ULTRASOUND CONFERENCE

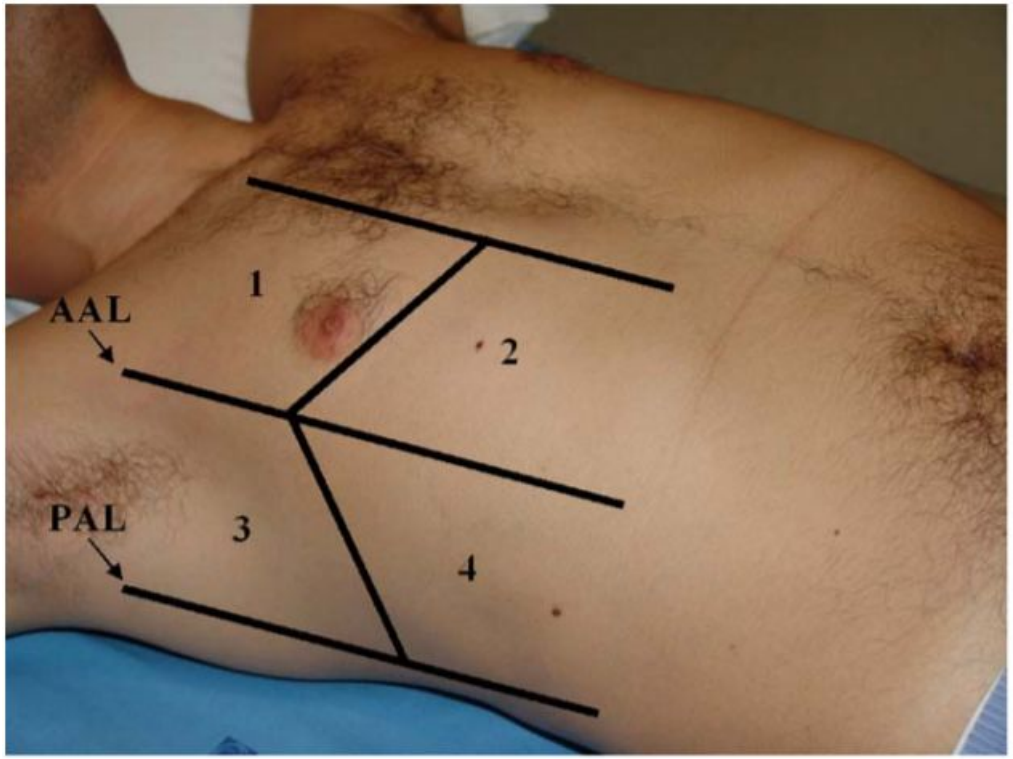
WILL WHALEN, PGY IV

OVERVIEW

- Patient Positioning
- General Terms
- Case 1 with Literature Review
- Case 2 with Literature Review
- Key Points

TECHNIQUE

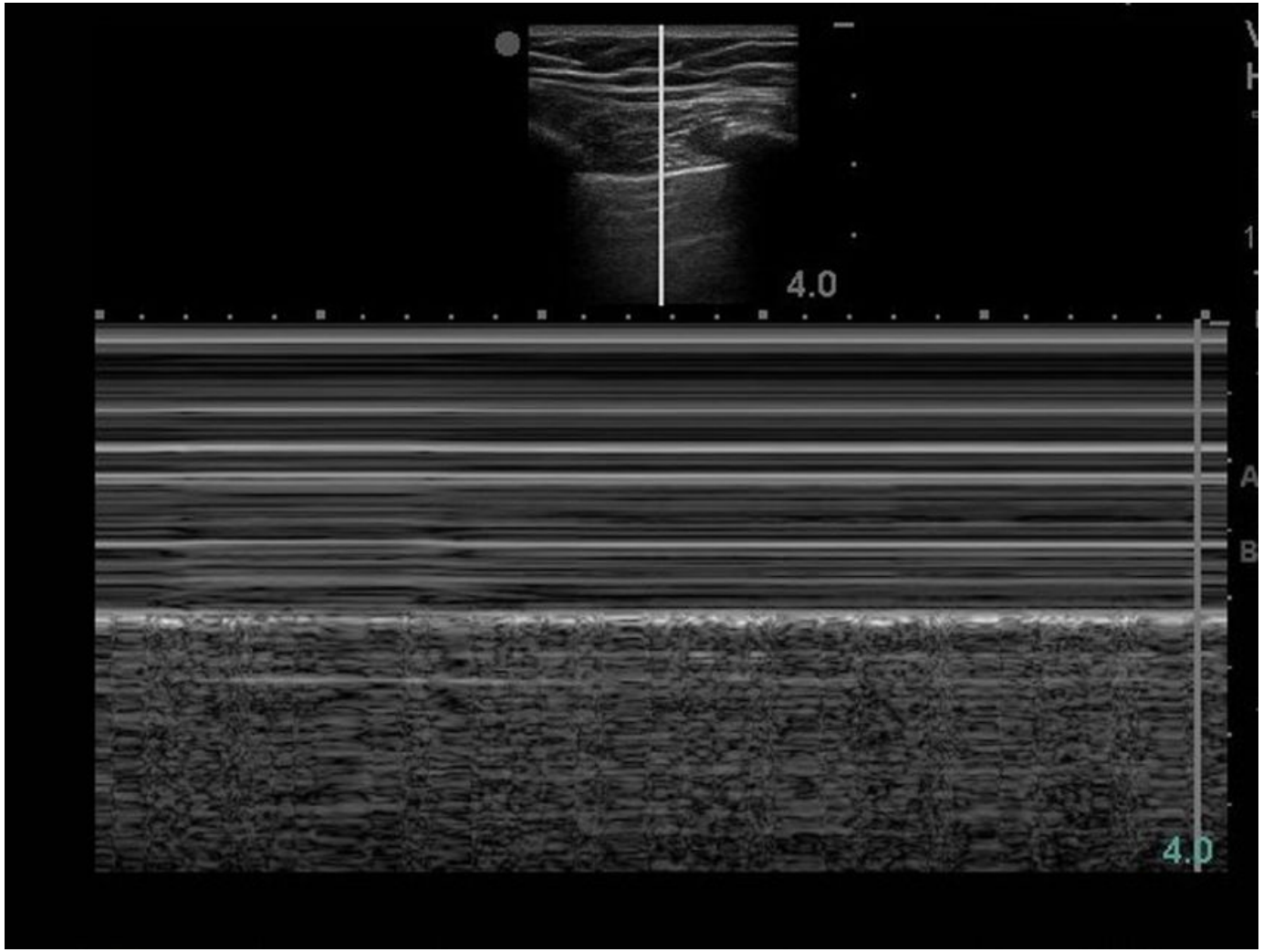
- Supine position or semi-supine at 30 degrees.
- Start at the anterior chest between 3rd and 4th intercostal space midclavicular line.
- Probe is oriented longitudinal position with the maker placed cephalad.
- Scan methodically trying to identify key landmarks.
- Try to think about the pathology you are detecting; gravity independent vs dependent.



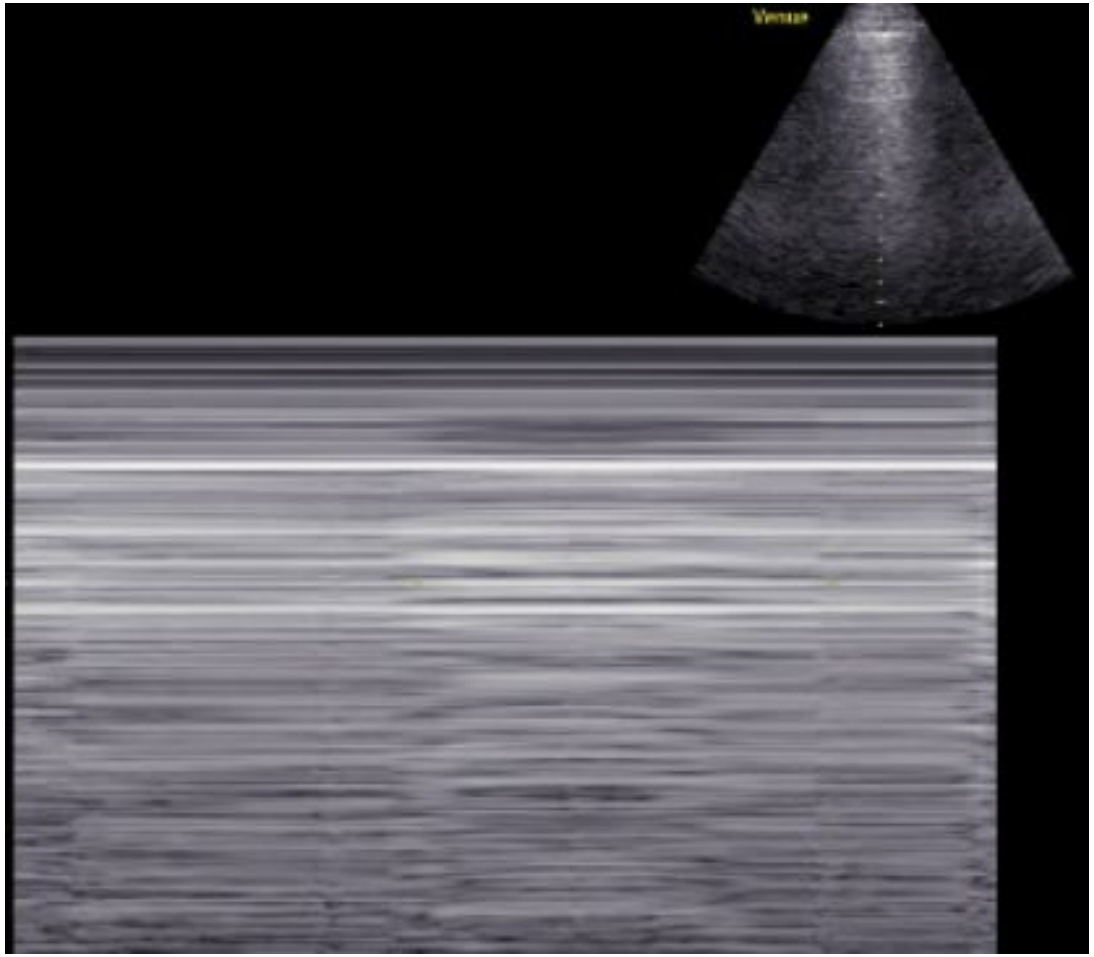
REVIEW OF TERMS

- B – Lines: Occur when there is an alveolar-interstitial abnormality at the visceral pleural surface.
- Lung Sliding: Respirophasic movement of the visceral pleura against the parietal pleura. Shimmering band that moves in synchrony with respirations.

REVIEW OF TERMS: SEASHORE SIGN



REVIEW OF TERMS: STRATOSPHERE SIGN



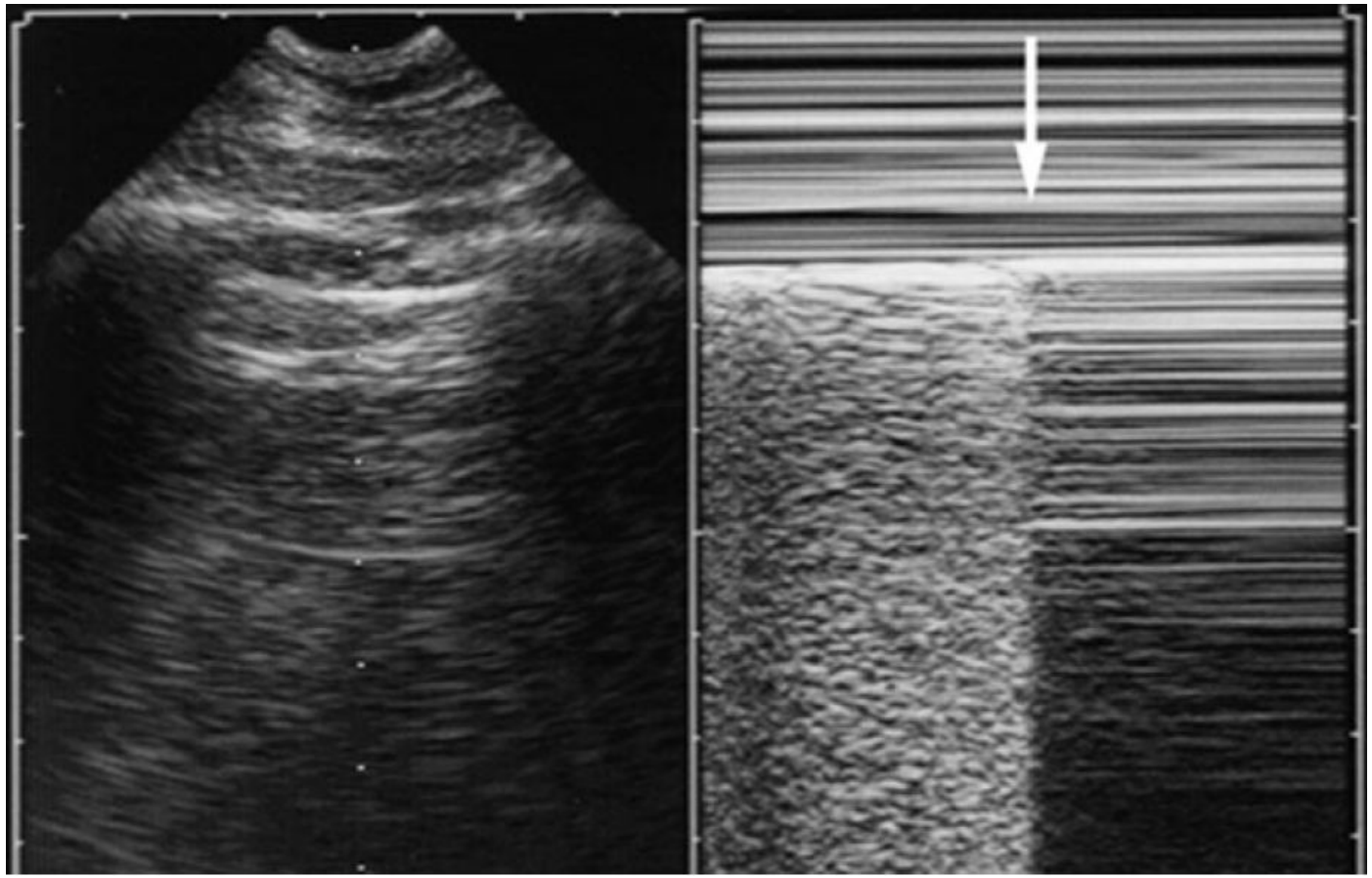
REVIEW OF TERMS

- Lung Point: Boundary between the pneumothorax and the partially deflated lung. Visceral pleura is abutting the parietal pleura where the lung is still inflated and ***slides*** across the screen during respiration.

REVIEW OF TERMS: LUNG POINT

Source: https://criticalcarenorthampton.com/thoracic-other-ima

M-MODE AND LUNG POINT



Lichtenstein DA. Lung ultrasound in the critically ill. *Ann Intensive Care*. 2014.

CASE 1

CASE 1

70 year old female s/p stem cell transplant with post transplant course complicated by BOOP, requiring 4 L NC at baseline.

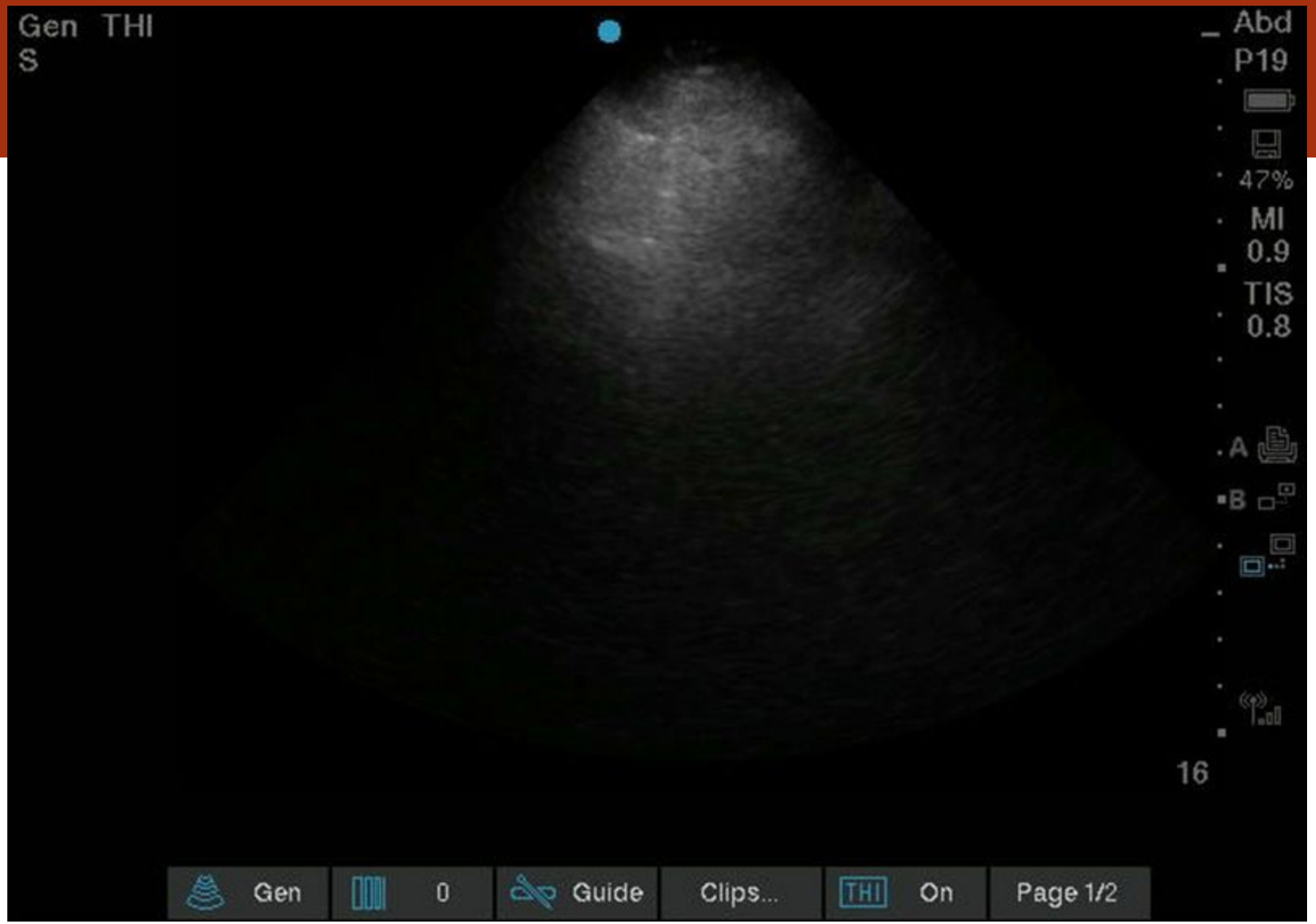
Paged as patient acutely short of breath, tachycardic, hypoxic requiring non-rebreather.

Quick chart review shows patient on DVT prophylaxis, and CT scan with subpleural blebs.

ROS: SOB (+), CP (-)

Exam: HR 130's, RR 35, 92% on NRB, BP 90/60, absent breath sounds on the right with hyperresonance to percussion, regular rhythm but tachycardic.

POCUS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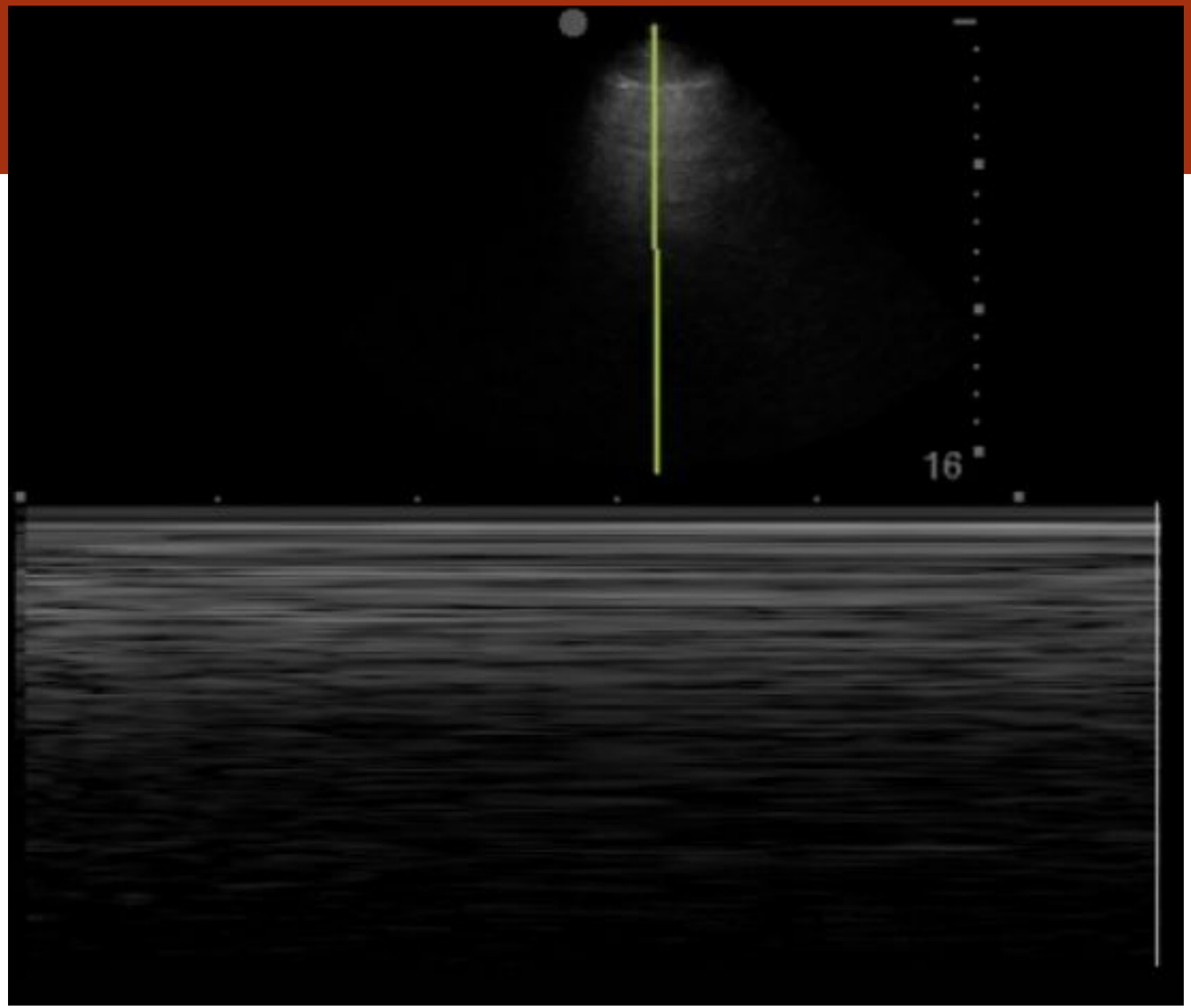
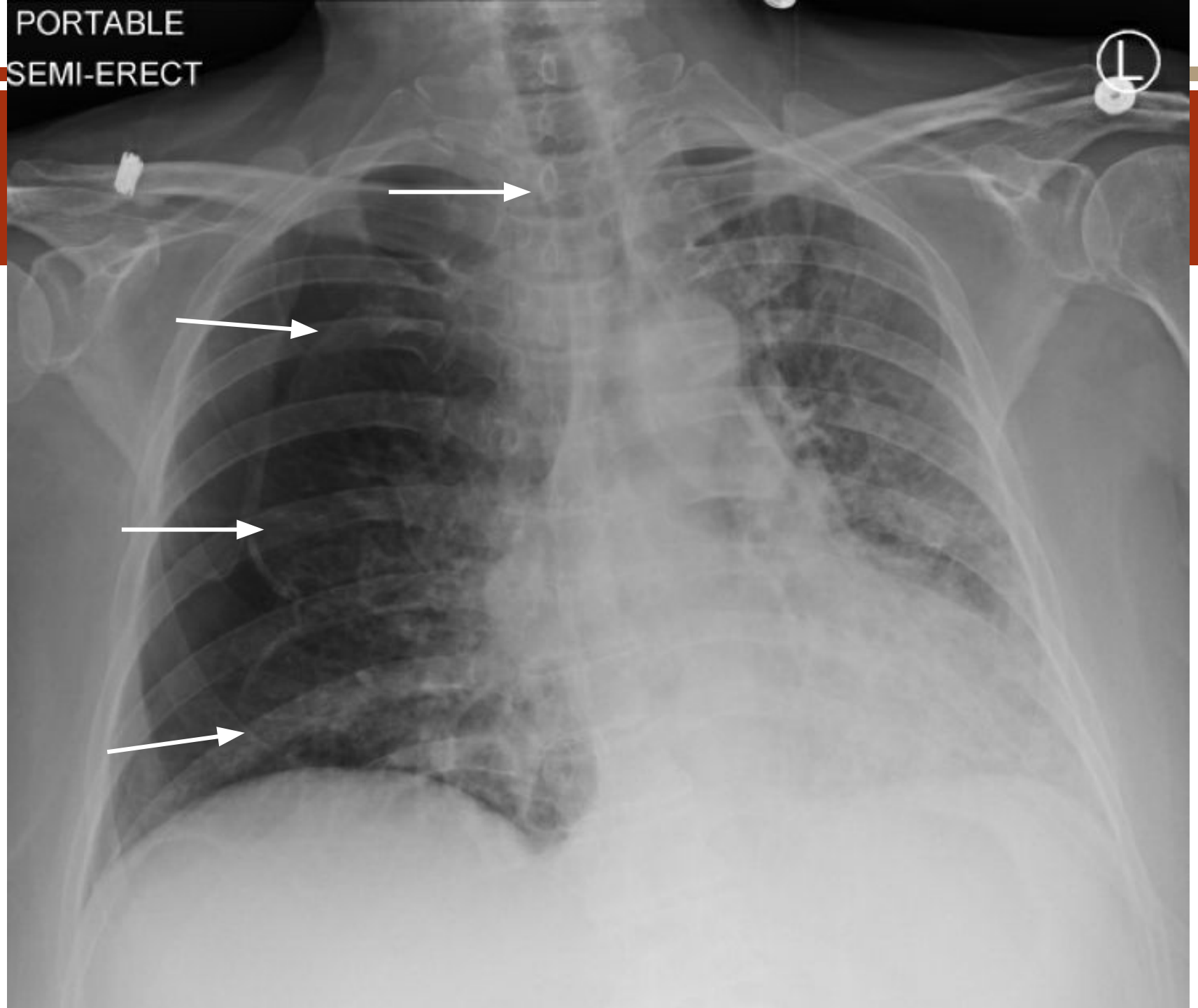
POCUS



CXR



NEXT STEP

- 14 French Chest tube inserted into the 4th intercostal space, mid-axillary line.
- Patient shortness of breath improved immediately.
- Repeat POCUS performed.

POCUS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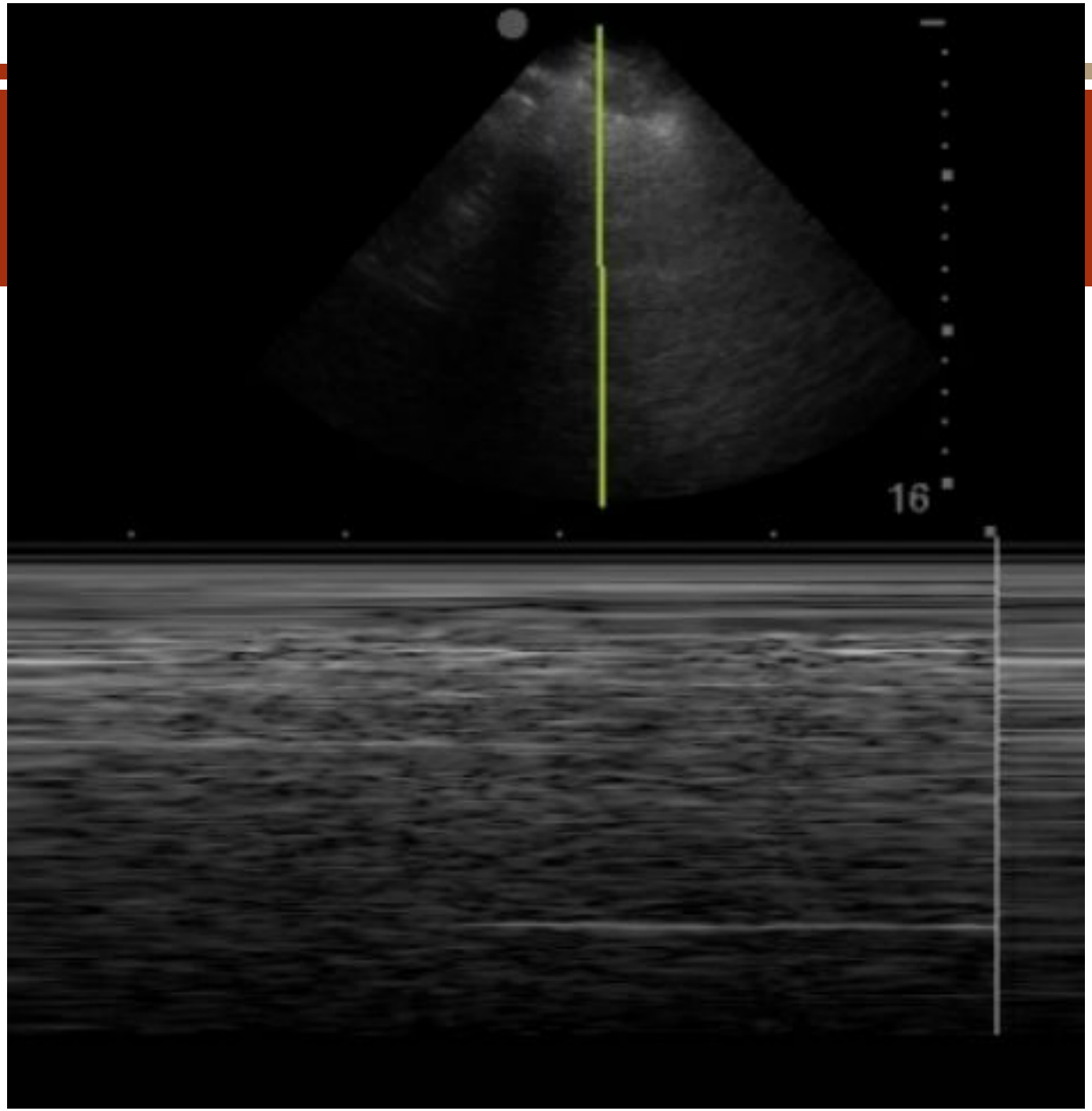
POCUS



WHAT FINDINGS WERE SEEN IN BOTH SEQUENCES?

A-LINES

- A-Lines are reverberation artifacts that arise when the ultrasound beam reflects off the pleura, back to the transducer, back to the pleura, and finally re-entering the transducer. *The more reverberations, the more a-lines.*
- Presence of A-lines is strictly dependent on the operator, the pathway must be perpendicular to the pleural surface in order for the cycle to generate.
- The presence of A-lines indicates air, and that the lungs are not edematous.
- **HOWEVER:** Unable to differentiate between alveolar air, and pleural air.

HOW CAN ULTRASOUND BE USED TO DIAGNOSE PNEUMOTHORAX?

- Retrospective study of patients admitted to the MICU of a university-affiliated teaching hospital.
- Population: Patient admitted to the SICU/MICU who received a whole-body US, CXR, and CT scan.
  - Study Group: No pneumothorax on CXR who underwent an US and CT.
  - Control Group: No radiologic pneumothorax, who underwent CT that confirmed no pneumothorax.
  - Patients were excluded if they had a visible pneumothorax on CXR as there was no diagnostic dilemma *(600 hemi-thoraces).*
- Other things to note: 21 patients in the study group had chest trauma, almost all CXR's were supine.

Crit Care Med 2005; 33:1231–1238

ACCURACY OF LUNG US

	Pneumothorax	Control Group
Lung sliding (LS) abolished	43 of 43	65 of 302
LS abolished + A line sign	41 of 43	16 of 302
LS abolished + A line sign + lung point	34 of 43	0 of 302

	Sensitivity, %	Specificity, %
LS abolished	100	78
LS abolished + A line sign	95	94
LS abolished + A line sign + lung point	79	100

DIAGNOSTIC ACCURACY OF US

EVIDENCE FROM SYSTEMATIC REVIEWS

EUR RESPIR REV 2016; 25: 230–246 | DOI: 10.1183/16000617.0047-2016

DIAGNOSTIC ACCURACY

	Number of studies	Population, unit of analysis	US features, comparator	Reference standard	Prevalence and number	Sensitivity	Specificity
Pneumothorax							
Wilkerson 2010 [25]	4 studies No meta-analysis	Blunt trauma, By patient (3 studies) By hemithorax (1 study)	Not stated CXR	Chest CT or release of air	21.5–30.1% of 497 patients 11.5% of 218 hemithoraces	US: 86–98% CXR: 28–75%	US: 97–100% CXR: 100%
Ding 2011 [24]	20 studies	Trauma, post-lung biopsy, critically ill By hemithorax#	Absent lung sliding, absent comets, lung point CXR	Chest CT or clinical findings and release of air	13.2% of 7569 hemithoraces	US: 88% CXR: 52%	US: 99% CXR: 100%
Alrajhi 2012 [27]	8 studies	Trauma, iatrogenic By patient#	Absent lung sliding, absent comets CXR	Chest CT or release of air	Not stated (unable to calculate) 1048 patients	US: 90.9% CXR: 50.2%	US: 98.2% CXR: 99.4%
Alrajab 2013 [28]	13 studies	Trauma, post-lung biopsy, critically ill By hemithorax	Not defined CXR	Chest CT	22.5% of 3028 hemithoraces	US: 78.6% CXR: 39.8%	US: 98.4% CXR: 99.3%
Ebrahimi 2014 [29]	28 studies	Trauma, iatrogenic, critically ill By patient#	Not stated CXR	Chest CT	20% of 5314 patients	US: 87% CXR: 46%	US: 99% CXR: 100%

Eur Respir Rev 2016; 25: 230–246 | DOI: 10.1183/16000617.0047-2016

SO SHOULD WE ABANDON CONVENTION CXR?

- The populations in this study involved mostly trauma, critically ill, and patients who underwent thoracic procedures. *Can this be used accurately in COPD patients or even those with spontaneous pneumothorax?*
- The rate of pneumothorax in the majority of trials was 15 to 30%.
- Many studies excluded patients in whom ultrasound was technically challenging.
- Majority of patients who underwent CXR in these studies were in the supine position, which has a low sensitivity.

IN THE ***IDEAL*** PATIENT WHAT IS THE LIKELIHOOD MY PATIENTS HAS A PNEUMOTHORAX?

Study	Ultrasound		CXR		Likelihood US		Likelihood CXR	
	Sn	Sp	Sn	Sp	LR+	LR-	LR+	LR-
Wilkerson 2010	86	97	75	100	28.67	0.14	Infinity	0.25
Ding 2011	88	99	52	100	88	0.12	Infinity	0.48
Alrajhi 2012	91	98	50	99	45.5	0.09	50	0.51
Alrajab 2013	78	98	40	99	39	0.22	40	0.61
Ebrahimi 2014	87	99	46	100	87	0.13	Infinity	0.54
Average (unweighted)	**86.00**	**98.20**	**52.60**	**99.60**	**57.63**	**0.14**	**Infinity**	**0.48**

Negative LR of 0.1 changes the probability of disease by negative 45%

Positive LR of 10 changes the probability of disease by positive 45%

PROBABILITY OF PNEUMOTHORAX

Pre-Test Probability of Pneumothorax is 50 %

Ultrasound

Positive Test:	98%
Negative Test:	2%

Chest X-Ray

Positive Test:	100%
Negative Test:	32%

Remember, likelihood ratios are only as good as the study data that was used to generate them!

COCHRANE REVIEW: PENDING

Cochrane Database of Systematic Reviews

Chest ultrasonography versus supine chest radiography for diagnosis of pneumothorax in trauma patients in the emergency department

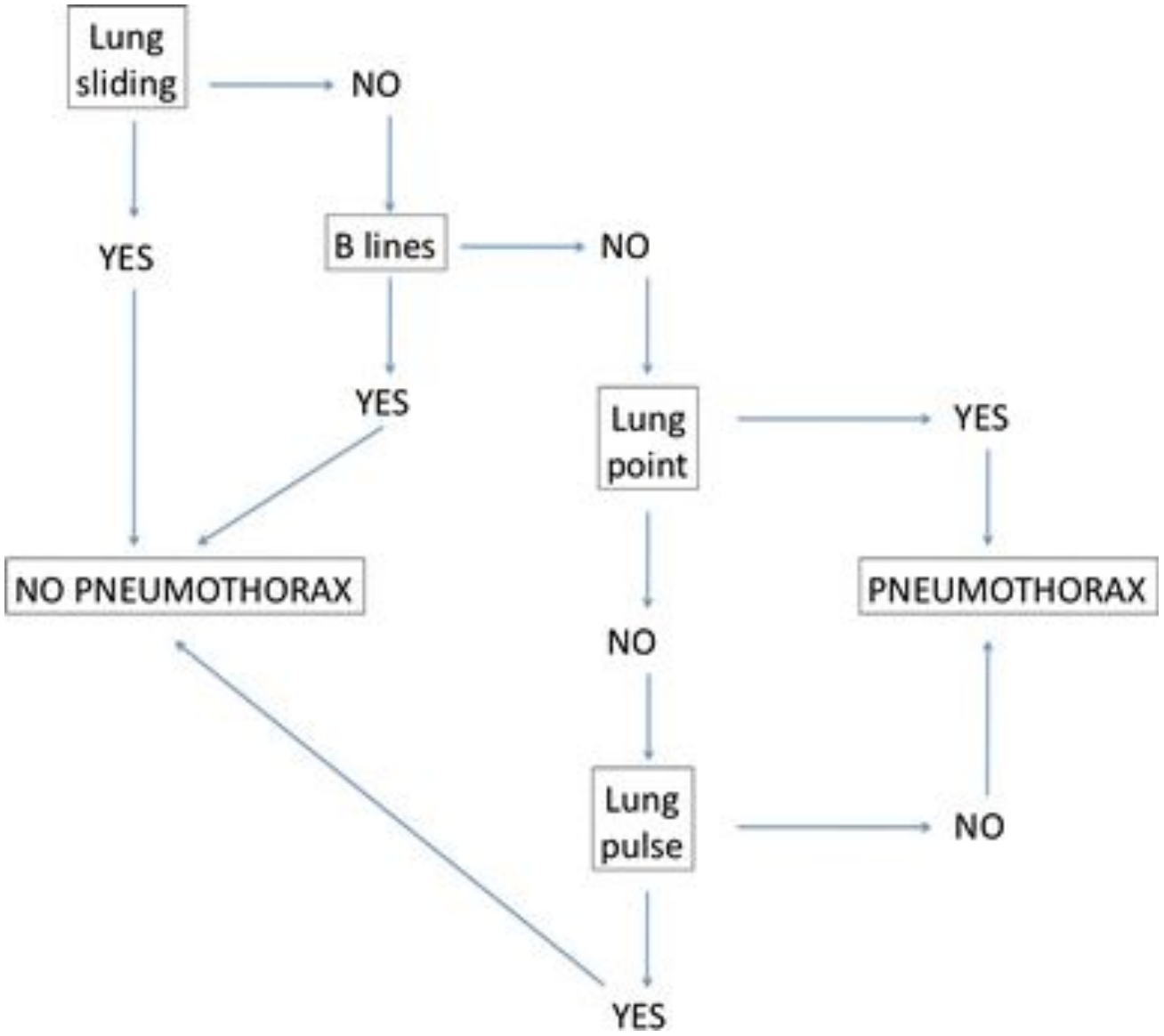
Cochrane Systematic Review - Diagnostic - Protocol | Version published: 15 May 2018 see what's new

https://doi.org/10.1002/14651858.CD013031

Am score 1 View article information

Kenneth K Chan | Daniel A Joo | Andrew D McRae | Yemisi Takwoingi | Zahra A Premji | Eddy Lang | Abel Wakai

View authors' declarations of interest



Lung Pulse: Rhythmic movement of the visceral pleural along the stationary parietal pleura when the cardiac muscle contracts.

Volpicelli, Giovanni, et al. "International Evidence-Based Recommendations for Point-of-Care Lung Ultrasound." *Intensive Care Medicine*, vol. 38, no. 4, June 2012, pp. 577–591., doi:10.1007/s00134-012-2513-4.

CASE 2

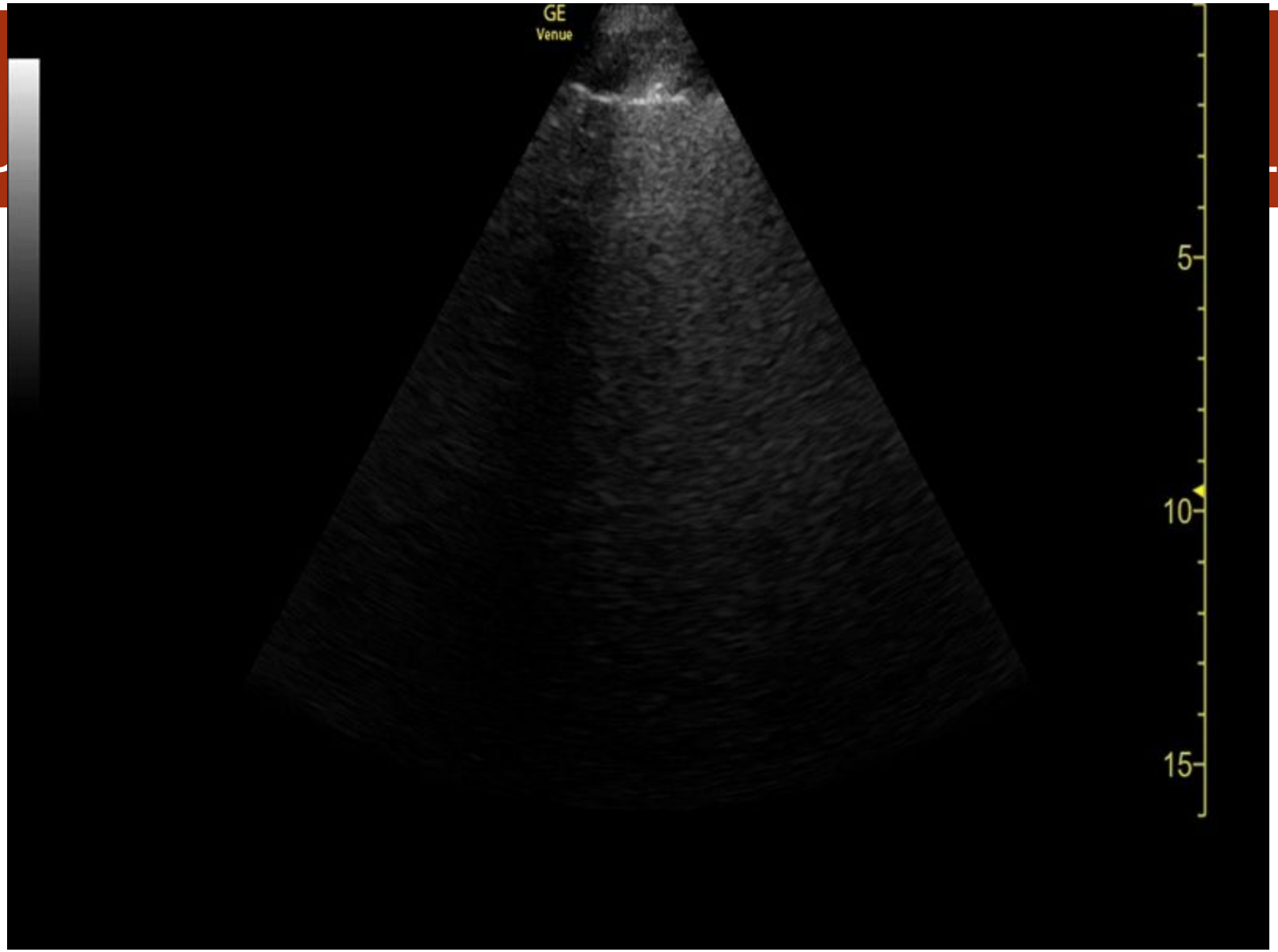
- 51 y/o male transferred for management of a flare of hypersensitivity pneumonitis causing severe ARDS (P/F < 100), **worsening oxygenation on the mechanical ventilator.**
- In order to maintain his pO2 and pCO2, the patient has had high plateau pressures, consistently around 35 cm H2O.

BEDSIDE ULTRASOUND: MID CLAVICULAR 4TH INTERCOSTAL

BEDSIDE ULTRASOUND: MID CLAVICULAR 4TH INTERCOSTAL

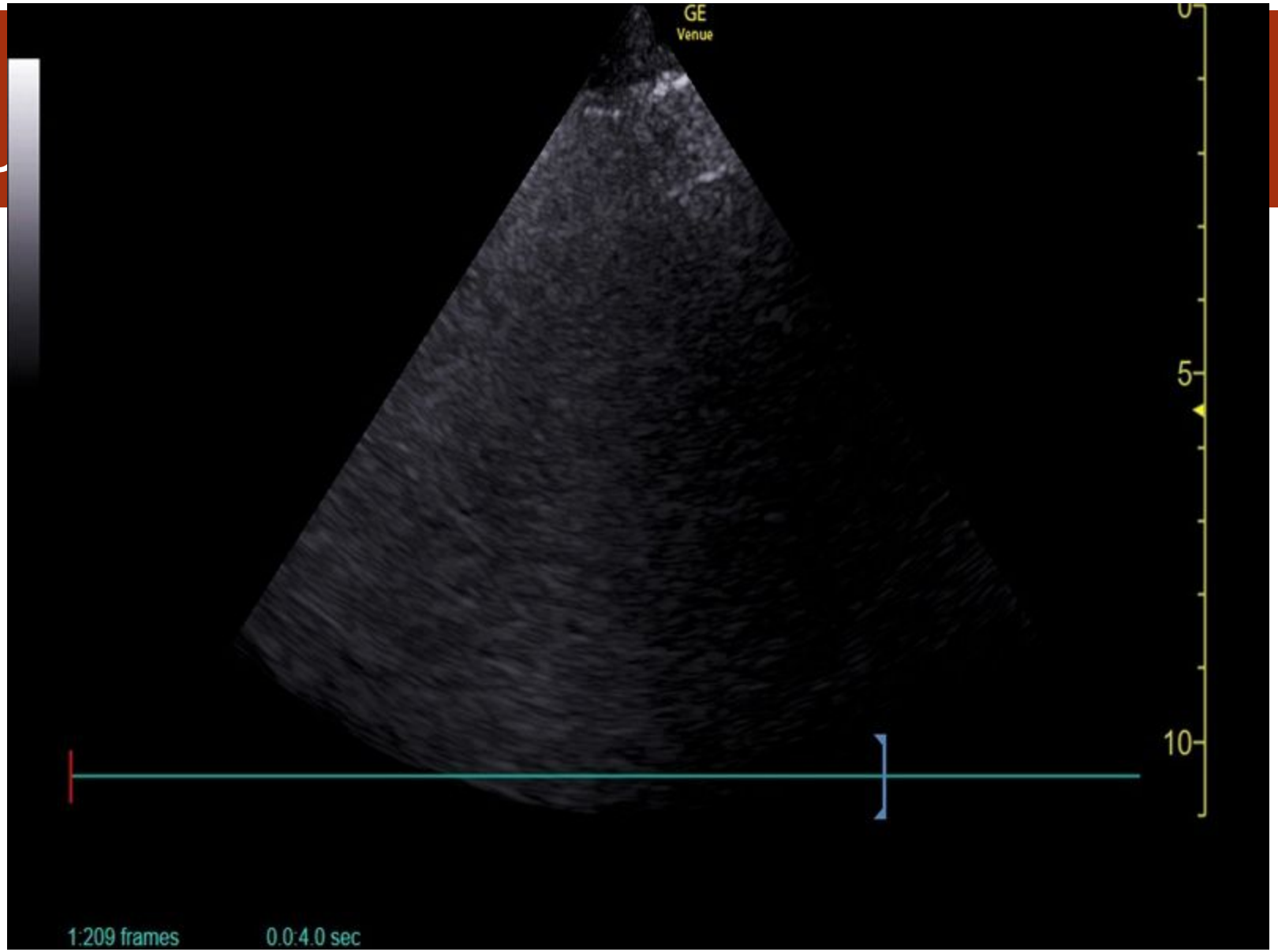
BEDSIDE ULTRASOUND: PARASTERNAL 4TH INTERCOSTAL

BEDSIDE U



BEDSIDE ULTRASOUND: PARASTERNAL LONG AXIS

BEDSIDE U

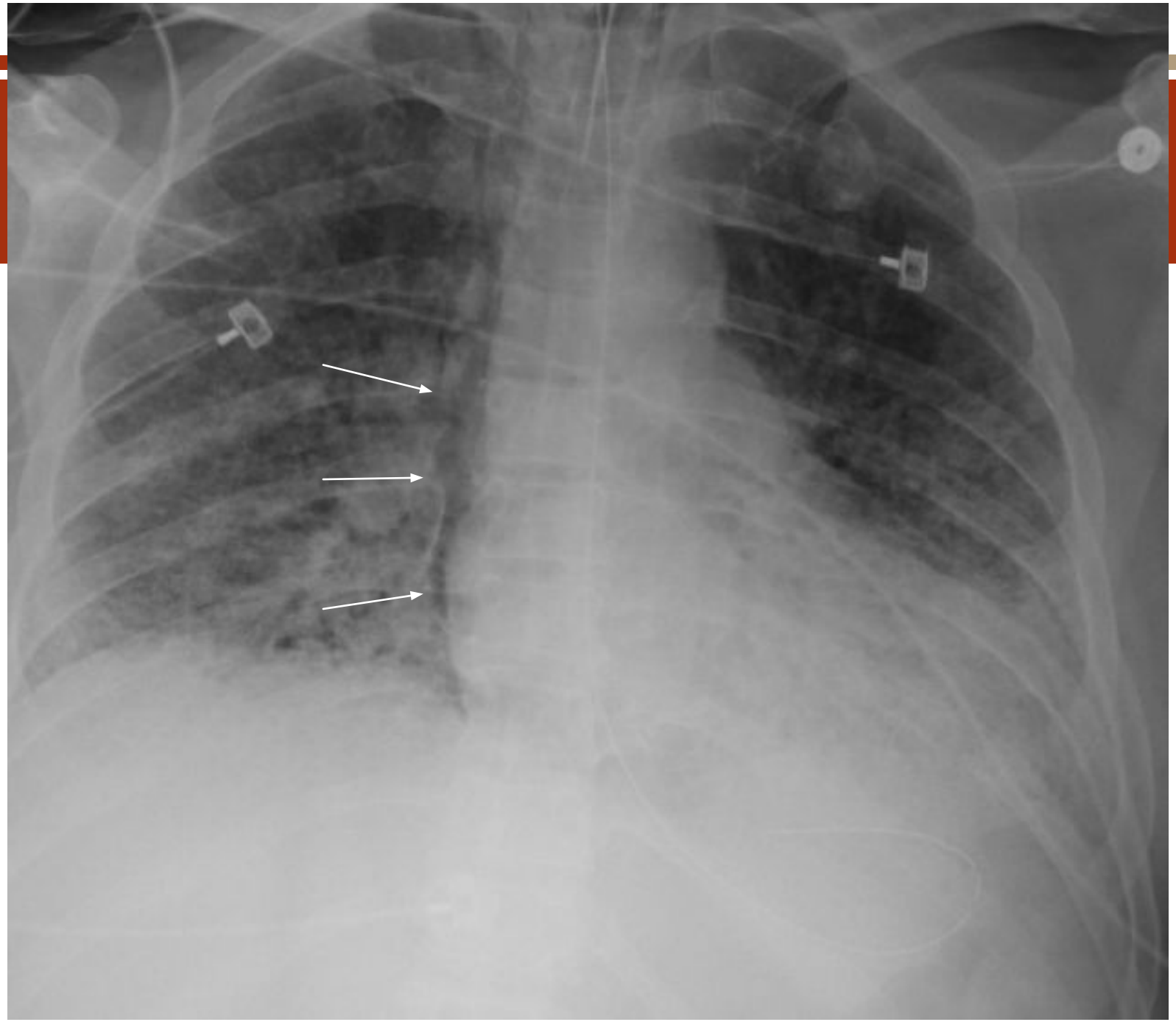


BEDSIDE ULTRASOUND: SUB-XIPHOID

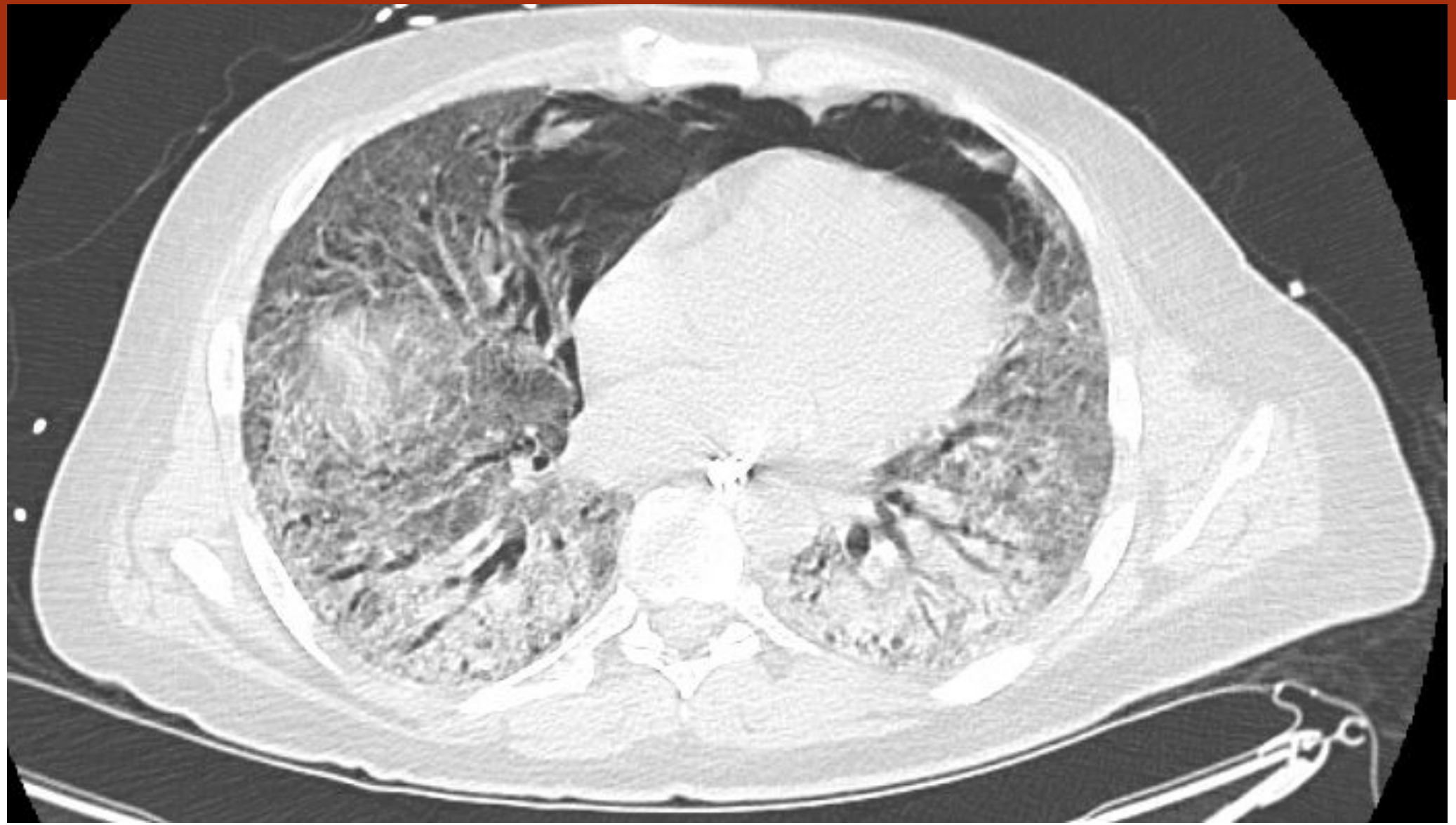
BEDSIDE U

DIAGNOSIS?

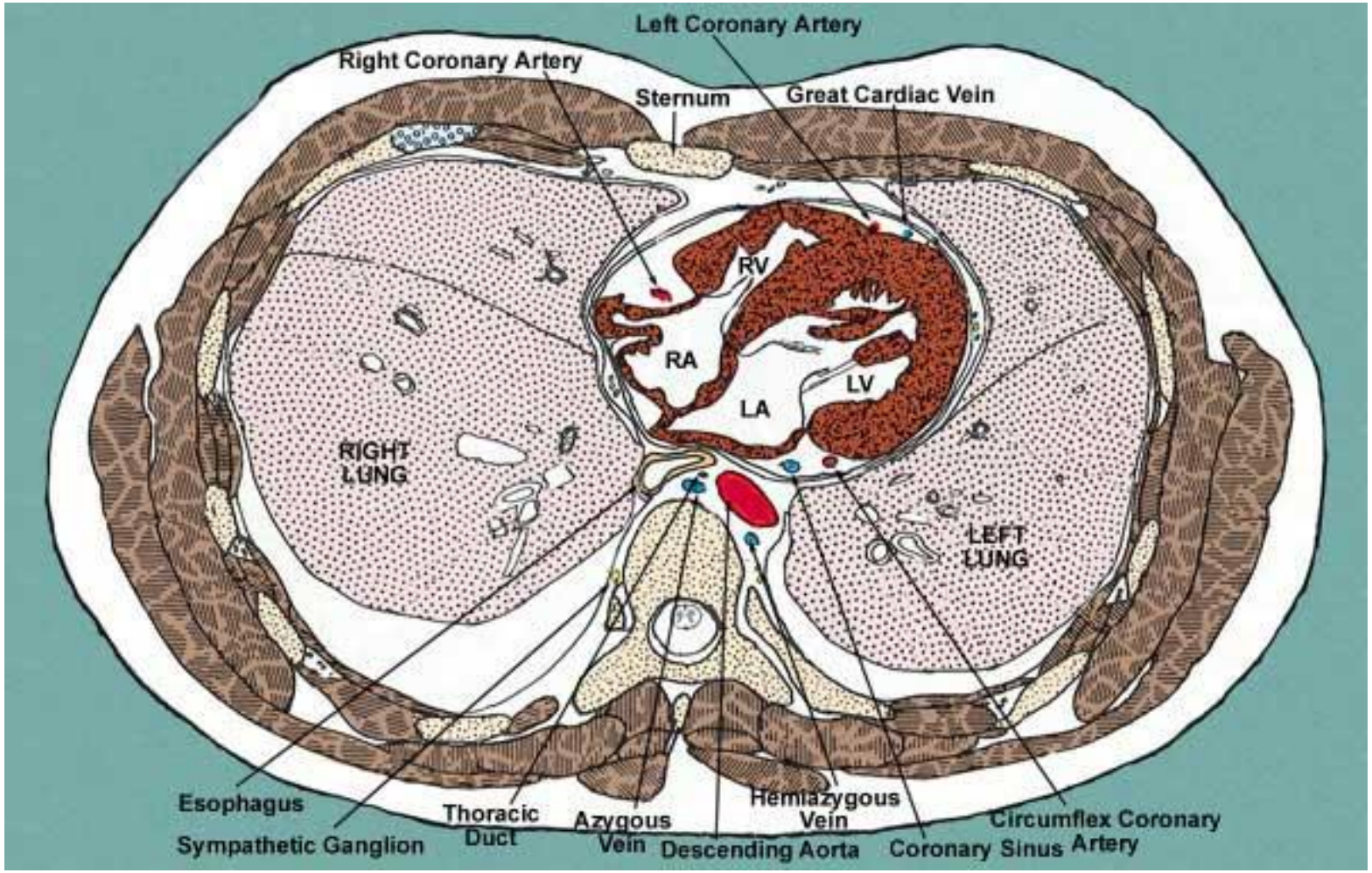
CXR



CT CHEST

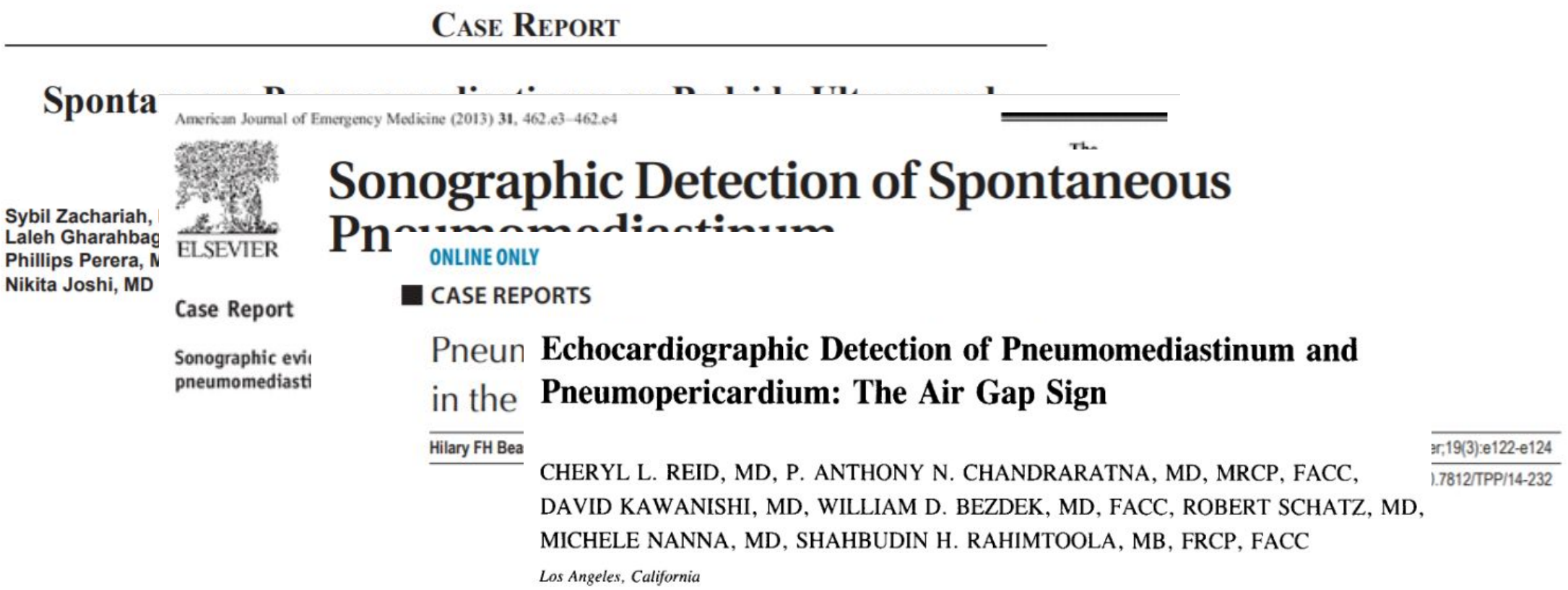


MEDIASTINUM ANATOMY



Norman, Wess. "Representative Levels of Cross Sections of the Thorax." *Cross Sections Through the Thorax*, http://www.wesnorman.com/thoraxcrosssections.htm.

PNEUMOMEDIASTINUM ON ULTRASOUND



CASE REPORT

Sponta

Sybil Zachariah,
Laleh Gharahbag
Phillips Perera, M
Nikita Joshi, MD

Case Report

Sonographic evi
pneumomediasti

American Journal of Emergency Medicine (2013) 31, 462.e3–462.e4

ELSEVIER

Sonographic Detection of Spontaneous Pneumomediastinum

ONLINE ONLY

CASE REPORTS

Pneun in the

Hilary FH Bea

Echocardiographic Detection of Pneumomediastinum and Pneumopericardium: The Air Gap Sign

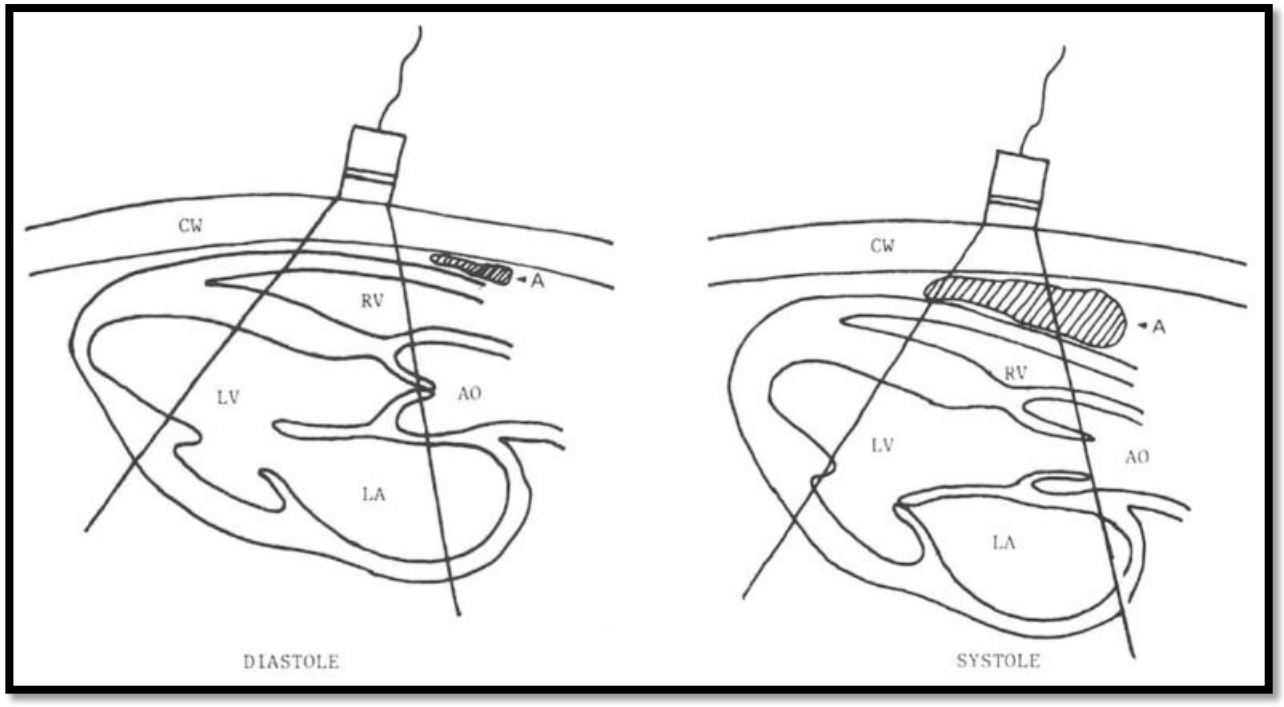
CHERYL L. REID, MD, P. ANTHONY N. CHANDRARATNA, MD, MRCP, FACC, DAVID KAWANISHI, MD, WILLIAM D. BEZDEK, MD, FACC, ROBERT SCHATZ, MD, MICHELE NANNA, MD, SHAHBUDIN H. RAHIMTOOLA, MB, FRCP, FACC

Los Angeles, California

er;19(3):e122-e124
).7812/TPP/14-232

1. Testa, Americo, et al. "Sonographic Detection of Spontaneous Pneumomediastinum." *Journal of Ultrasound in Medicine*, vol. 27, no. 10, 2008, pp. 1507–1509., doi:10.7863/jum.2008.27.10.1507.
2. Saracino, Christine, and Mark Tessaro. "Pneumomediastinum as a Sonographic Mimic of Pneumothorax." *Journal of Ultrasound in Medicine*, vol. 34, no. 8, 2015, pp. 1521–1522., doi:10.7863/ultra.34.8.1521.
3. Ng, Lorraine, et al. "Sonographic Evidence of Spontaneous Pneumomediastinum." *The American Journal of Emergency Medicine*, vol. 31, no. 2, 2013, doi:10.1016/j.ajem.2012.08.019.
4. Beason, Hilary. "Pneumomediastinum Diagnosed on Ultrasound in the Emergency Department: A Case Report." *The Permanente Journal*, Oct. 2015, doi:10.7812/tpp/14-232.
5. Zachariah, Sybil, et al. "Spontaneous Pneumomediastinum on Bedside Ultrasound: Case Report and Review of the Literature." *Western Journal of Emergency Medicine*, vol. 16, no. 2, 2015, pp. 321–324., doi:10.5811/westjem.2015.1.24514
6. Reid, Cheryl L., et al. "Echocardiographic Detection of Pneumomediastinum and Pneumopericardium: The Air Gap Sign." *Journal of the American College of Cardiology*, vol. 1, no. 3, 1983, pp. 916–921., doi:10.1016/s0735-1097(83)80209-5..

AIR GAP SIGN



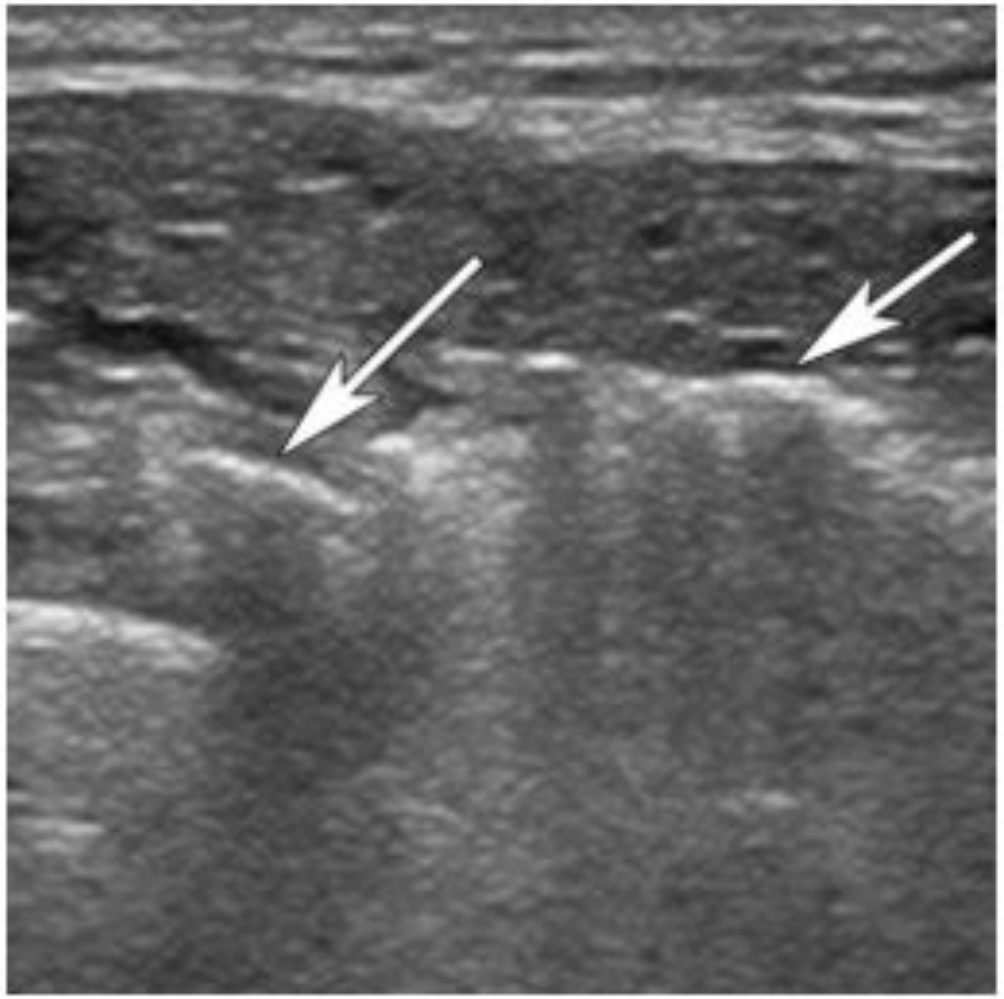
- Air is a poor conductor of ultrasound, therefore no cardiac structures will be recorded.
- Air accumulates within the pericardium or mediastinum during systole as chamber size diminishes, but air is displaced during diastole as the chamber enlarges.
- The probe should be placed at multiple cardiac views.

1. Reid, Cheryl L., et al. "Echocardiographic Detection of Pneumomediastinum and Pneumopericardium: The Air Gap Sign." *Journal of the American College of Cardiology*, vol. 1, no. 3, 1983, pp. 916–921., doi:10.1016/s0735-1097(83)80209-5..

SUMMARY OF CASE REPORTS

- Cardiac views (apical, parasternal short/long) showed a-lines, while only subcostal provided a cardiac view.
- Lung sliding can be visible over the anterior chest, but disappears towards the sternum with a “stratosphere” sign being evident with a 5-10 MHz linear transducer in M-Mode.
- Ultrasound of the anterior and anterolateral cervical region can show air or gas artifacts (comet tails / E-Lines).
- CXR can diagnose, but is not definitive, therefore if high suspicion pursue a CT chest!

E-LINES



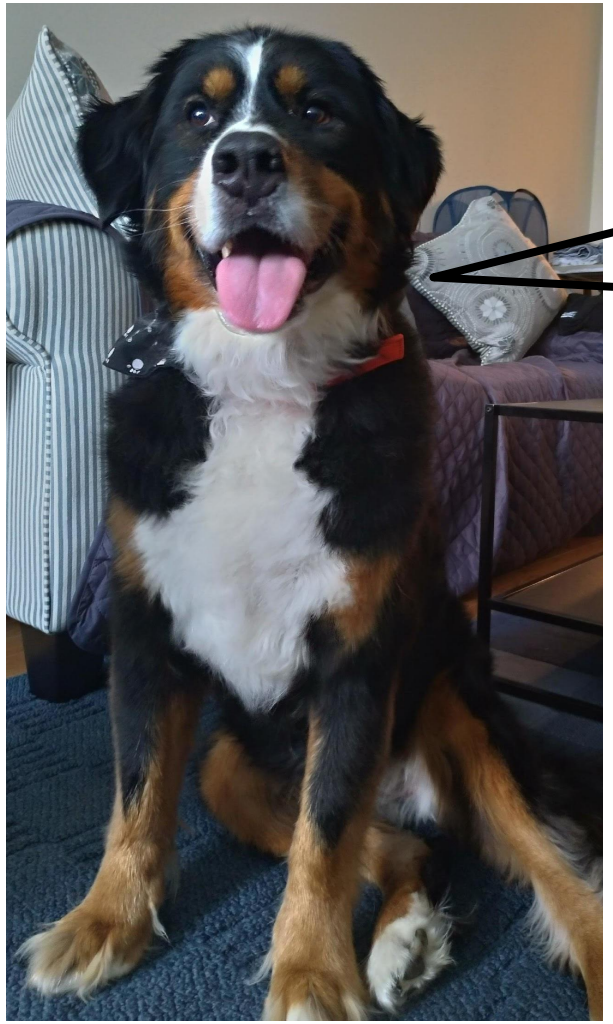
- Subcutaneous emphysema creates multiple hyperechoic lines.
- Lines are seen at a lower depth than one would expect to see the pleura, and actually erase the pleural line.
- Loss of “bat sign”.

Wongwaisayawan, S., Suwannanon, R., Sawatmongkorngul, S., & Kaewlai, R. (2016). Emergency Thoracic US: The Essentials. *RadioGraphics*, *36*(3), 640–659. doi: 10.1148/rg.2016150064

TAKE HOME POINTS

- The positive and negative likelihood ratio for US can alter your pre-test probability significantly.
  - However one should always get a PA/Lateral, erect, CXR.
- Don't be fooled!
  - Edema, musculature, and obesity can degrade image quality.
  - In patients with vigorous intercostal muscle contraction, the movement of the parietal pleura can mimic lung sliding.
  - Occluded lung will not slide: Foreign body, intubation of contralateral bronchus, mucous plug, tumor.
  - Areas of the pleura that have undergone pleurodesis will not move.
  - Lung point mimics are the edge of bullae or edge of the diaphragm.
- There is more in the chest than just the lungs, consider mediastinal air if there is an "air gap" sign and/or the only visible cardiac window is sub-xiphoid.

QUESTIONS



Yes!

When is dinner?!?!?!