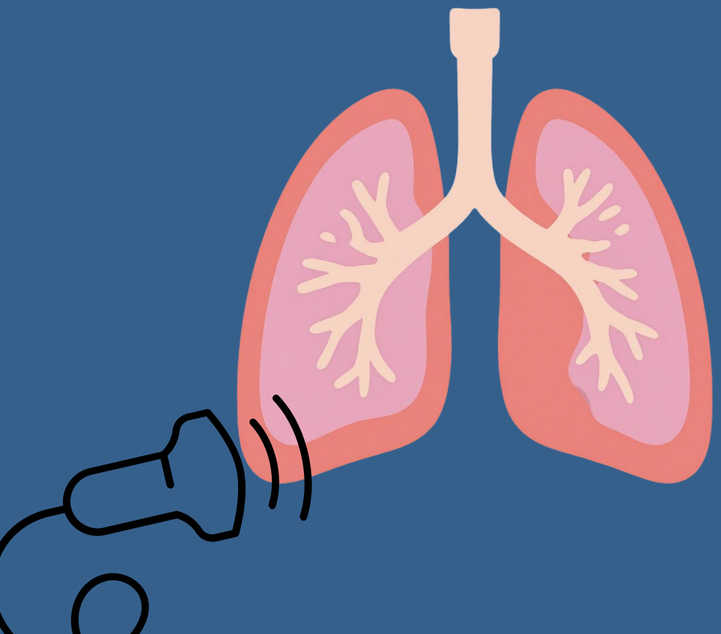
- Density is further increased so that ultrasound is able to penetrate through lung tissue and return to the transducer

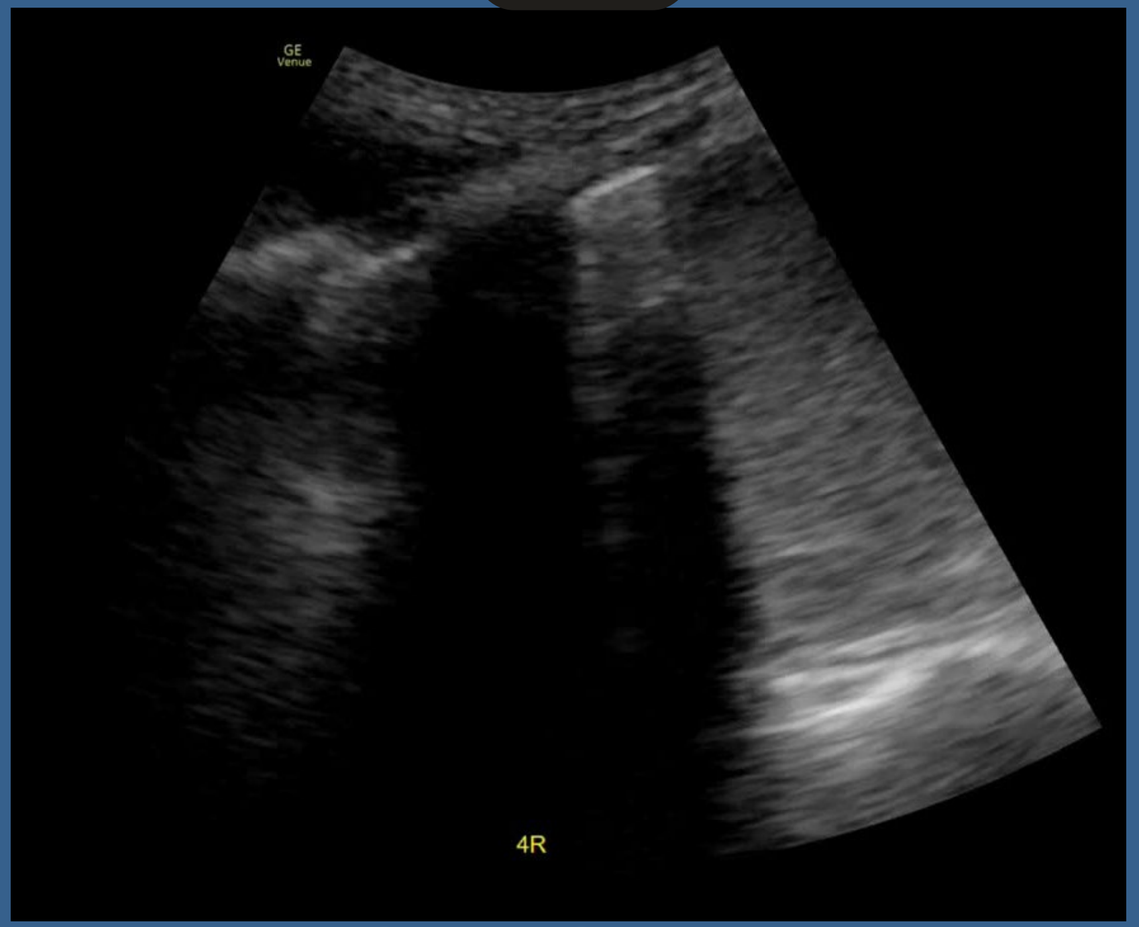


Lung Hepatization

3 Evaluate the Supradiaphragmatic Space

Most gravity - dependent area on upright or semi - upright patient.

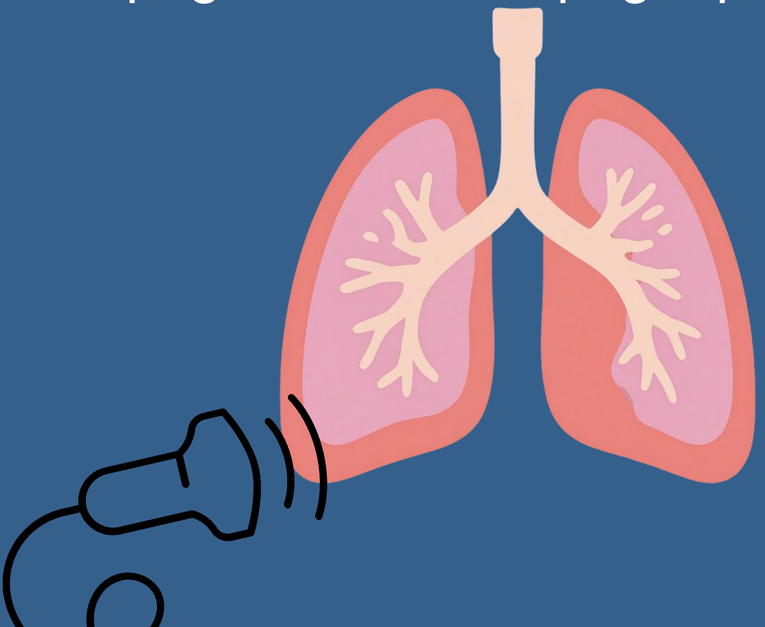


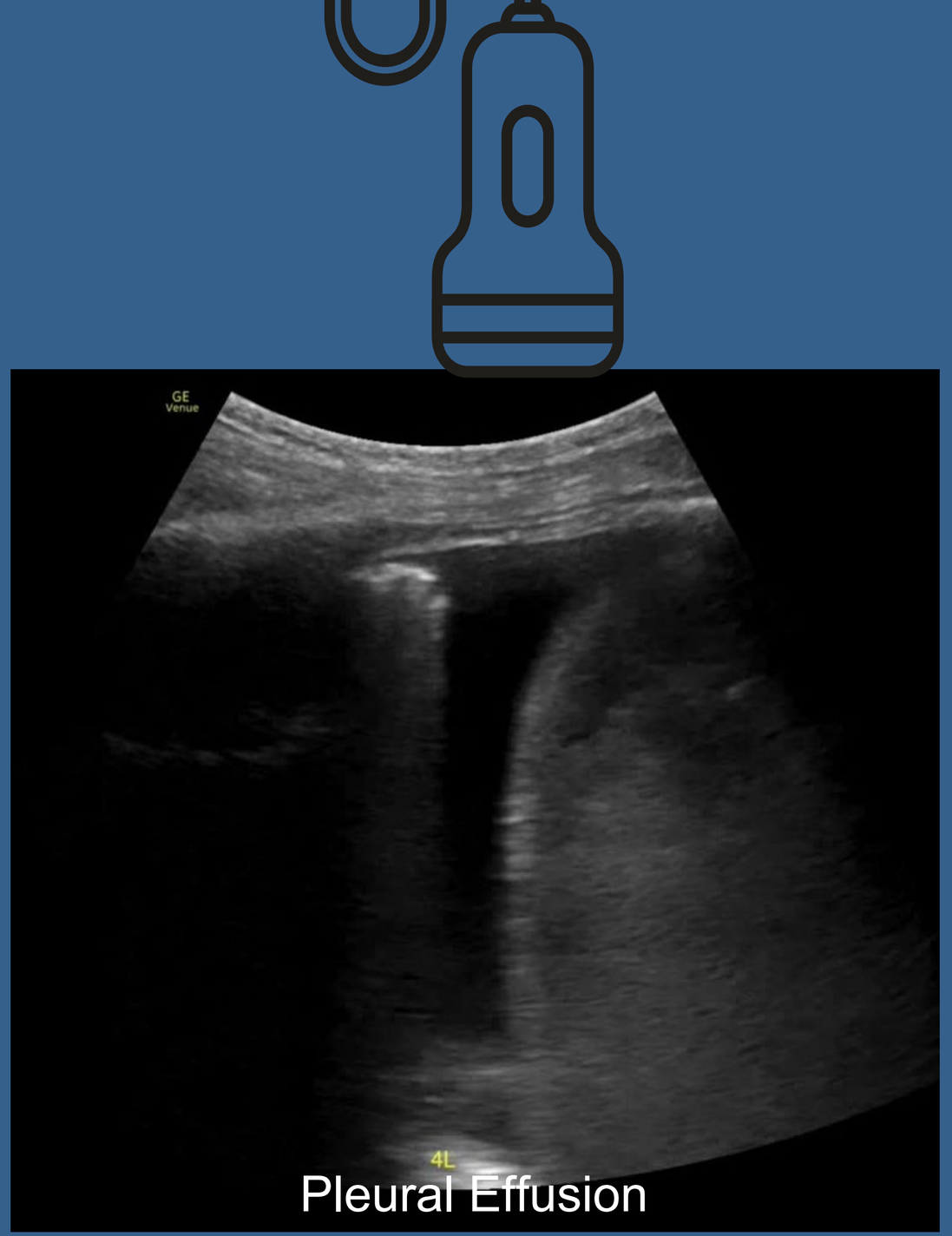


Curtain Sign

3 Evaluate the Supradiaphragmatic Space

Most gravity - dependent area on upright or semi - upright patient.





Pleural Effusion

Scanning Protocols

Many Published Lung Ultrasound Scanning Protocols

Variable in the number of locations evaluated by ultrasound and the order in which the exam is completed.

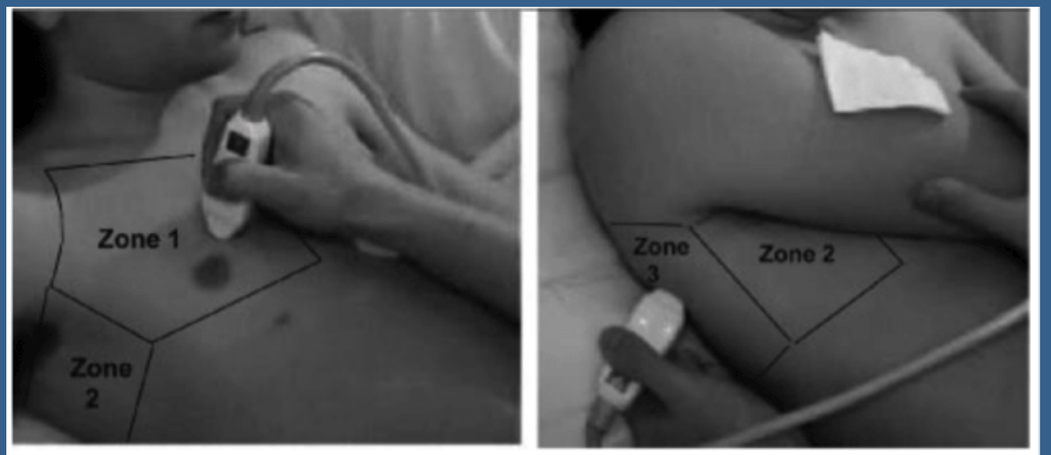


FIGURE 1. Ultrasound areas. Stage 1 defines the investigation of the anterior chest wall (zone 1) in a supine patient (1′ in this semirecumbent patient). Stage 2 adds the lateral wall (zone 2) [left panel]. Stage 3 adds the posterolateral chest wall using a short probe, moving the patient only minimally (zone 3) [right panel]. Each wall is divided into upper and lower halves, resulting in six areas of investigation. Note the shape of the microconvex probe, which allows satisfactory analysis of the intercostal space, and satisfactorily controlled compression maneuvers at the veins investigated in this study: internal jugular, subclavian, iliofemoropopliteal veins, and as far as possible, inferior vena cava and calf veins.

Lichtenstein, Mezière , Chest. 2008

Scanning Protocols

Many Published Lung Ultrasound Scanning Protocols

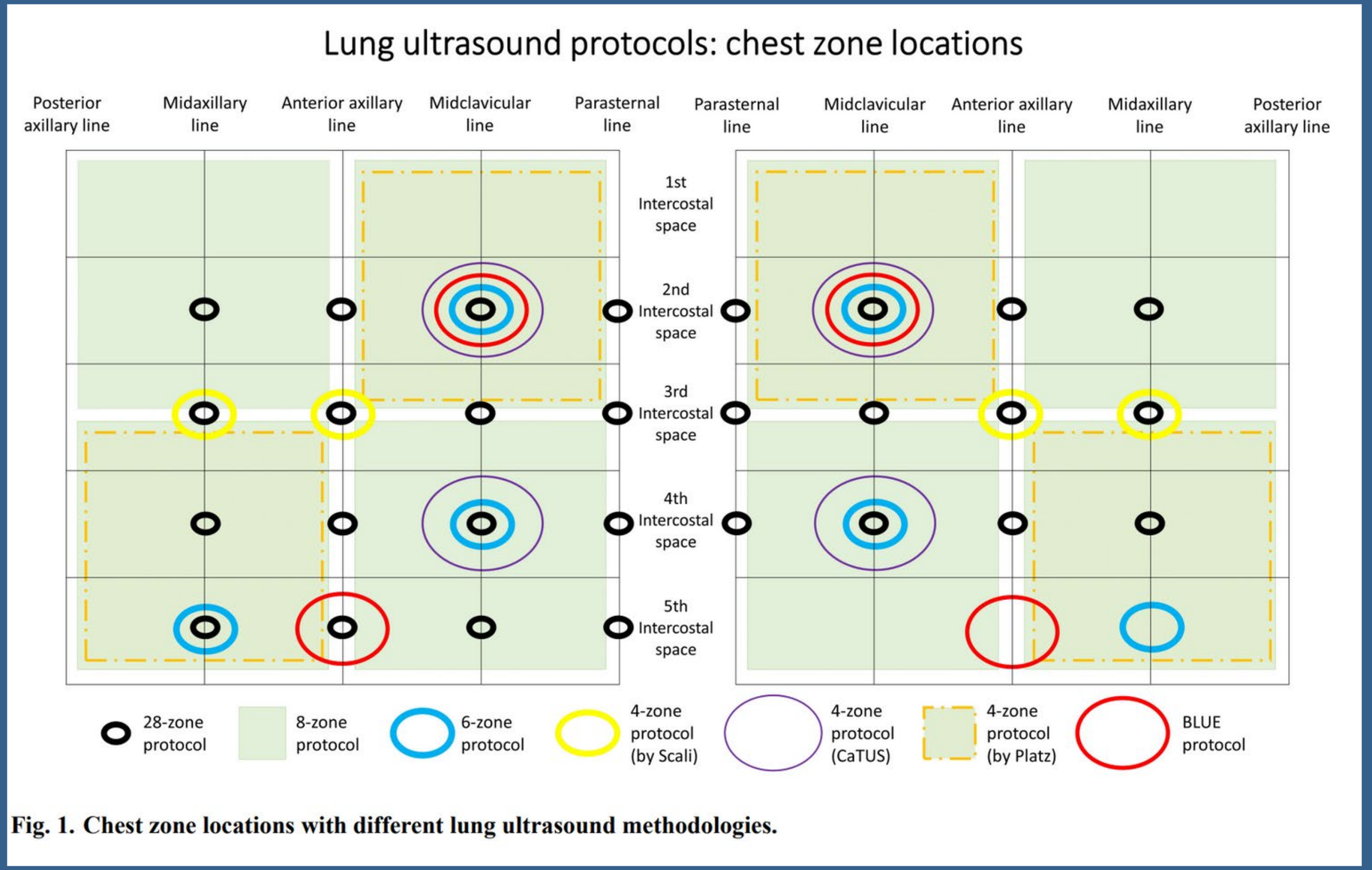


Fig. 1. Chest zone locations with different lung ultrasound methodologies.

Coirio. Rev Cardiovasc Med. 2022 May 30;23(6):198.

Putting it Together

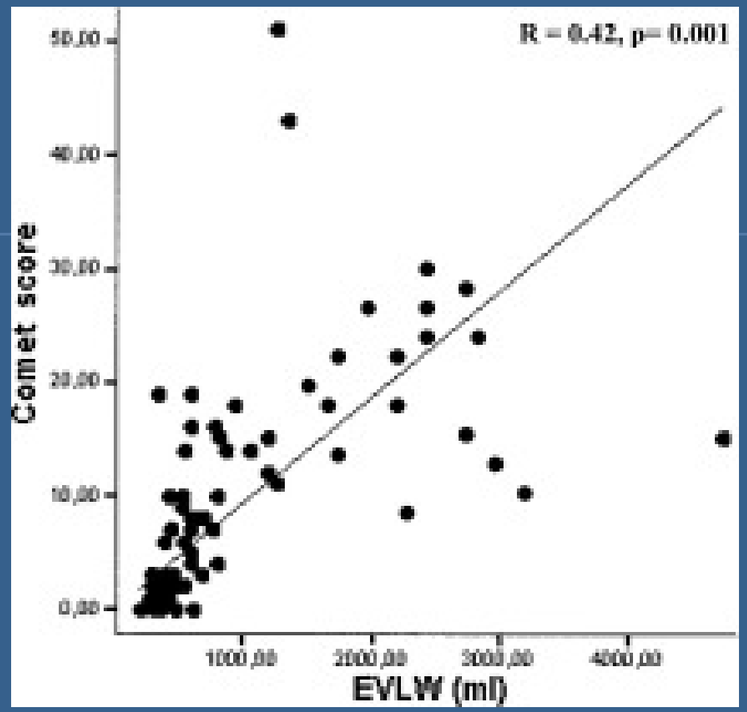
Condition	Lung Sliding	Lung Profile	Supradiaphragmatic Space
Pneumothorax	Absent	A-line pattern	No effusion
Asthma or COPD	Present	A-line pattern	No effusion
Pulmonary Edema	Present	Gravity-dependent B-line pattern	Bilateral effusions
Pneumonia	Present / Lung Pulse	Focal B-line pattern	No effusion vs. unilateral effusion
ARDS	Present / Lung Pulse	Heterogenous A and B-line pattern	No effusion

Evidence for Lung Ultrasound

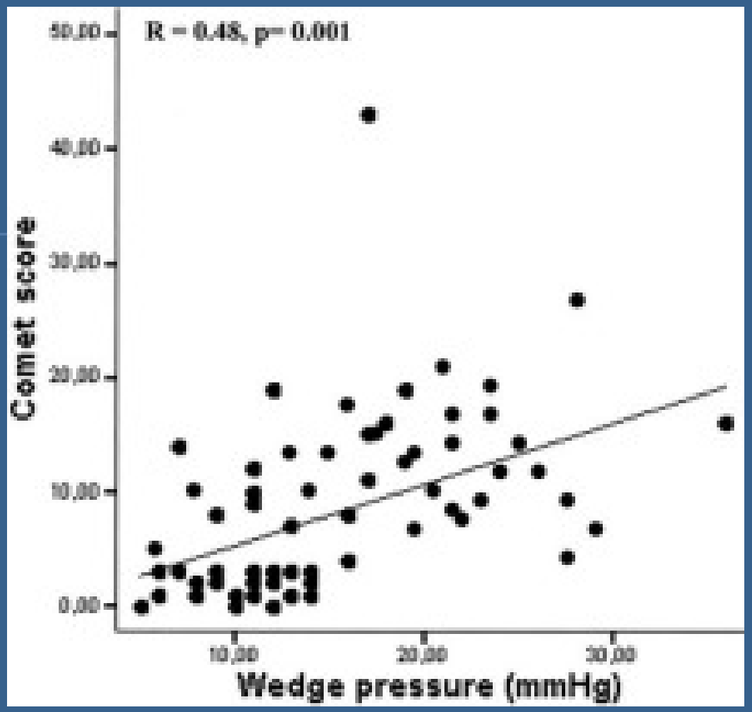
Acute Decompensated Heart Failure

Evidence for Lung Ultrasound

Absolute number of B-lines correlates with:



Extravascular Lung Water

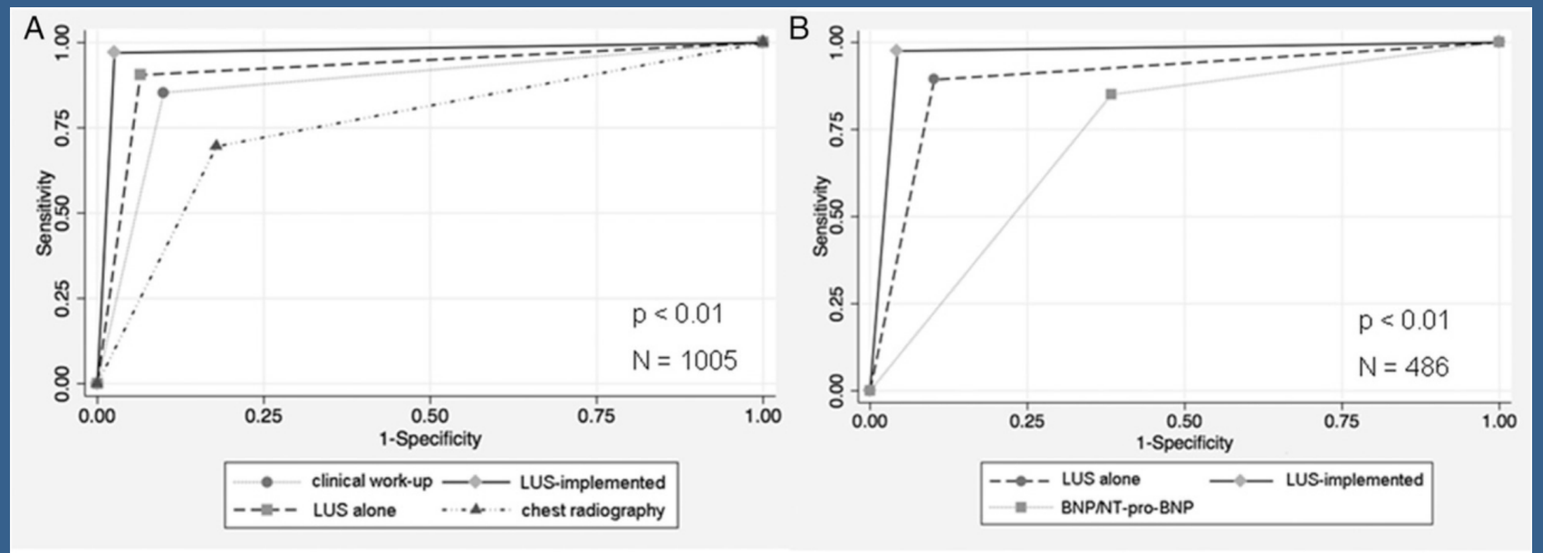


Wedge Pressure

Agricola et al. Chest. May 2005.

Evidence for Lung Ultrasound

Lung ultrasound improves diagnostic accuracy in differentiating patients with acute decompensated heart failure vs. noncardiac dyspnea



	Area under curve (AUC)	
Clinical work-up	0.876	p < 0.01
LUS-implemented	0.972	
LUS-alone	0.920	p < 0.01
Chest radiography	0.758	

	Area under curve (AUC)	
LUS-implemented	0.966	
LUS-alone	0.895	p < 0.01
BNP/NT-pro-BNP	0.733	

Figure 3. A, Receiver operating characteristic (ROC) curve comparing accuracy of clinical workup, LUS -implemented diagnosis, LUS alone, and chest radiography. B, ROC curve comparing accuracy of clinical workup, LUS -implemented diagnosis, LUS alone, and BNP/NT -pro -BNP levels.

Pivetta , et al. Chest. July 2015.

Evidence for Lung Ultrasound

Persistence of B -Lines at discharge predicts 6 -month readmission for patients treated for decompensated heart failure

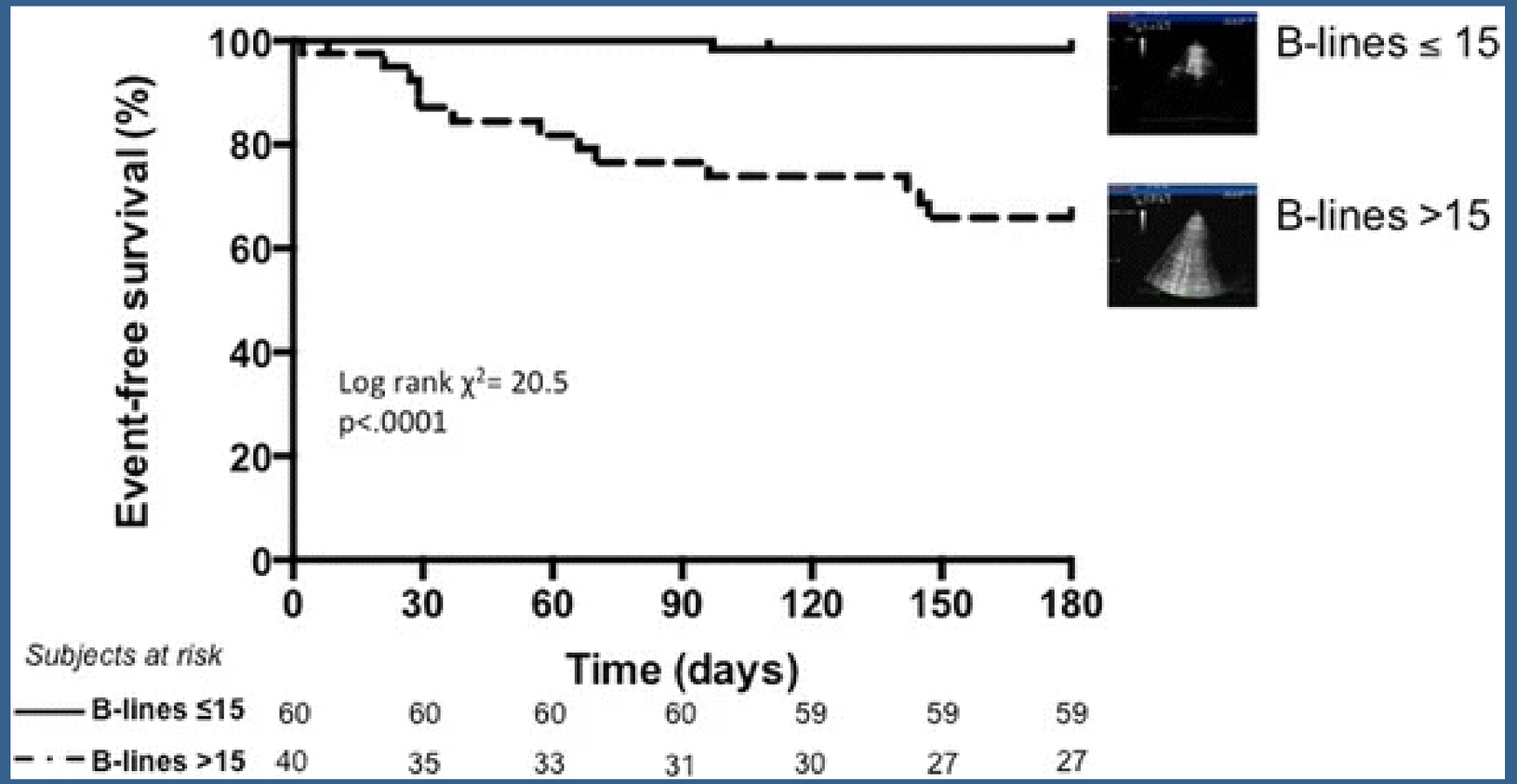
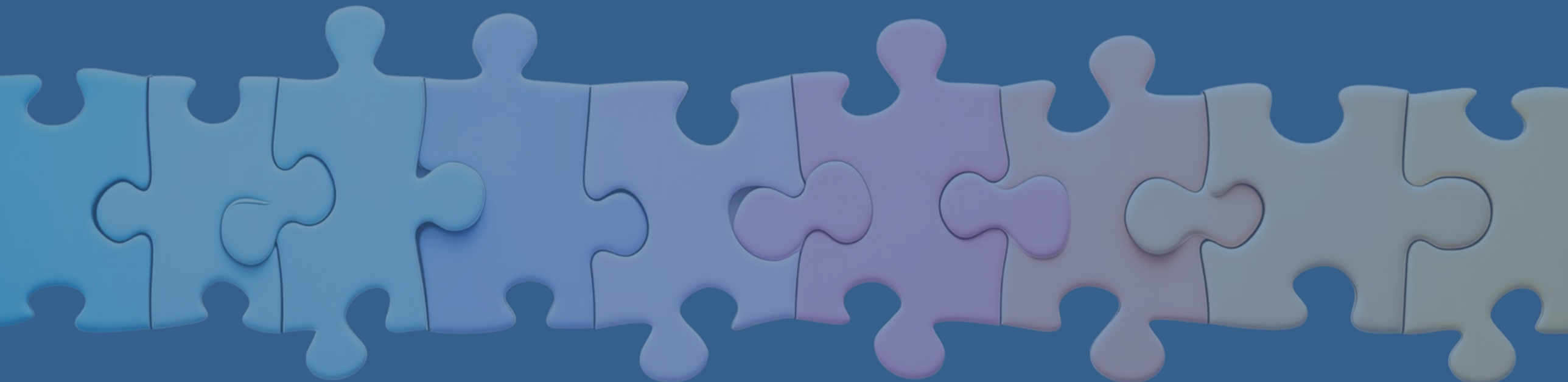


Figure 2: Kaplan -Meier survival curves in HF patients stratified according to the number of B -lines before discharge, at 6 -months follow -up

Gargani, et al. Cardiovascular Ultrasound. September, 2015.

Evidence for Lung Ultrasound

Pneumonia



Evidence for Lung Ultrasound

Lung ultrasound and Chest XR compared to CT for adult CAP

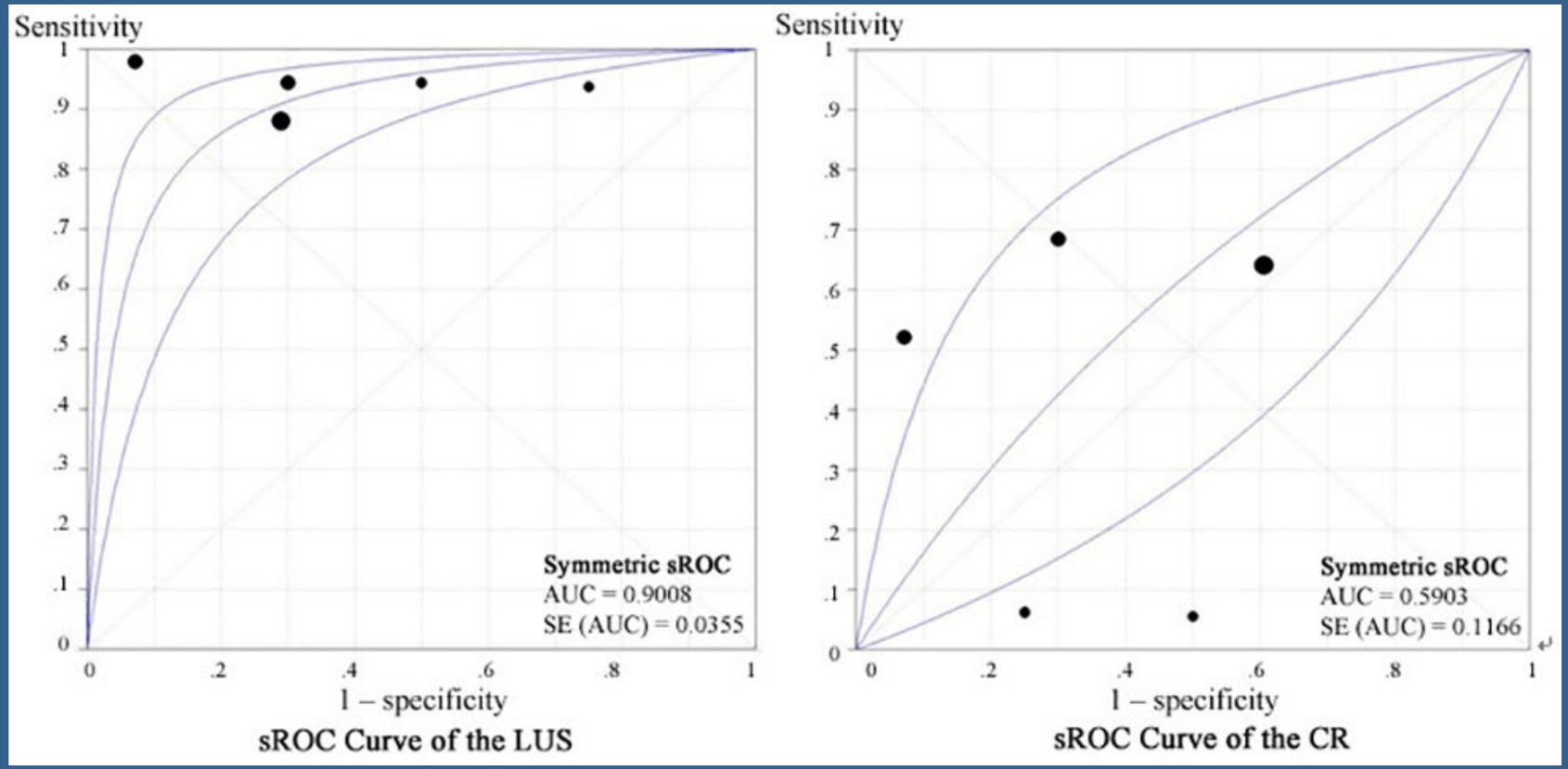
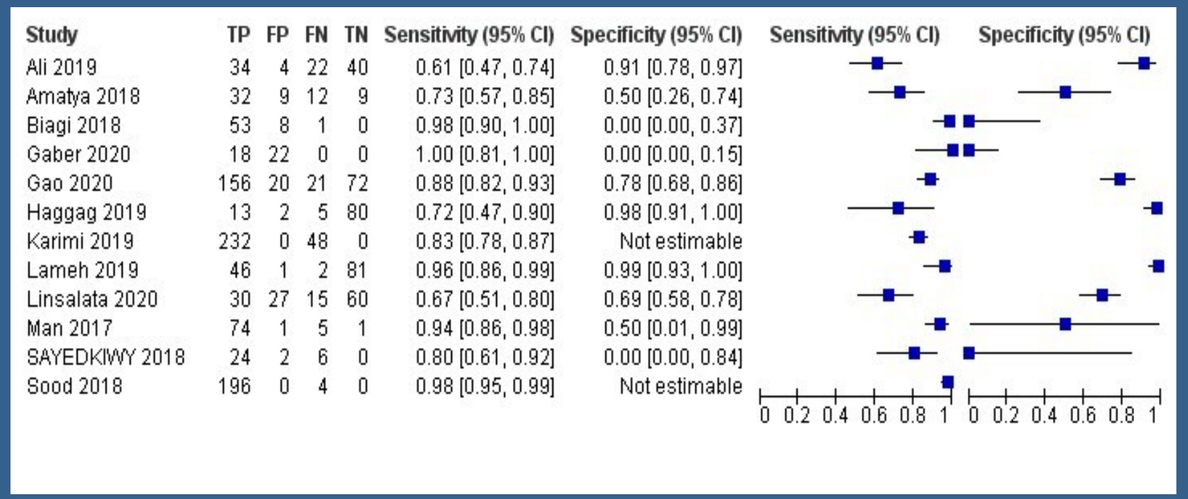


Fig 4. The summary receiver operating characteristic of lung ultrasonography and chest radiography for the detection of pneumonia compared with computed tomography scan.

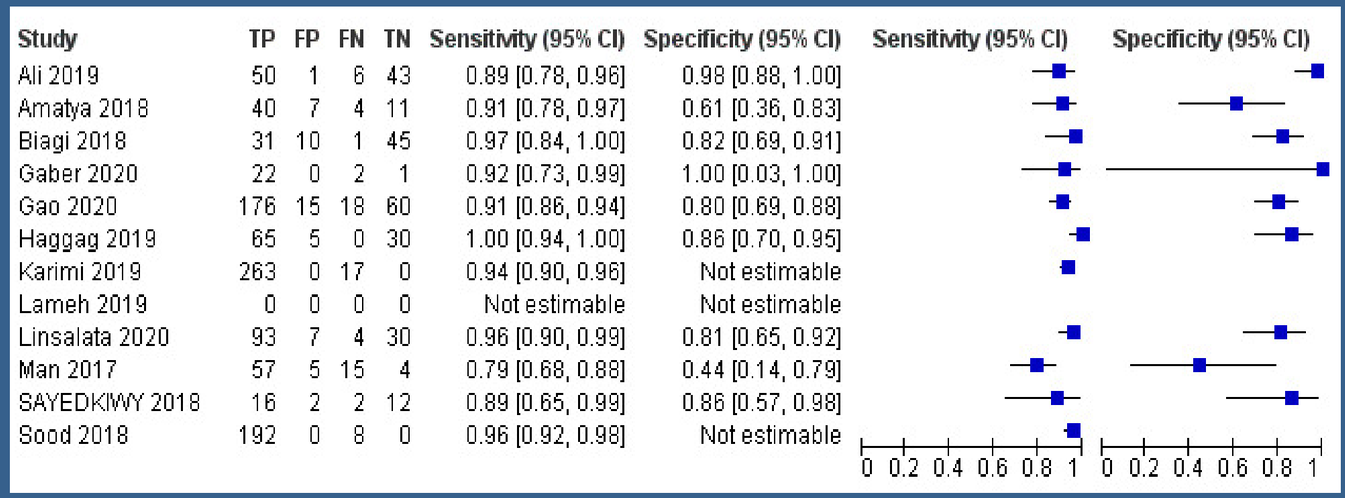
Ye, X, et al. PLOS one. June 2014.

Evidence for Lung Ultrasound



Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Ali 2019	34	4	22	40	0.61 [0.47, 0.74]	0.91 [0.78, 0.97]
Amatya 2018	32	9	12	9	0.73 [0.57, 0.85]	0.50 [0.26, 0.74]
Biagi 2018	53	8	1	0	0.98 [0.90, 1.00]	0.00 [0.00, 0.37]
Gaber 2020	18	22	0	0	1.00 [0.81, 1.00]	0.00 [0.00, 0.15]
Gao 2020	156	20	21	72	0.88 [0.82, 0.93]	0.78 [0.68, 0.86]
Haggag 2019	13	2	5	80	0.72 [0.47, 0.90]	0.98 [0.91, 1.00]
Karimi 2019	232	0	48	0	0.83 [0.78, 0.87]	Not estimable
Lameh 2019	46	1	2	81	0.96 [0.86, 0.99]	0.99 [0.93, 1.00]
Linsalata 2020	30	27	15	60	0.67 [0.51, 0.80]	0.69 [0.58, 0.78]
Man 2017	74	1	5	1	0.94 [0.86, 0.98]	0.50 [0.01, 0.99]
SAYEDKIWY 2018	24	2	6	0	0.80 [0.61, 0.92]	0.00 [0.00, 0.84]
Sood 2018	196	0	4	0	0.98 [0.95, 0.99]	Not estimable

CXR vs. CT



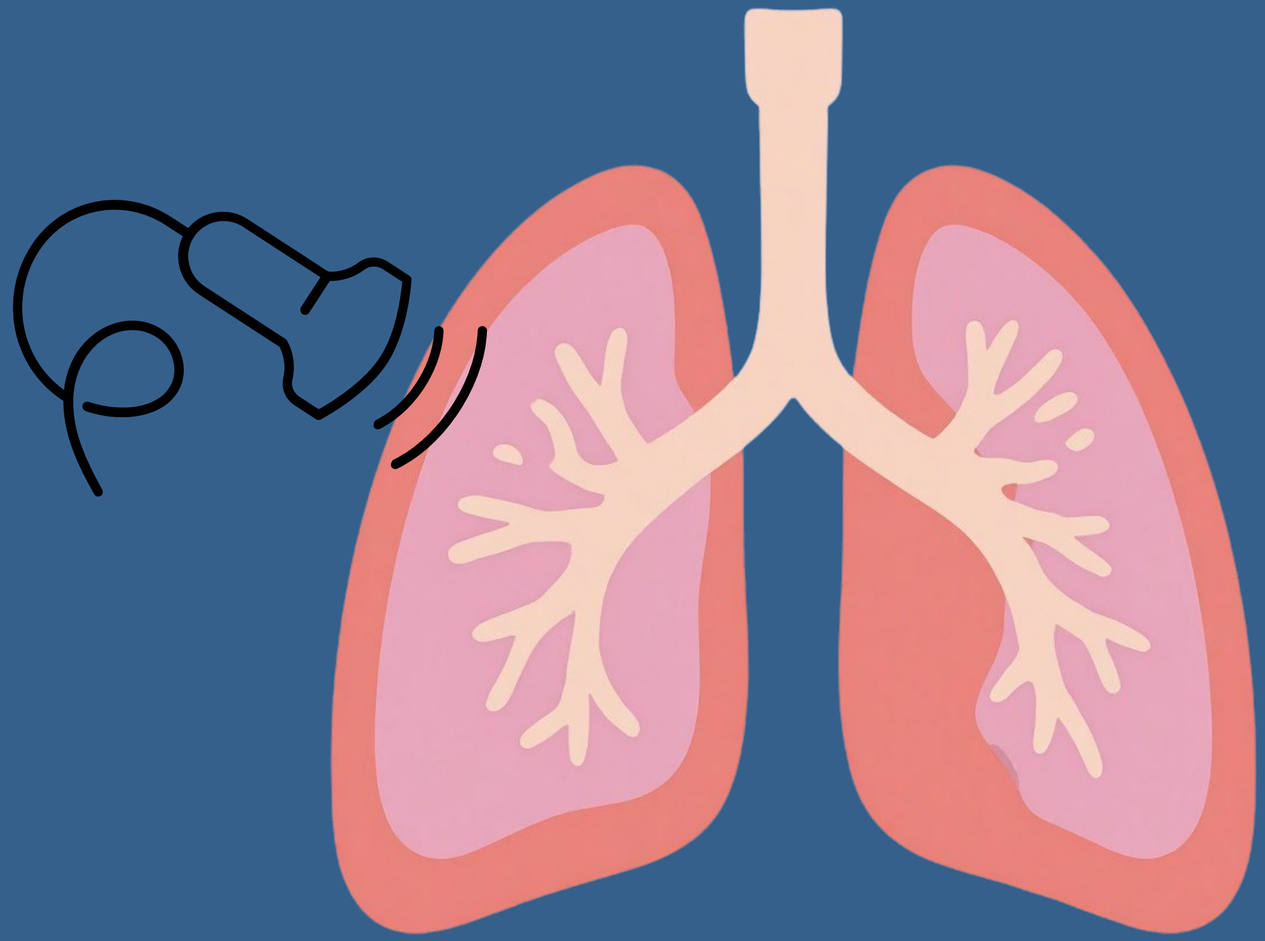
Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Ali 2019	50	1	6	43	0.89 [0.78, 0.96]	0.98 [0.88, 1.00]
Amatya 2018	40	7	4	11	0.91 [0.78, 0.97]	0.61 [0.36, 0.83]
Biagi 2018	31	10	1	45	0.97 [0.84, 1.00]	0.82 [0.69, 0.91]
Gaber 2020	22	0	2	1	0.92 [0.73, 0.99]	1.00 [0.03, 1.00]
Gao 2020	176	15	18	60	0.91 [0.86, 0.94]	0.80 [0.69, 0.88]
Haggag 2019	65	5	0	30	1.00 [0.94, 1.00]	0.86 [0.70, 0.95]
Karimi 2019	263	0	17	0	0.94 [0.90, 0.96]	Not estimable
Lameh 2019	0	0	0	0	Not estimable	Not estimable
Linsalata 2020	93	7	4	30	0.96 [0.90, 0.99]	0.81 [0.65, 0.92]
Man 2017	57	5	15	4	0.79 [0.68, 0.88]	0.44 [0.14, 0.79]
SAYEDKIWY 2018	16	2	2	12	0.89 [0.65, 0.99]	0.86 [0.57, 0.98]
Sood 2018	192	0	8	0	0.96 [0.92, 0.98]	Not estimable

Lung US vs. CT

Abid, et al. Can J Respir Therapy 2024 July.

Evidence for Lung Ultrasound

Lung ultrasound is insufficient to rule out pneumonia in cases with high pre -test probability

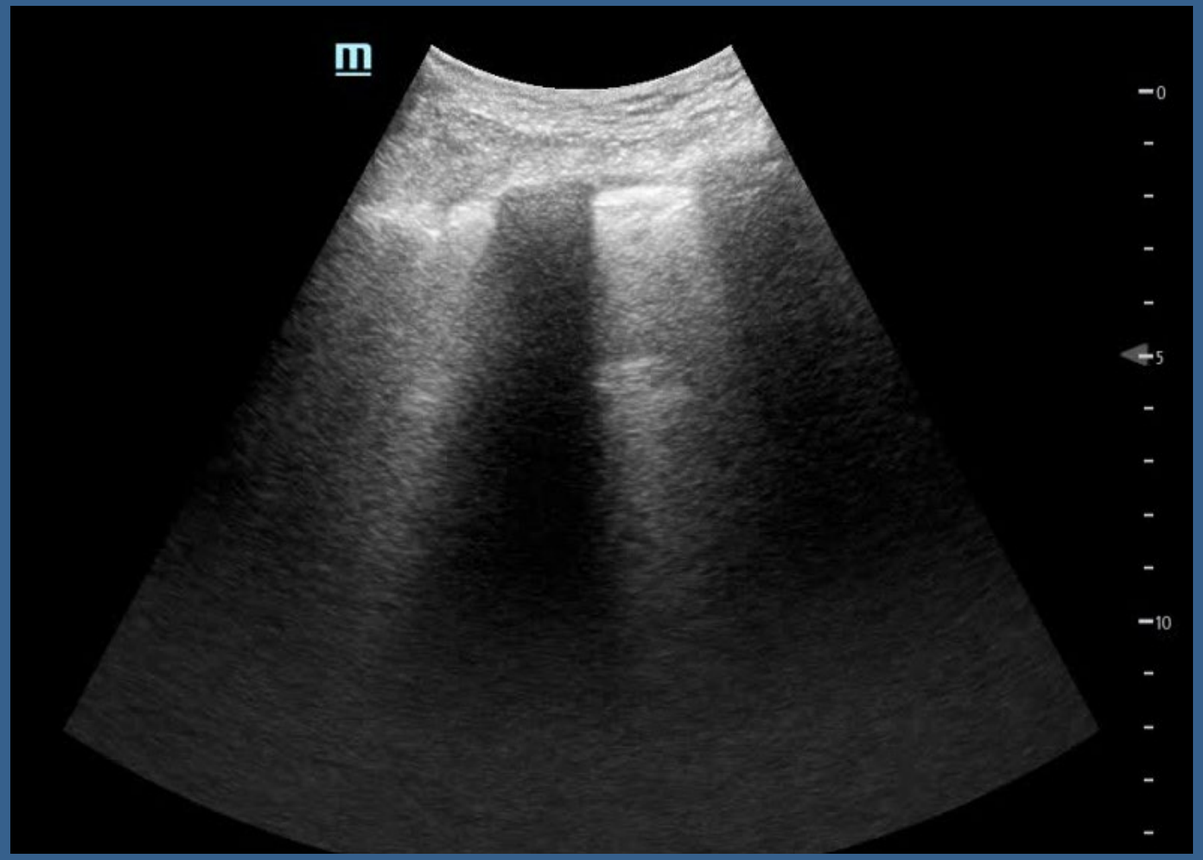


Case: Dyspnea

1

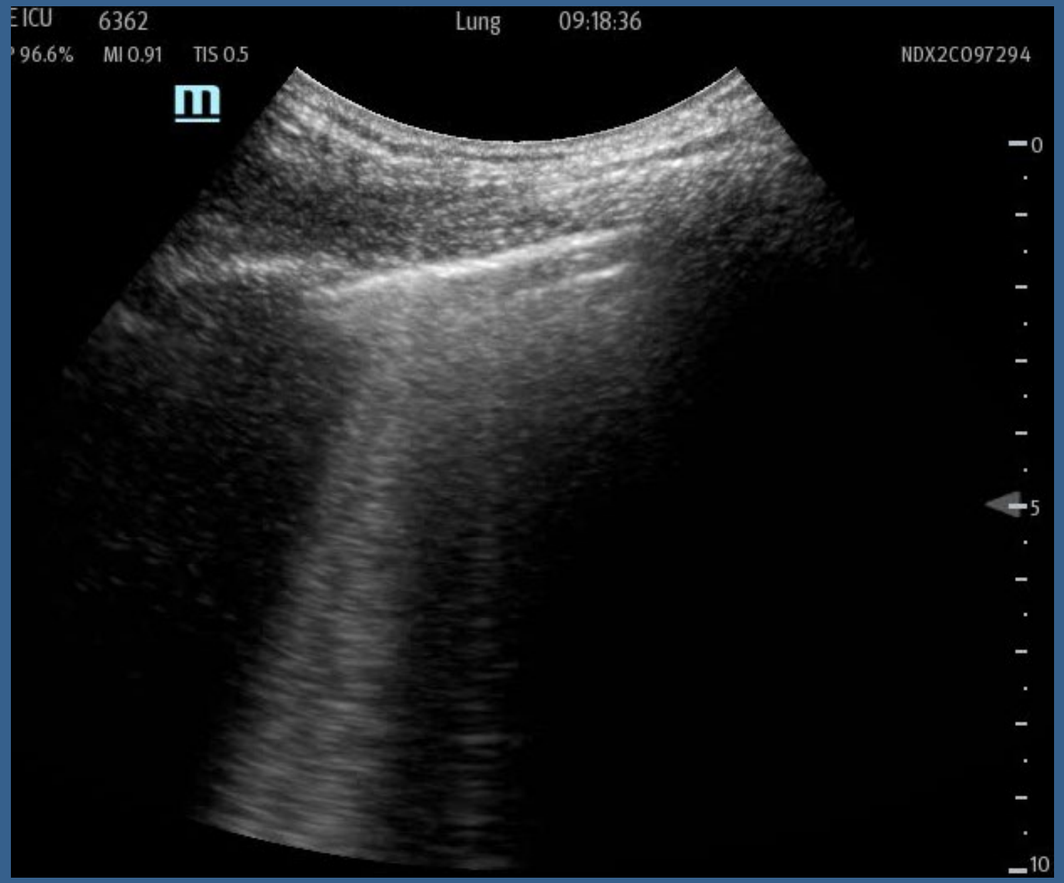
Evaluate the Pleura

2 Evaluate the Interstitial Profile



3

Evaluate the Supradiaphragmatic Space



Case

- Normal lung sliding
- A-pattern in apex
- B-pattern in bases
- Small pleural effusions

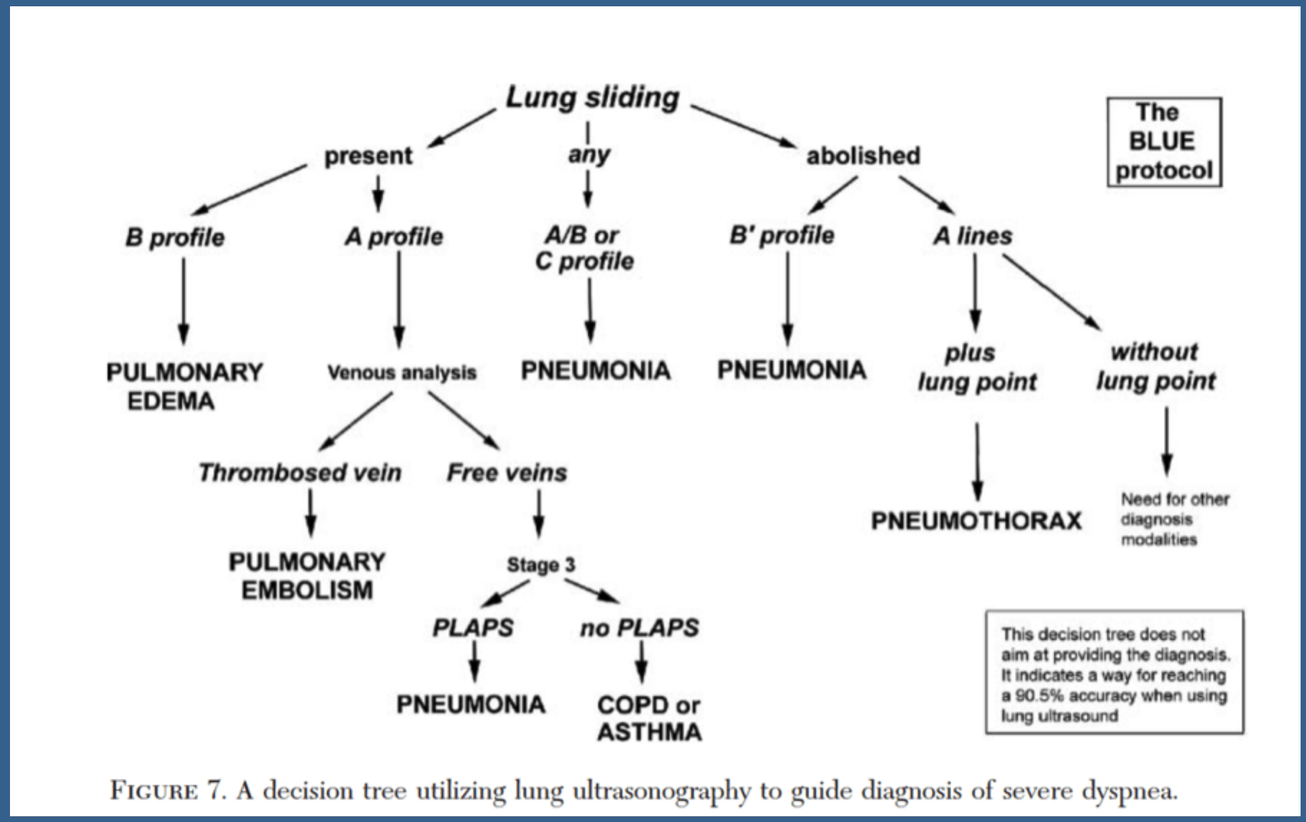
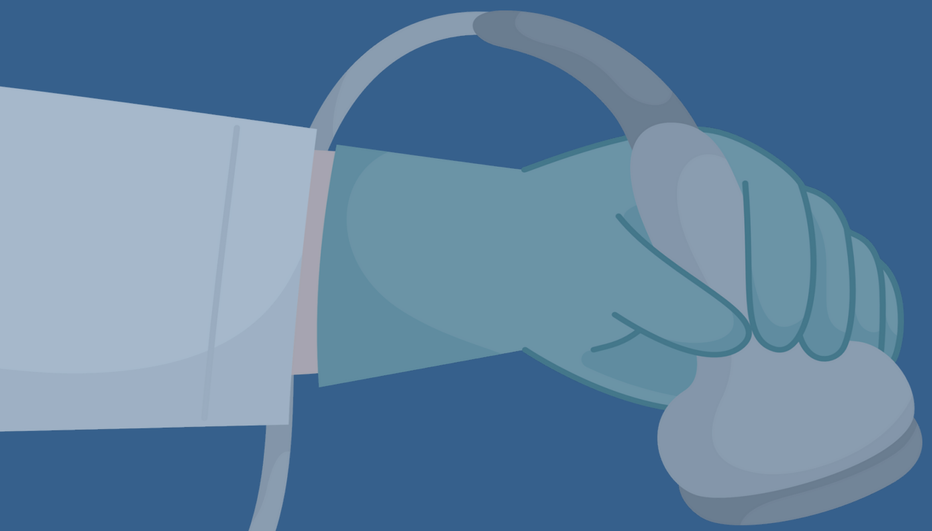


FIGURE 7. A decision tree utilizing lung ultrasonography to guide diagnosis of severe dyspnea.

Lichtenstein, Mezière , Chest. 2008

Ultrasound Training Options

- Local Mentorship
- Local/Regional Conferences
- National POCUS Programs



Summary

1. Ultrasound -first is an effective diagnostic approach for patients with undifferentiated dyspnea

2. Lung ultrasound can outperform chest xray and BNP when used in addition to clinical evaluation in differentiating cardiac dyspnea from other causes

3. Point-of-care ultrasound skills are built with hands-on experiences and feedback. Find a coach!