

# Thoracic POCUS: Current trends and perspectives of point-of-care ultrasound

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# Financial Disclosures

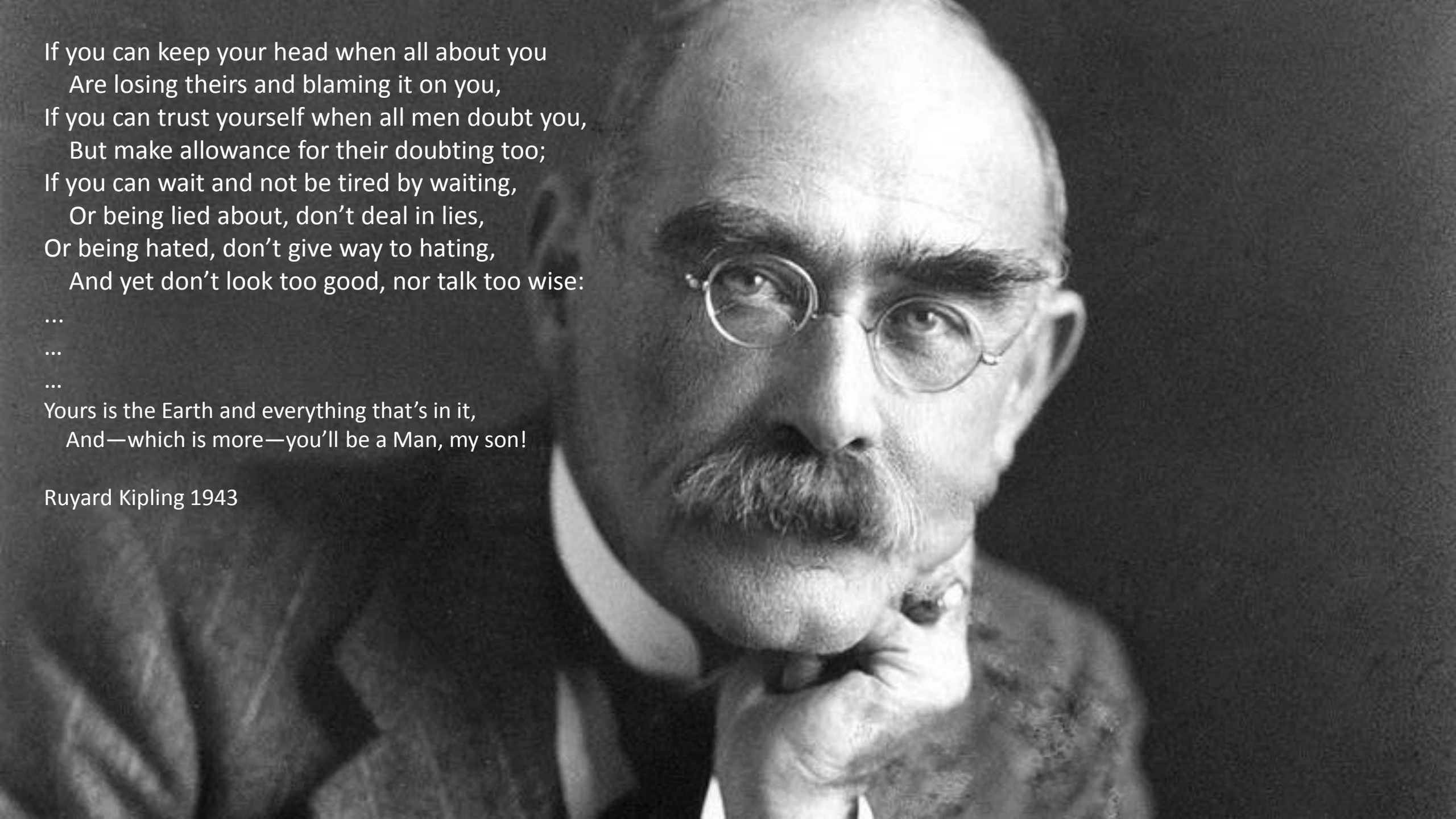
- *UpToDate*: Critical Care Ultrasonography



# Objectives

1. Understand the technique of performing thoracic ultrasound and how certain reverberation artifacts have specific characteristics defining normal aerated lung pattern, interstitial syndromes and consolidation.
2. Review diagnostic algorithms incorporating lung ultrasound artifacts in achieving a confident and rapid clinical diagnosis
3. Understand the application of pleural ultrasound in the management of pleural disease (pneumothorax and pleural effusion)



A black and white portrait of Rudyard Kipling, an older man with a prominent mustache and round glasses, resting his chin on his hand in a thoughtful pose. The background is dark and out of focus.

If you can keep your head when all about you  
Are losing theirs and blaming it on you,  
If you can trust yourself when all men doubt you,  
But make allowance for their doubting too;  
If you can wait and not be tired by waiting,  
Or being lied about, don't deal in lies,  
Or being hated, don't give way to hating,  
And yet don't look too good, nor talk too wise:

...

...

...

Yours is the Earth and everything that's in it,  
And—which is more—you'll be a Man, my son!

Rudyard Kipling 1943

# Point of Care Ultrasound

## Point of Care/Bedside US

- Fast
- Cheap
- Effective
- No Radiation
- Patient doesn't have to leave the floor



# Why are you here?

- I don't need this. I have a stethoscope
- I don't need this. I have a CXR
- OK I need this. How do I do it?
- I'm doing this. What do I do with the findings?



# Indications

- *-Acute Respiratory Failure*
- *Pleural disease assessment*
  - pleural effusion
  - pneumothorax
  - pleural mass/nodule
- *Procedural*
  - thoracentesis
  - chest tube
  - indwelling pleural catheter
- *Screening for early ILD and assess for ILD progression*
- *Compliment volume assessment to assess “lung water”*
- *Defining upper airway anatomy*



ORIGINAL INVESTIGATION

## Diagnosing Pneumonia by Physical Examination

*Relevant or Relic?*

*Arch Intern Med. 1999;159:1082-1087*



**Sensitivity 47% - 69%**  
**Specificity 58% - 75%.**

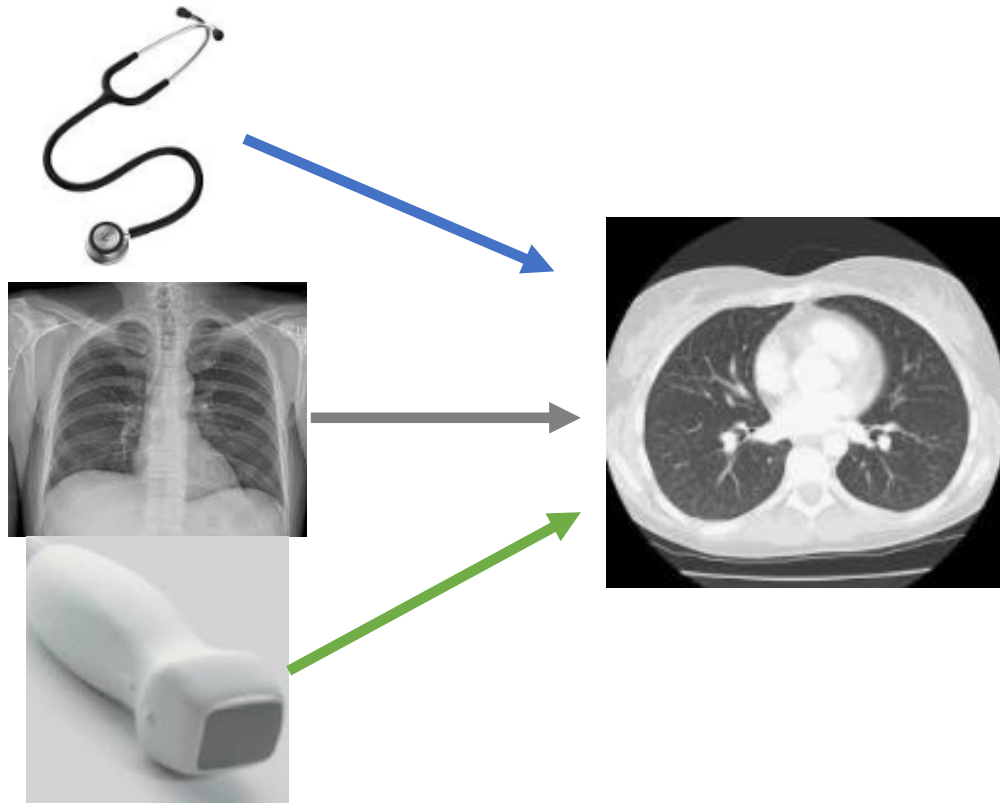
the pulmonary examination has, at best, modest ability to predict the presence of pneumonia and is inconsistently interpreted, even by expert examiners.”



# Comparative Diagnostic Performances of Auscultation, Chest Radiography, and Lung Ultrasonography in Acute Respiratory Distress Syndrome

Daniel Lichtenstein, M.D.,\* Ivan Goldstein, M.D.,† Eric Mourgeon, M.D.,† Philippe Cluzel, M.D., Ph.D.,‡  
Philippe Grenier, M.D.,§ Jean-Jacques Rouby, M.D., Ph.D.¶

Anesthesiology 2004; 100:9-15



	Auscultation, %	Chest Radiography, %	Lung Ultrasonography, %
<b>Pleural effusion</b>			
Sensitivity	42	39	92
Specificity	90	85	93
Diagnostic accuracy	61	47	93
<b>Alveolar consolidation</b>			
Sensitivity	8	68	93
Specificity	100	95	100
Diagnostic accuracy	36	75	97
<b>Alveolar-interstitial syndrome</b>			
Sensitivity	34	60	98
Specificity	90	100	88
Diagnostic accuracy	55	72	95

# Lung Ultrasound:7 Guiding Principles

1. Keep It Simple and Cost Effective: The machine does not need to be complex
2. Gravity Rules: Gas is toward the Sky, Fluids to the Earth
3. Define the Rules of the Game: Thoracic Points
4. Find the Pleural Line
5. Lung US Focuses in on Artifacts
6. Lung Sliding (2-D and M-mode)
7. All acute life-threatening disorders about the visceral pleura surface

Lichtenstein; BLUE-Protocol and FALLS-Protocol:  
Two Applications of Lung US in the Critically Ill.  
CHEST 2015; 147(6):1659-1670

# **Relevance of Lung Ultrasound in the Diagnosis of Acute Respiratory Failure\***

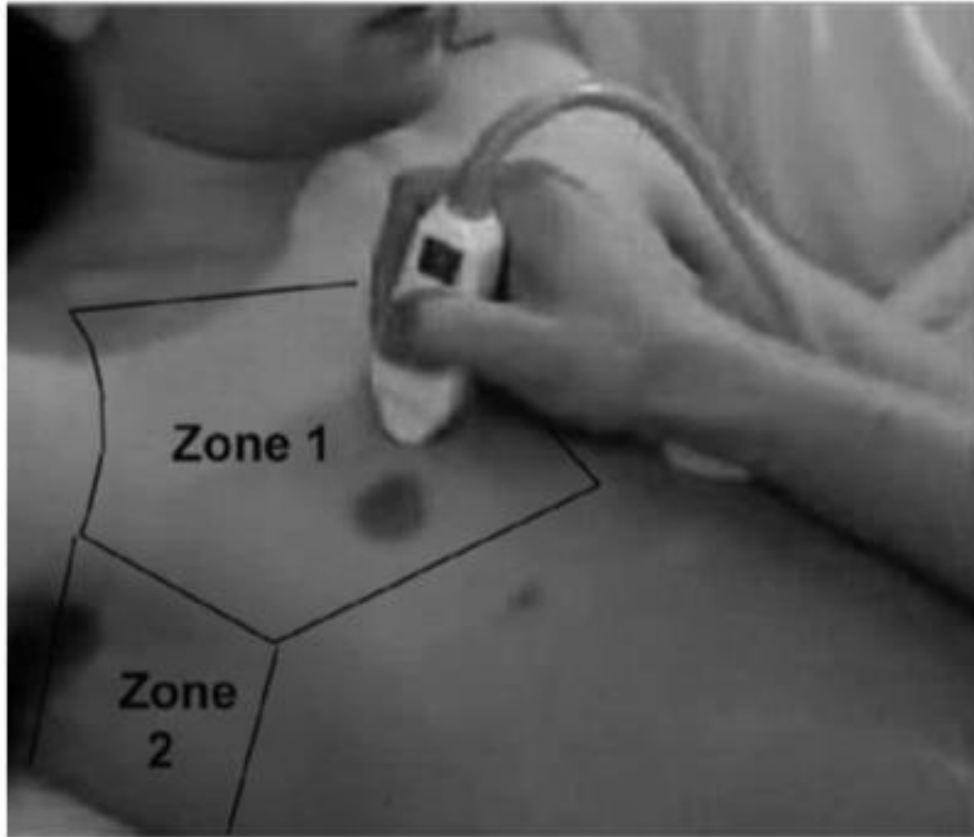
## **The BLUE Protocol**

*Daniel A. Lichtenstein, MD, FCCP; and Gilbert A. Mezière, MD*

4 Year Observational Study of 301 Consecutive Adult Patients with Acute  
Respiratory Failure

Lung US -- Can yield the correct diagnosis in 90.5% of cases

## 3 Zones: 6 Different Points



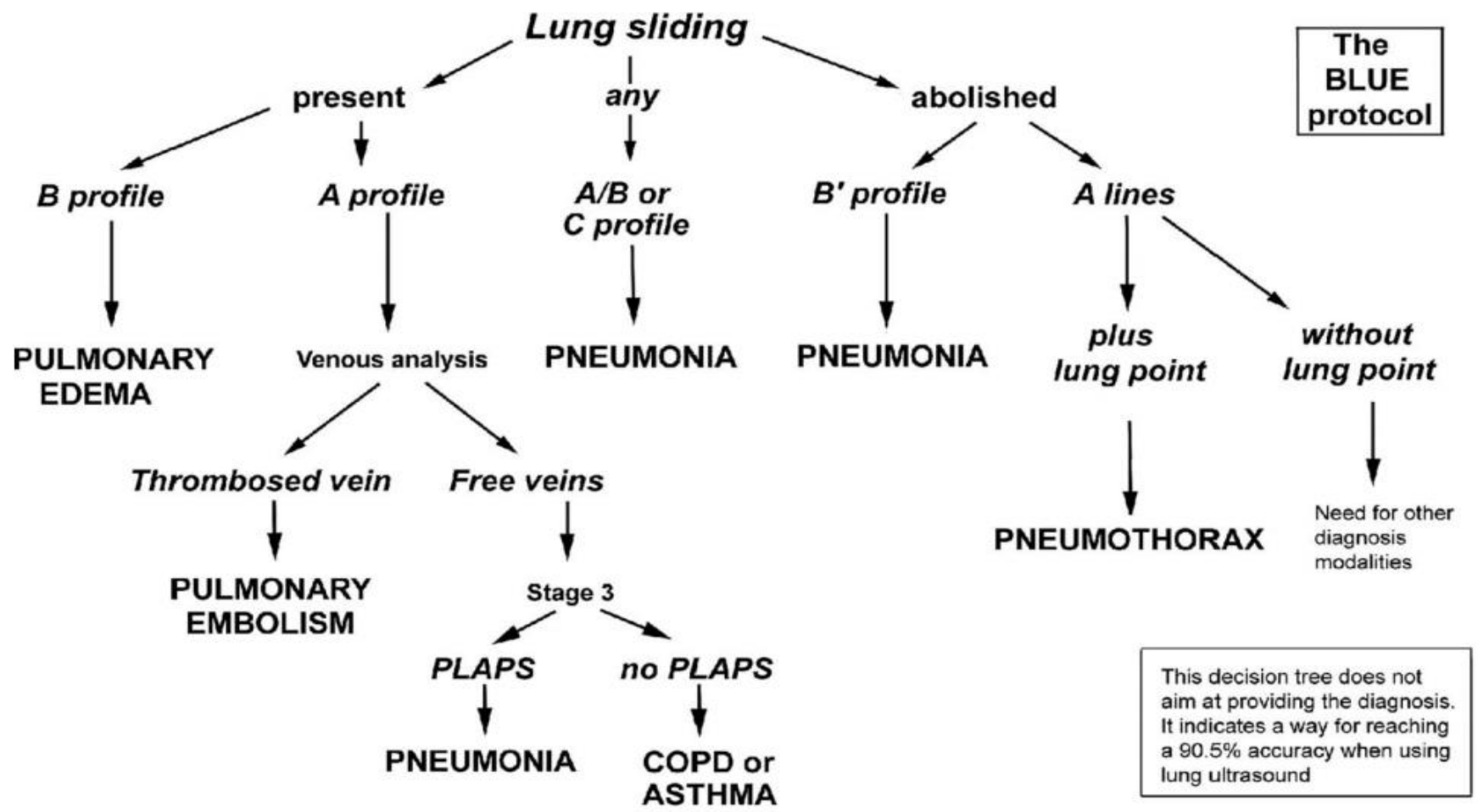


FIGURE 7. A decision tree utilizing lung ultrasonography to guide diagnosis of severe dyspnea.

# Step 1: Is Lung Sliding Present?

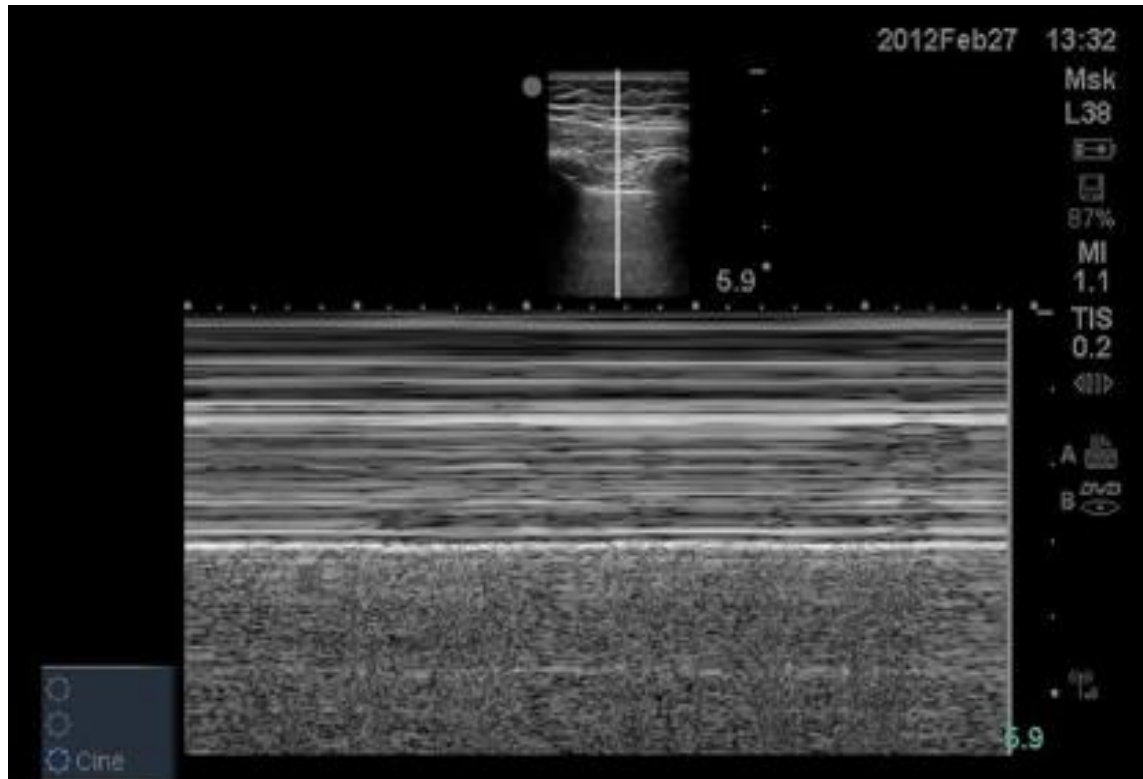


Sensitivity was 95.3%, Specificity 91.1% with a Negative predictive value of 100% ( $p < 0.001$ )

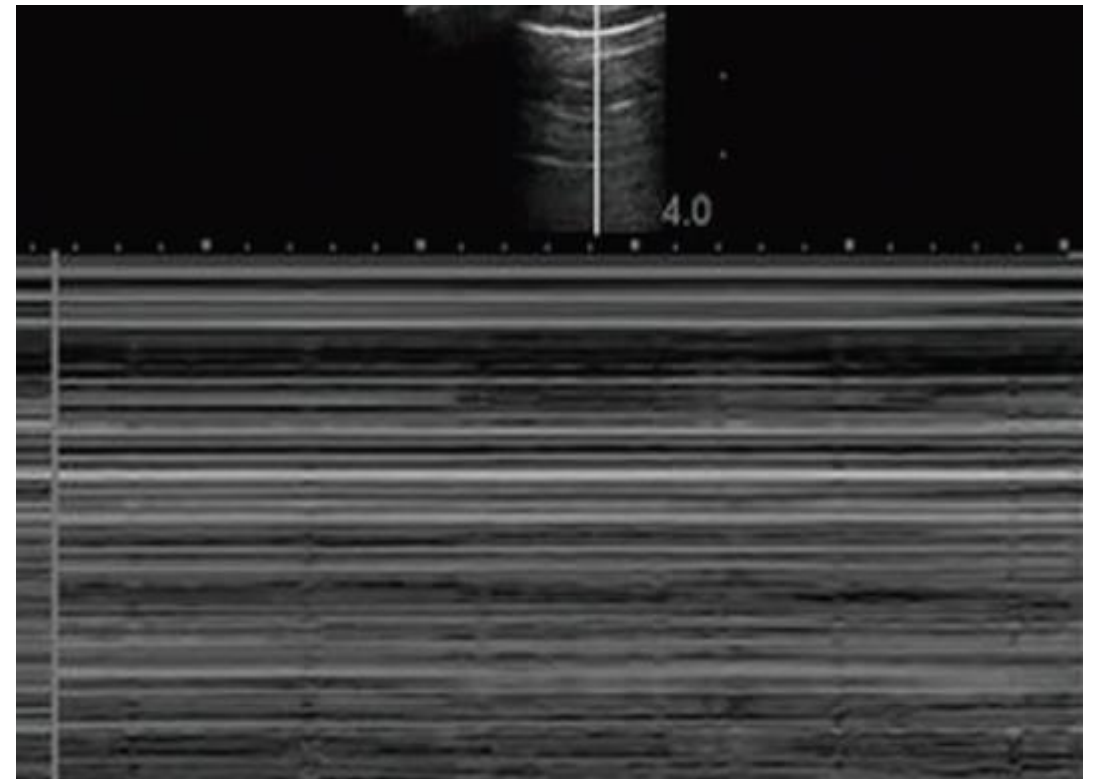
Lichtenstein, DA. Menu, Y: A Bedside Ultrasound Sign Ruling Out Pneumothorax in the Critically Ill. Lung Sliding. CHEST. 1995; 108 (5):1345-1348

# M-mode for Presence of Lung Sliding

Present: Stratosphere Sign

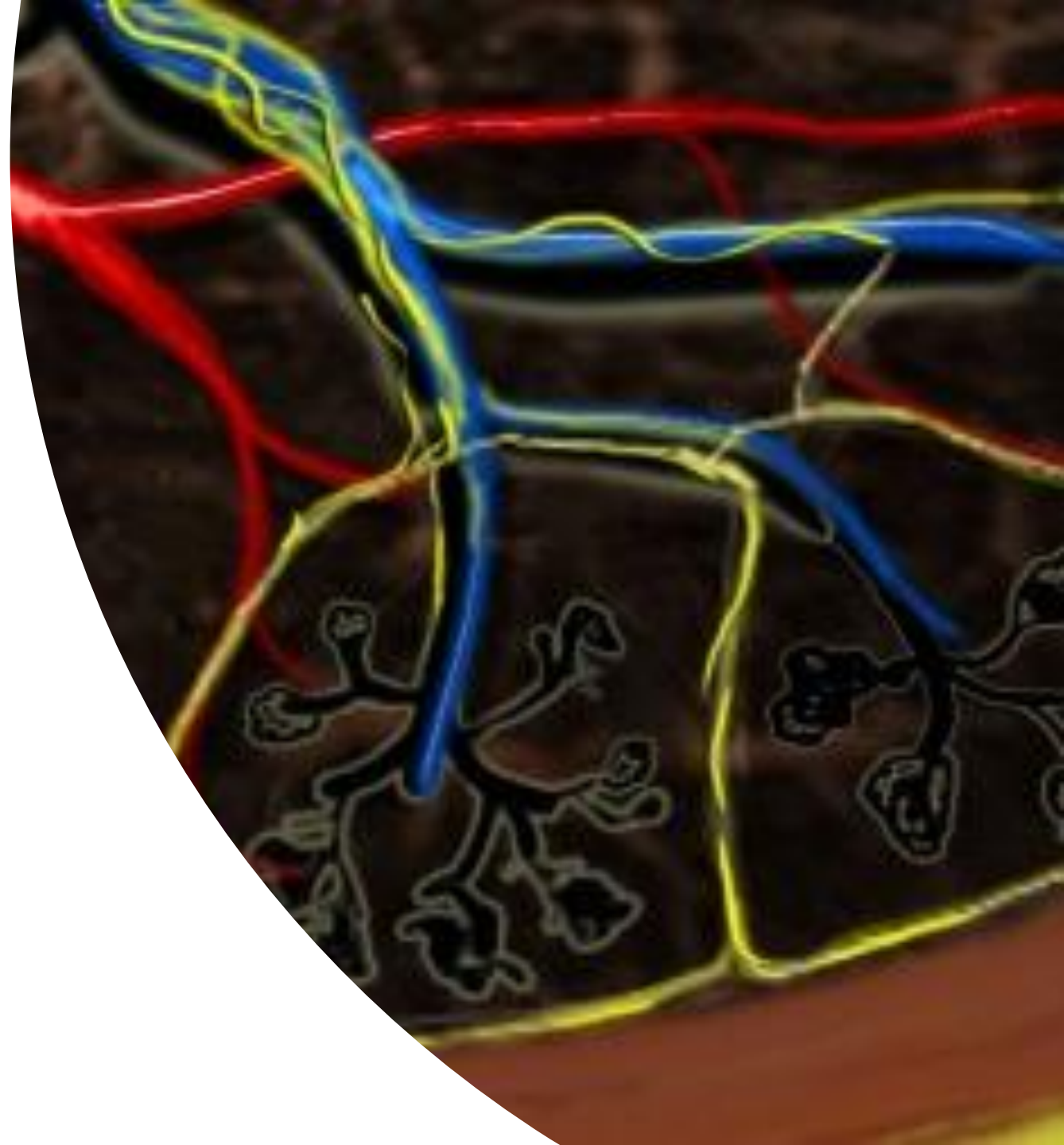


Absent: Barcode Sign



## Step 2: It's as simple as A, B, C! Analyze the Artifacts

- Secondary Pulmonary Lobule:
  - A – Lines: Thin Interlobular Septum
  - B – Lines: Widened Sub-pleura Interlobular Septum
  - C- Profile: Anterior Consolidation





# A-Lines: Reverberation Artifacts



A-lines:

Reverberation Artifacts created by repetitive reflection of ultrasound waves between the pleural line, a strong reflector and the transducer.

# B-Lines: Fluid Filled Interlobular Septum



# Interpretation

## A-line pattern

- Normal lung
- COPD
- Asthma
- Pulmonary Emboli
- Pneumothorax\*

## B-line pattern

- Pulmonary edema
- DAH
- ARDS
- Pneumonia
- ILD

Other

Interstitial and  
Alveolar syndromes



# C-Profile: Alveoli are Filled with Fluid or Debris



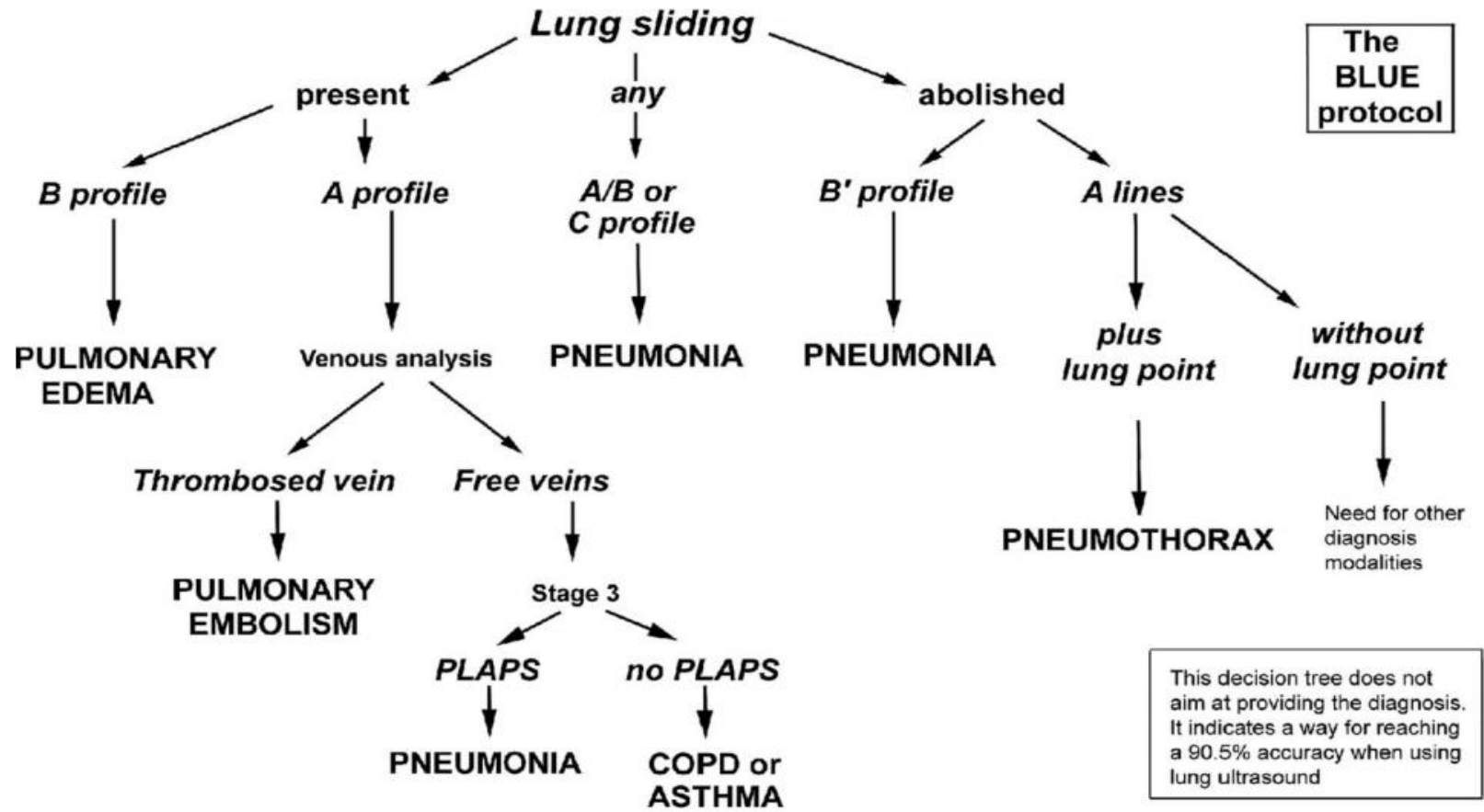


FIGURE 7. A decision tree utilizing lung ultrasonography to guide diagnosis of severe dyspnea.

# A-Lines: No Lung Sliding with Lung Point

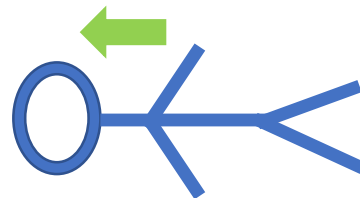


”Lung Point”: Sensitivity of 66%, but with a Specificity of 100% for Pneumothorax

Lichtenstein, et. Al. The Lung Point: An Ultrasound Sign Specific to Pneumothorax. Intensive Care Med 2000 Oct: 26 (10): 1434-40



# Lung Sliding



## Lung Sliding:

- Sens 100% Spec 78%
- Presence of lung sliding **rules out** PTX

## Lung Point:

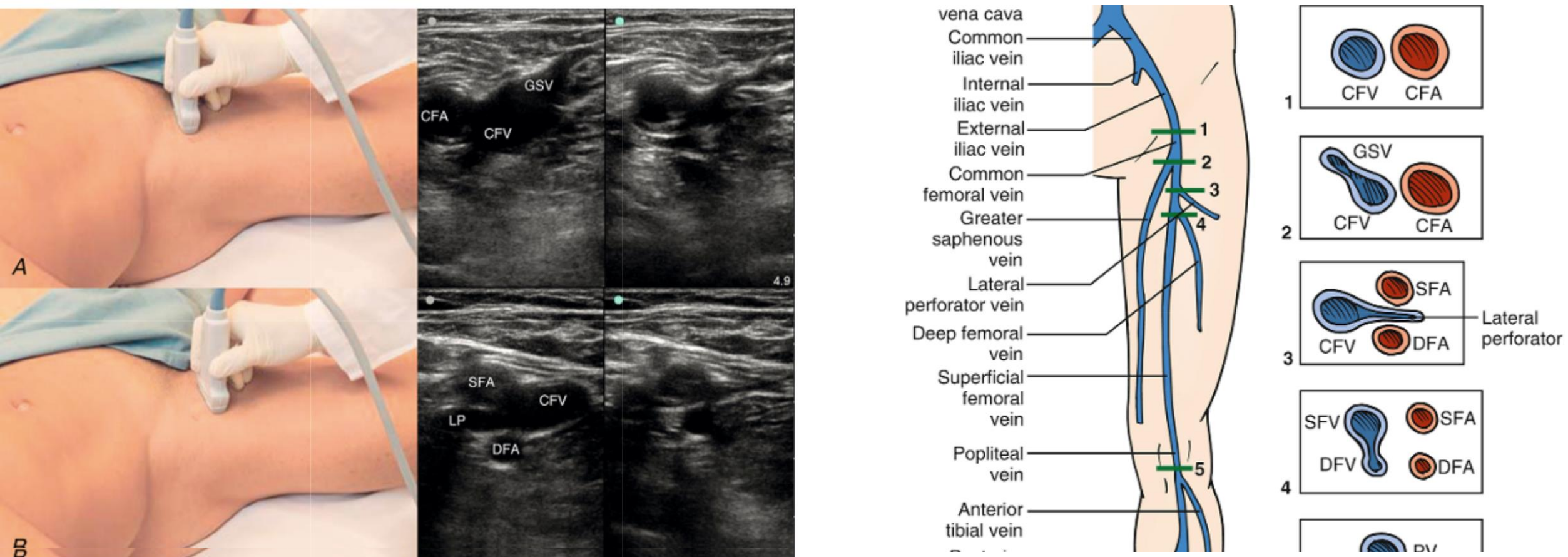
- Sens 79% Spec 100%
- Presence of a lung point **rules in** PTX



# Causes of loss of lung sliding

<u>Pleural separation</u>	<u>Pleural Adhesions</u>	<u>Non-ventilation</u>
Pneumothorax	Inflammatory adhesions	Apnea
Pleural Effusion	Pneumonia Acute lung injury	Severe hyperinflation Asthma
Artifact Mimics	Pleurodesis	COPD
Subcutaneous emphysema	ILD/fibrotic lung disorders	Atelectasis One-lung intubation  Endotracheal intubation complication





# Lung Sliding/A-lines: Acute Respiratory Failure

Intensivist performed compression ultrasonography: 86% sensitivity and 96% Specificity; Diagnostic Accuracy of 95%

Kory et. Al. Accuracy of Ultrasonography Performed by Critical Care Physicians for the Diagnosis of DVT. CHEST 2011; 139(3): 538-542

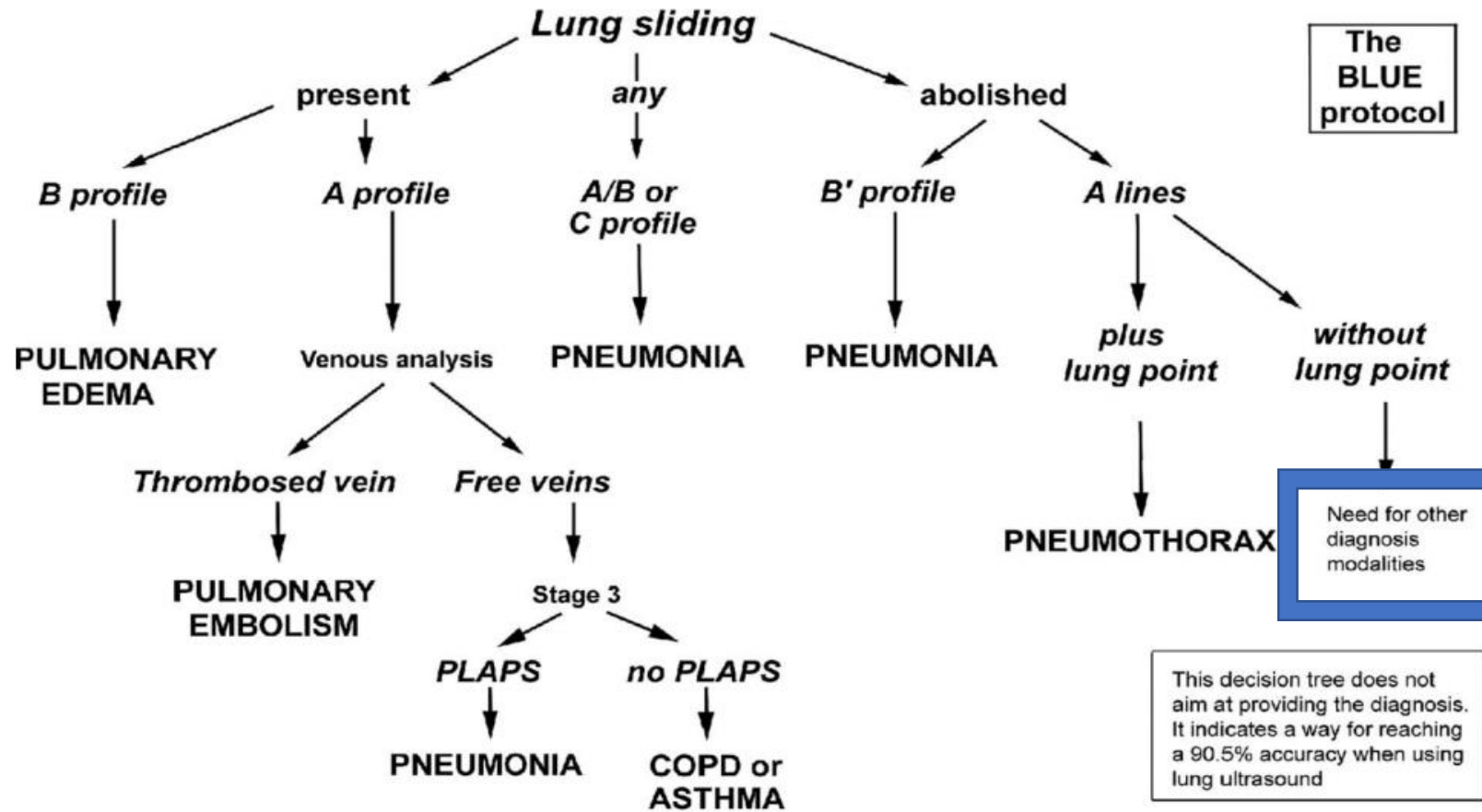


FIGURE 7. A decision tree utilizing lung ultrasonography to guide diagnosis of severe dyspnea.

Research

# Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome

Roberto Copetti\*<sup>1</sup>, Gino Soldati<sup>2</sup> and Paolo Copetti<sup>1</sup>

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58 Patients Affected by Acute Lung Injury/ARDS and Acute Pulmonary Edema

Table 4: Sensitivity and specificity of each ultrasonographic sign in the two groups.

SONOGRAPHIC SIGNS	SENSITIVITY		SPECIFICITY	
	ALI/ARDS	APE	ALI/ARDS	APE
AIS	100%	100%	0%	0%
Pleural line abnormalities	100%	25%	45%	0%
Reduction or absence of lung sliding	100%	0%	100%	0%
"Spared areas"	100%	0%	100%	0%
Consolidations	83.3%	0%	100%	0%
Pleural effusion	66.6%	95%	5%	33.3%
"Lung pulse"	50%	0%	100%	50%



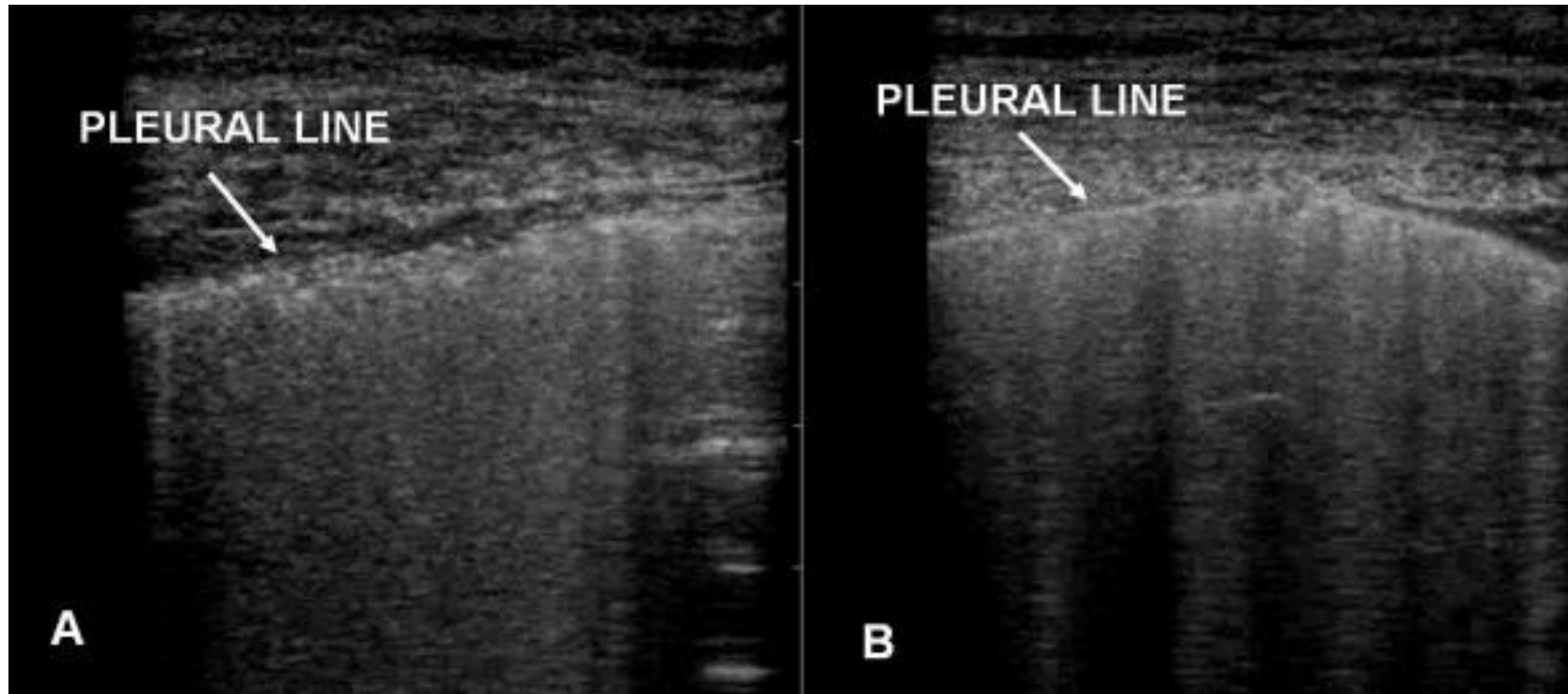
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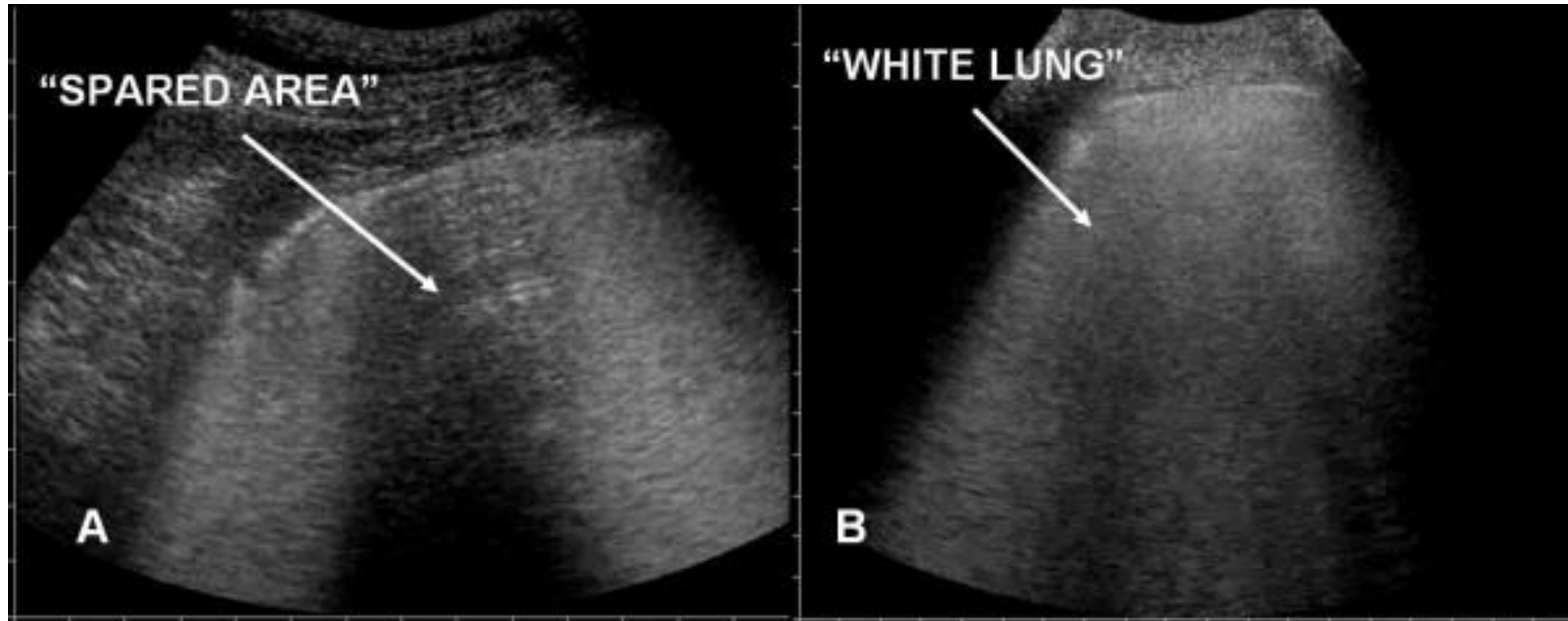
Address: <sup>1</sup>Emergency Department S. Antonio Abate General Hospital, Tolmezzo, Italy and <sup>2</sup>Emergency Department Valle del Serchio General Hospital, Lucca, Italy

Email: Roberto Copetti\* - robcopet@tin.it; Gino Soldati - g.soldati@usl2.toscana.it; Paolo Copetti - paolo.cop@libero.it

\* Corresponding author



# How About In ARDS? Injured Lung, Probably on Higher PEEP



Thickened Pleura and Subpleural Consolidations:  
a diagnostic feature of severe COVID-19 pneumonia?



# Point-of-Care Lung Ultrasound findings in novel coronavirus disease-19 pneumoniae: a case report and potential applications during COVID-19 outbreak

D. BUONSENSO<sup>1,2</sup>, A. PIANO<sup>3</sup>, F. RAFFAELLI<sup>2,4</sup>, N. BONADIA<sup>3</sup>,  
K. DE GAETANO DONATI<sup>4</sup>, F. FRANCESCHI<sup>3</sup>

<sup>1</sup>Department of Woman and Child Health and Public Health, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy

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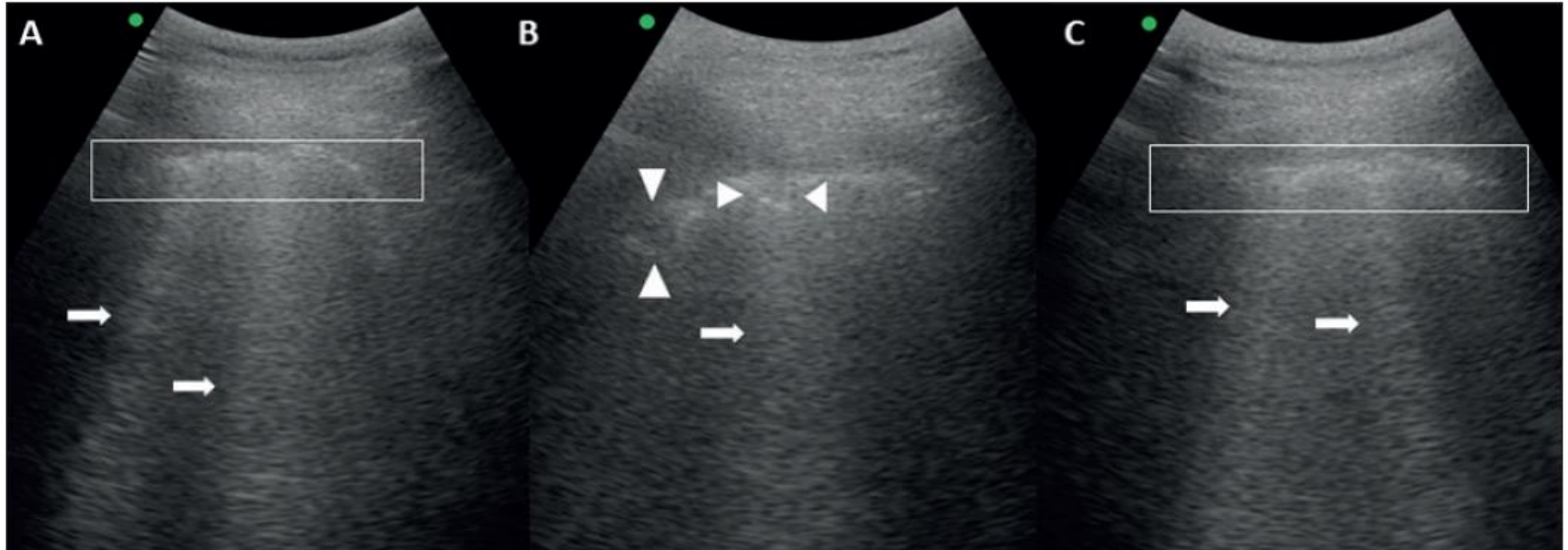
<sup>3</sup>Medicina d'Urgenza - Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy

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# COVID-19 Positive Patient



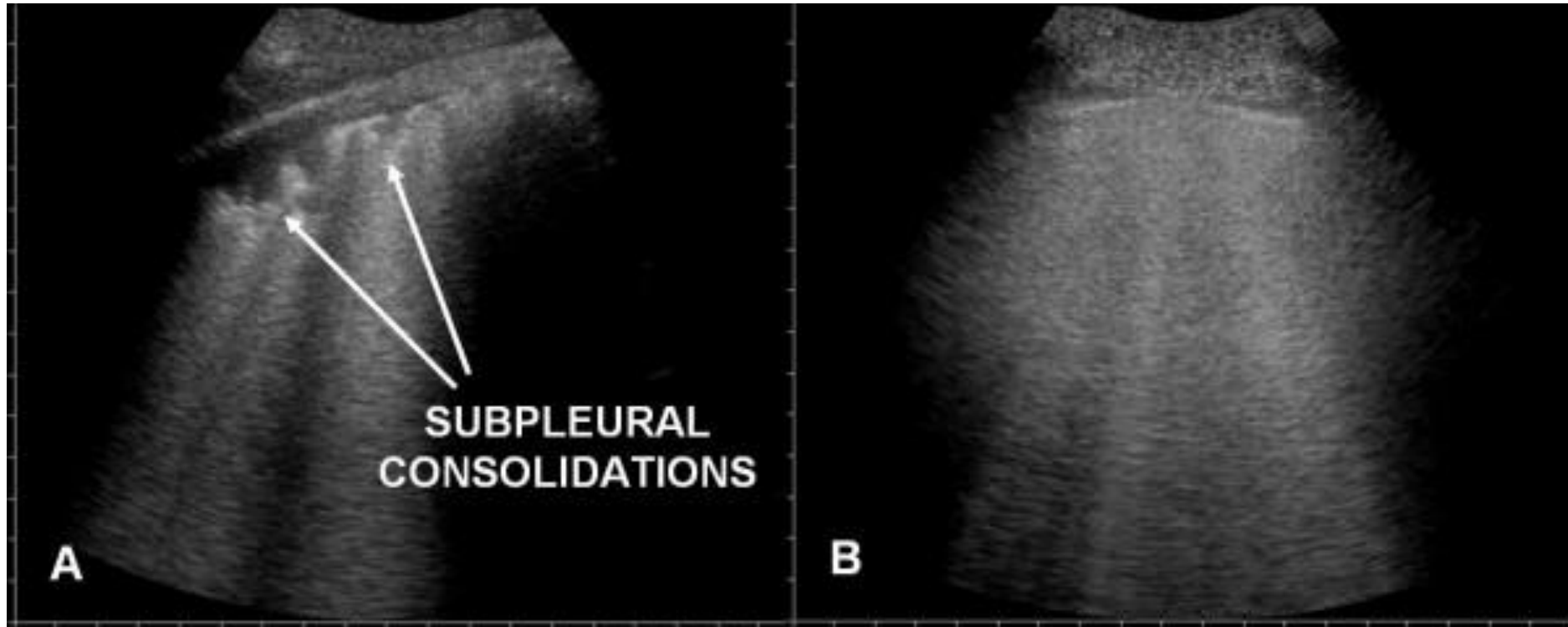
Thickened Pleura

Subpleural Consolidations

Thickened Pleura

Buonsenso, et al. Point-of-Care Lung Ultrasound Findings in Novel Coronavirus Disease -19: A Case Report of Potential Applications. *Eu Rev Med Pharmacol Sci.* 2020 Mar; 24

# LUS Findings in Severe COVID-19 Pneumonia



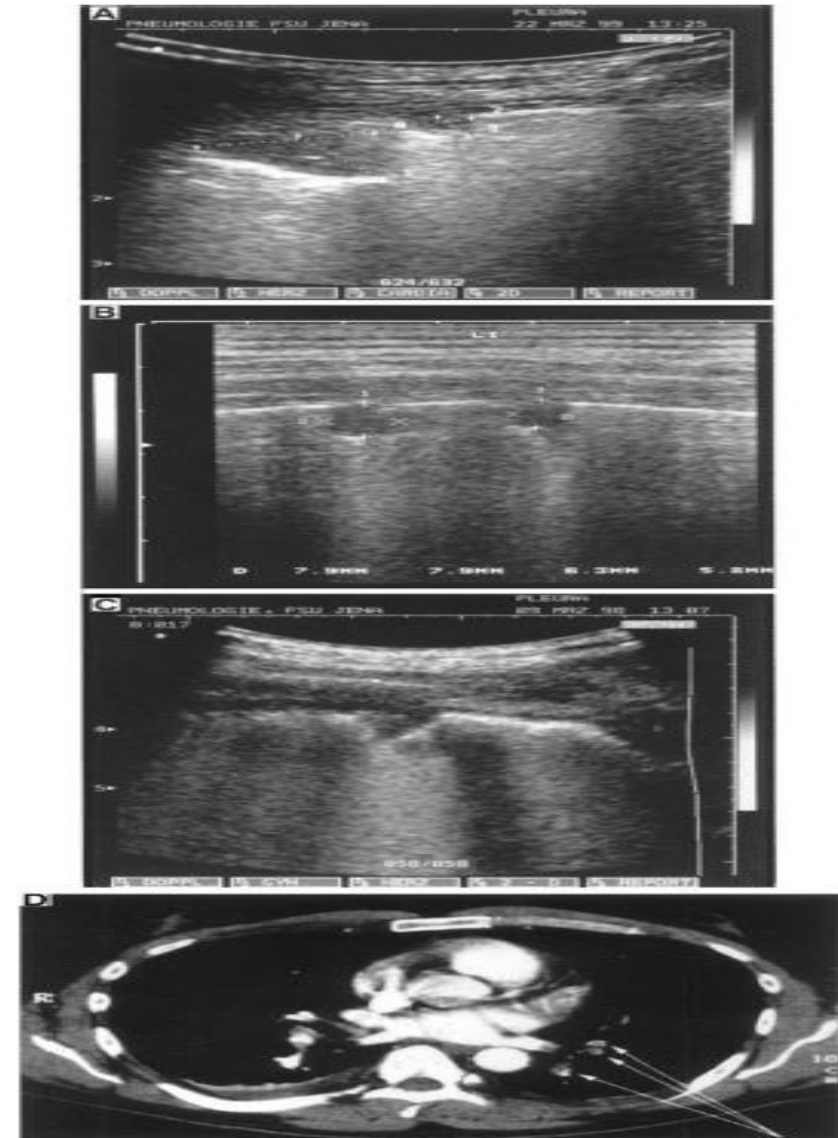
Thickened, “lumpy bumpy” pleura and subpleural consolidations were so true 2001, 2008, and 2012!



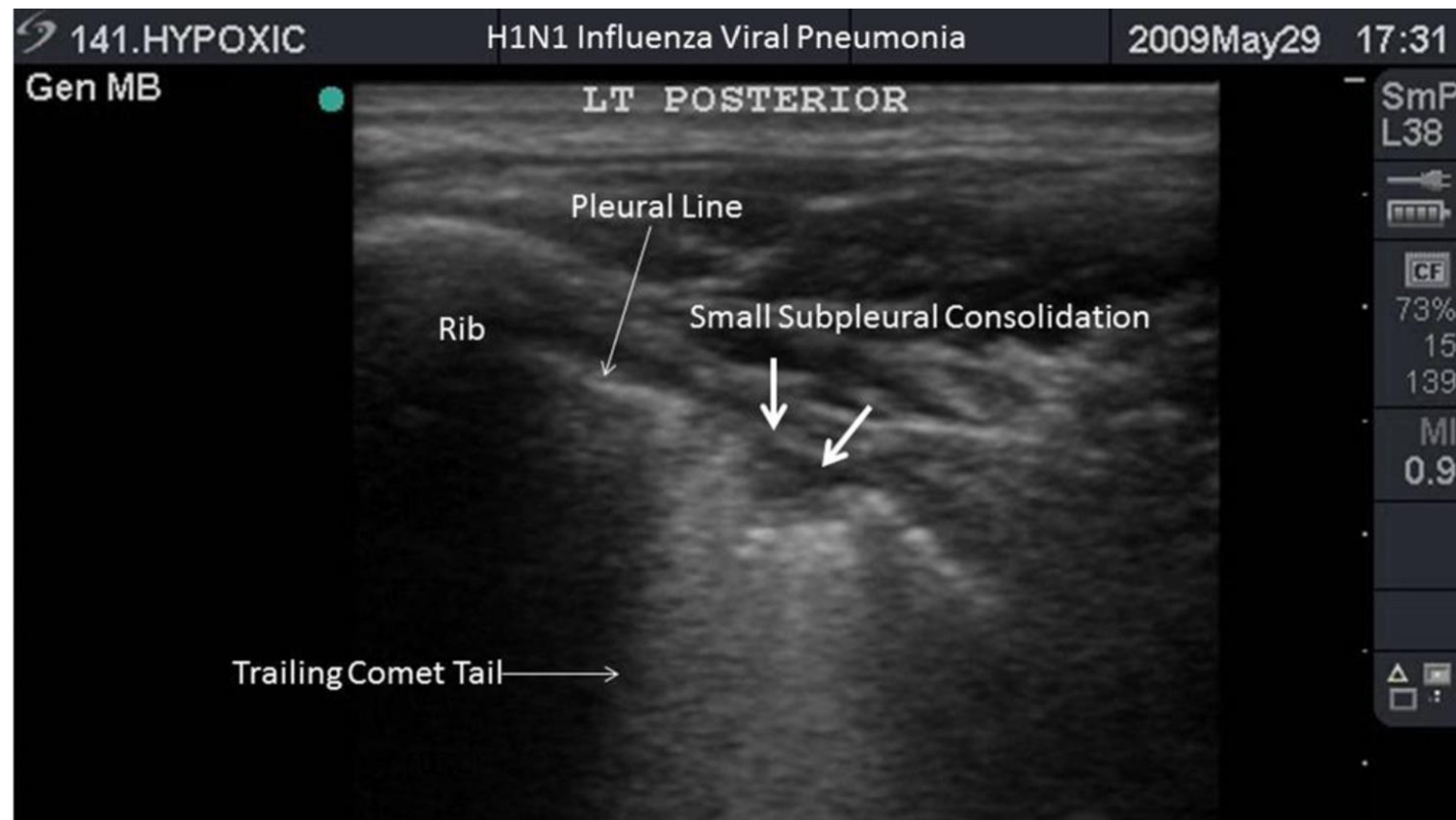
# Sonography of Lung and Pleura in Pulmonary Embolism\*

## Sonomorphologic Characterization and Comparison With Spiral CT Scanning

*Angelika Reissig, MD; Jens-Peter Heyne, MD; and  
Claus Kroegel, MD, PhD, FCCP*



# Prospective application of clinician-performed lung ultrasonography during the 2009 H1N1 influenza A pandemic: distinguishing viral from bacterial pneumonia

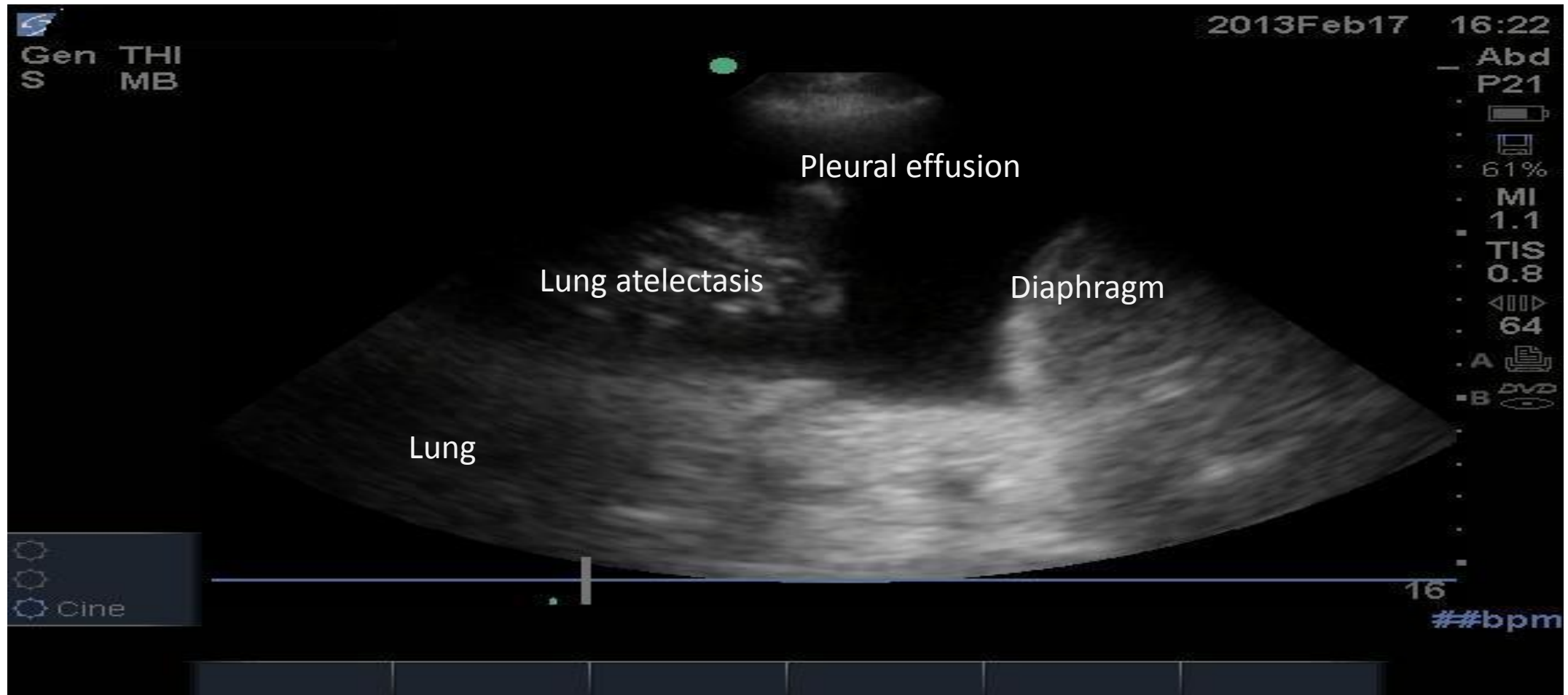


Lessons From Our Last Pandemic:

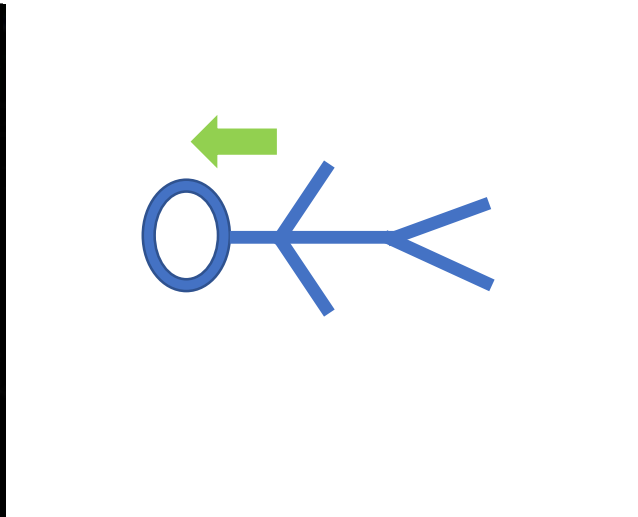
Case Series of 20 patients with H1N1 Influenza with a goal to distinguish from Bacterial Pneumonia.

Tsung et al. Critical Care Ultrasound 2012: 4:16

# Anechoic Pleural Effusion



# Pleural Effusions



# Non-Septate Complex Pleural Effusion: Hemothorax





# Accuracy of Pleural Ultrasonography in Diagnosing Complicated Parapneumonic PE

	Ultrasound (n=66)	Chest CT (n=66)	CXR (n=66)
Sensitivity % (95% CI)	69.2% (48.2% to 85.7%)	76.9% (56.3% to 91.0%)	61.5% (40.6% to 79.8%)
Specificity % (95% CI)	90.0%* (76.3% to 97.2%)	65.0% (48.3% to 79.4%)	60.0% (43.3% to 75.1%)
PPV % (95% CI)	81.8%* (59.7% to 94.8%)	58.8% (40.7% to 75.3%)	50% (31.9% to 68.1%)
NPV % (95% CI)	81.8% (67.3% to 91.8%)	81.3% (63.6% to 92.8%)	70.6% (52.5% to 84.9%)
LR+ estimate (95% CI)	6.92* (3.18 to 28.1)	2.20 (1.42 to 3.75)	1.54 (0.94 to 2.63)
LR- estimate (95% CI)	0.34 (0.15 to 0.55)	0.36 (0.12 to 0.66)	0.64 (0.32 to 1.05)

\*p<0.05 when compared with chest CT and when compared with CXR.

CXR, chest radiograph; LR-, negative likelihood ratio; LR+, positive likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

# Clinical Application of POCUS



# Case 1

58-year-old WM presents with undiagnosed transudative pleural effusion

2 prior therapeutic thoracentesis (serous fluid and both are transudates)

Referred to MUSC for further evaluation

PMH: COPD

Type II DM

Meds: Albuterol

Budesonide/Formoterol

Insulin

Metformin



# Case 1 :Undiagnosed Transudative Pleural Effusion



## Case 2

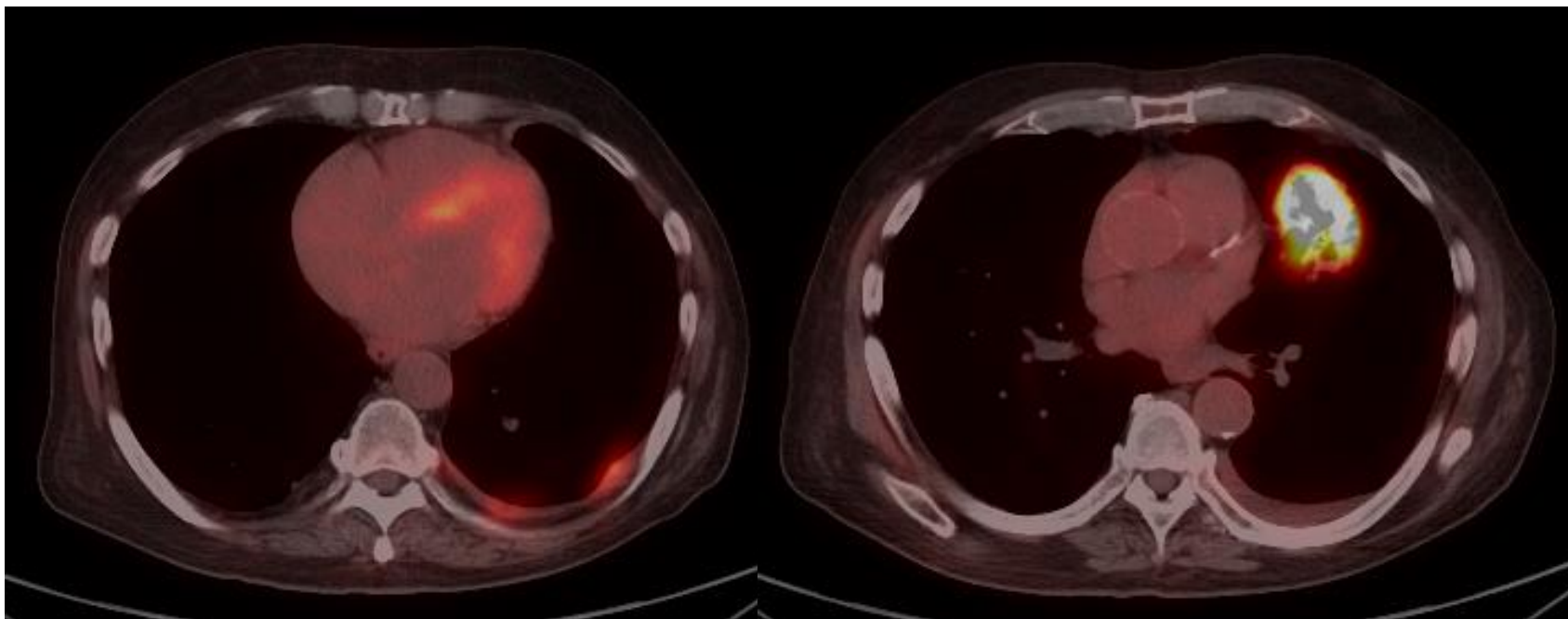
- 64-year-old AAF with end-stage COPD on home O2 at 4 LPM
- Developed a LUL cavitory lung mass and small pleural effusion
- Therapeutic thoracentesis revealed a serosanguineous, lymphocytic exudative pleural effusion
- Cytology was negative



## Case 2: Non-contrast Chest CT



## Case 2: CT/PET Images



# Case 2



Pleural US shows parietal based nodule

US-guided pleural biopsy performed using a 2 18 G Coaxial needle

Cytology times 2 were negative for malignancy

Biopsy c/w non-small cell lung cancer





# Case 3

- 74 y/o veteran who presented with an intracranial hemorrhage several days prior who develops increasing oxygen requirement overnight from 2 L to 8L Oxymizer!
- Your Patient Has Increase In O2 Overnight!
- Do whole body ultrasound (WBU!)







# Clot In Transit!!!



# Limitations

- Obesity
- Patient positioning
- Experience / Skill
- Equipment



# Conclusions:

1. Lung Ultrasound is easy, effective, and can help guide therapy.
2. Bilateral A-line pattern in an acutely dyspneic patient has a limited differential and includes airway disorders (asthma or COPD exacerbation) or vascular disease (PE).
3. Subpleural Consolidations – Can be seen in more than just COVID-19
4. Be Skeptical of Publications – LUS pattern is not diagnostic of COVID PNA; however, LUS patterns can determine the severity of COVID related pulmonary involvement.
5. Ultrasound should be used as an aid to clinical judgement and not to replace it! If your images and clinical judgement don't align- Don't be afraid to pursue further imaging.
6. Pleural exudates can assume the appearance of an anechoic pleural effusion in 50% of cases; however, the identification of complexity is most likely representative of an exudative cause.
7. Due to a high specificity, PPV and positive LR, few patients are subjected to the placement of a small-bore chest tube in patients who are presenting with a high clinical suspicion of a parapneumonic pleural effusion. Place a 14 F chest tube and submit the PFA after placement.

