Thoracic Ultrasound

Objectives

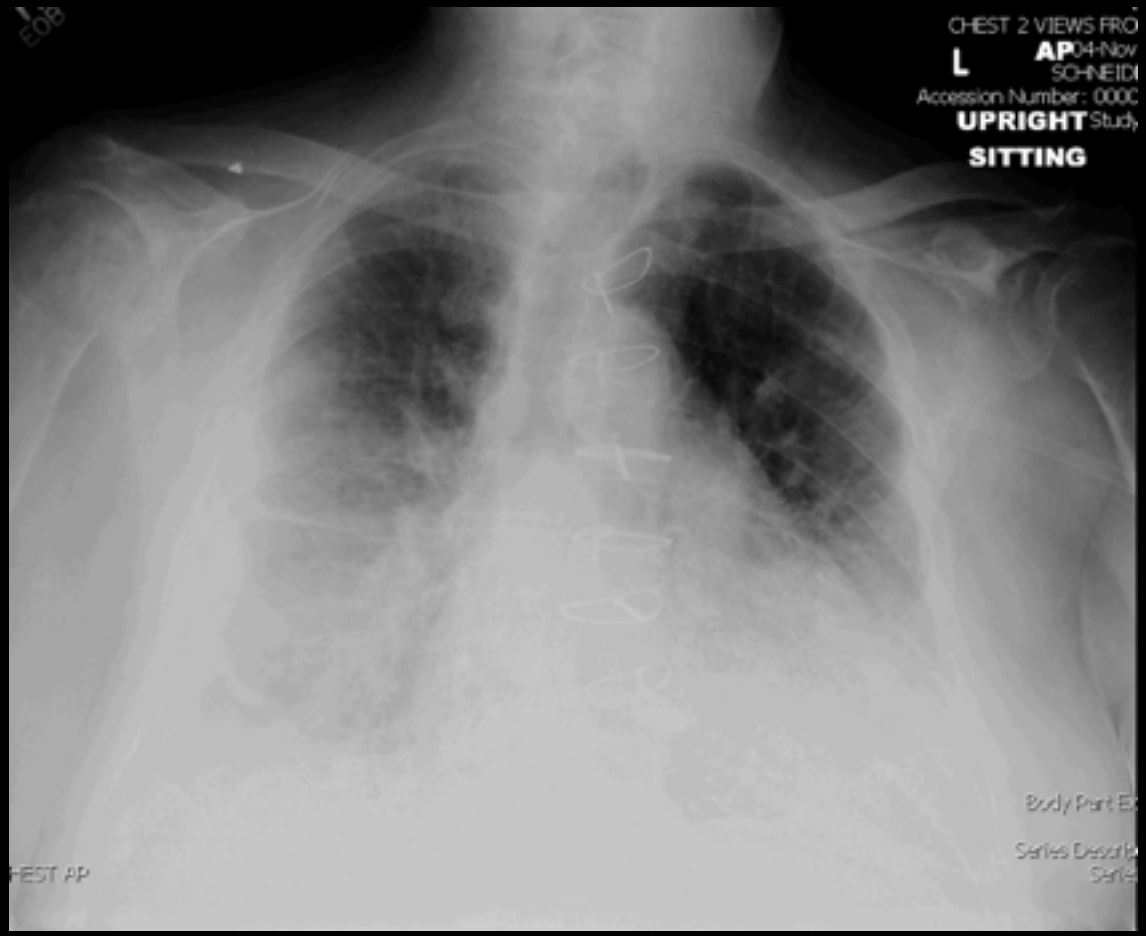
- pneumothoraces, pleural effusions, pulmonary edema, consolidations
- When to use
- false positives/negatives

Clinical Indication

- Acute shortness of breath or hypoxia
  - Obtain information rapidly
  - Initiate treatment
- Use in conjunction with other ultrasound exams

Introduction

Clinical Indication



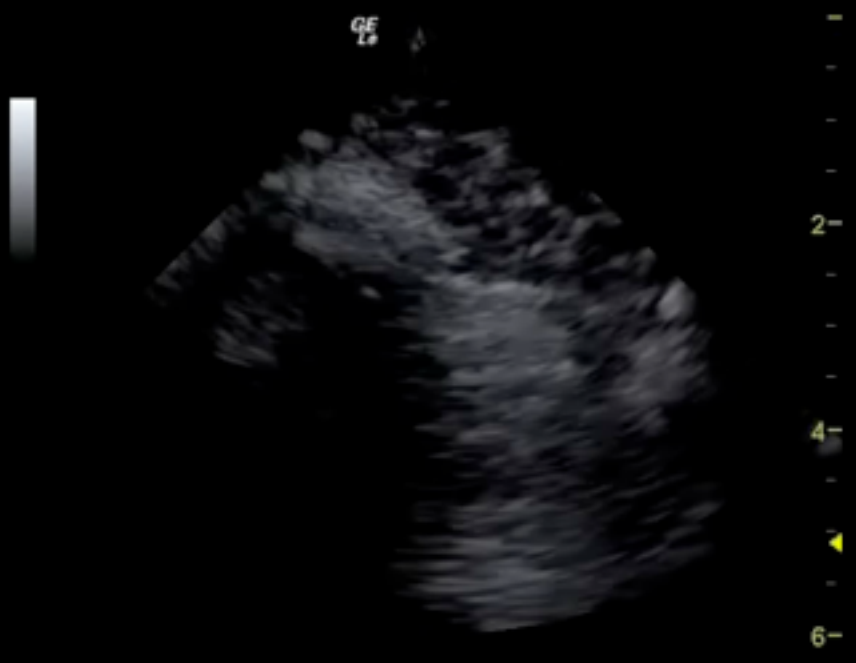
plain films may be ambiguous

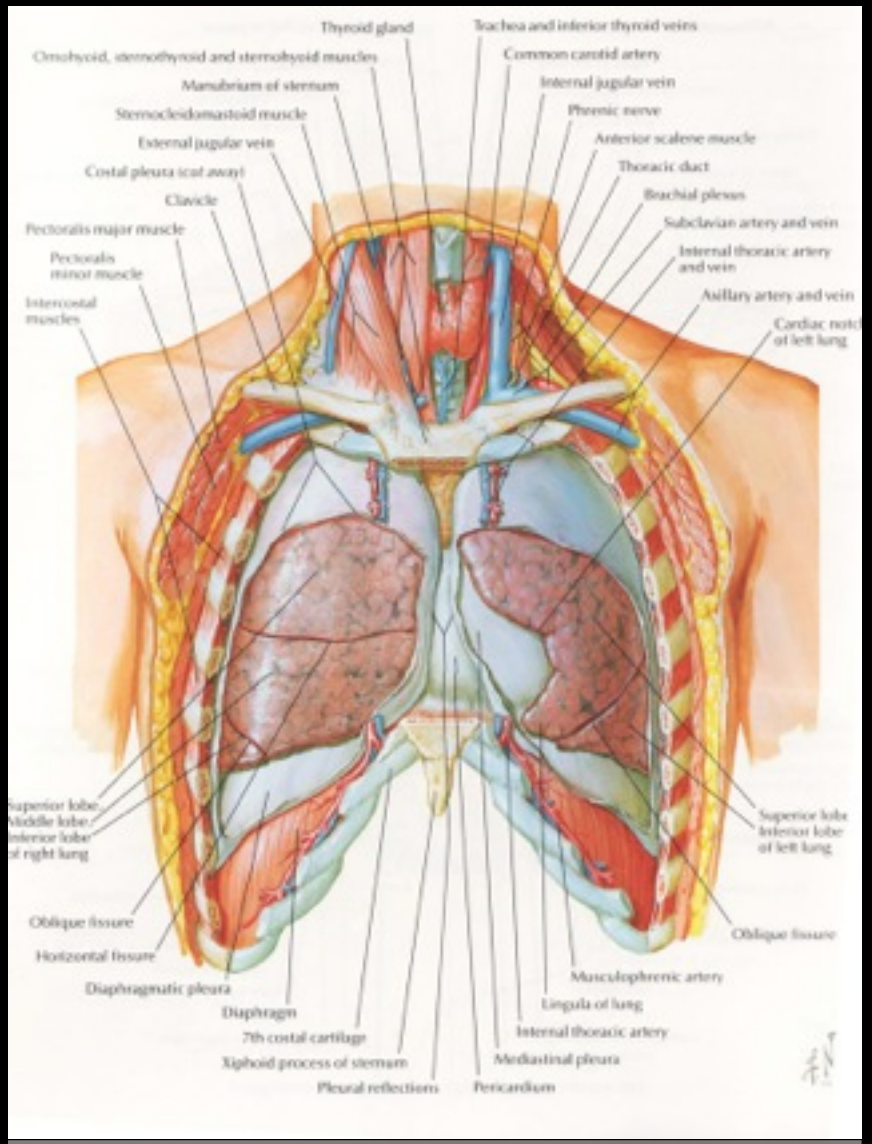
- pneumonia, pulmonary edema, pleural effusions appear similar on x-ray
- distinct appearances with ultrasound

Introduction

Anatomy

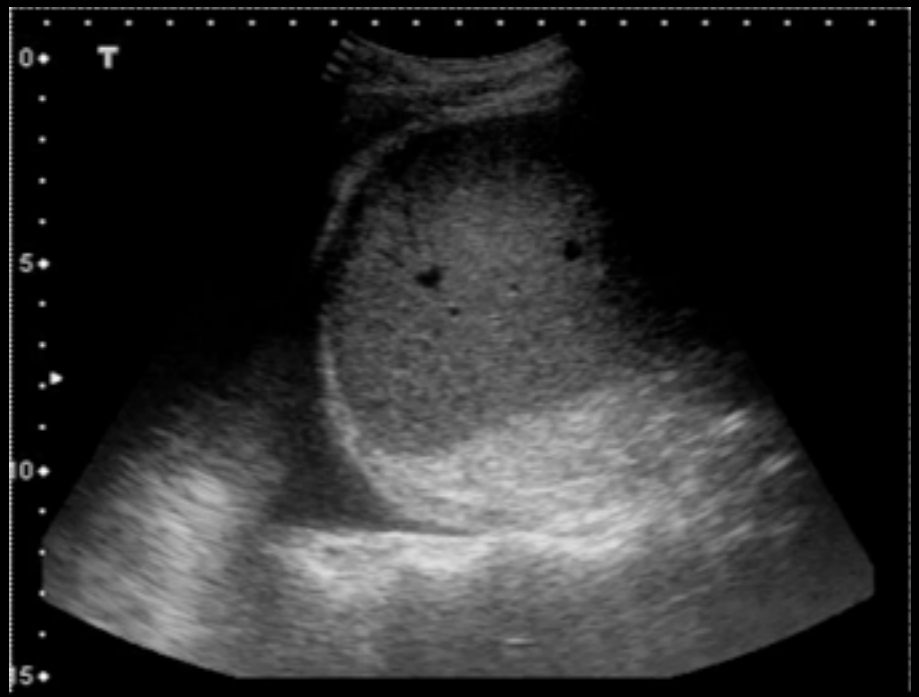
- Pre-1980s: lung ultrasound thought to be ineffective



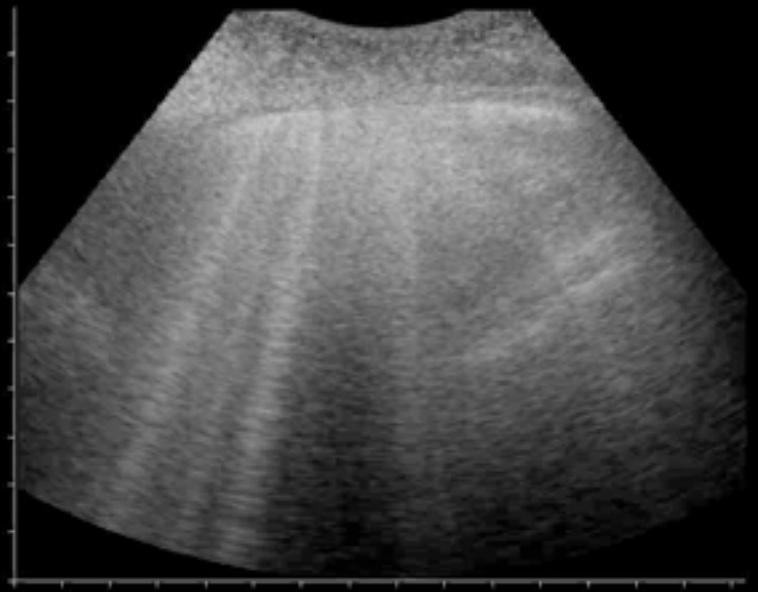


Introduction

Normal Sonographic Findings



solid organs



artifact

Ultrasound of lungs and pleura may be useful

Technical Considerations

Technical Considerations

Probe Selection

- 6-13 MHz
- Linear Array

Most useful for pneumothorax exam

Technical Considerations

Probe Selection

- 2-5 MHz
- Curvilinear array
- Large footprint

- 1-5 MHz
- Deep penetration
- Small footprint

Most useful for pulmonary edema, pleural effusions, or consolidations

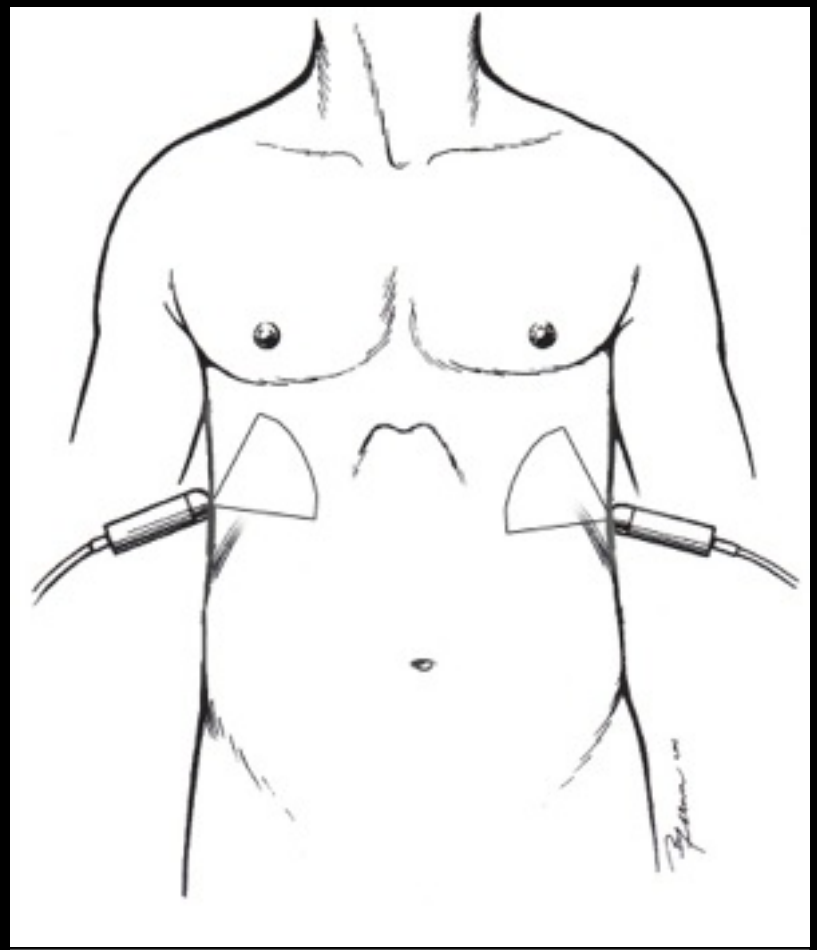
Pleural Effusions

Normal Sonographic Findings

Costophrenic Angles

Pleural Effusions

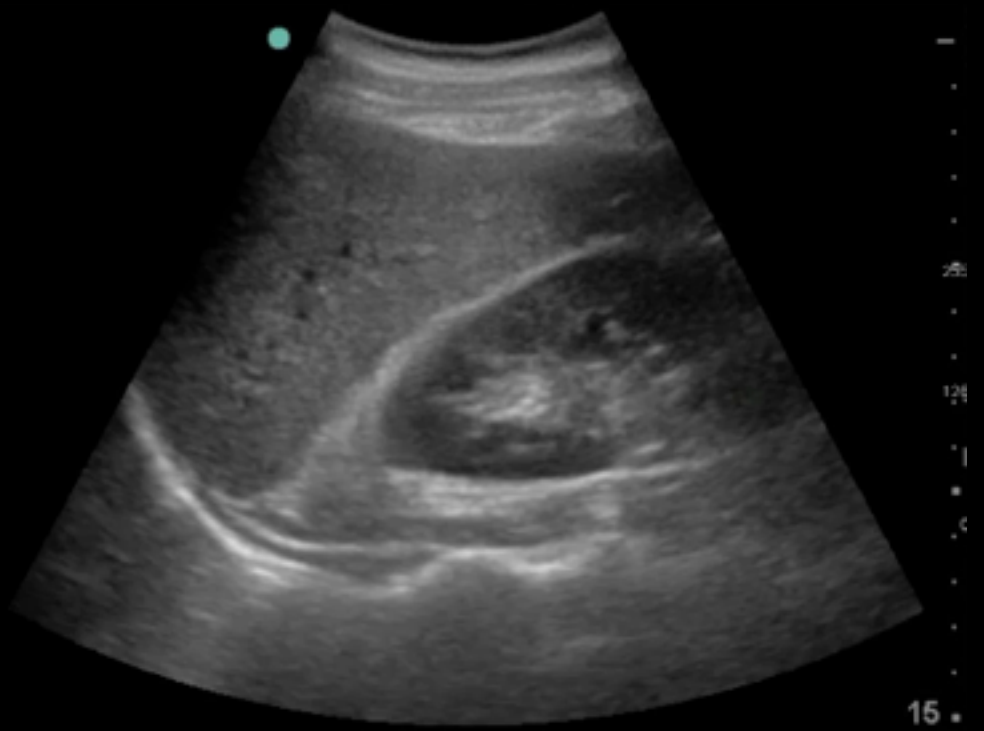
- Right and left costophrenic angles evaluated separately
- liver and spleen as sonographic windows



Normal Sonographic Findings

Right Costophrenic Angle

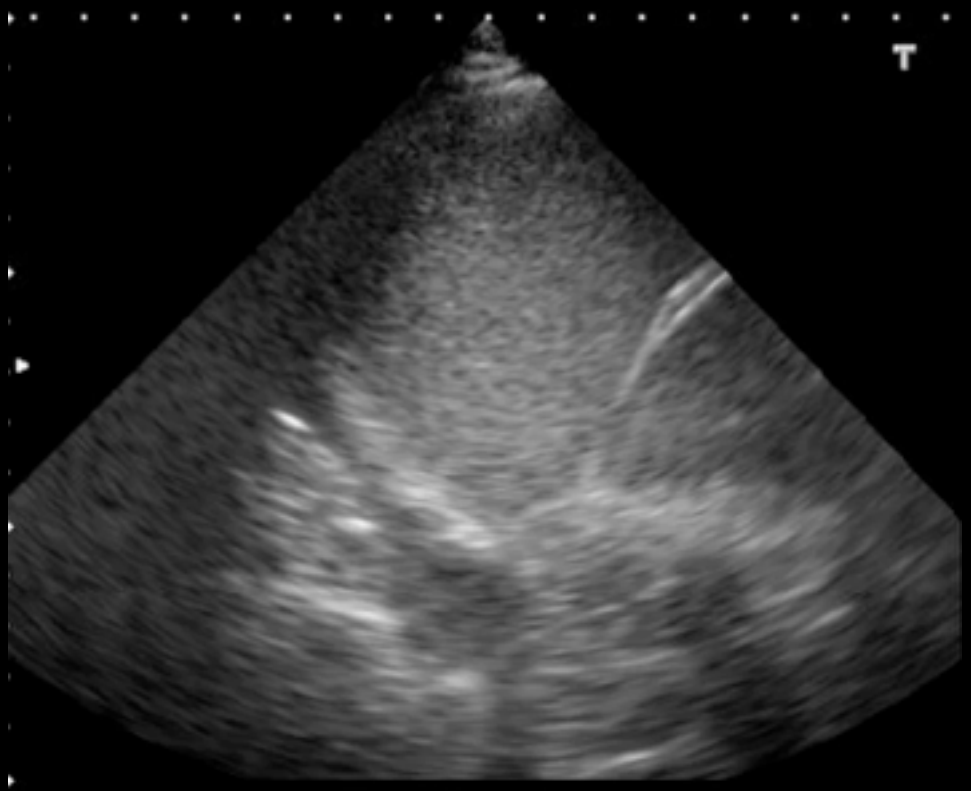
right CFA



Normal Sonographic Findings

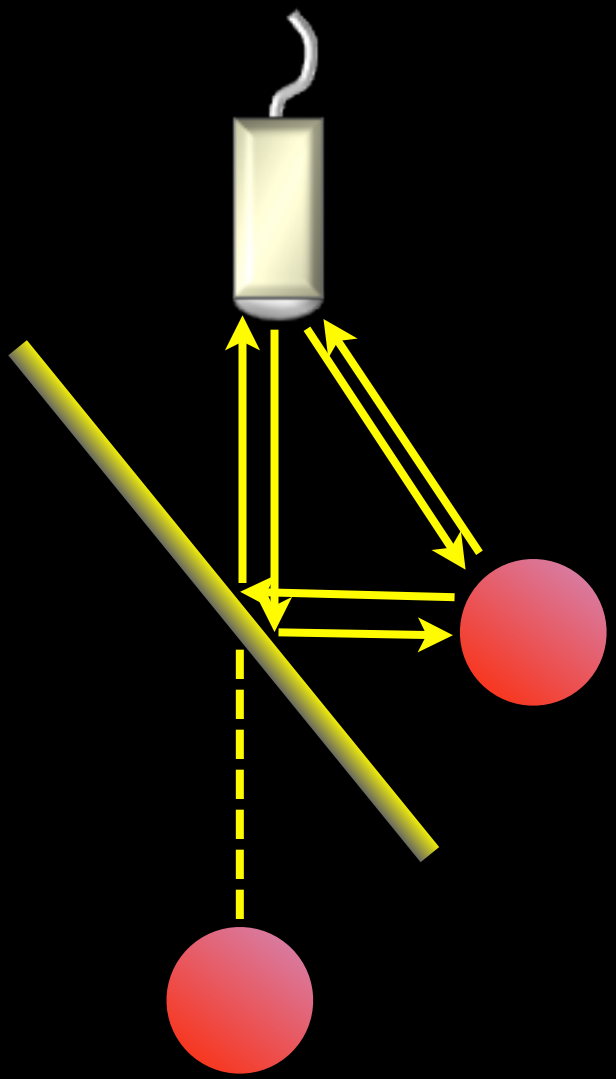
Left Costophrenic Angle

left CFA



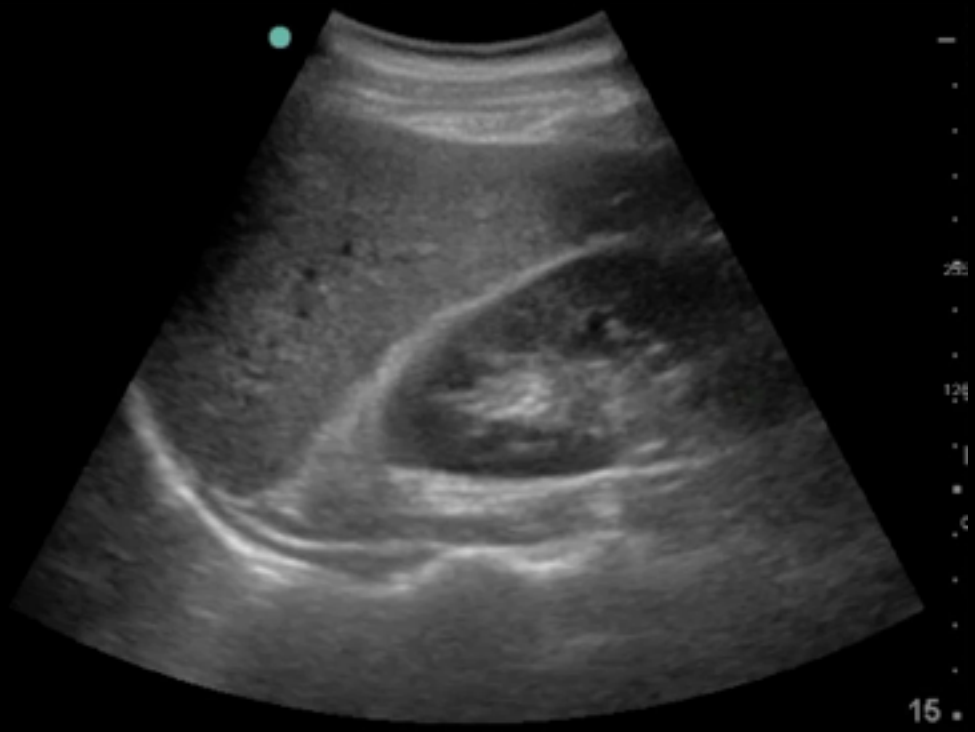
Normal Sonographic Findings

Mirror Artifact



Normal Sonographic Findings

Mirror Artifact



- Liver is mirrored superior to diaphragm
- Presence of mirror artifact indicates *absence of pleural effusion*

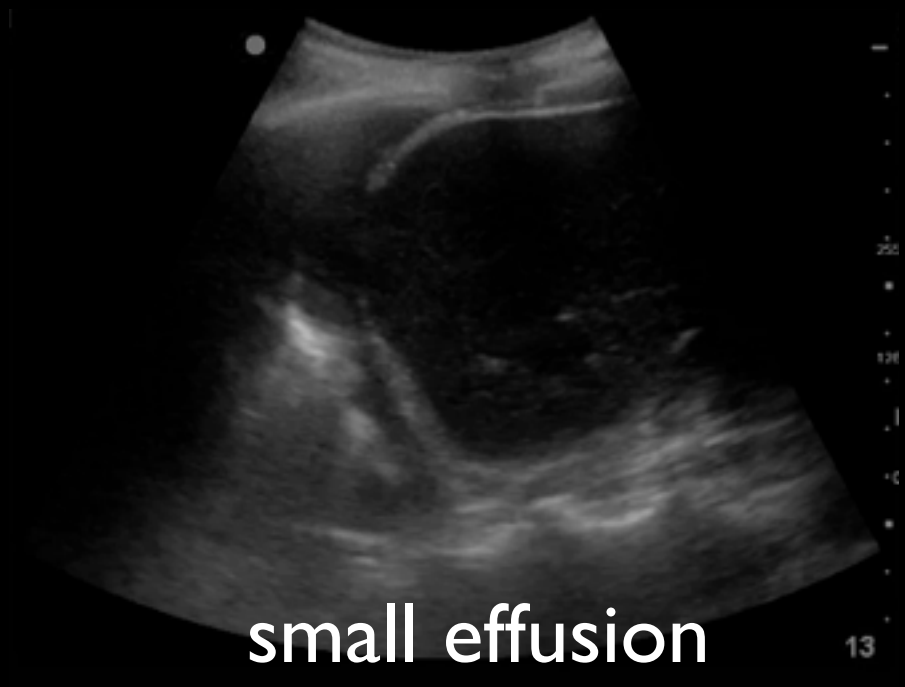
Sonographic Pathology

Pleural Effusion

- Loss of mirror artifact
- Fluid is visible
- Lung parenchyma may be visible

Sonographic Pathology

Pleural Effusion



small effusion

large effusion

Two scenarios:
Trauma = Hemothorax
Medical = Pleural Effusion

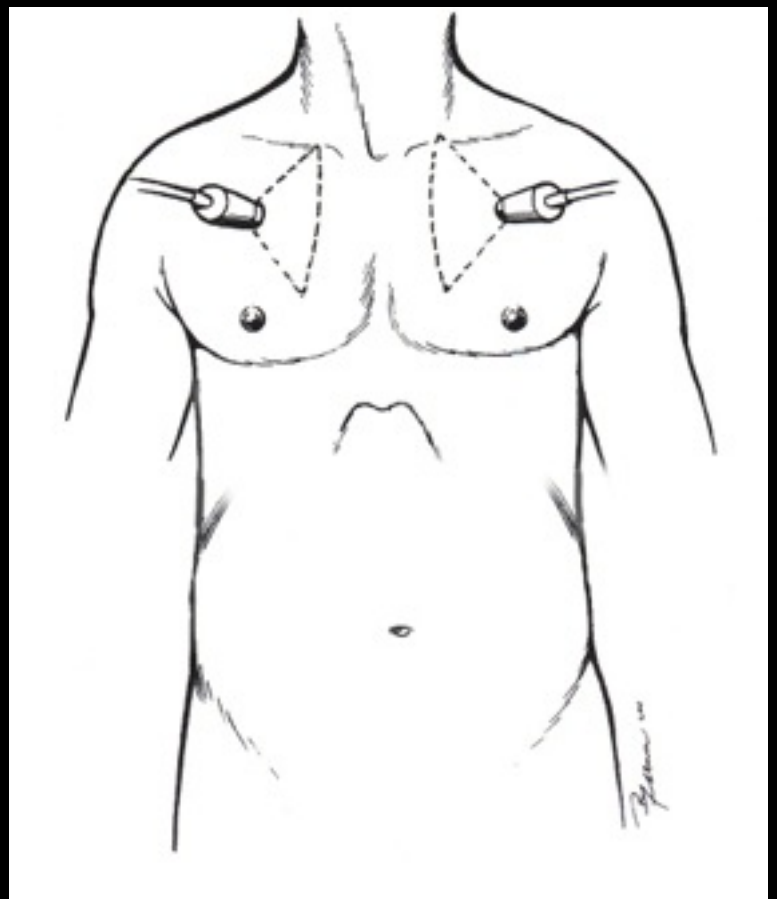
Pneumothorax

Normal Sonographic Findings

Pleural Interface

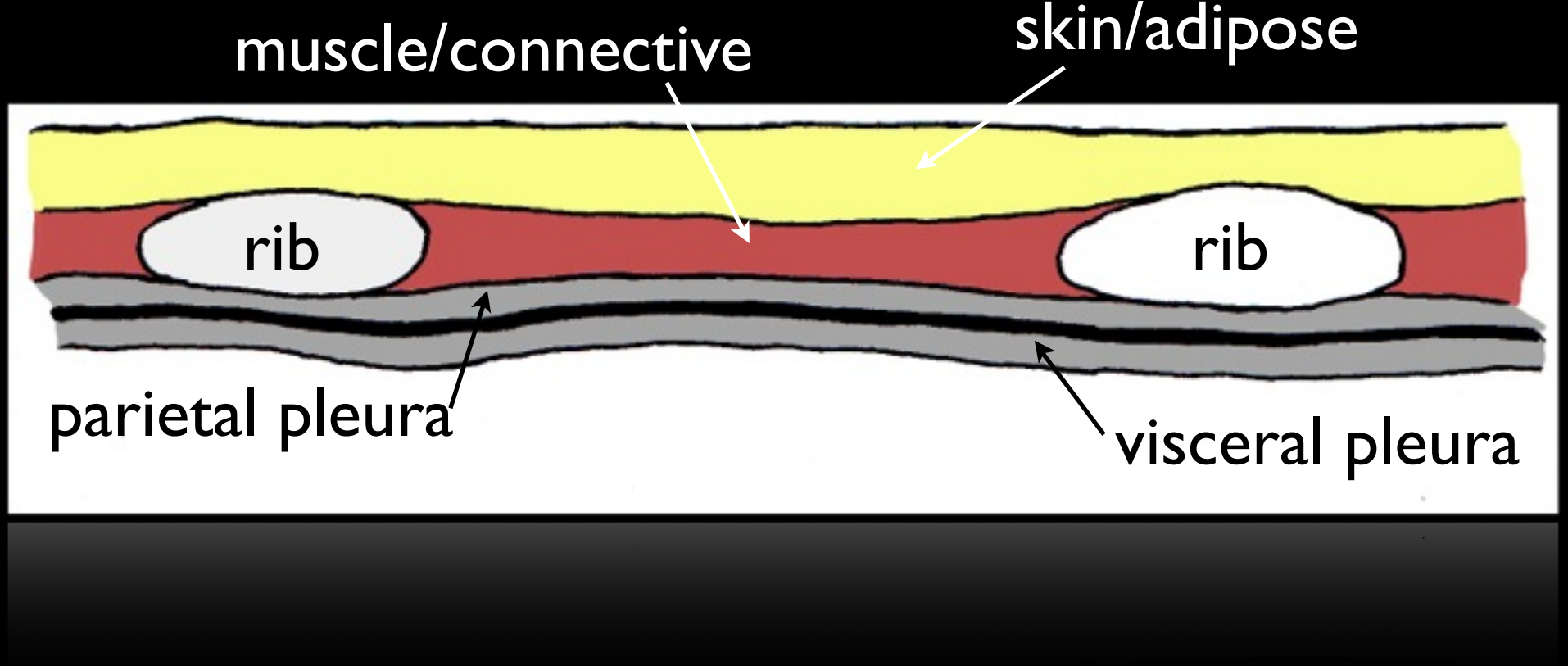
Evaluation for pneumothorax and pulmonary edema

- identifies the interface of visceral and parietal pleura
- uses "ring-down artifact" to exclude pneumothorax
- excessive "ring-down" indicates pulmonary edema



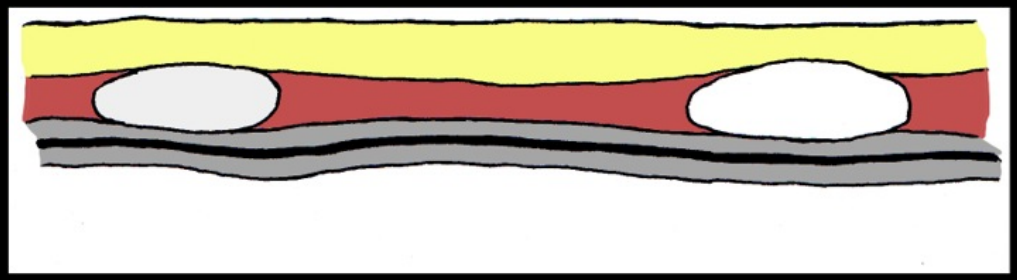
Normal Sonographic Findings

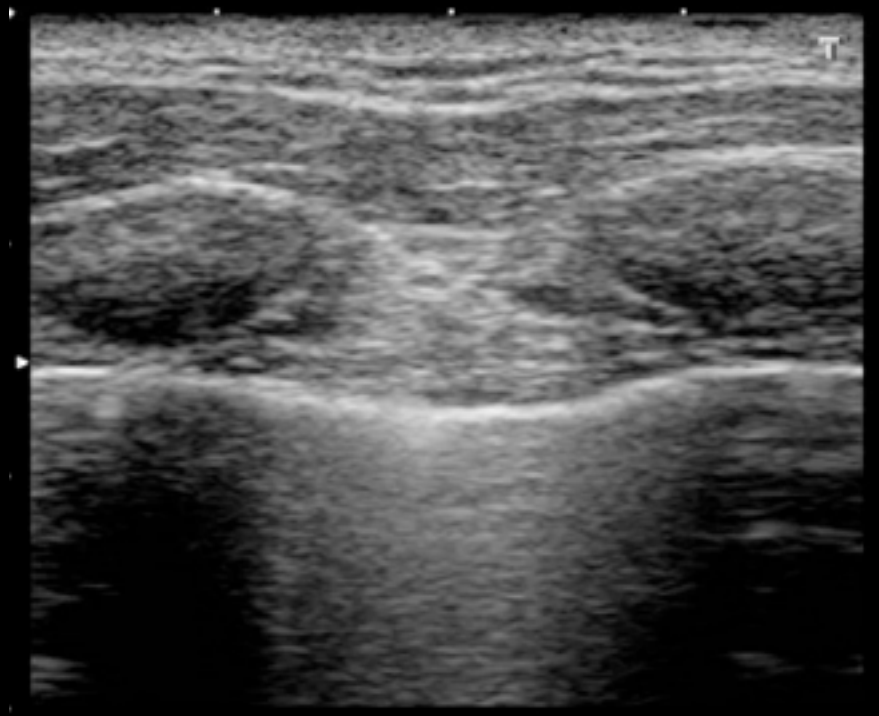
Pleural Interface



Normal Sonographic Findings

Pleural Interface

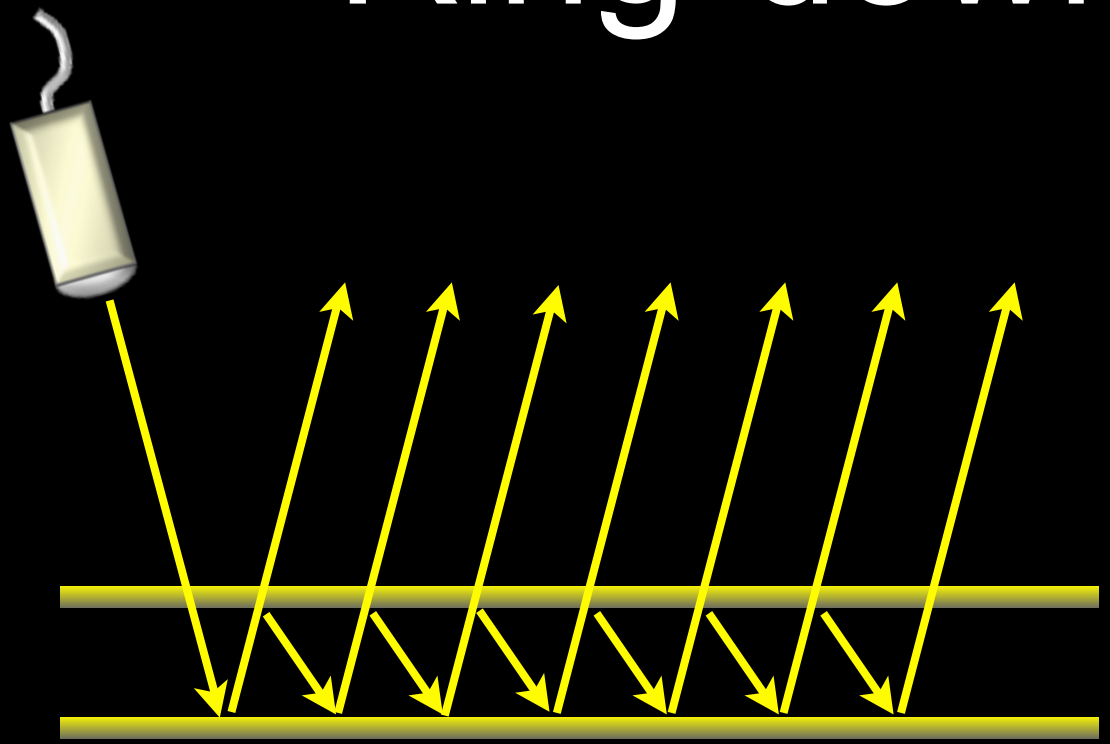


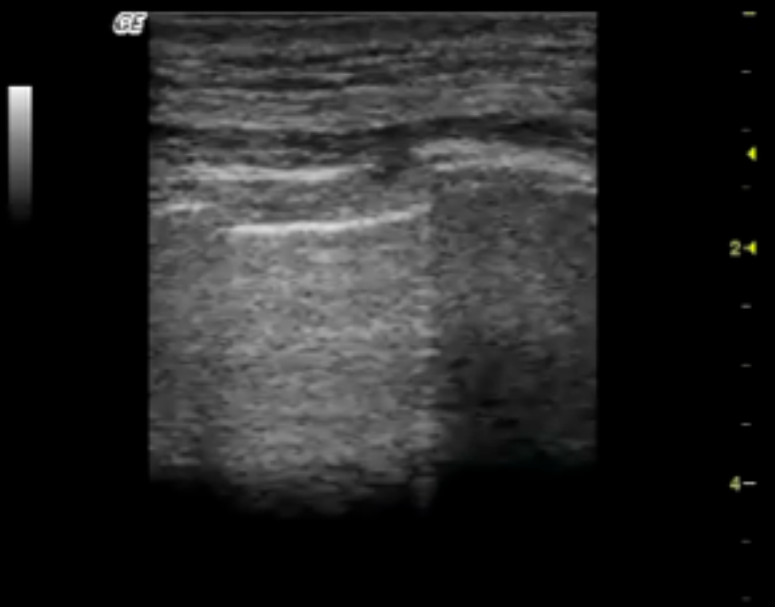


- Ring-down artifact and lung sliding are normal findings

Normal Sonographic Findings

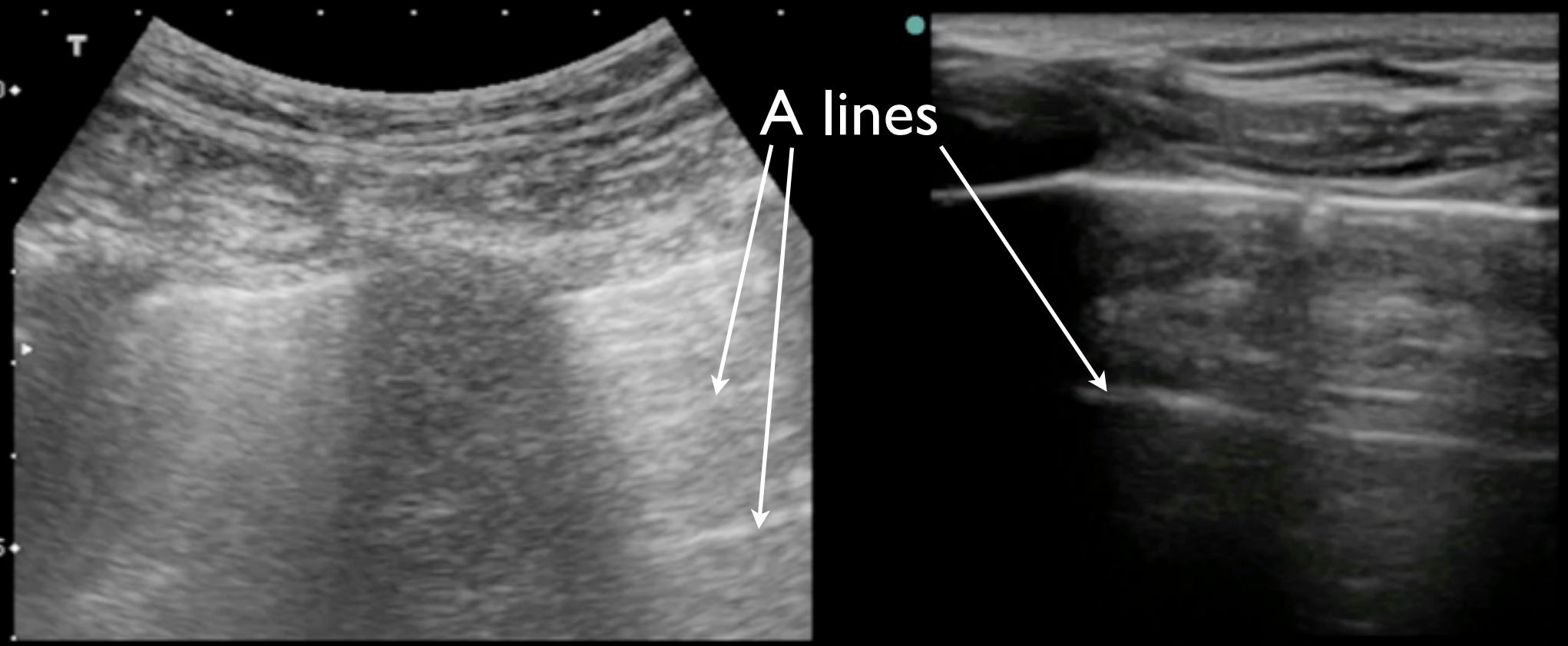
Ring-down Artifact





Normal Sonographic Findings

Pleural Interface

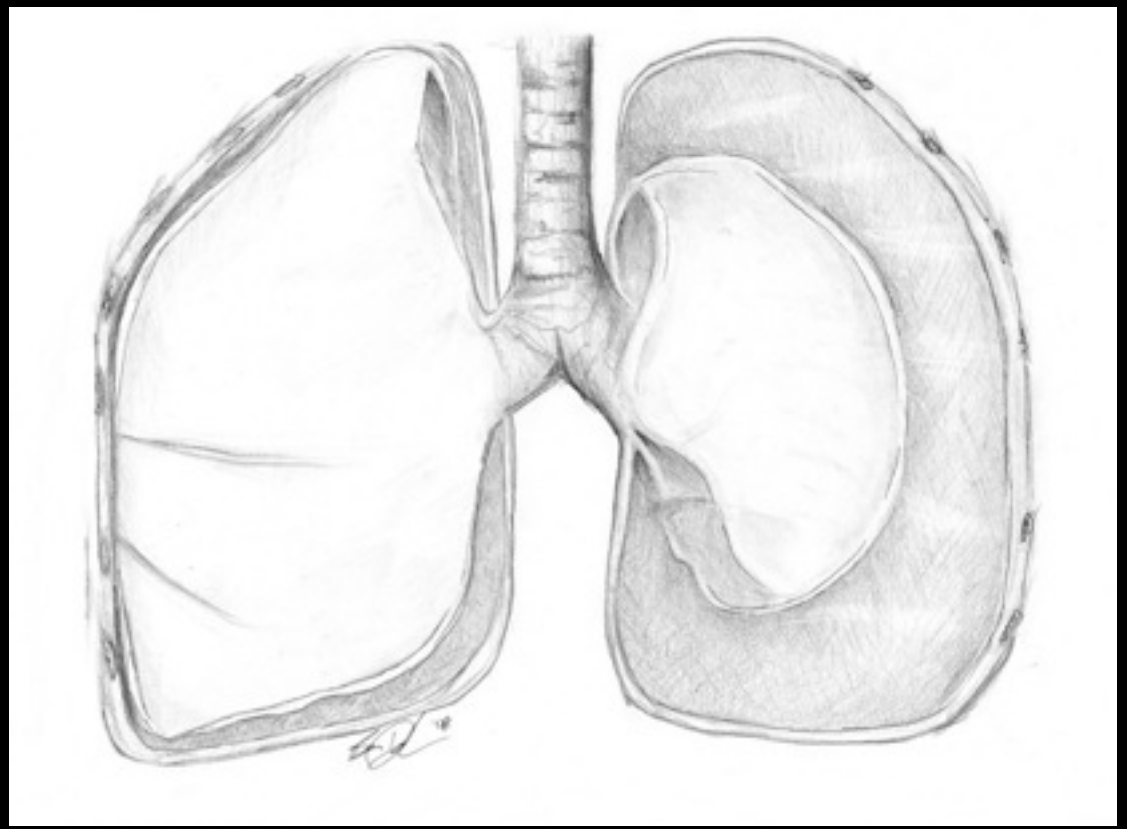


Regularly repeating lines that mirror pleural interface

Sonographic Pathology

Pneumothorax

- separation of visceral and parietal pleura



Sonographic Pathology

Pneumothorax

normal

no sliding

absence of lung sliding or ring-down artifact indicates pneumothorax

Sonographic Pathology

Pneumothorax

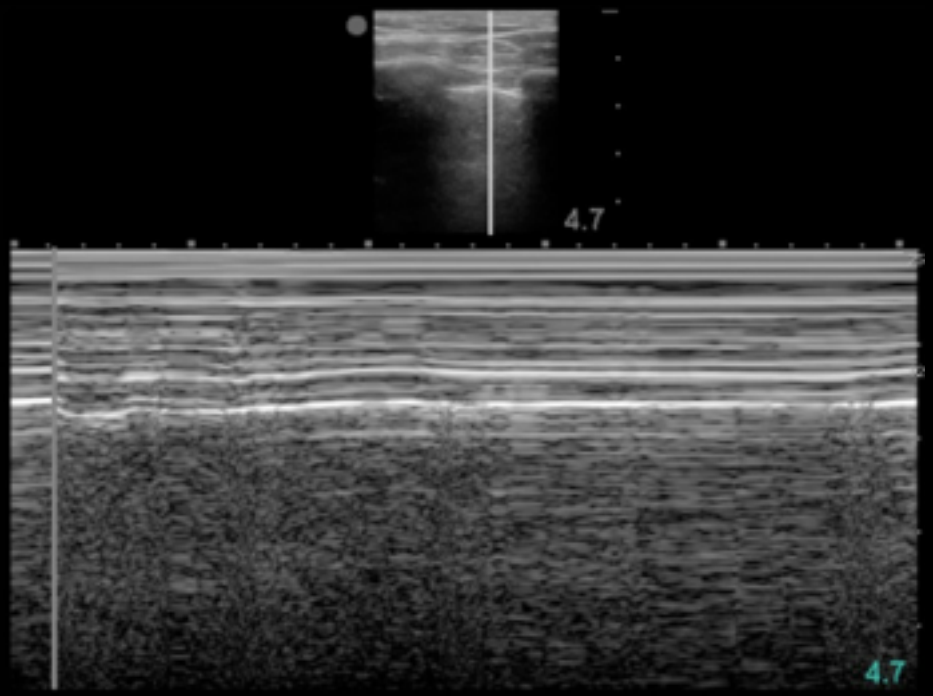
M-mode

may make detection of pneumothorax easier

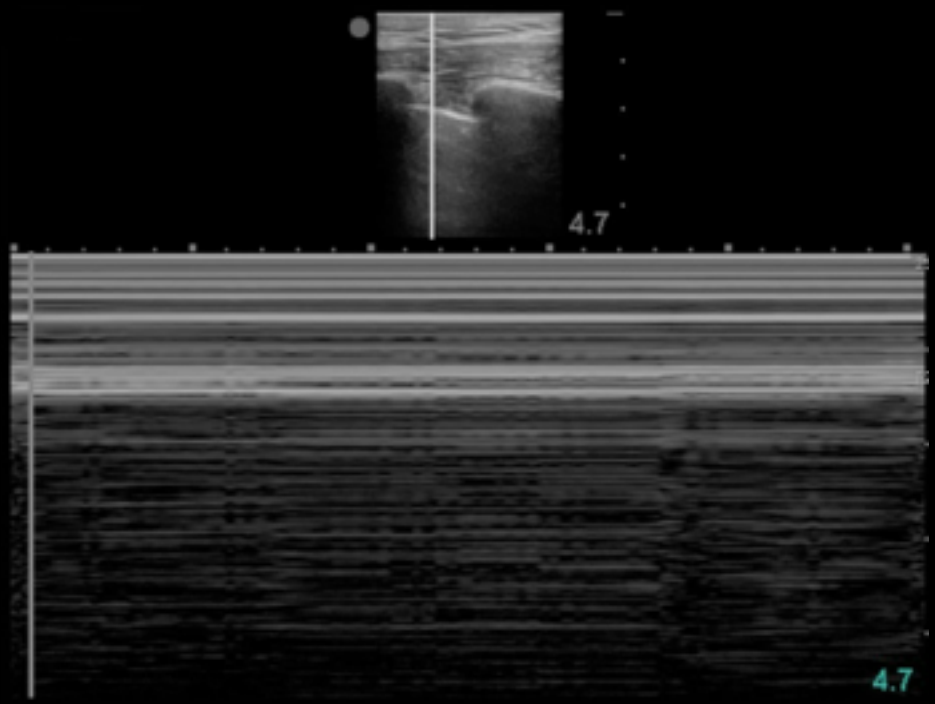
Sonographic Pathology

Pneumothorax

M-mode



normal

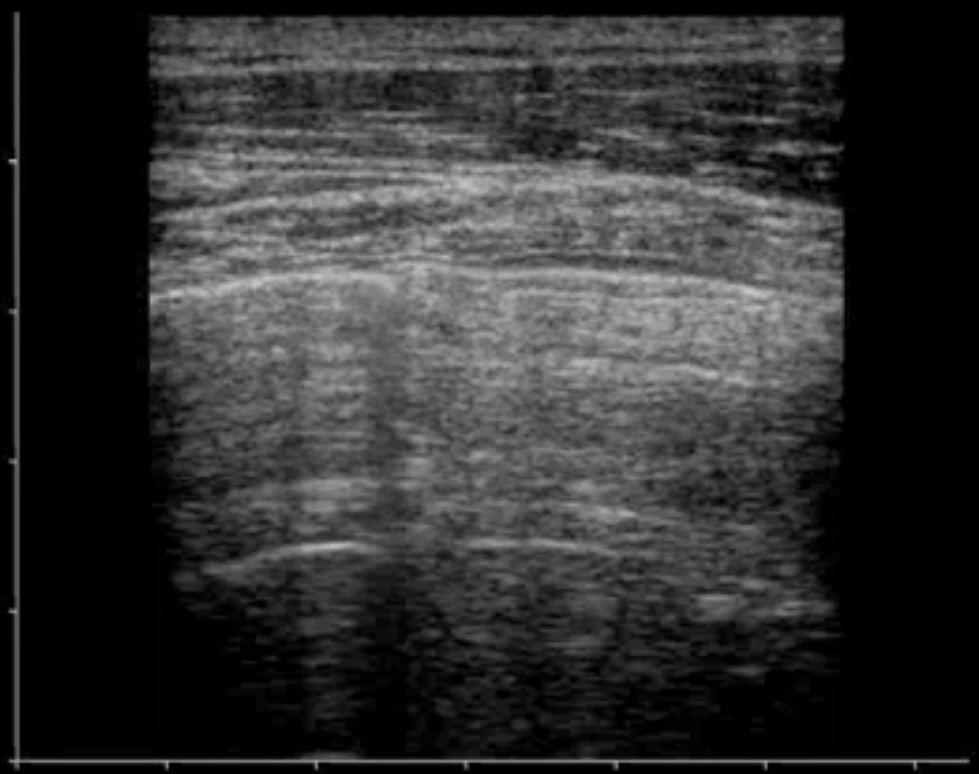


pneumothorax

Sonographic Pathology

Pneumothorax

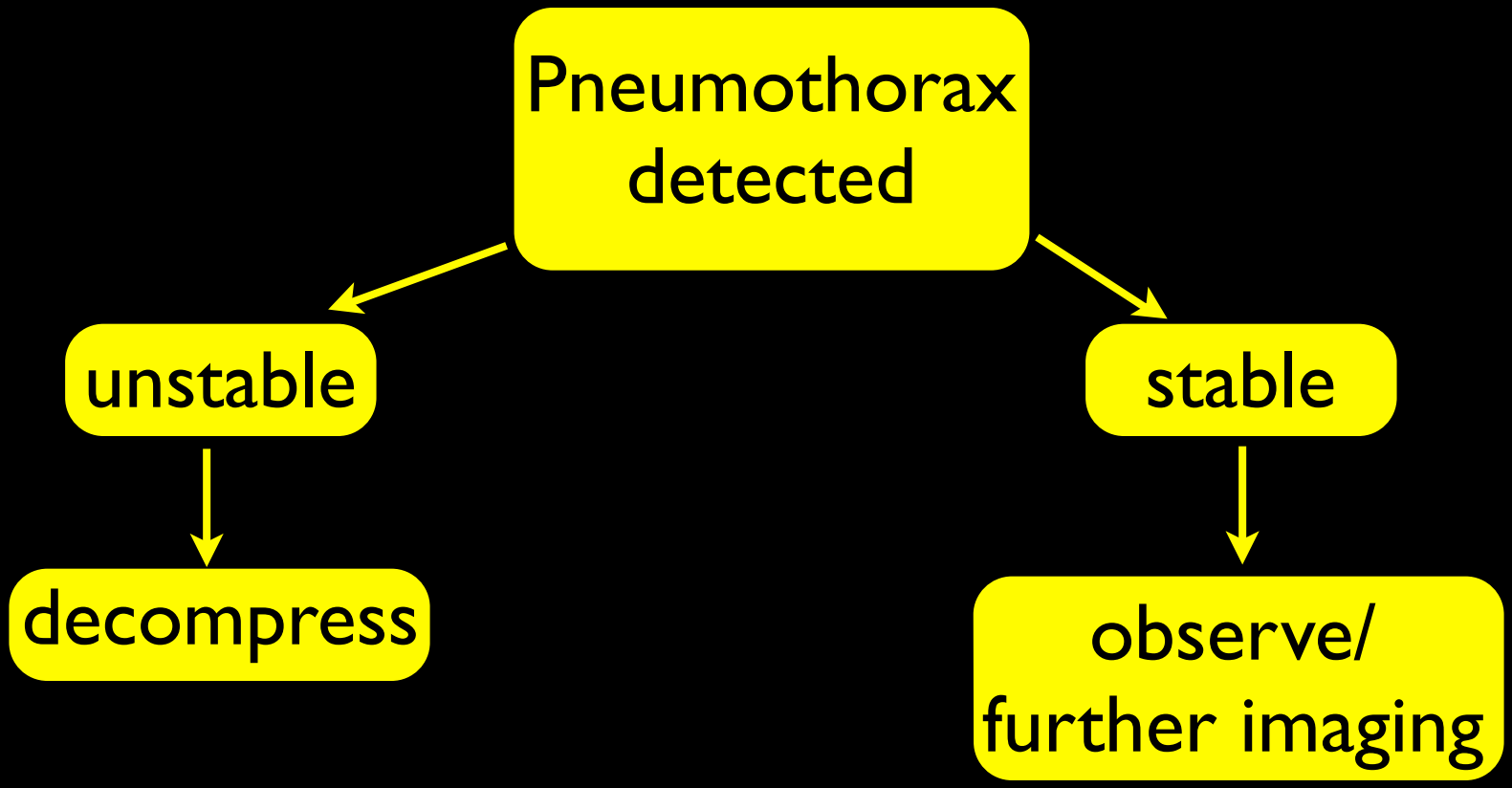
Lung Point Sign



- Occurs at interface between normal lung and pneumothorax
- The "point" where the pneumothorax and normal lung occurs under the probe
- Very specific finding

Sonographic Pathology

Pneumothorax



Suggested Algorithm for Pneumothorax

Sonographic Pathology

Pneumothorax

	Sensitivity	Specificity	PPV	NPV
Zhang	86%	97%	89%	94.8%
Soldati	92%	99%	96%	99%
Nandipati	95%	99%	95%	99%
Nagarsheth	82%	100%	100%	93%

Zhang et al. Rapid detection of pneumothorax by ultrasonography in patients with multiple trauma. *Crit Care* 2006, 10:4

Soldati et al. Occult traumatic pneumothorax: diagnostic accuracy of lung ultrasonography in the emergency department. *Chest* 2008, 133:204-211

Nandipati et al. EFAST in the diagnosis of pneumothorax: experience at a community based level I trauma center. *Injury* 2011, 42: 511-514

Nagarsheth et al. Ultrasound detection of pneumothorax compared with chest x-ray and computed tomography scan. *Am Surg* 2011, 77: 480-484.

Sonographic Pathology

Pneumothorax

- Ultrasound vs CXR:
- Alrajab *et al, 2013*—meta-analysis of 13 prospective randomized blinded studies comparing US and CXR to CT for PTX

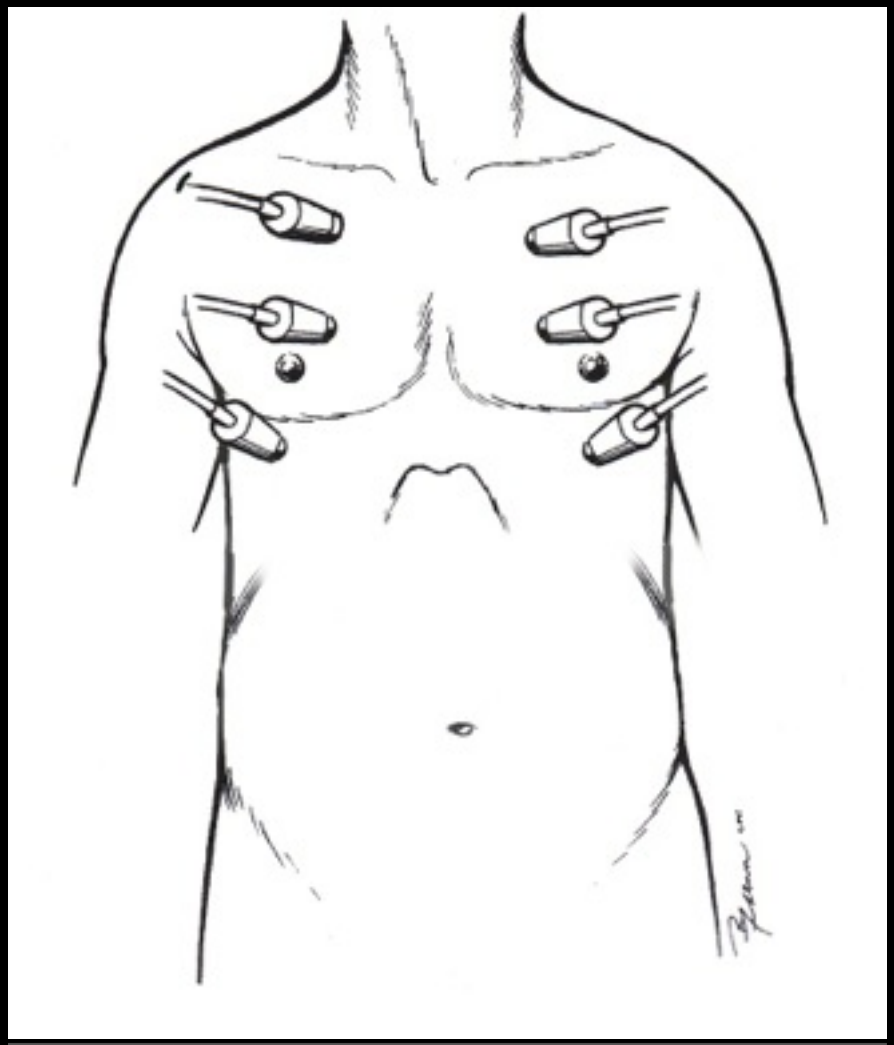
	US	CXR
Sensitivity	78.6%	39.8%
Specificity	98.4%	99.3%

Alrajab et al. Pleural ultrasonography vs chest radiography for the diagnosis of pneumothorax: review of the literature and meta-analysis. *Crit Care* 2013, 17: R208.

Pitfalls

Scanning too Quickly

- scan multiple locations to increase sensitivity
- overall, US much more sensitive than CXR



Pitfalls

False Positives

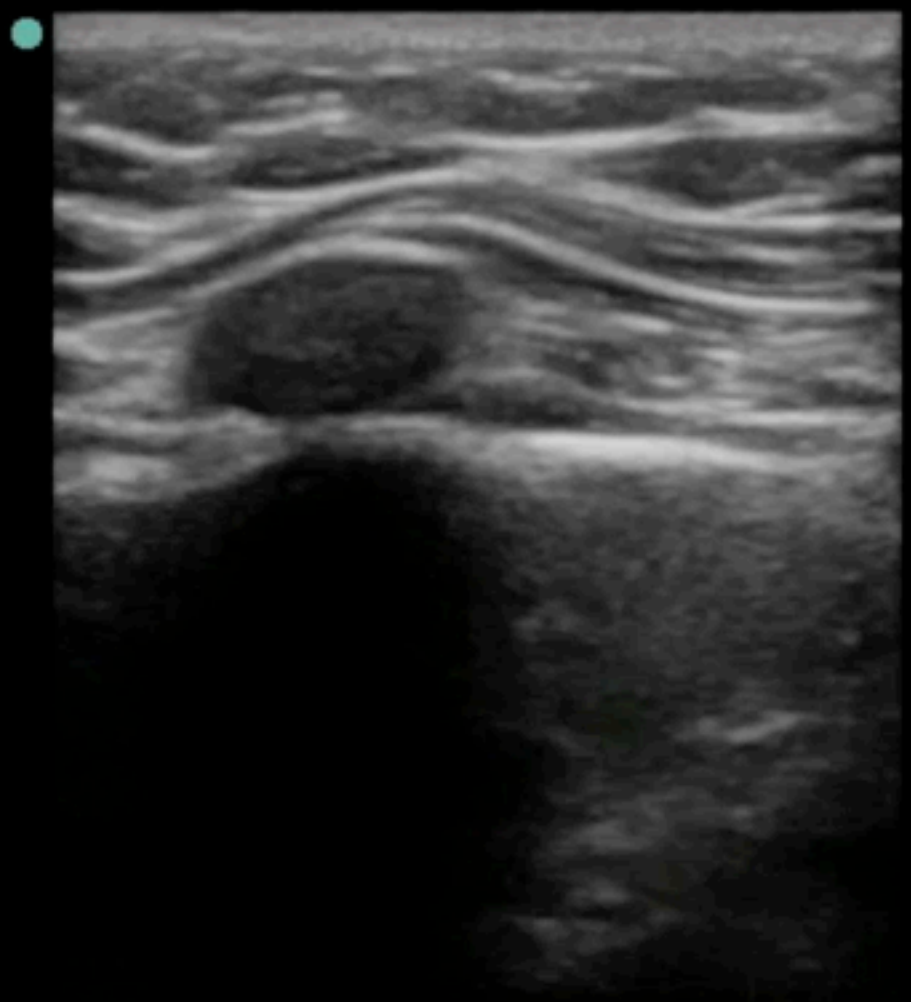
Lack of lung sliding may arise in several situations:

- mainstem intubation
- COPD
- large lung masses
- pleural adhesions
- blebs

Pitfalls

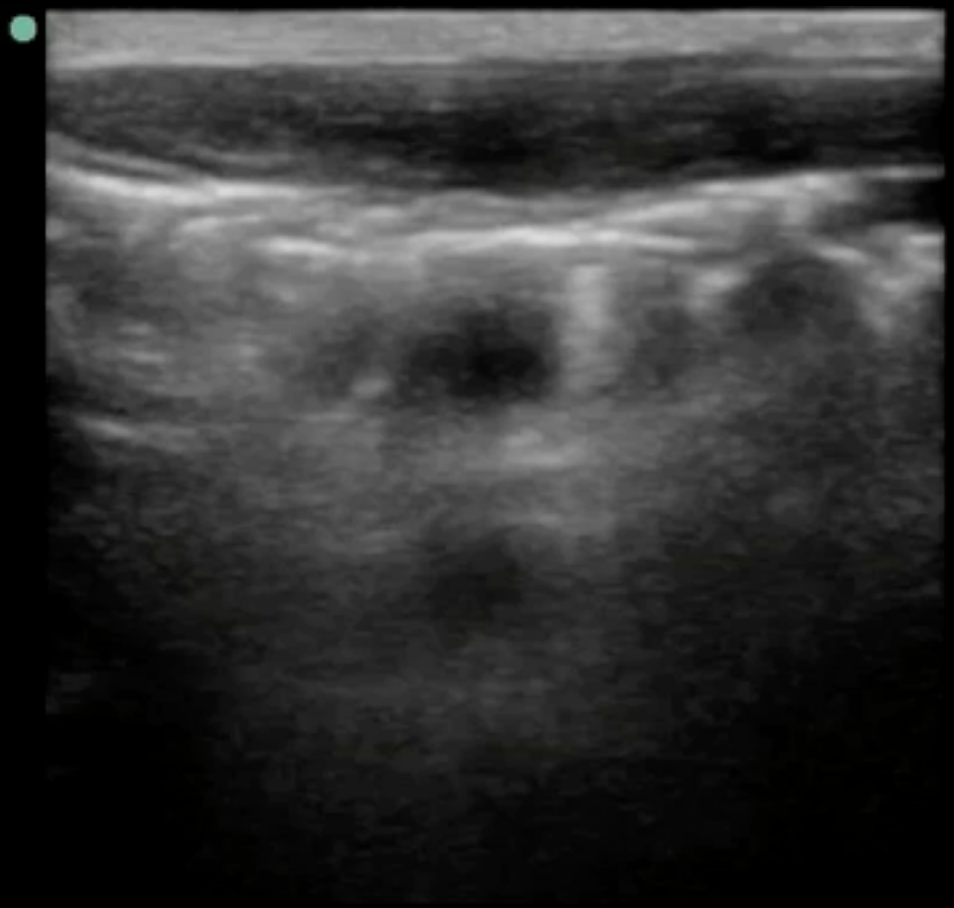
Cardiac Movement

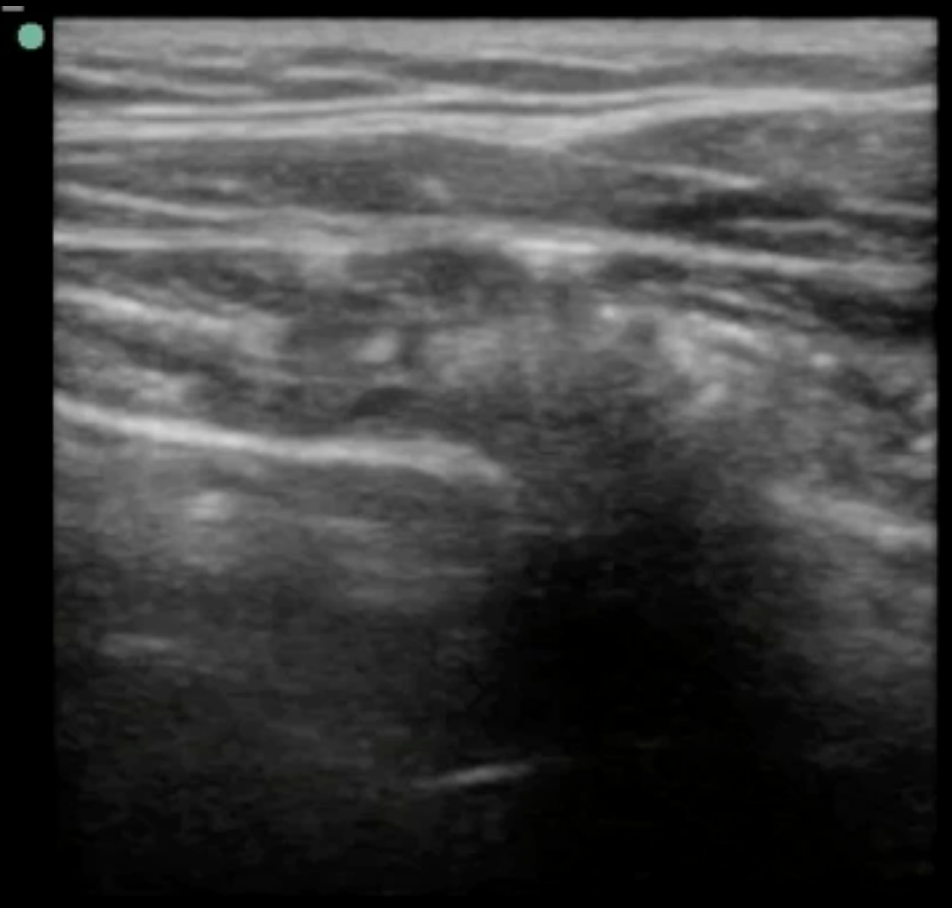
- Heart movement may imitate lung sliding



Pitfalls

Subcutaneous Air





Pulmonary Edema

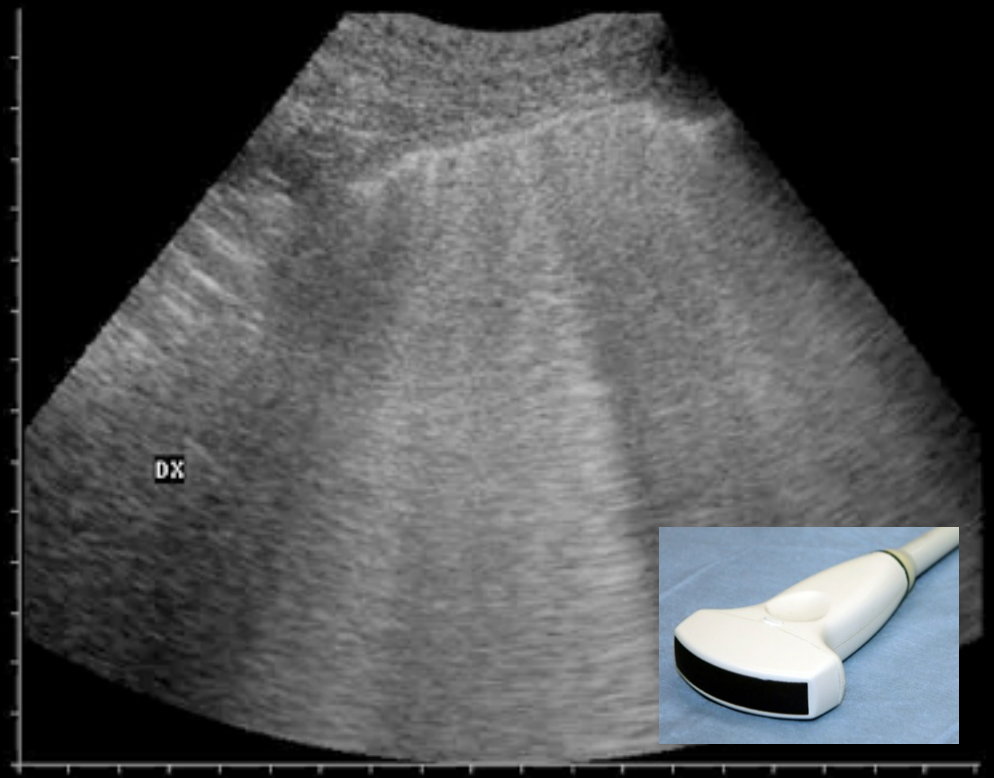
Sonographic Pathology

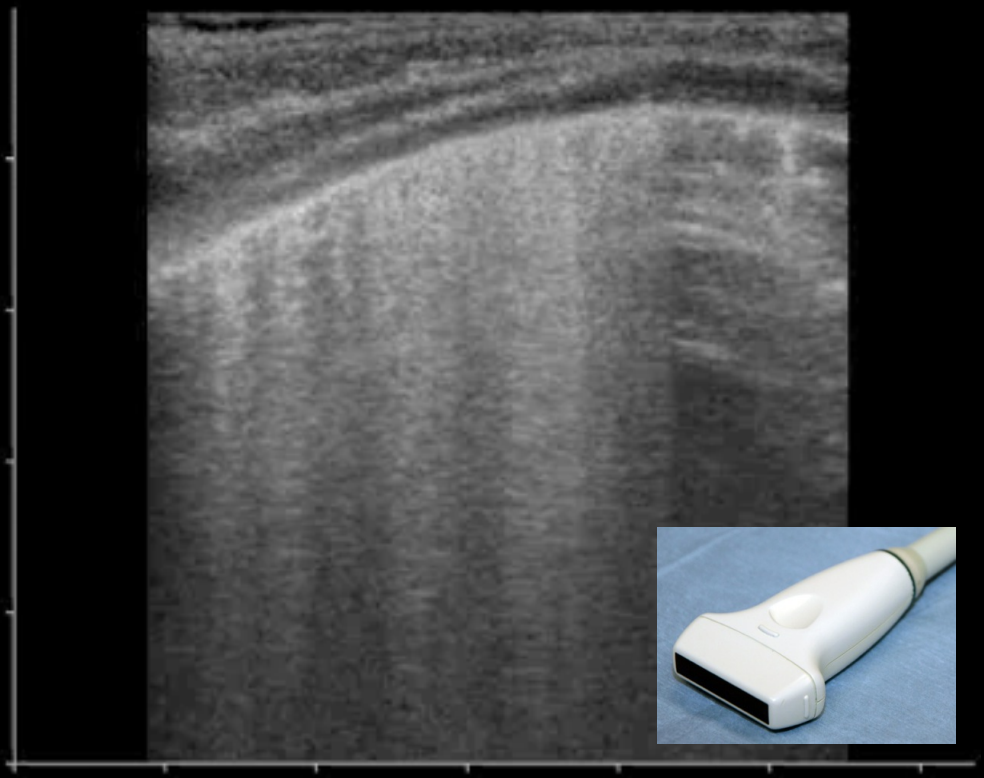
Pulmonary Edema

- Presence of numerous "lung rockets" indicate pulmonary edema
- Represent fluid in interlobular septae
- Ultrasound equivalent of "Kerly B" lines
- Lung rockets = B-lines = multiple comet tail artifacts

Sonographic Pathology

Pulmonary Edema





may use either a curvilinear or linear probe

Sonographic Pathology

Pulmonary Edema

- B-lines appear quickly and resolve quickly
- B-lines are as reliable as BNP but changes quicker

Noble et al. Ultrasound assessment for extravascular lung water in patients undergoing hemodialysis. Chest 2009
LIteplo et al. Emergency Thoracic Ultrasound in the Differentiation of the Etiology of Shortness of Breath (ETUDES): Sonographic B-lines and N-terminal Pro-brain-type Natriuretic Peptide in Diagnosing Congestive Heart Failure. *J Acad Emerg Med* 2009. 16: 1-10

Pitfalls

Pulmonary Edema

- "Alveolar Interstitial Syndrome"
  - pulmonary fibrosis
  - ARDS
  - *pulmonary edema*

Consolidation

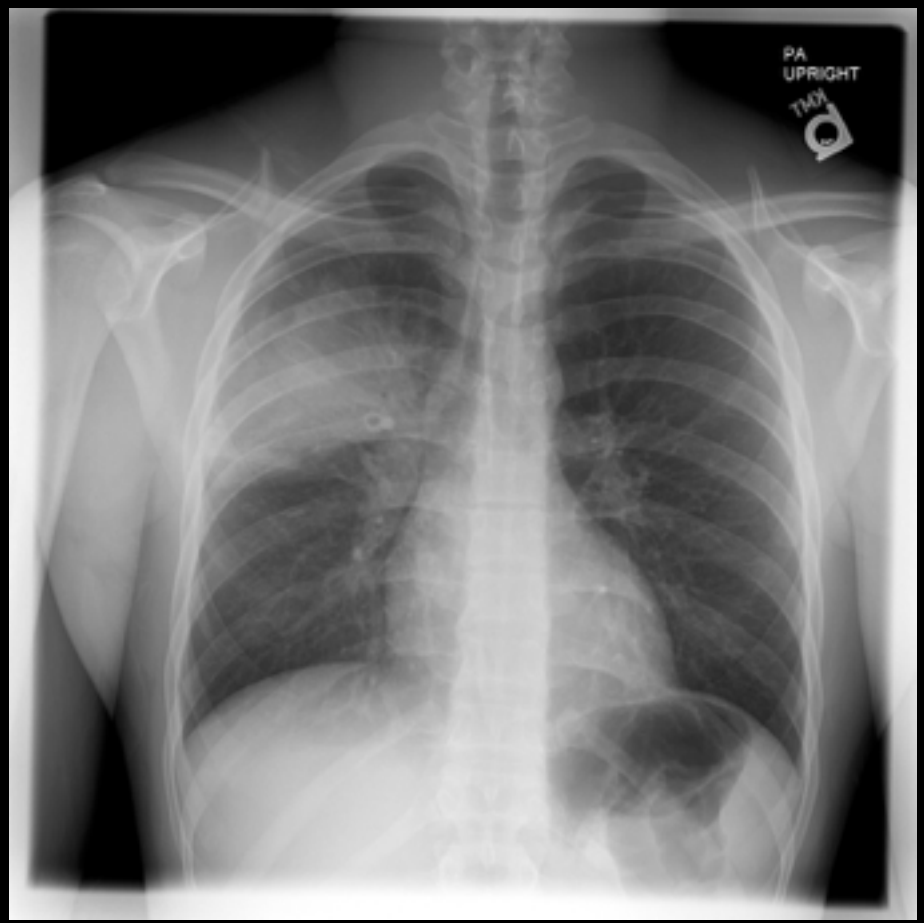
Sonographic Pathology

Pulmonary Consolidation

"Hepatization": no residual air in lung parenchyma

Sonographic Pathology

Pulmonary Consolidation



Sonographic Pathology

Pulmonary Consolidation

Aerated lung reflects ultrasound signal

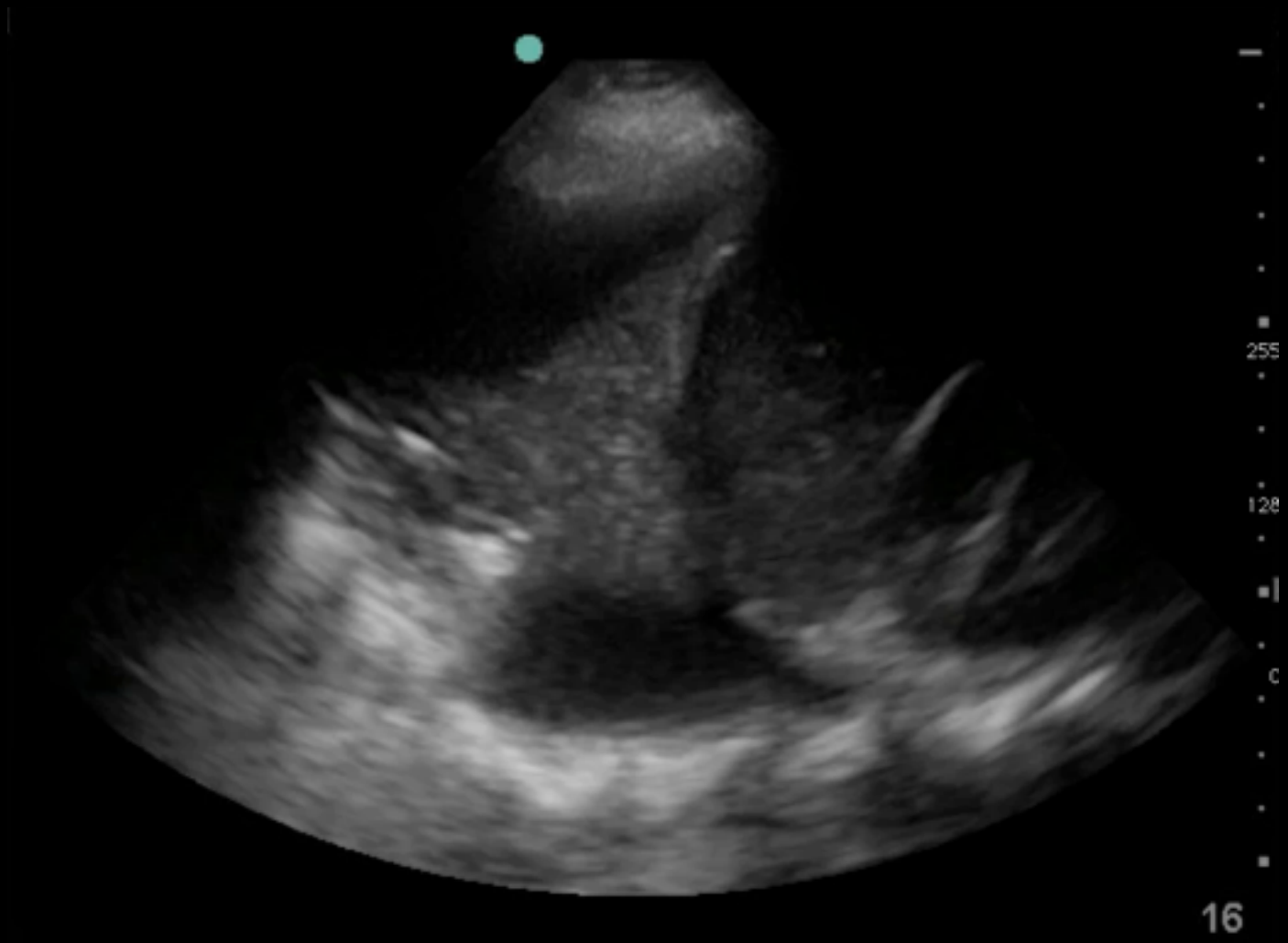
Sonographic Pathology

Effusion and Consolidation

fluid and consolidated lung are usually easily seen

Sonographic Pathology

Effusion and Consolidation



Cases

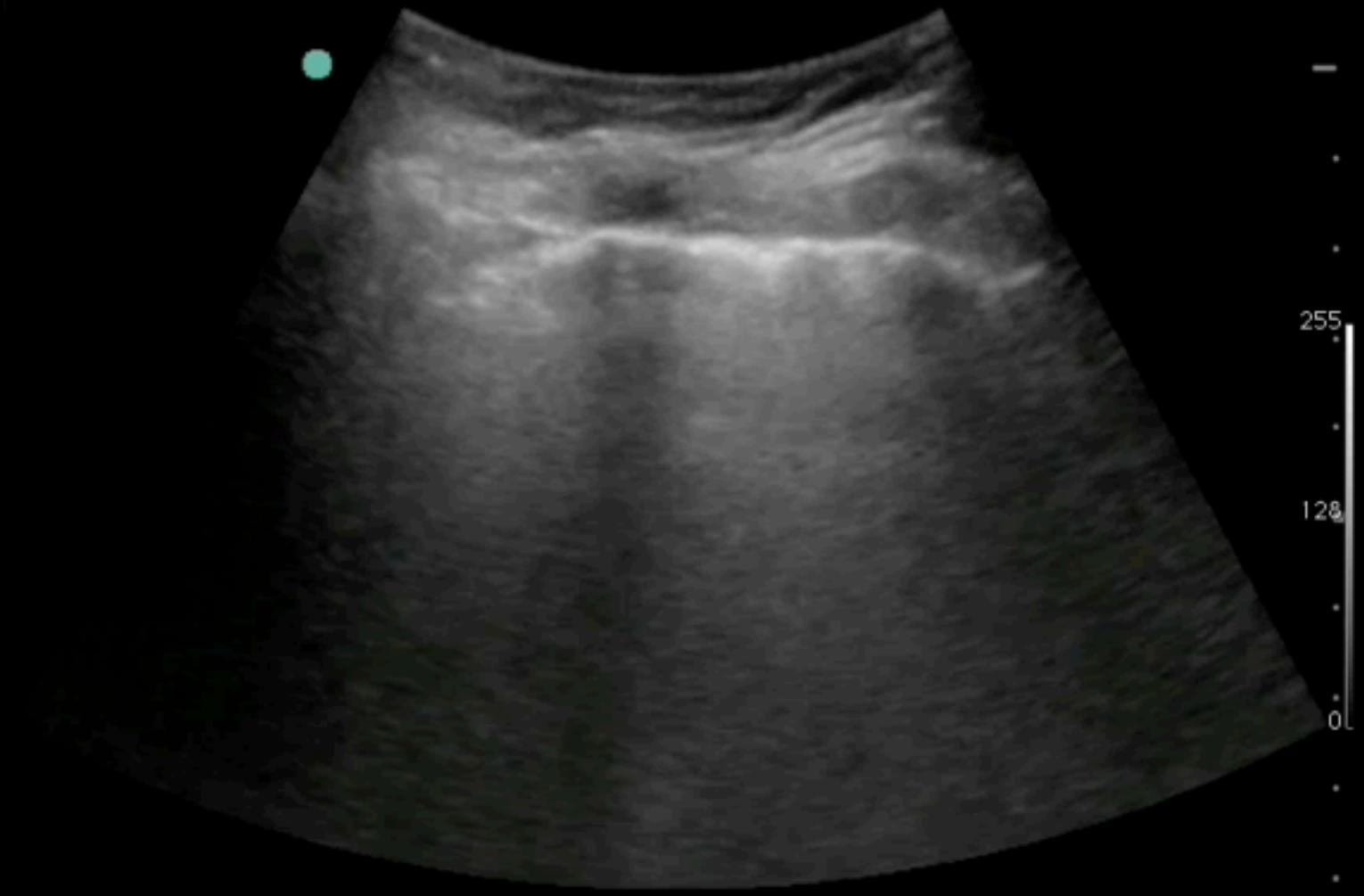
Case #1

Dyspnea on Exertion

- 83 y/o female with recent lateral wall myocardial infarction
- Increasing dyspnea on exertion x3 days, now dyspneic at rest
- 147/56, 69, 91%, afebrile
- +murmur, distant breath sounds

Case #1

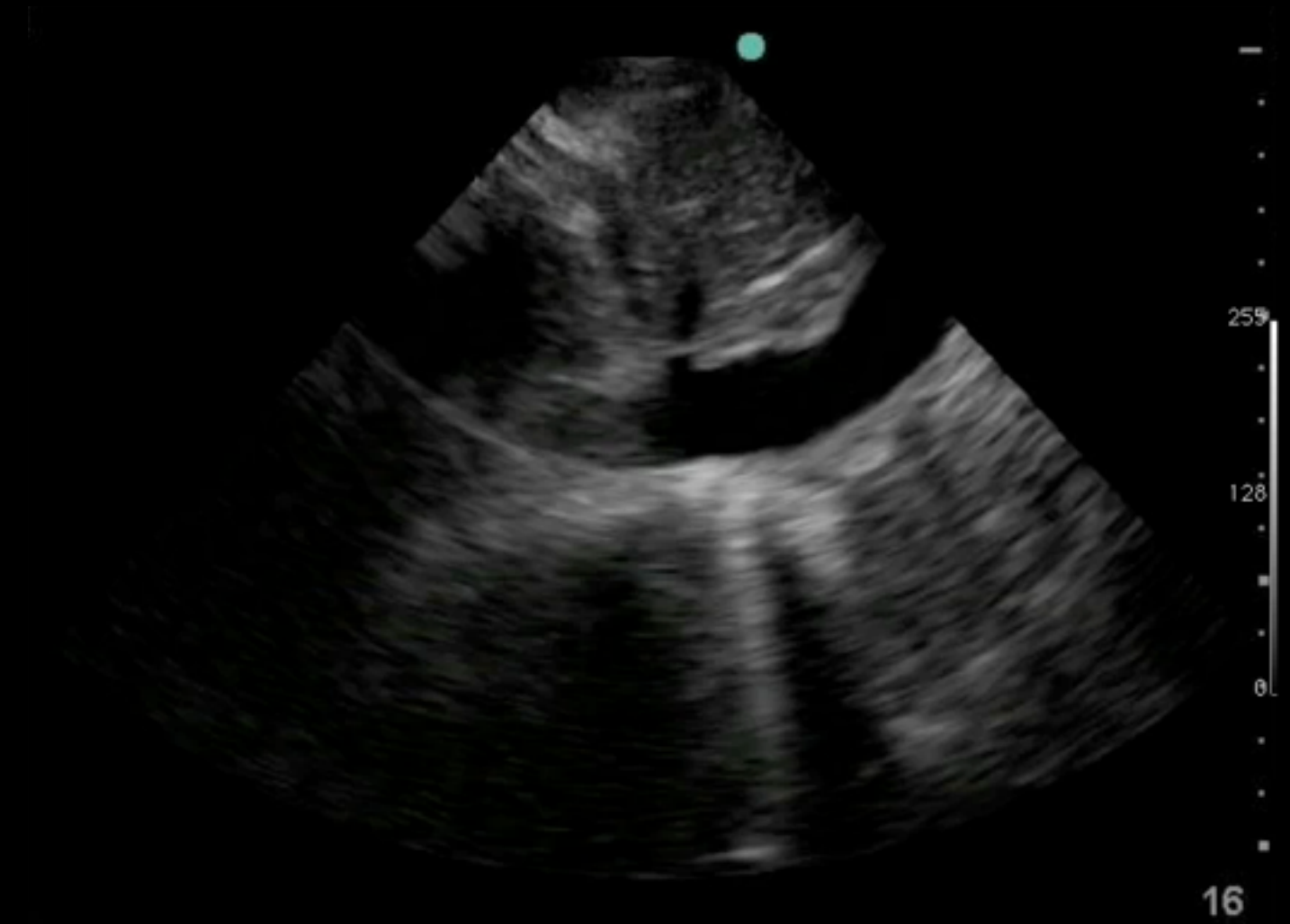
Dyspnea on Exertion



numerous “B” lines

Case #1

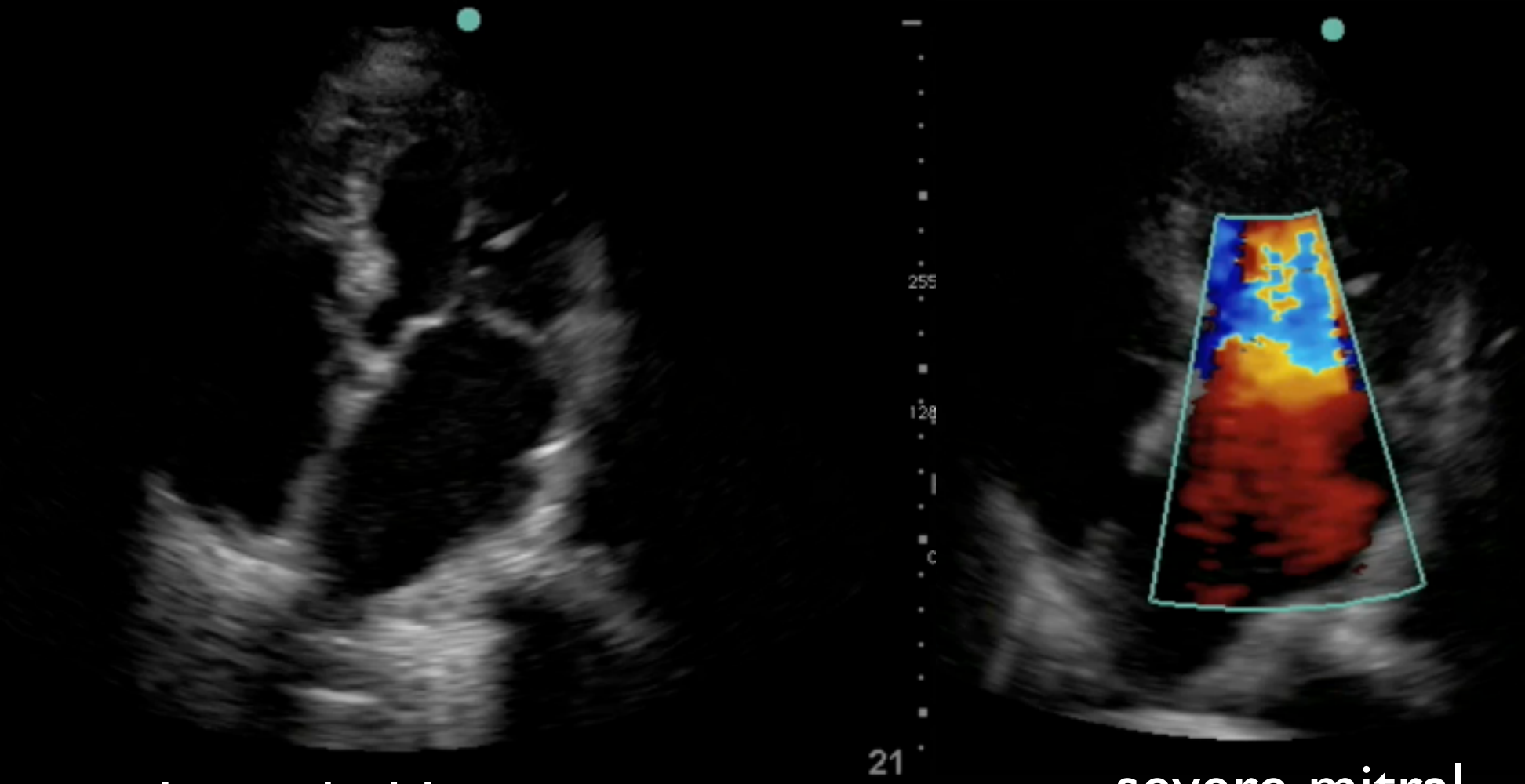
Dyspnea on Exertion



IVC distended

Case #1

Dyspnea on Exertion

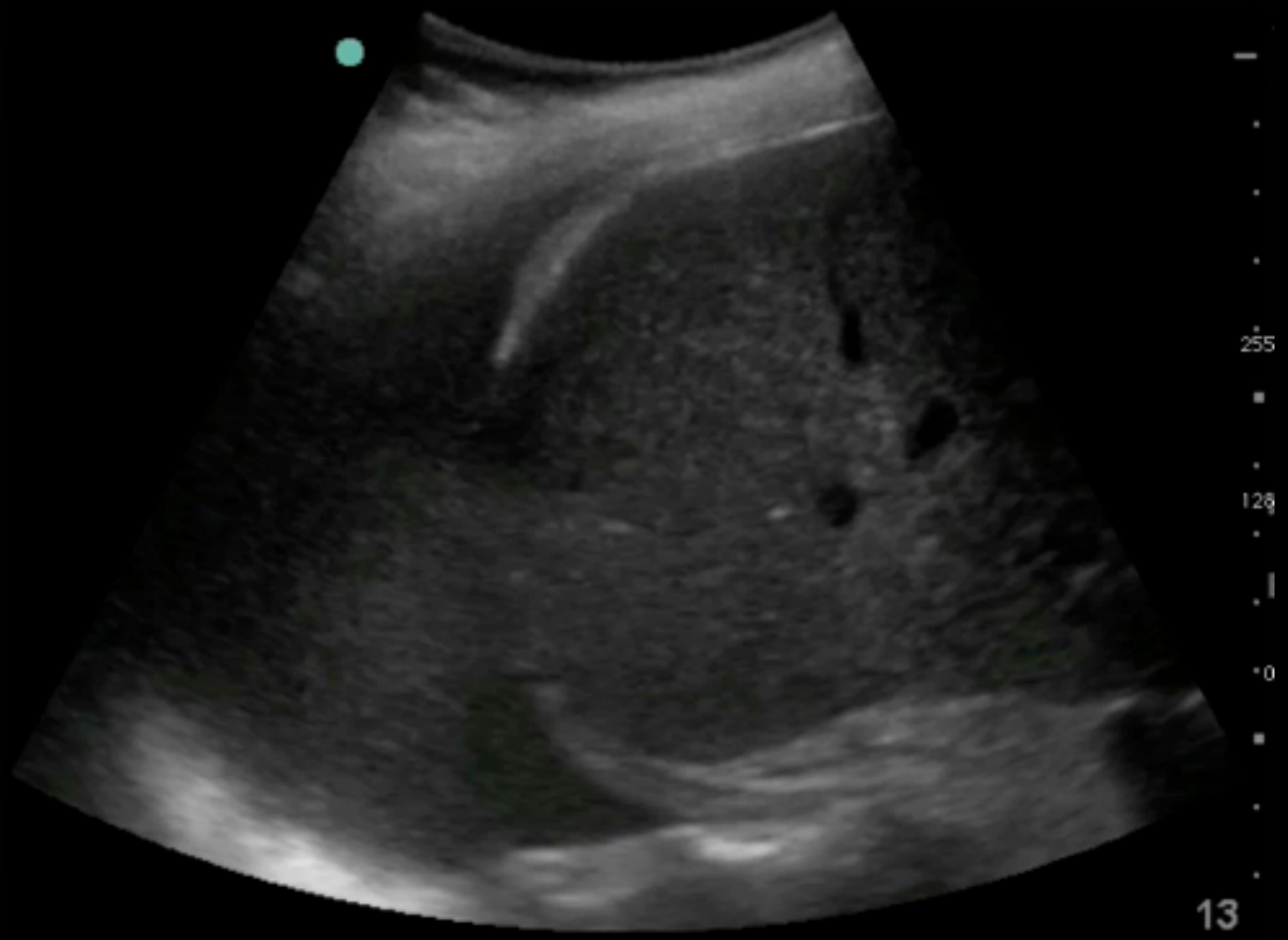


distended L. atrium

severe mitral regurgitation

Case #1

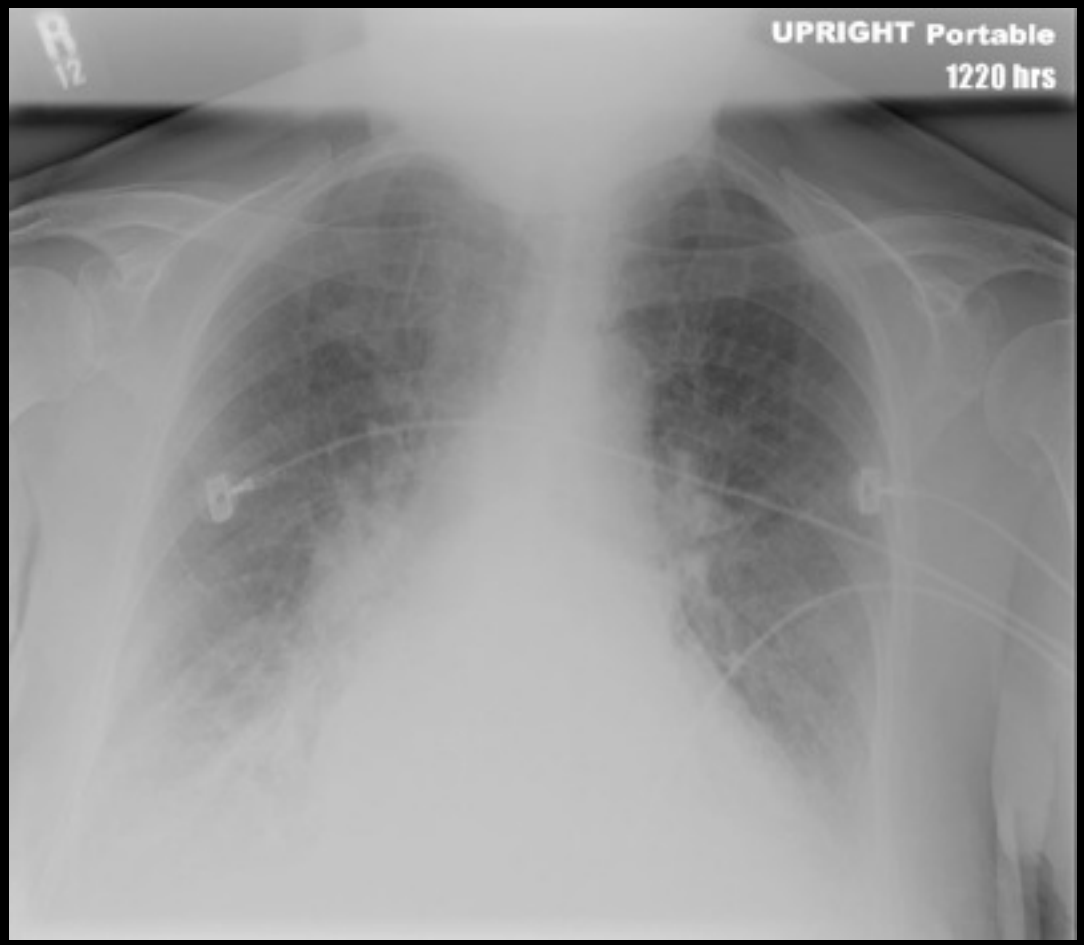
Dyspnea on Exertion



pleural effusion

Case #1

Dyspnea on Exertion



- Chest radiography confirms diagnosis
- ...but results not available for 20 minutes
- pt admitted for urgent valvuloplasty

Case #2

Chest Pain, Hypotensive

- 72 y/o male sent from NH for CP, hypotension.
- Previous MI with stenting

Case #2

Chest Pain, Hypotensive

- BP: 70/30, P 105, RR 24, O2 89%, T 95
- awake but confused, tachycardic, decreased breath sounds, skin warm & dry
- EKG nondiagnostic
- Initial presumption: cardiogenic shock

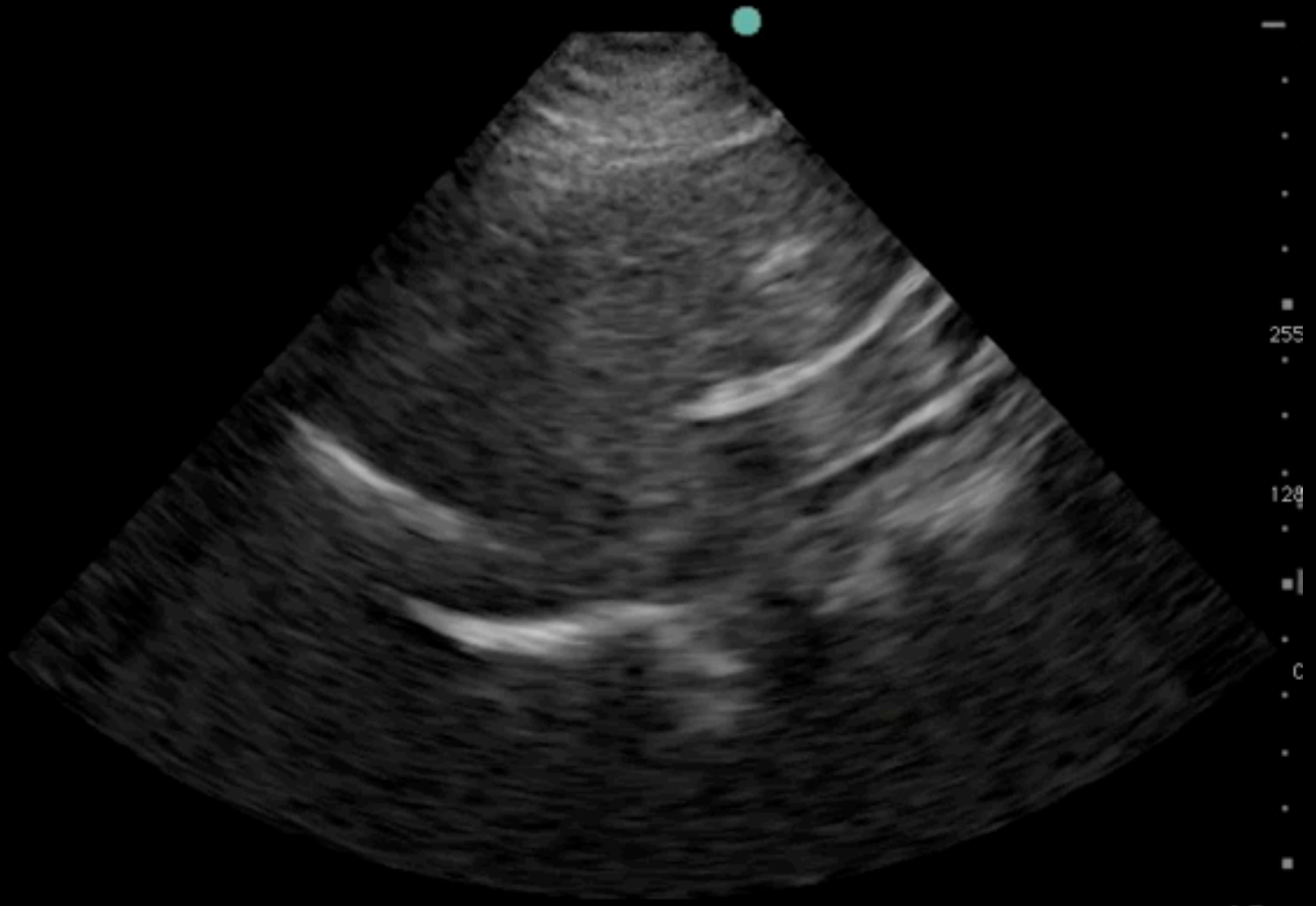
Case #2

Chest Pain, Hypotensive

ultrasound negative for pulmonary edema but does show consolidation

Case #2

Chest Pain, Hypotensive



collapsed IVC

Case #2

Chest Pain, Hypotensive

hyperdynamic LV

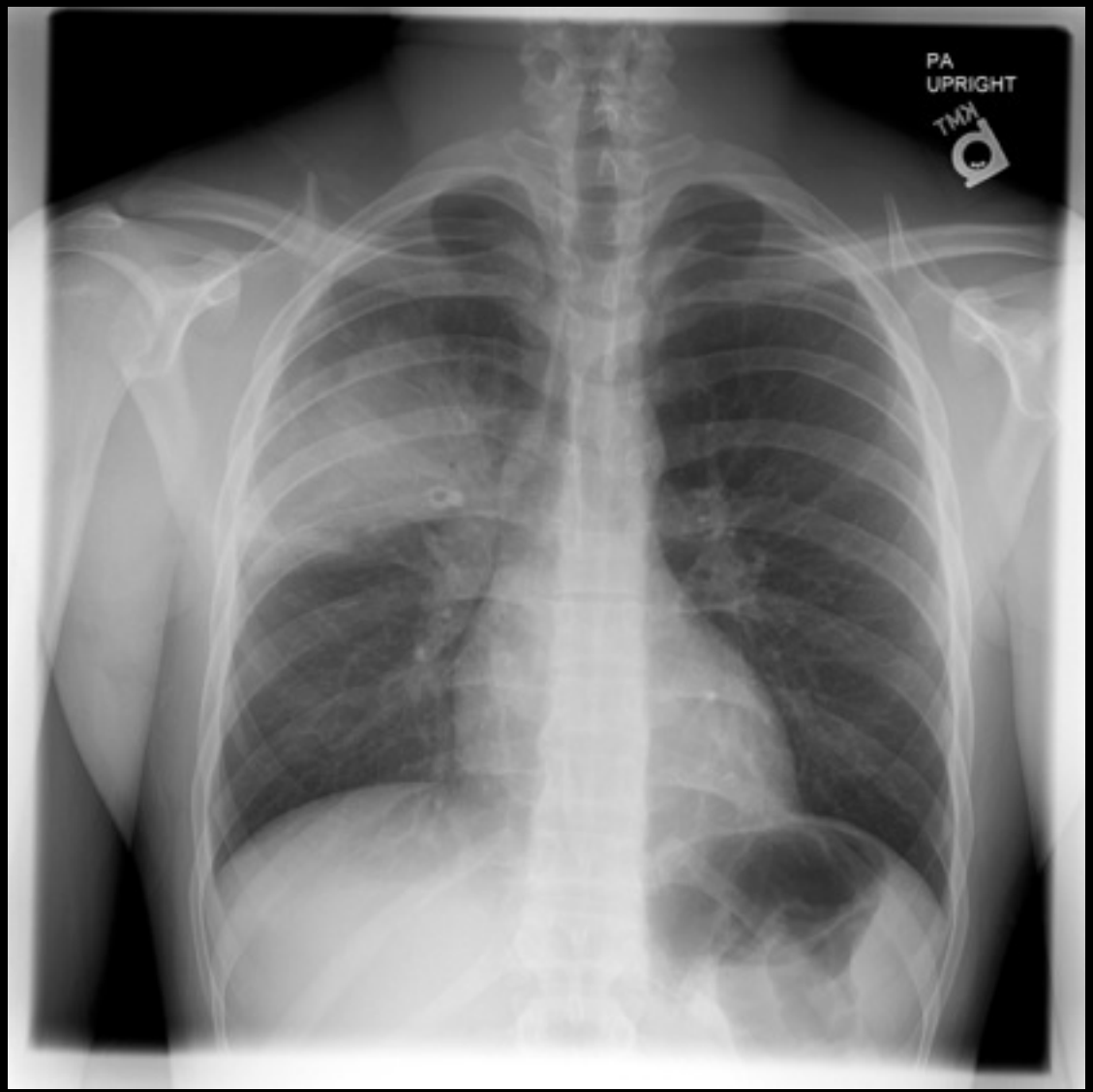
Case #2

Chest Pain, Hypotensive

Right pleural effusion

Case #2

Chest Pain, Hypotensive



- Chest radiography confirms diagnosis
- ...but results not available for 20 minutes
- Septic shock due to pneumonia

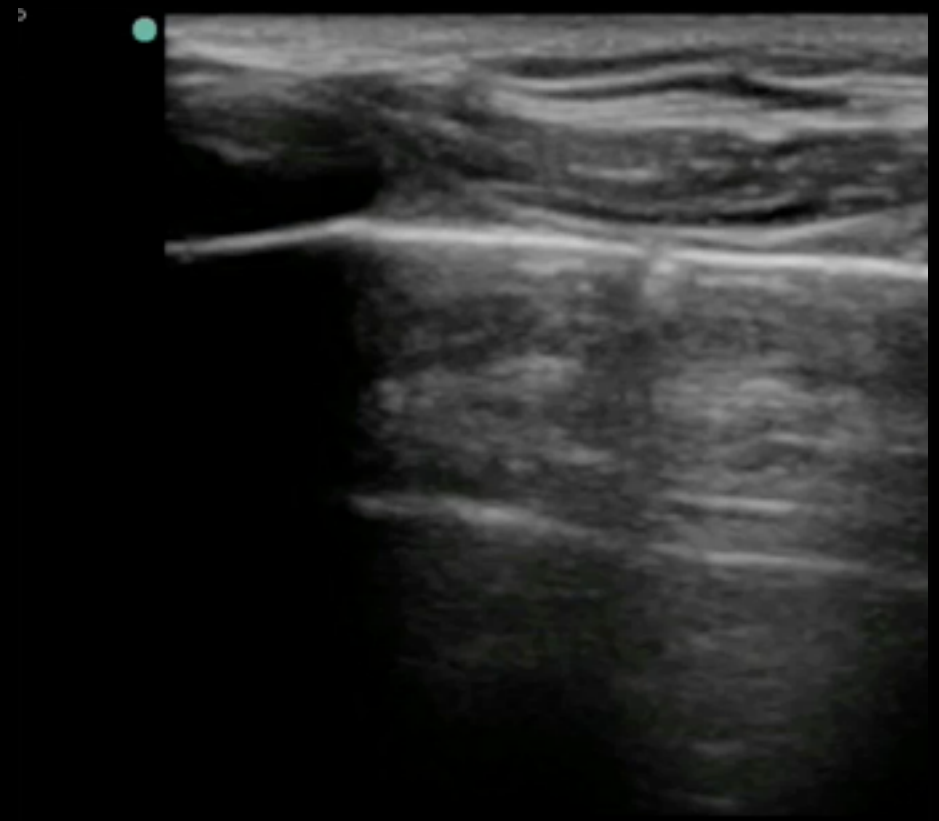
Case #3

Acute Dyspnea, Hypotensive

- 45 y/o female, h/o previous spontaneous pneumothorax
- acute SOB and chest discomfort
- P145, O2 85%, BP 90/45

Case #3

Acute Dyspnea, Hypotensive



left

right

Case #3

Acute Dyspnea, Hypotensive

Case #3

Acute Dyspnea, Hypotensive

- right sided needle thoracostomy, followed by right sided chest tube
- rush of air
- vitals: 105, 110/70. Pt feels better
- admitted to thoracic surgery service

Summary

Thoracic Ultrasound

- Use in conjunction with cardiac, IVC exams
- Obtain information in seconds
  - allows initiation of treatment
- Useful when chest radiography is ambiguous
- False positives with lung sliding

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Baystate Medical Center
Springfield, MA