Ultrasonography in Trauma

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Cases

Epigastric Stab Wound

- 35 y/o AAM, self-inflicted stab wound to epigastrium about 20 min PTA
- Confused, agitated, tachycardic
- P 120 BP 105/70 O2 95%
- Pt exposed, single 2cm stab wound epigastrium

Cases

Epigastric Stab Wound

- Screaming, moaning. Abd soft, equal BS, trachea midline, rapid thready pulses
- Bilateral IV’s established, fluid boluses
- Intubated for agitation

Cases

Epigastric Stab Wound

Cases

Epigastric Stab Wound

Cases

Epigastric Stab Wound

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Epigastric Stab Wound

Cases

Epigastric Stab Wound

Cases

Epigastric Stab Wound

- Pt loses pulses, vitals unobtainable.

Cases

Epigastric Stab Wound

- If ultrasound had been unavailable:
  - no information about location of bleeding
  - no information about presence of pneumothoraces
  - no guidance in event of cardiac arrest

Introduction

Ultrasonography in Trauma

- First case reports of ultrasound in trauma in early 1970's
- 1980's: large case series report high sensitivities compared with DPL

Introduction

Ultrasonography in Trauma

Armenian Earthquake, 1988

- 25,000 deaths
- 150,000 injured
- Republic Diagnostic Center
  - Yerevan
- 750 mass casualty patients
- 72 hours
- 1 CT scanner, 2 ultrasounds
- 400 screened in reception
- 52 positives
- 1% false negatives
- no false positives

Introduction

FAST Exam

- Focused Assessment with Sonography Trauma
- Intraperitoneal bleeding
  - Replaced DPL
- Pericardial effusion
  - Replaced waiting for tamponade

EFAST Exam

- Extended FAST exam
  - Hemothorax
  - Pneumothorax

Introduction

Trauma Evaluation

- Cardiac
  - Pericardial effusion
  - Cardiac function
  - Volume status
- Abdominal
  - Intraperitoneal free fluid
- Chest
  - Hemothorax
  - Pneumothorax

Technical Considerations

Probe Selection

- 2-5 MHz
- Curvilinear Array
- Large footprint
- Abdominal imaging

Technical Considerations

Probe Selection

- 1-5 MHz
- Phased Array
- Smaller footprint
- Cardiac/abdominal imaging

Technical Considerations

Probe Selection

- 6-13 MHz
- Linear Array
- Pneumothorax

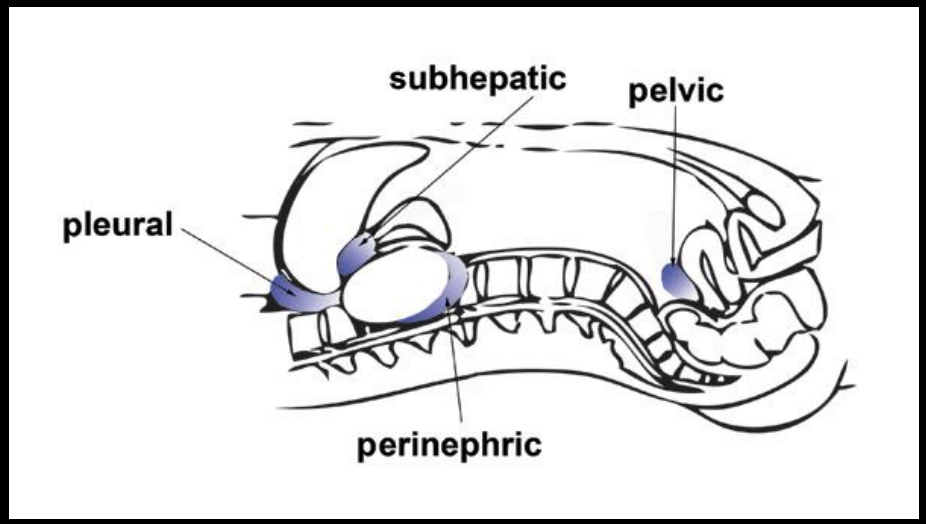
Abdominal Evaluation

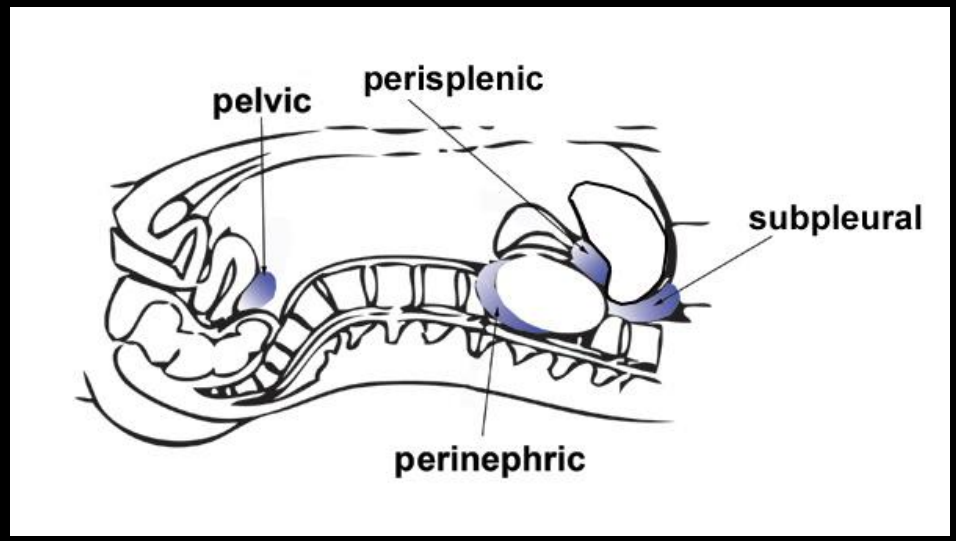
Introduction

- DPL
  - More sensitive for intra-abdominal hemorrhage
  - Led to unnecessary laparotomy
- Ultrasound
  - Less sensitive
  - In shock, accurately predicts need for laparotomy

Anatomy

Dependent Areas





Normal and Pathologic Findings

Right Upper Quadrant

- Most common site for fluid
- Potential space
- Liver = acoustic window
- 200-600cc

Normal and Pathologic Findings

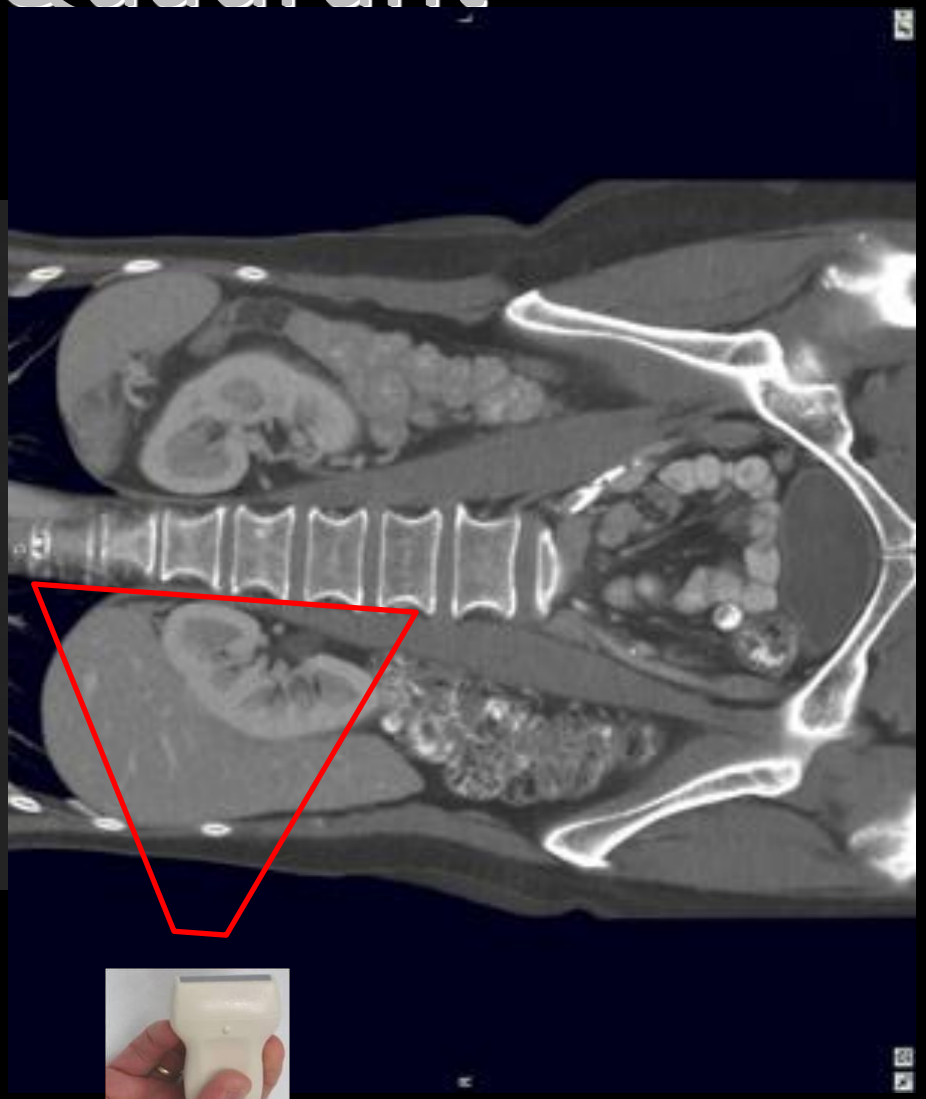
Right Upper Quadrant

- Probe Placement
  - Coronal orientation
  - Mid-axillary line
  - Intercostal positioning
    - Liver lies beneath ribs 7-11

- Probe Movement
  - Visualize Morison's Pouch
  - Fan anteriorly and posteriorly for complete examination of Morison's Pouch
  - Rock cephalad for pleural space and subphrenic recesses
  - Rock caudad for right paracolic gutter/liver tip

Normal and Pathologic Findings

Right Upper Quadrant



Normal and Pathologic Findings

Right Upper Quadrant

Normal and Pathologic Findings

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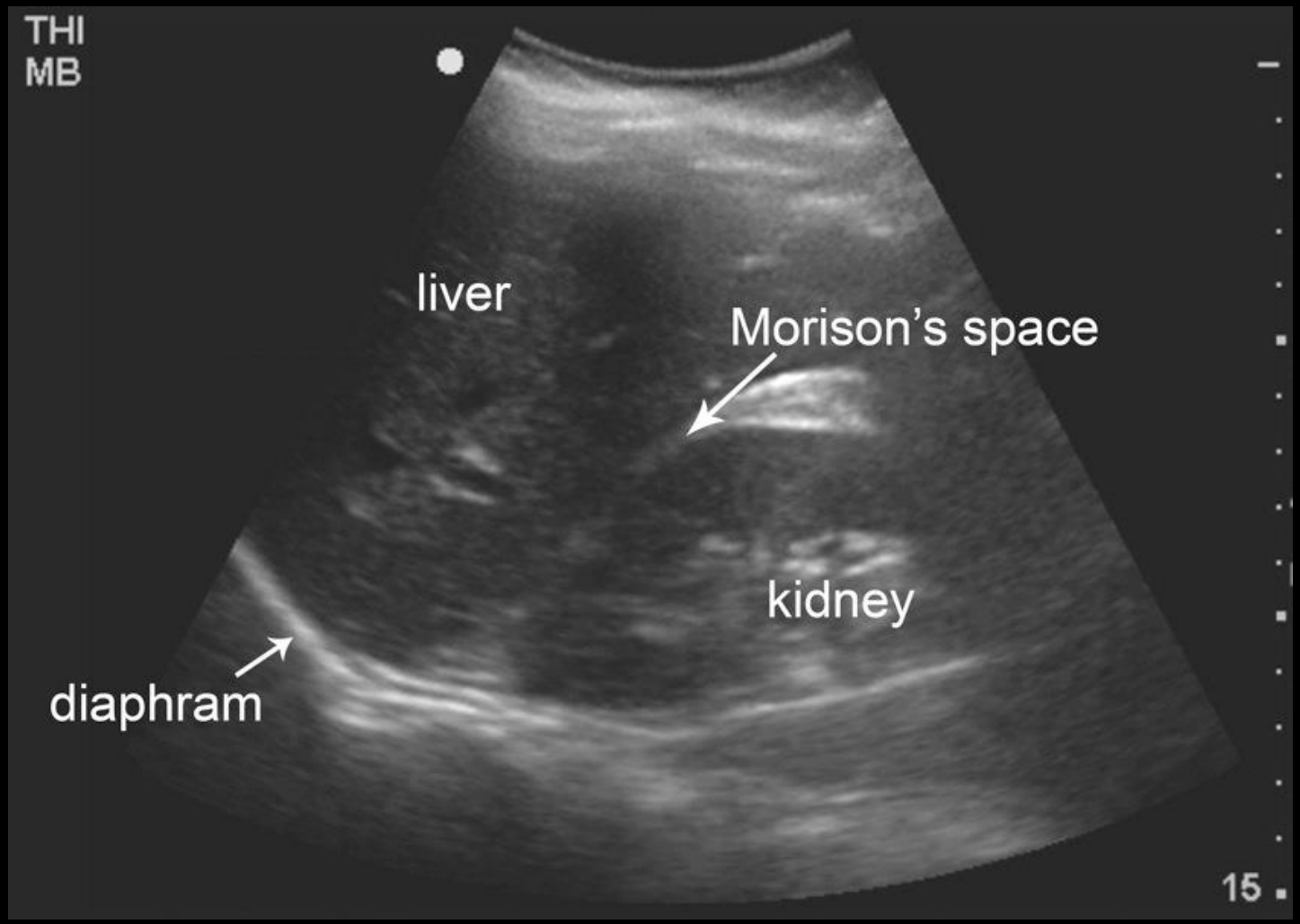

Normal and Pathologic Findings

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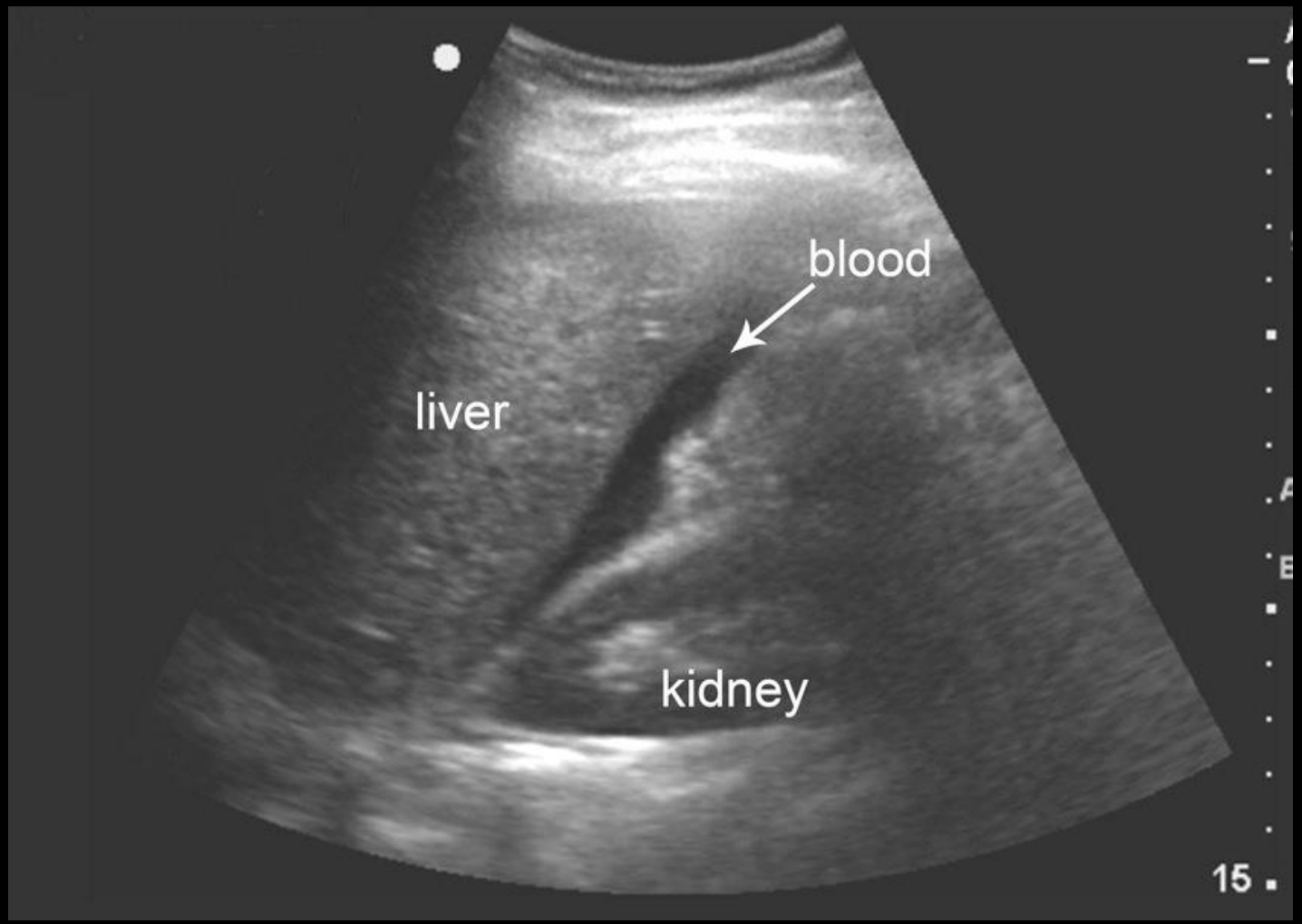

Normal and Pathologic Findings

Right Upper Quadrant

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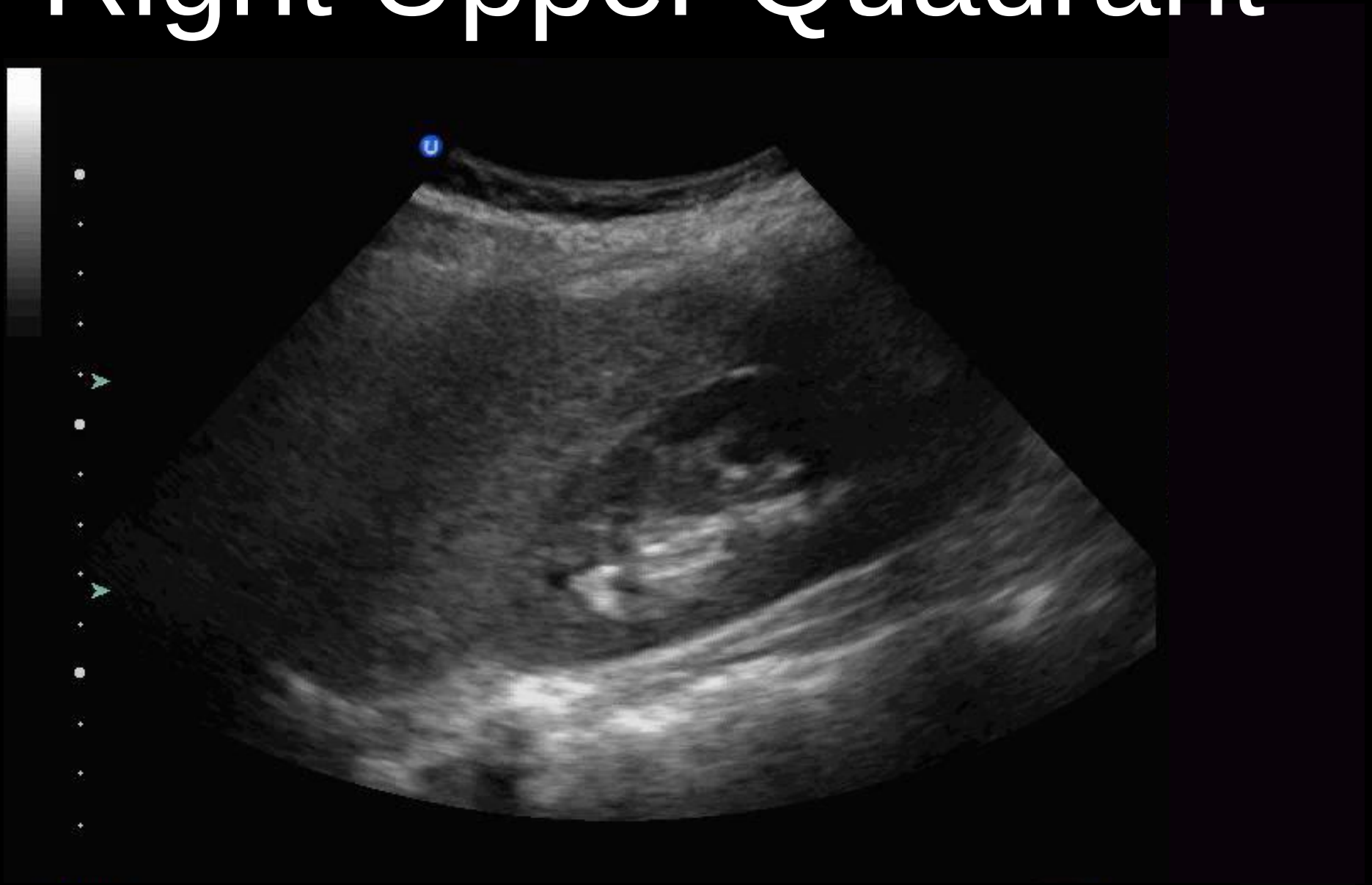

Normal and Pathologic Findings

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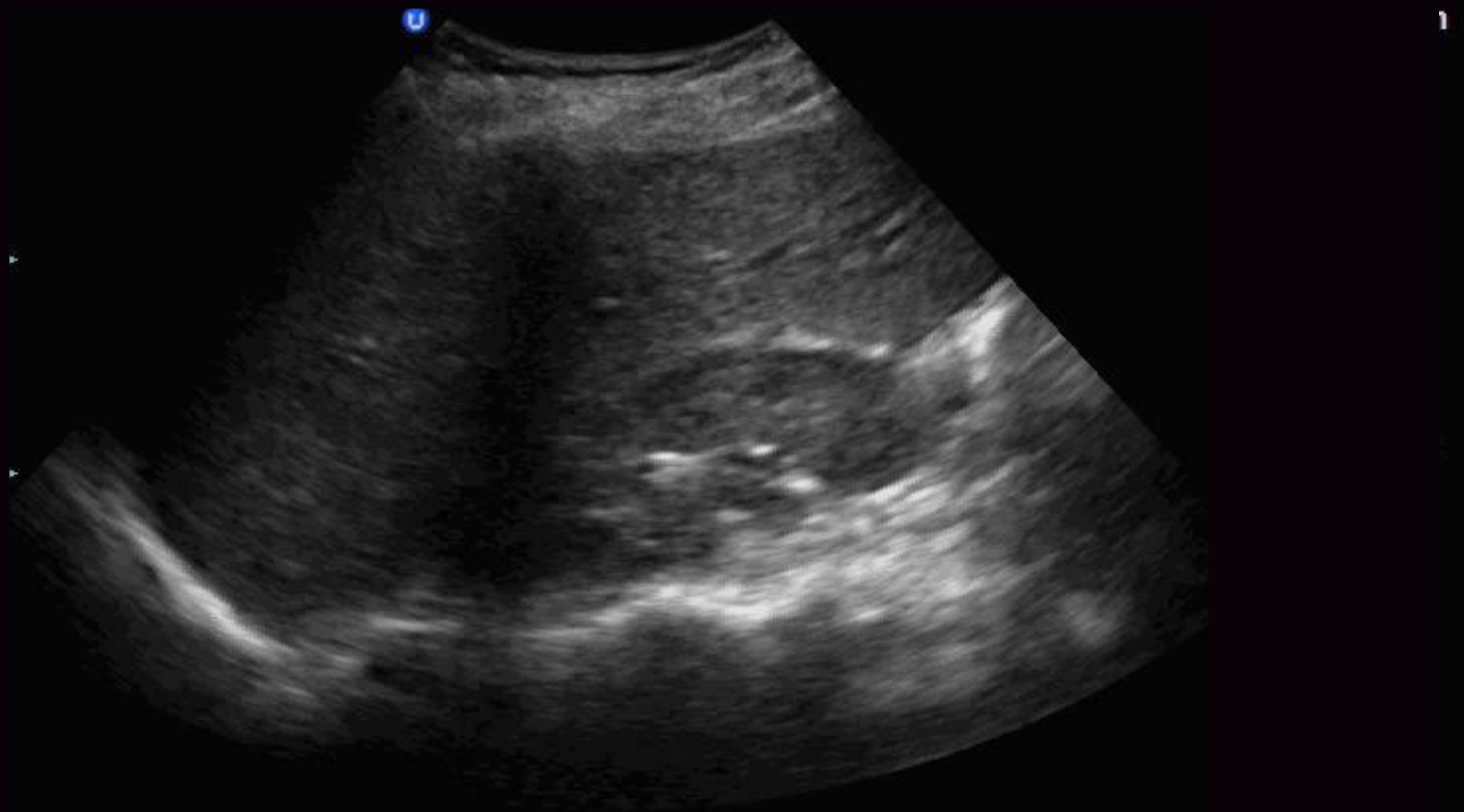

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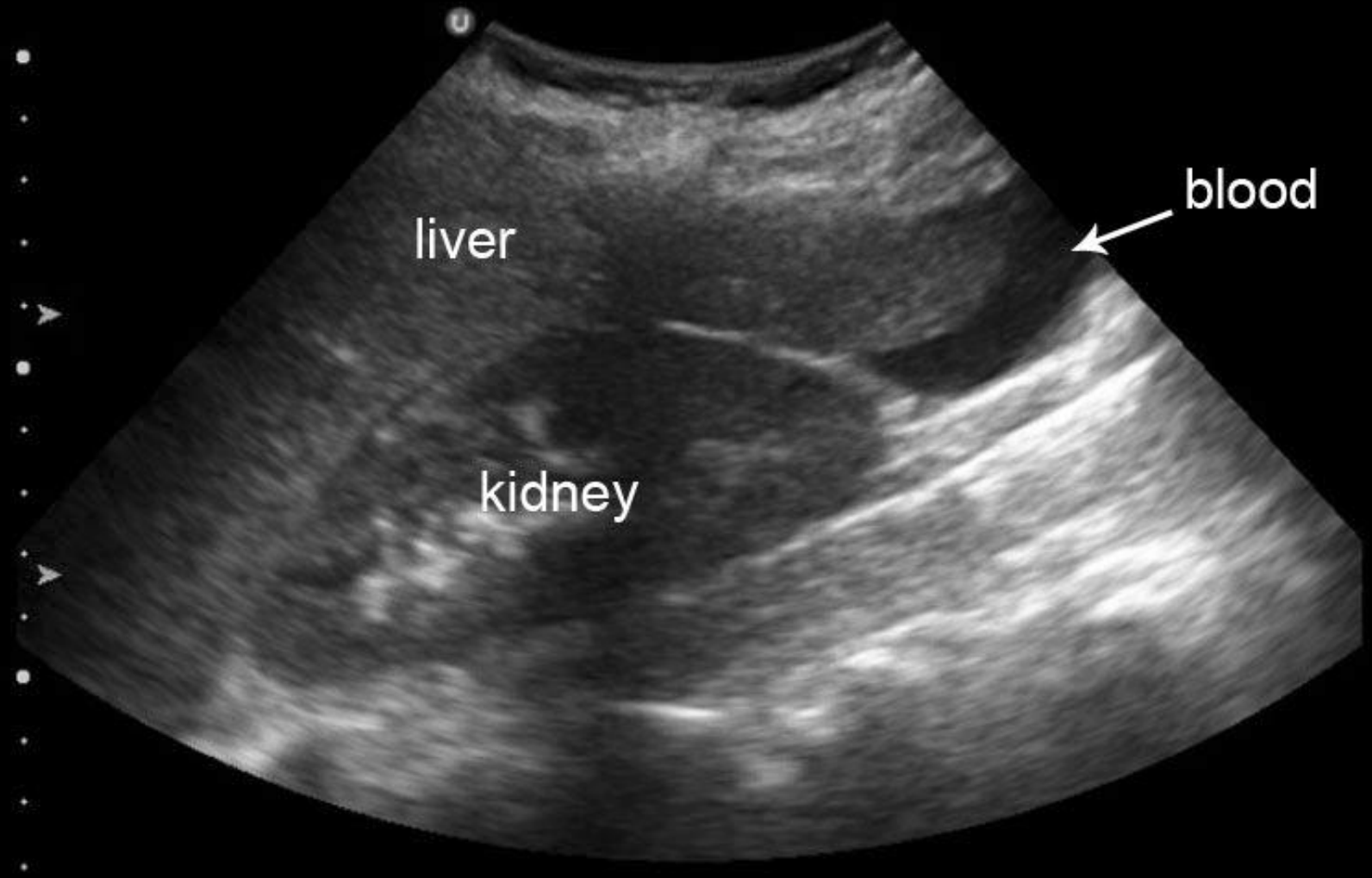

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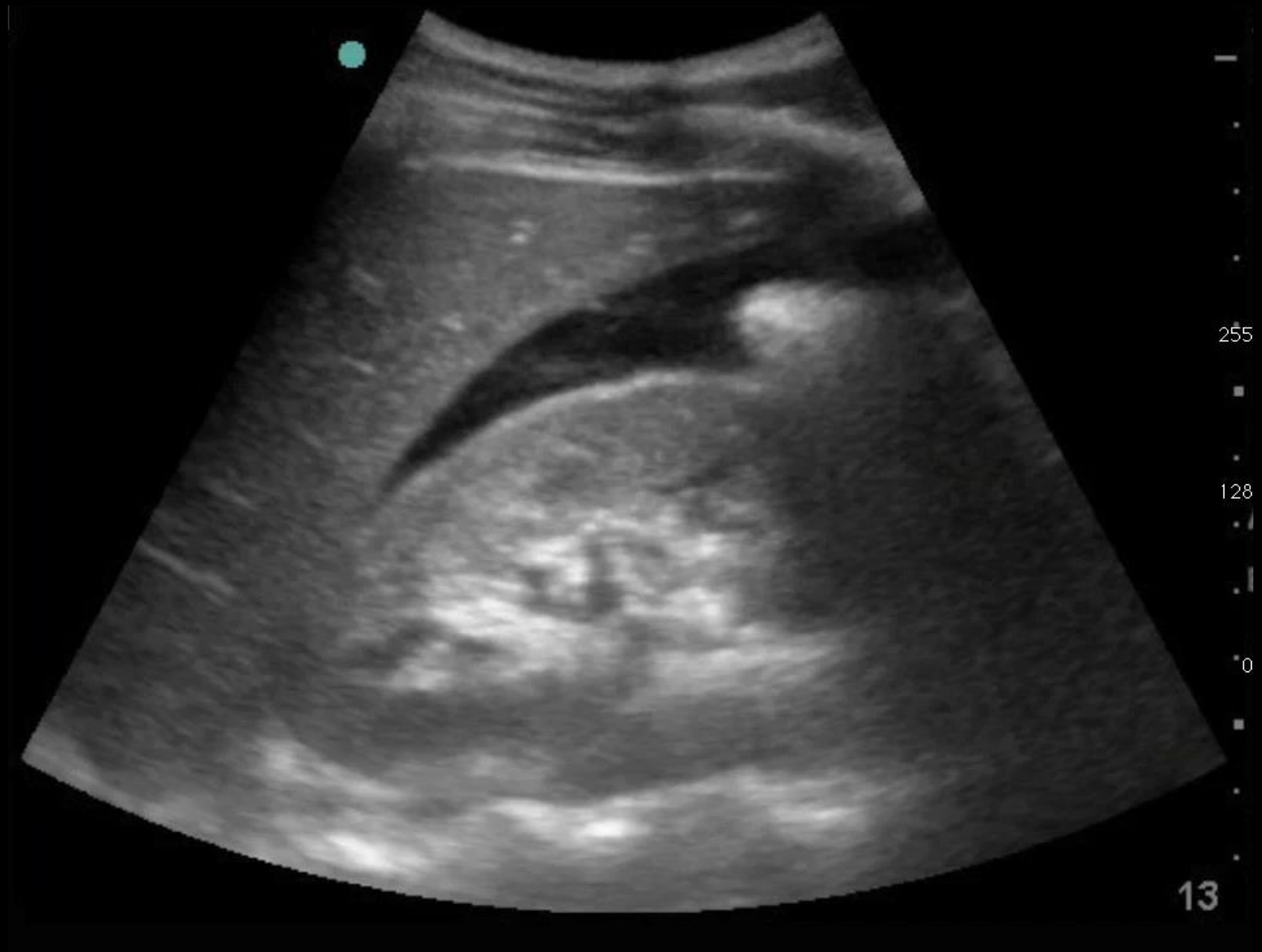


Pelvis

- Next most sensitive area
- Blood from liver or spleen
  - Paracolic gutters
- Pelvic fracture
- May not be positive

Normal and Pathologic Findings

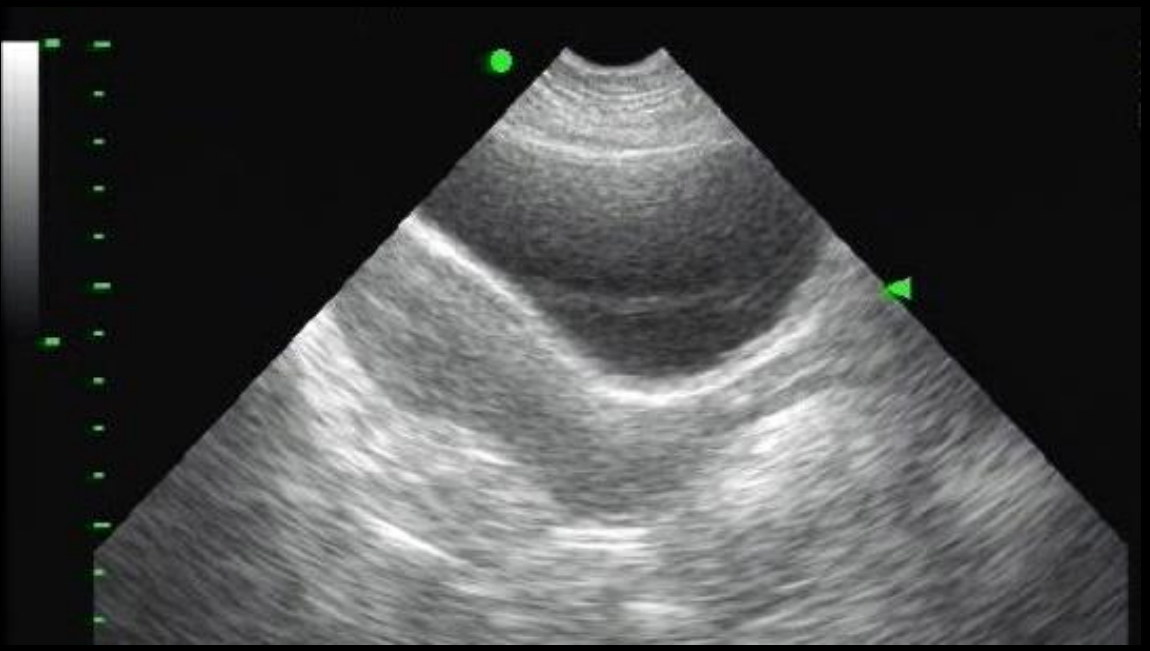
Pelvic

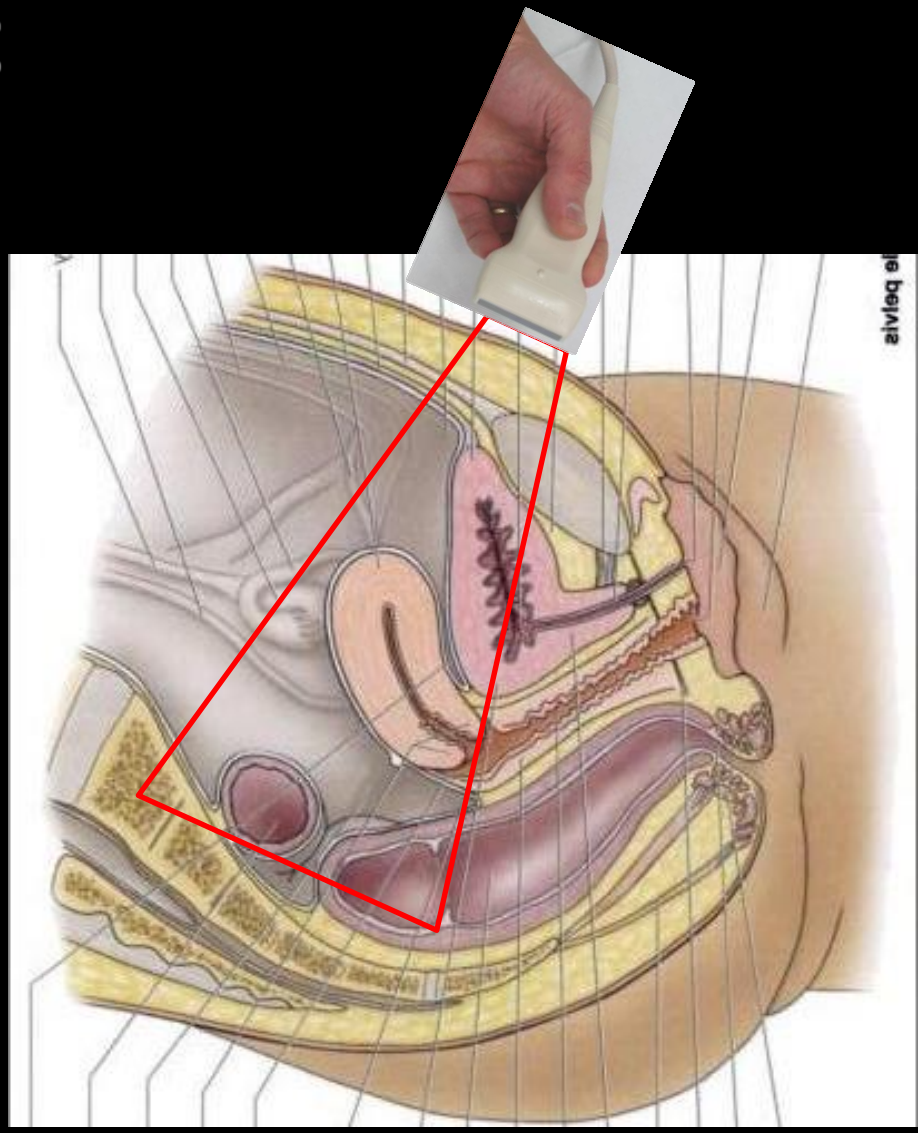
- Probe Placement
  - Superior to symphysis pubis
  - Transverse orientation
  - Sagital orientation
- Probe Movement
  - Cephalad, Caudad, Side to Side
  - Full visualization of perivesicular area

Normal and Pathologic Findings

Pelvic

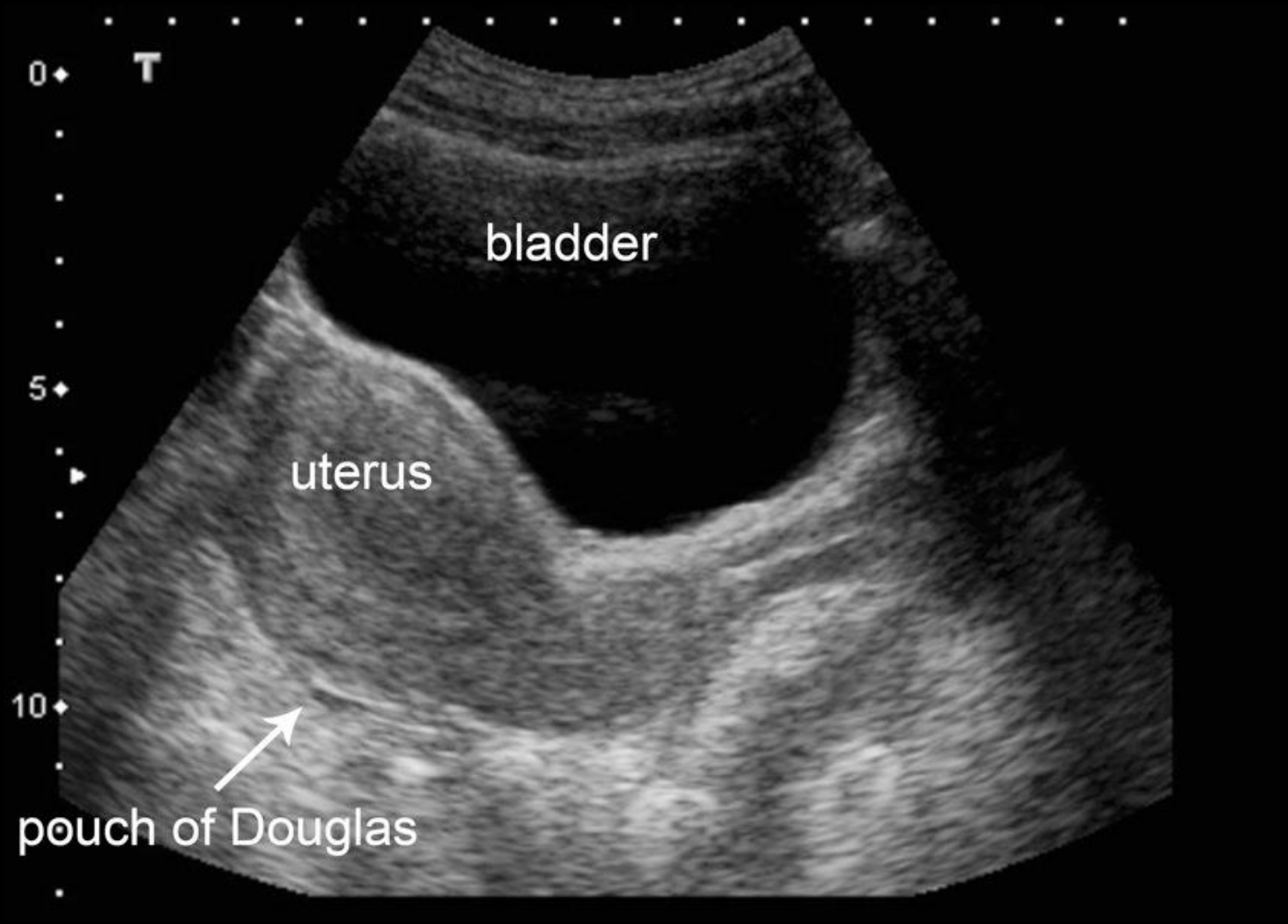
- Blank





Normal and Pathologic Findings

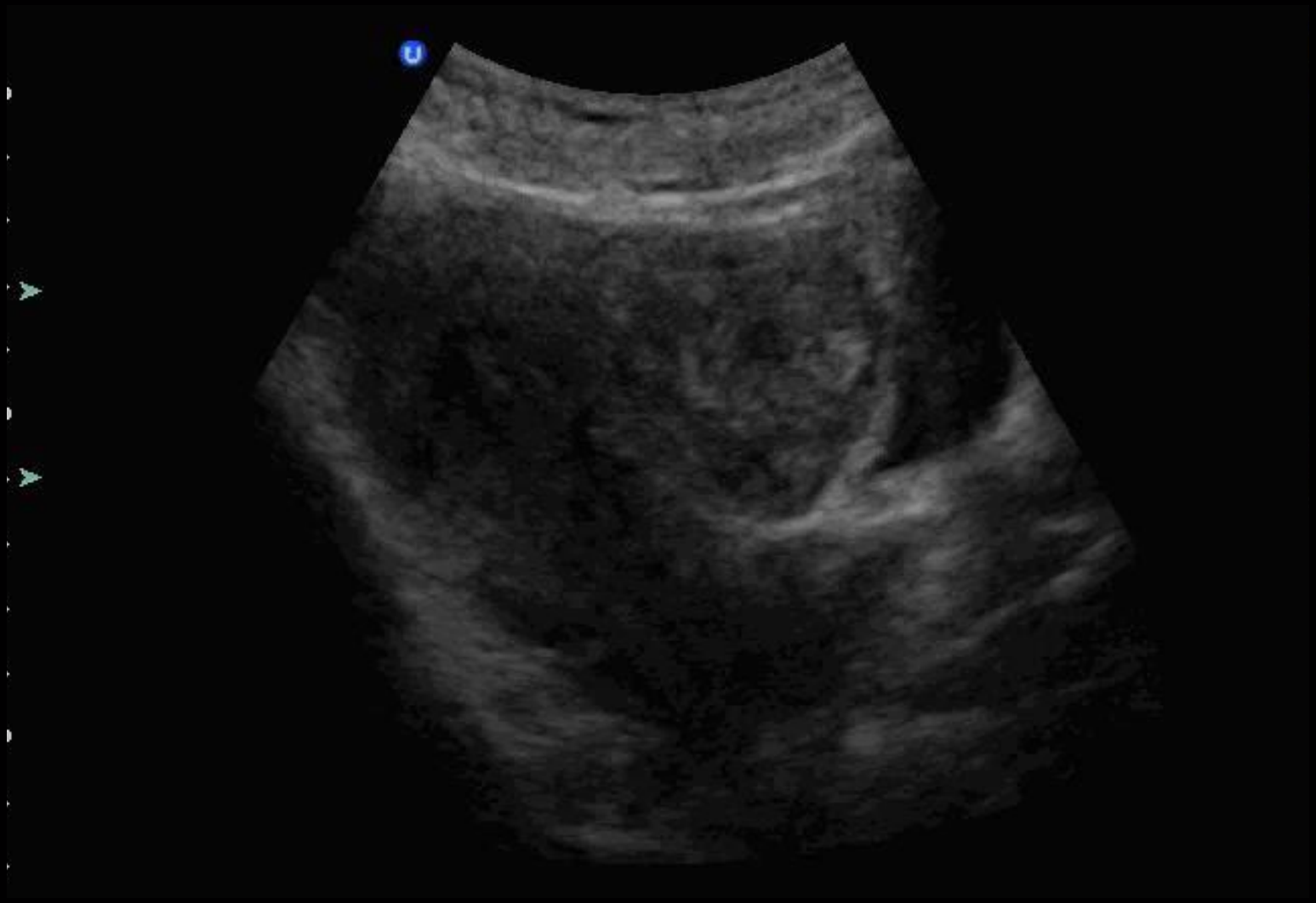
Pelvis



female pelvis

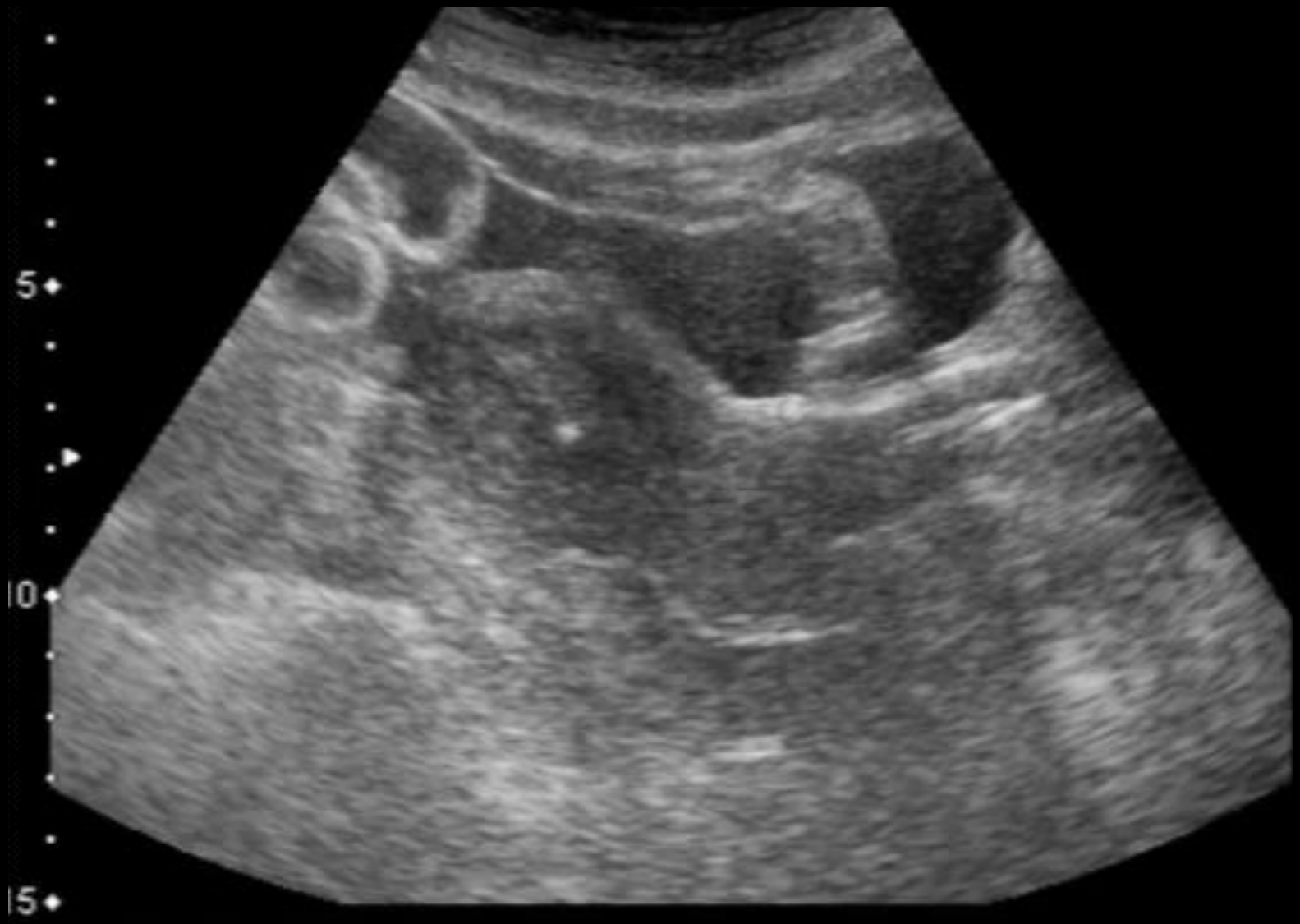
Normal and Pathologic Findings

Pelvis



Normal and Pathologic Findings

Pelvis



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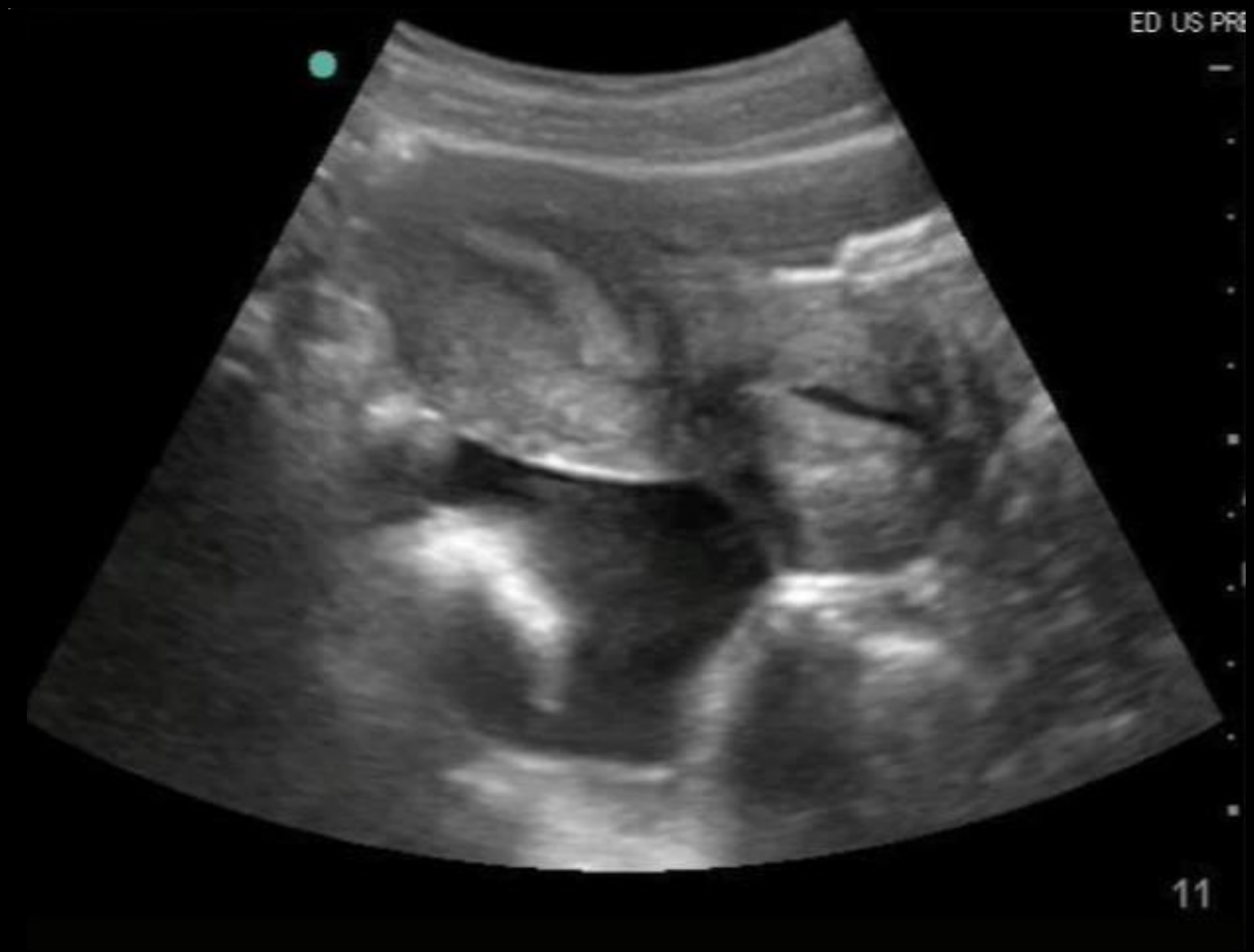
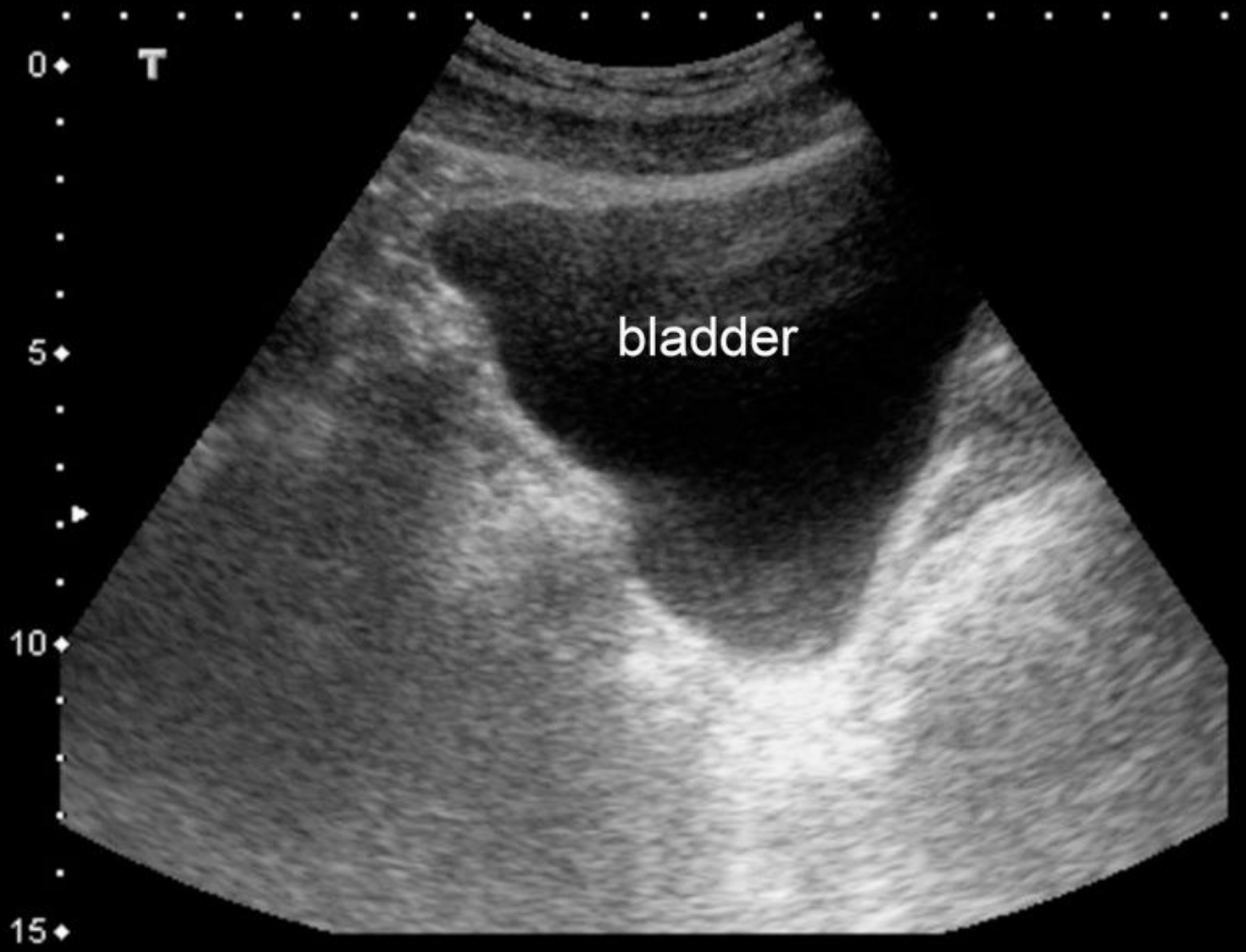
Pelvis



Normal and Pathologic Findings

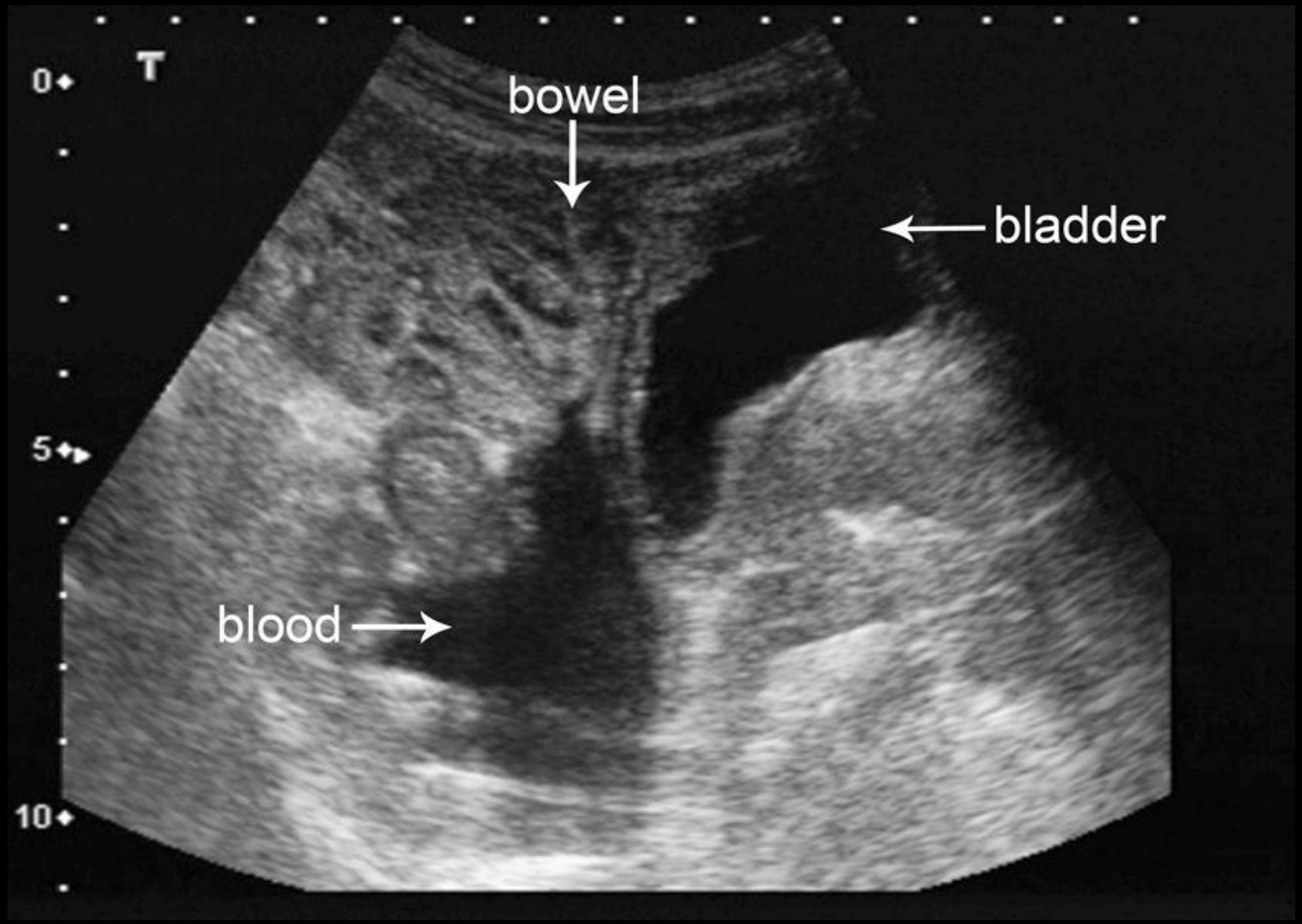
Pelvis



male pelvis

Normal and Pathologic Findings

Pelvis



Normal and Pathologic Findings

Pelvis

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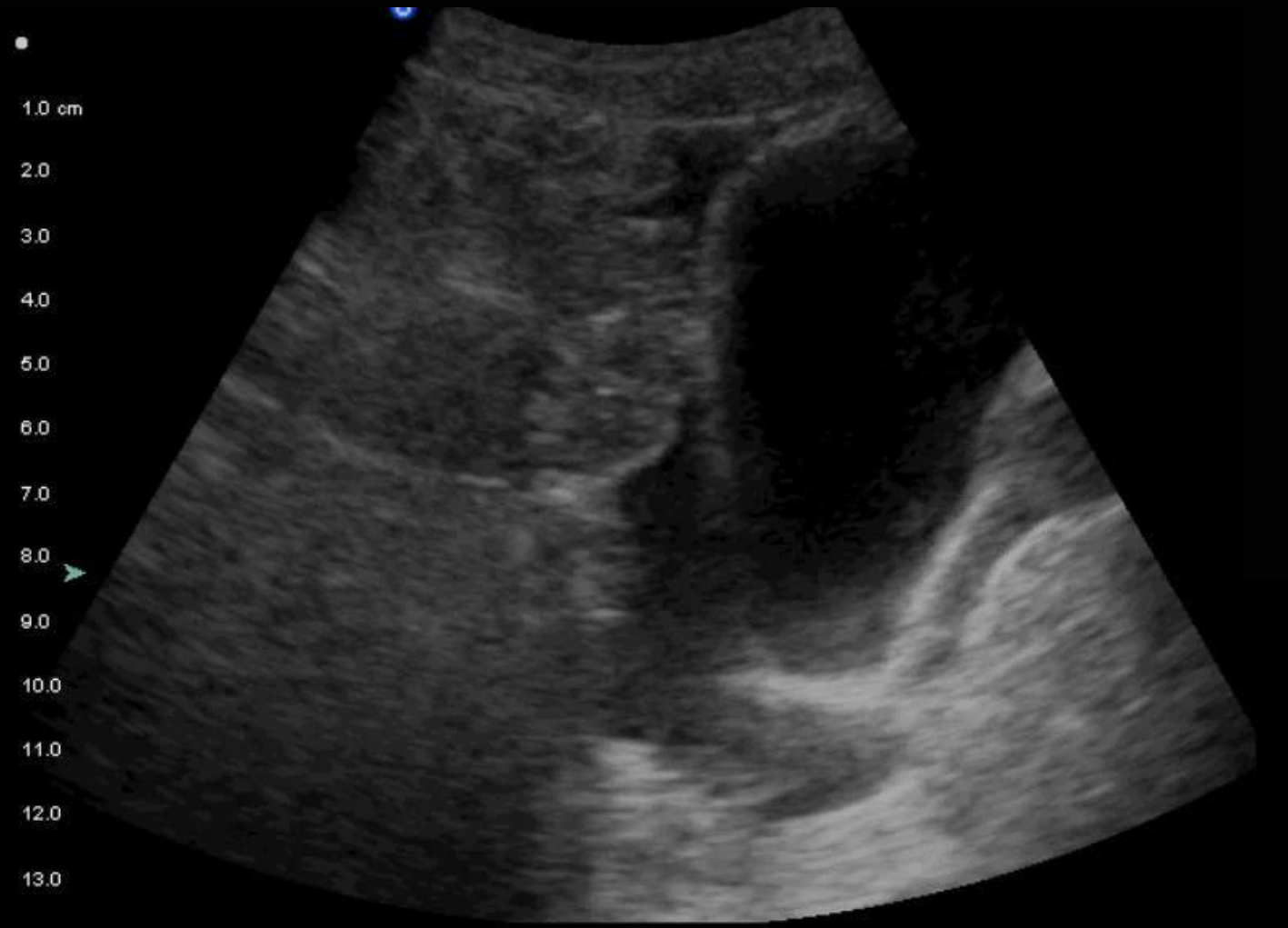


Left Upper Quadrant

- Spleen = acoustic window
- NOT sensitive for splenic parenchymal injury
- Most blood collects in RUQ

Normal and Pathologic Findings

Left Upper Quadrant

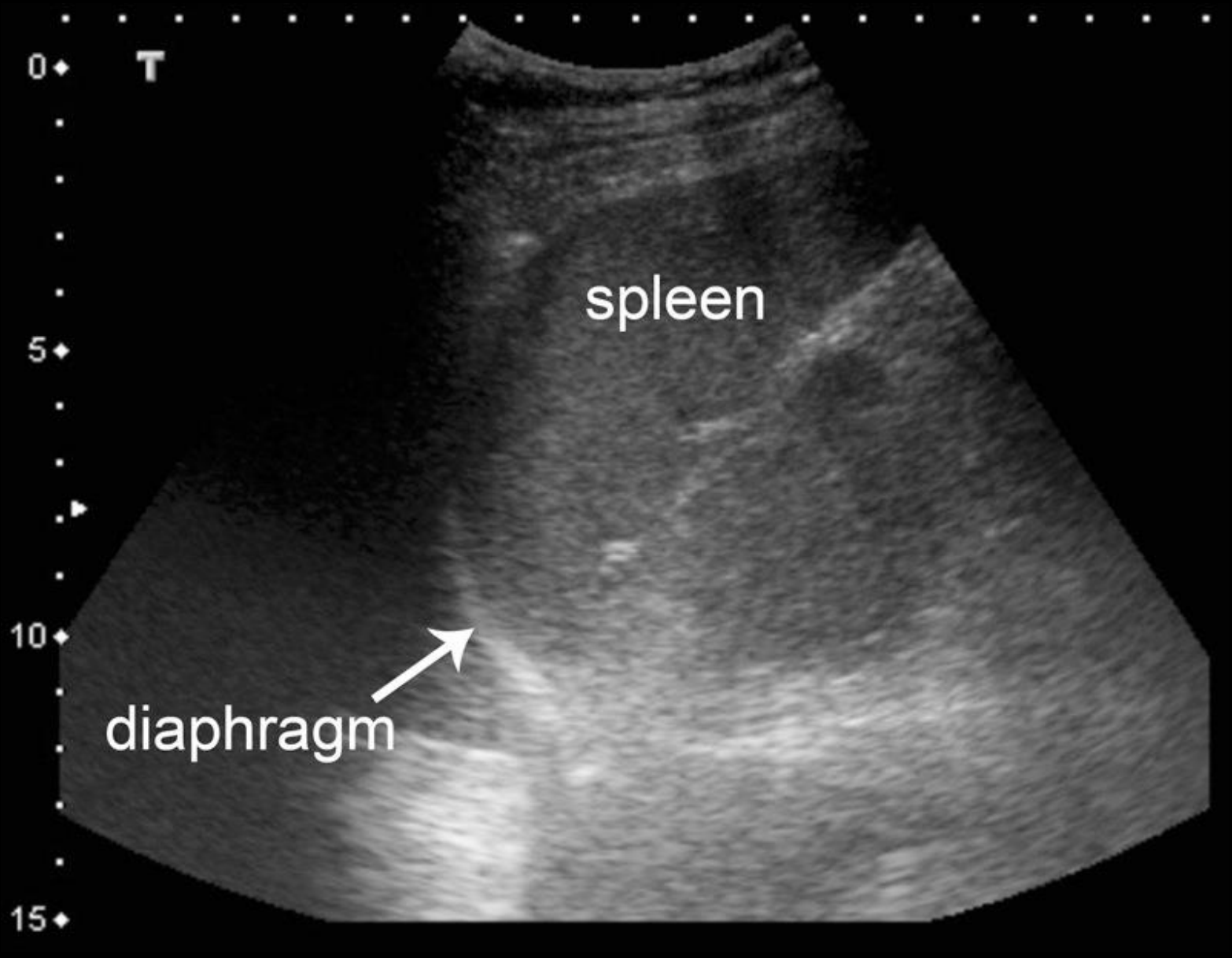
- Probe Placement
  - Posterior axillary line
  - Coronal plane
  - 9th and 10th intercostal spaces
  - More superoposterior
- Probe Movement
  - Anterior and Posterior
  - Caudad and Cephalad

Normal and Pathologic Findings

Left Upper Quadrant

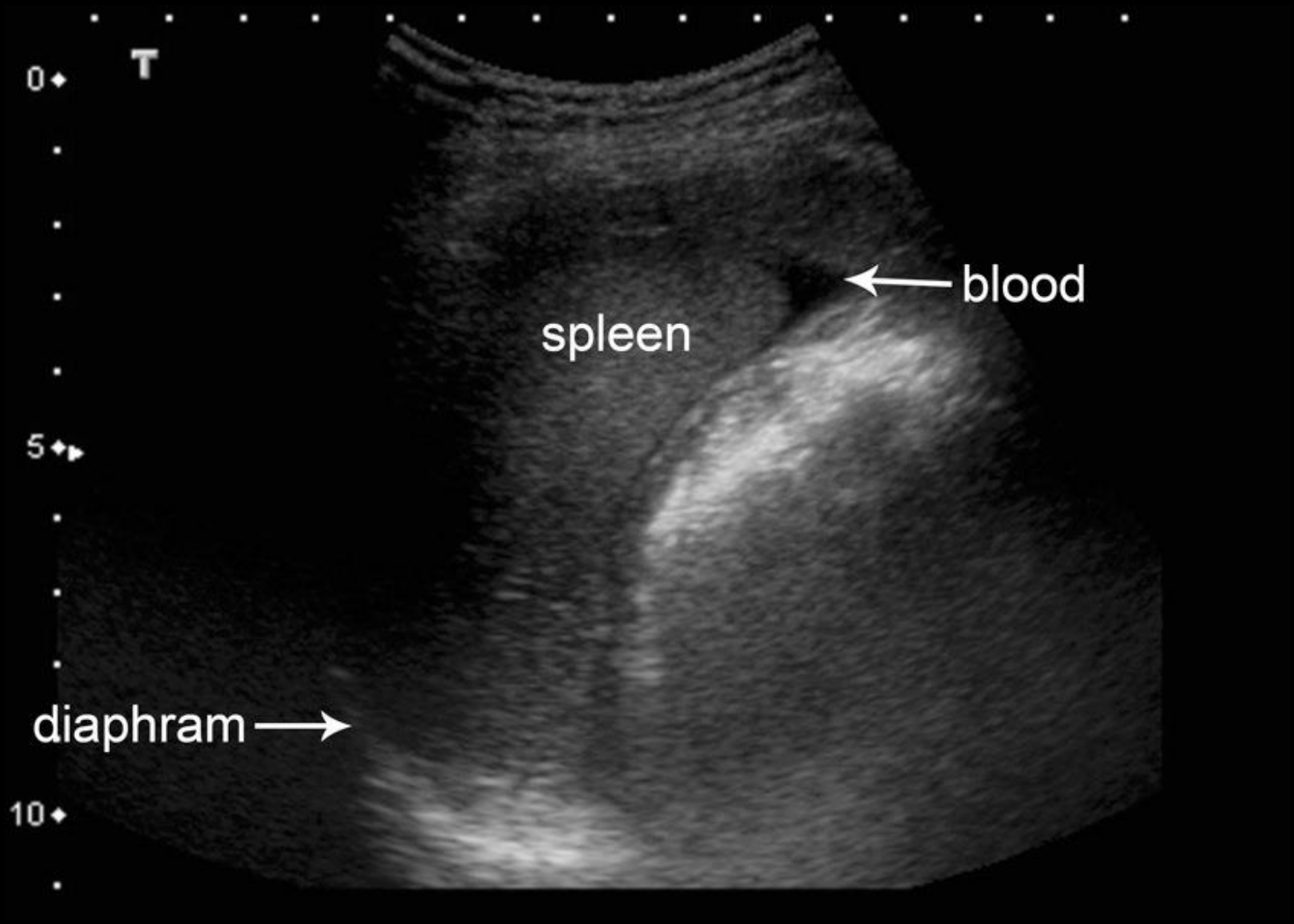
Normal and Pathologic Findings

Left Upper Quadrant



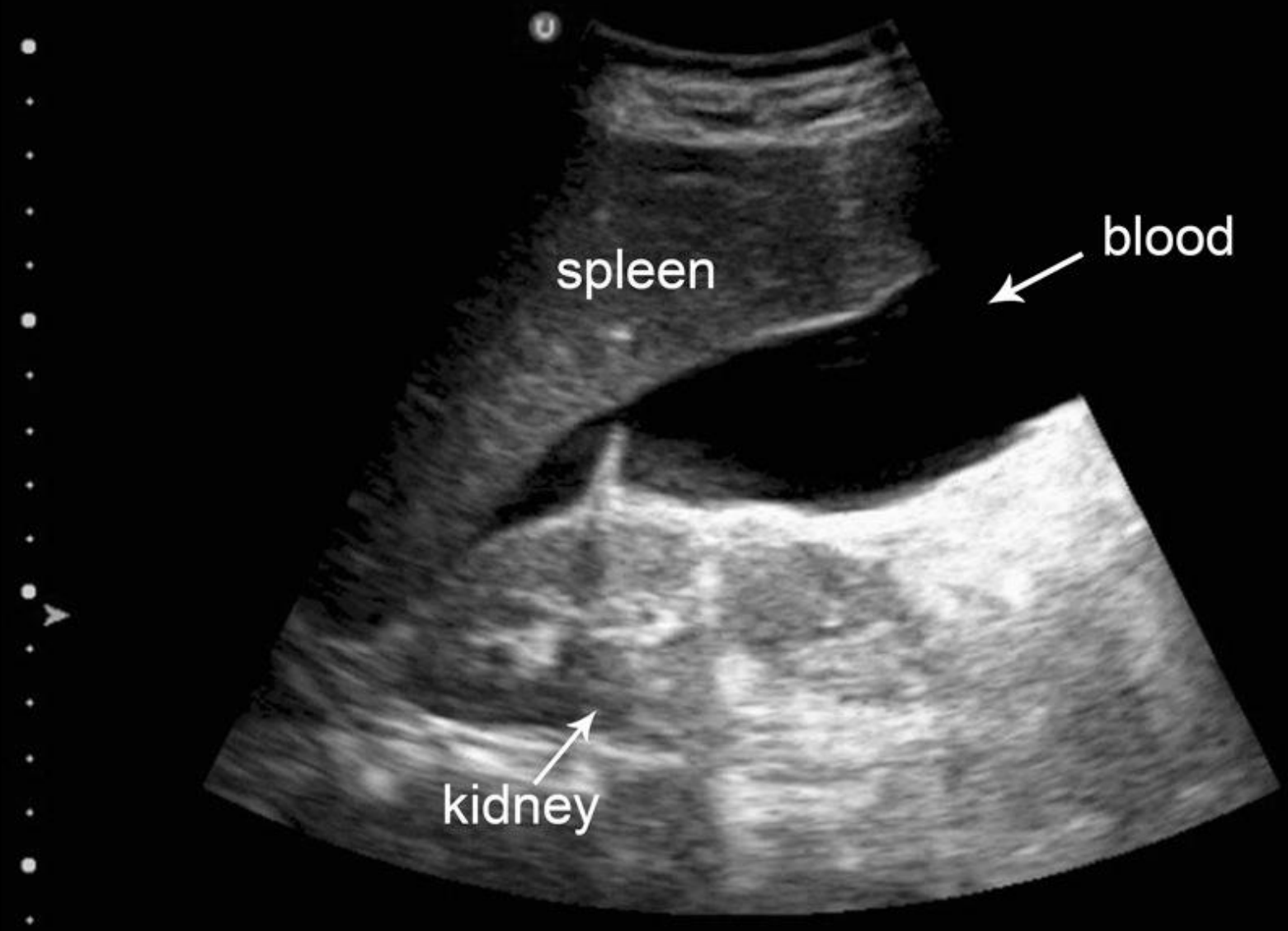
Normal and Pathologic Findings

Left Upper Quadrant



Normal and Pathologic Findings

Left Upper Quadrant



Normal and Pathologic Findings

Left Upper Quadrant

Normal and Pathologic Findings

Left Upper Quadrant

Normal and Pathologic Findings

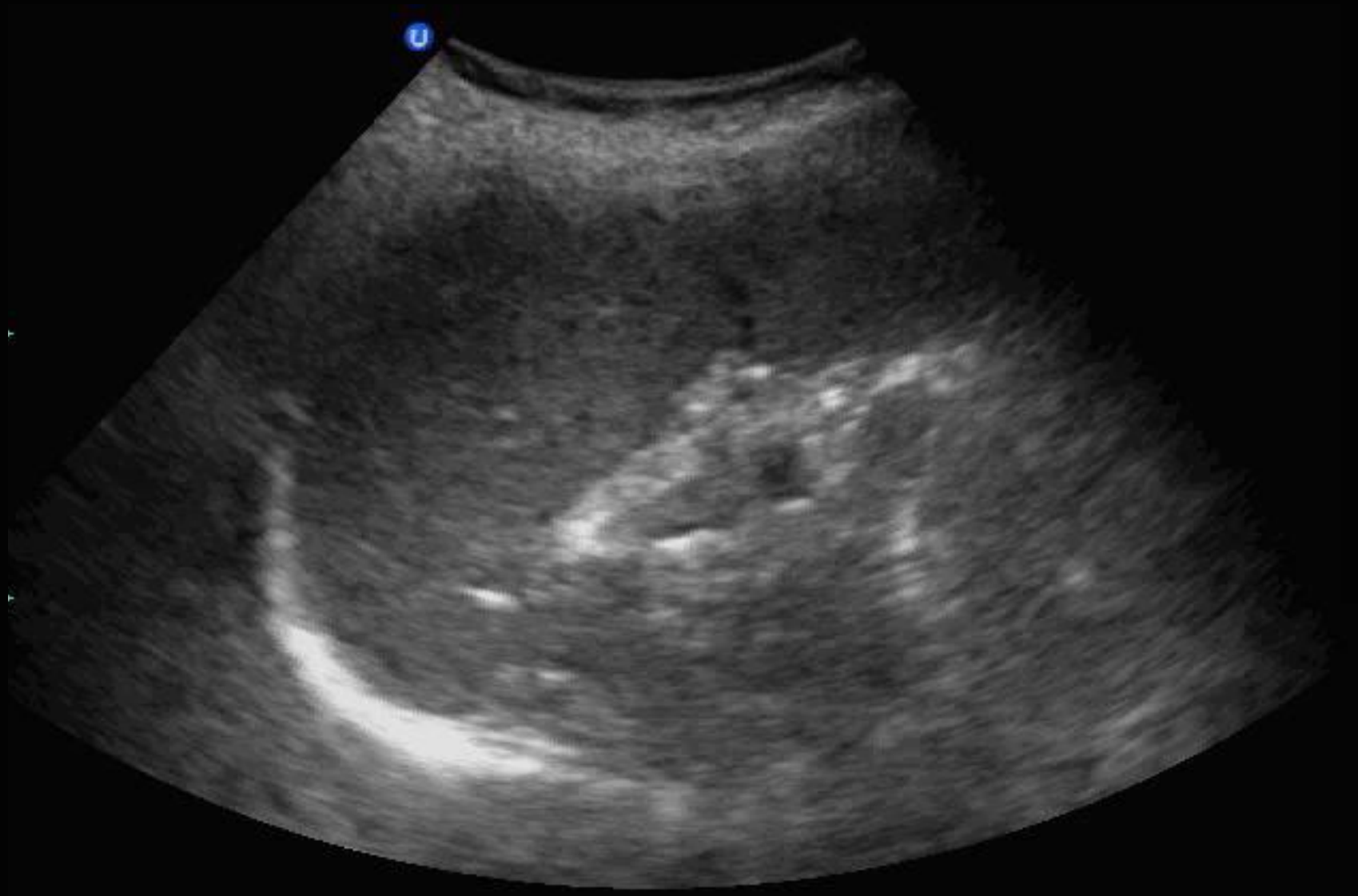
Left Upper Quadrant

Normal and Pathologic Findings

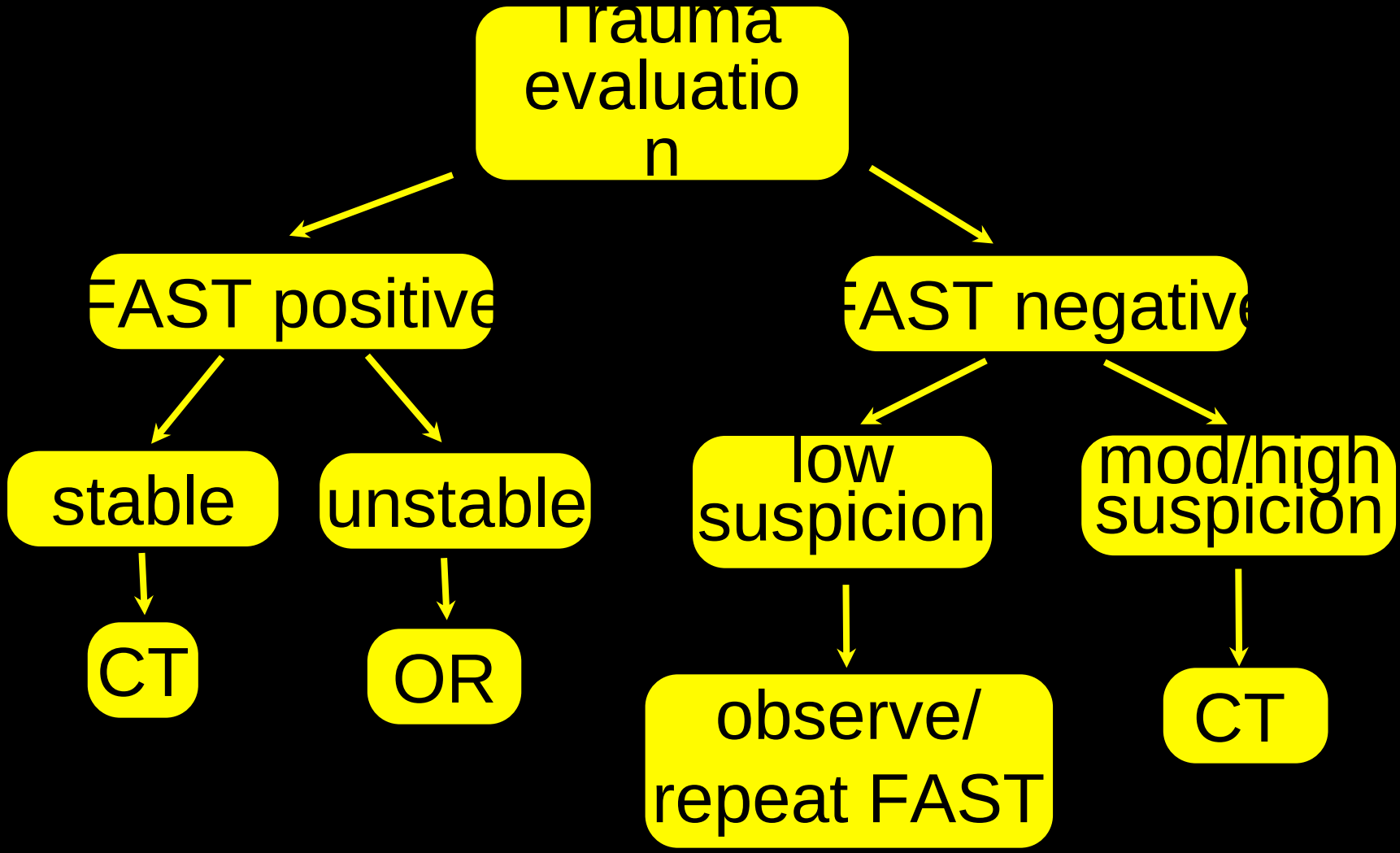
Right Upper Quadrant

Normal and Pathologic Findings

Left Upper Quadrant



Clinical Utility



Cardiac Evaluation

Normal and Pathologic Findings

Cardiac Evaluation

- Echocardiography in trauma
  - Most useful in penetrating trauma
  - Sensitivity nearly 100% for hemopericardium
  - Definitely saves lives
    - Plummer et al 1992
    - time to dx and dispo 43min → 15.5mins
    - survival 57.1% → 100%

Normal and Pathologic Findings

Cardiac Evaluation

Tamponade: Clinical Signs	Incidence
Pulsus paradoxus	36%
Tachycardia	74%
Distended neck veins	52%
Muffled heart tones	24%

Guberman BA, Fowler NO, Engel PJ et al. Cardiac tamponade in medical patients. *Circulation* 1981; 64:633-40

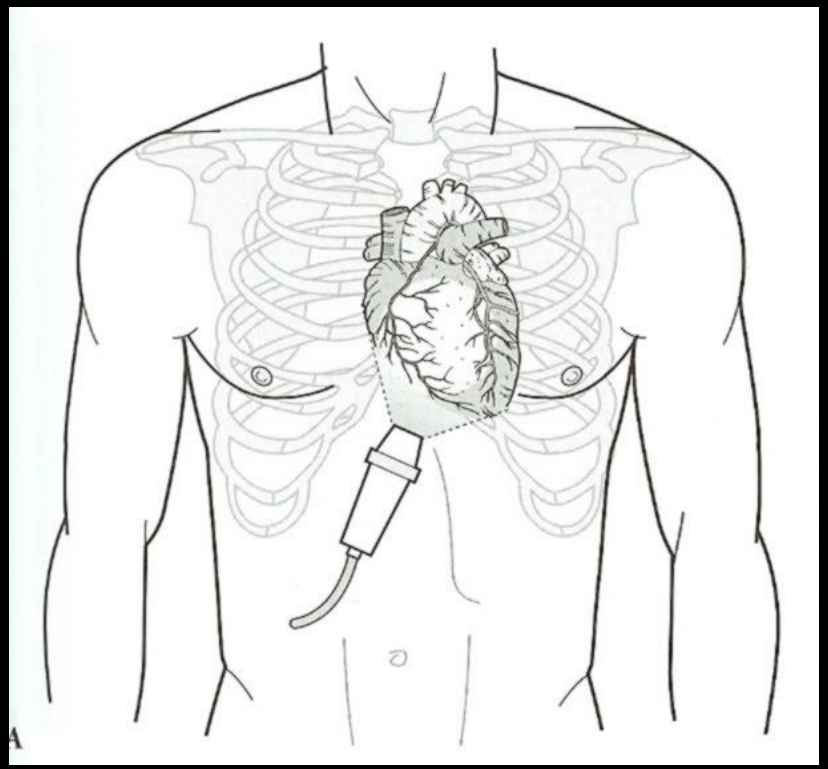
Cardiac Evaluation

- Subxiphoid:
  - Pericardial effusion
  - LV function
- Longitudinal IVC:
  - Volume status

Normal and Pathologic Findings

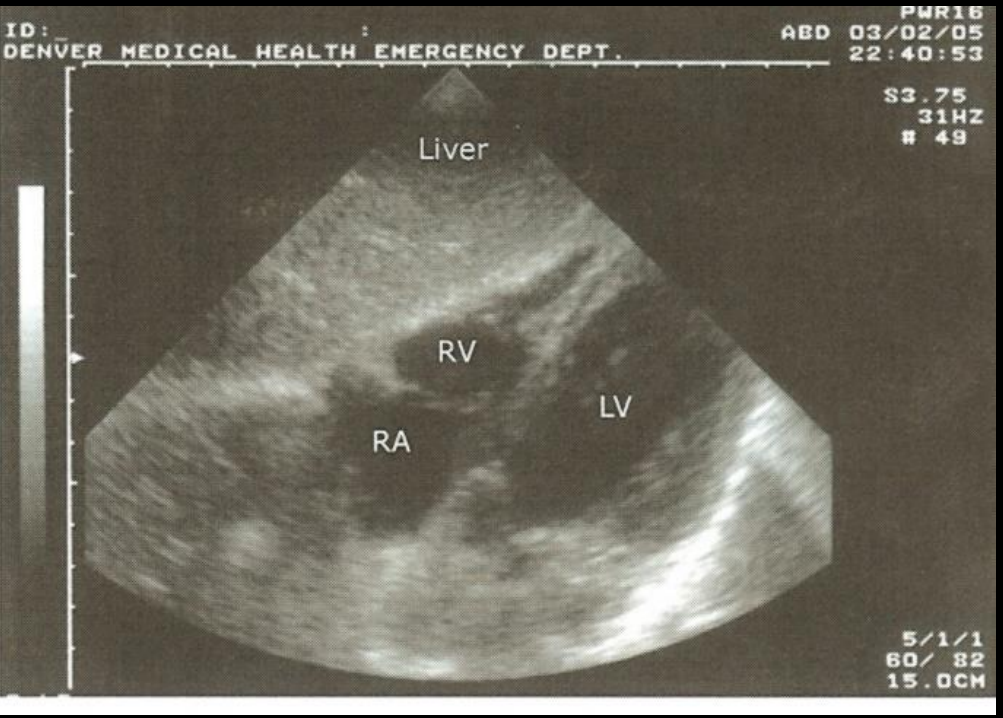
Cardiac Evaluation

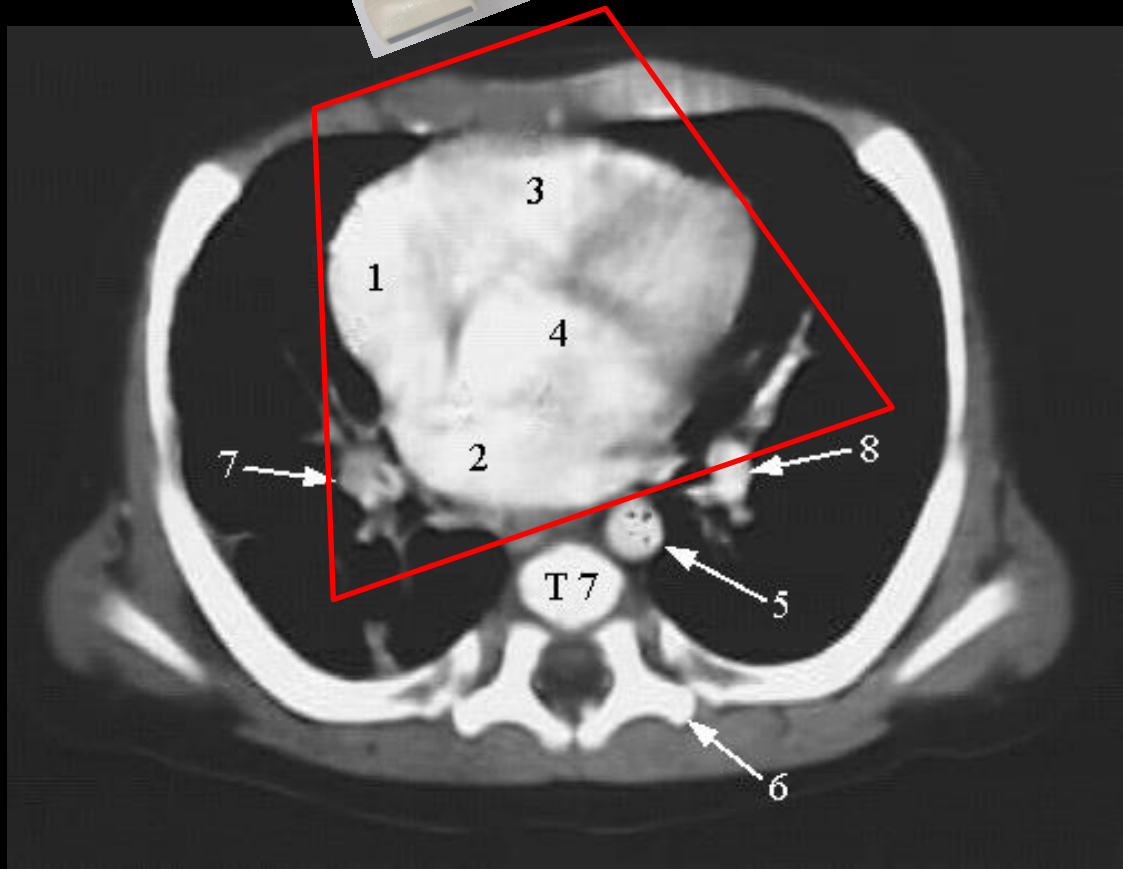
- Probe Placement
  - Subxiphoid, slightly to right of midline
  - Use liver as an acoustic window
  - Probe held almost parallel to skin



Normal and Pathologic Findings

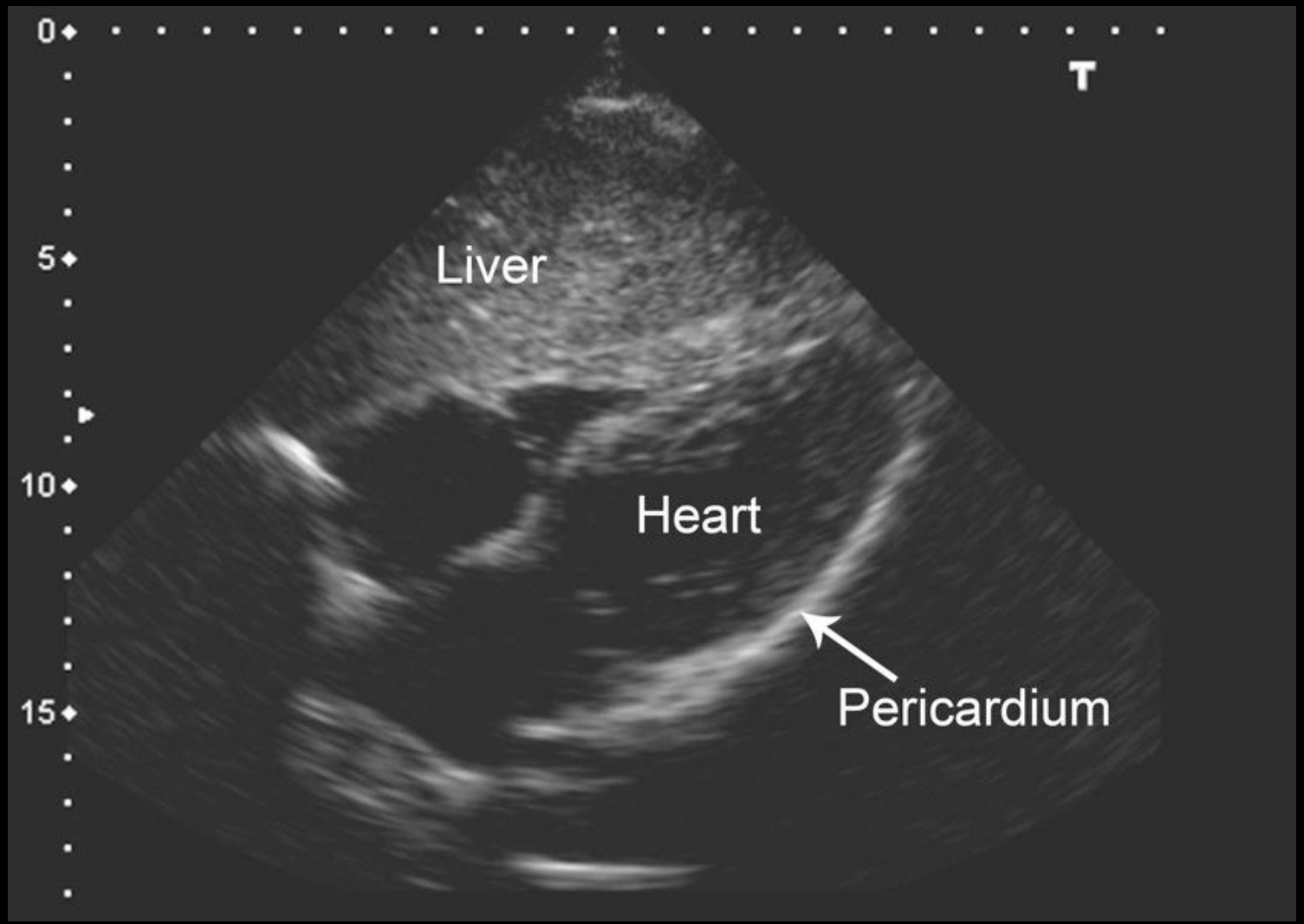
Cardiac Evaluation





Normal and Pathologic Findings

Subxiphoid



Normal and Pathologic Findings

Subxiphoid

Normal and Pathologic Findings

Subxiphoid

Normal and Pathologic Findings

Subxiphoid

Normal and Pathologic Findings

Parasternal Long Axis

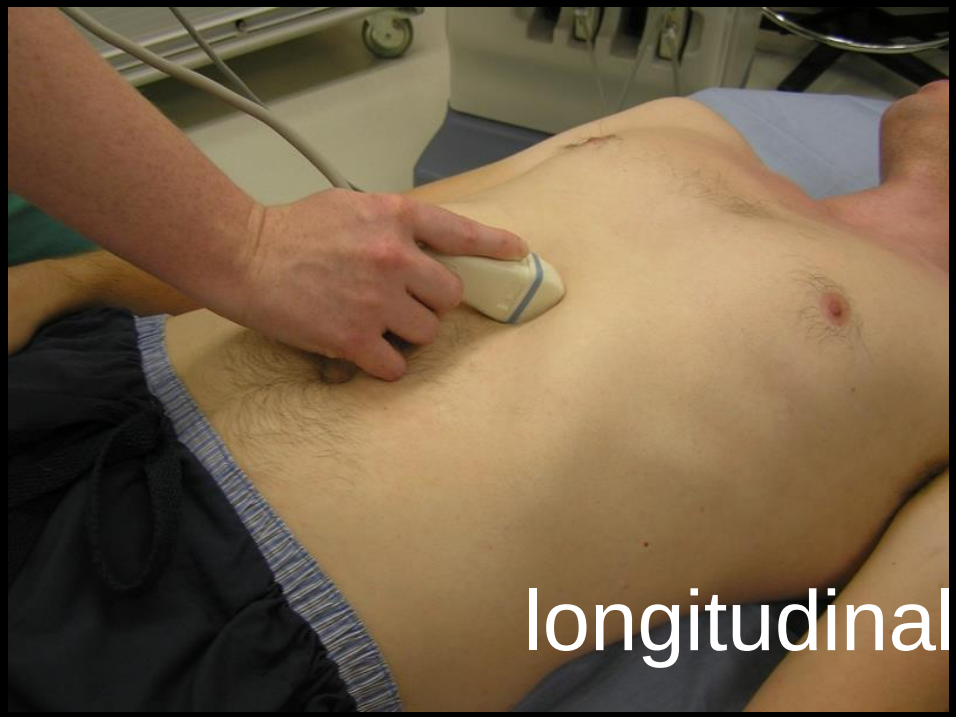
- Subxiphoid unattainable
  - Body habitus
  - Pain/distention

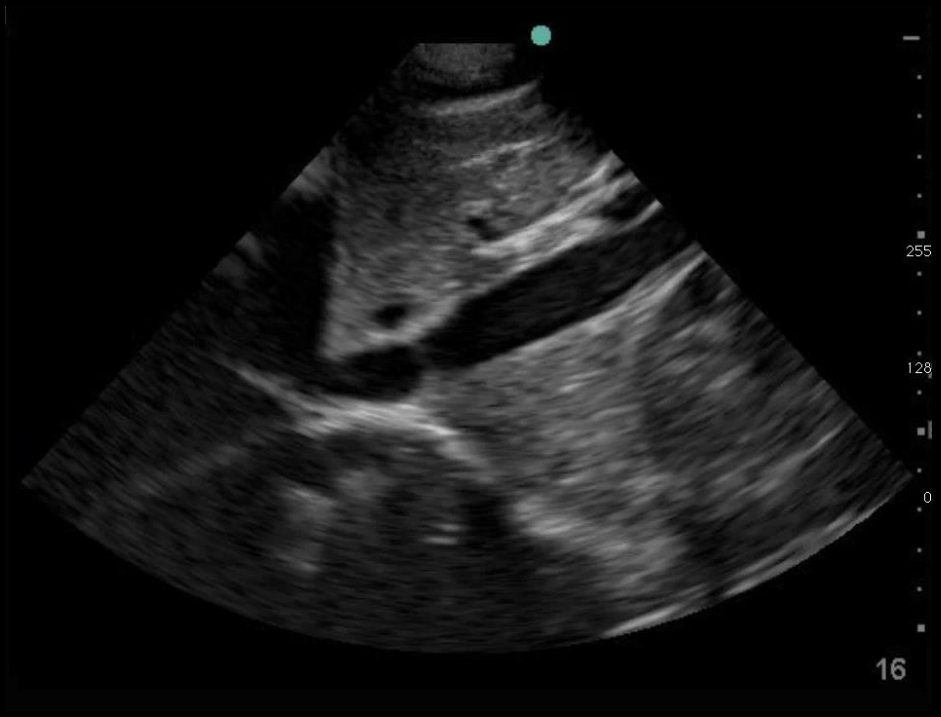
Normal and Pathologic Findings

Parasternal Long Axis

Normal and Pathologic Findings

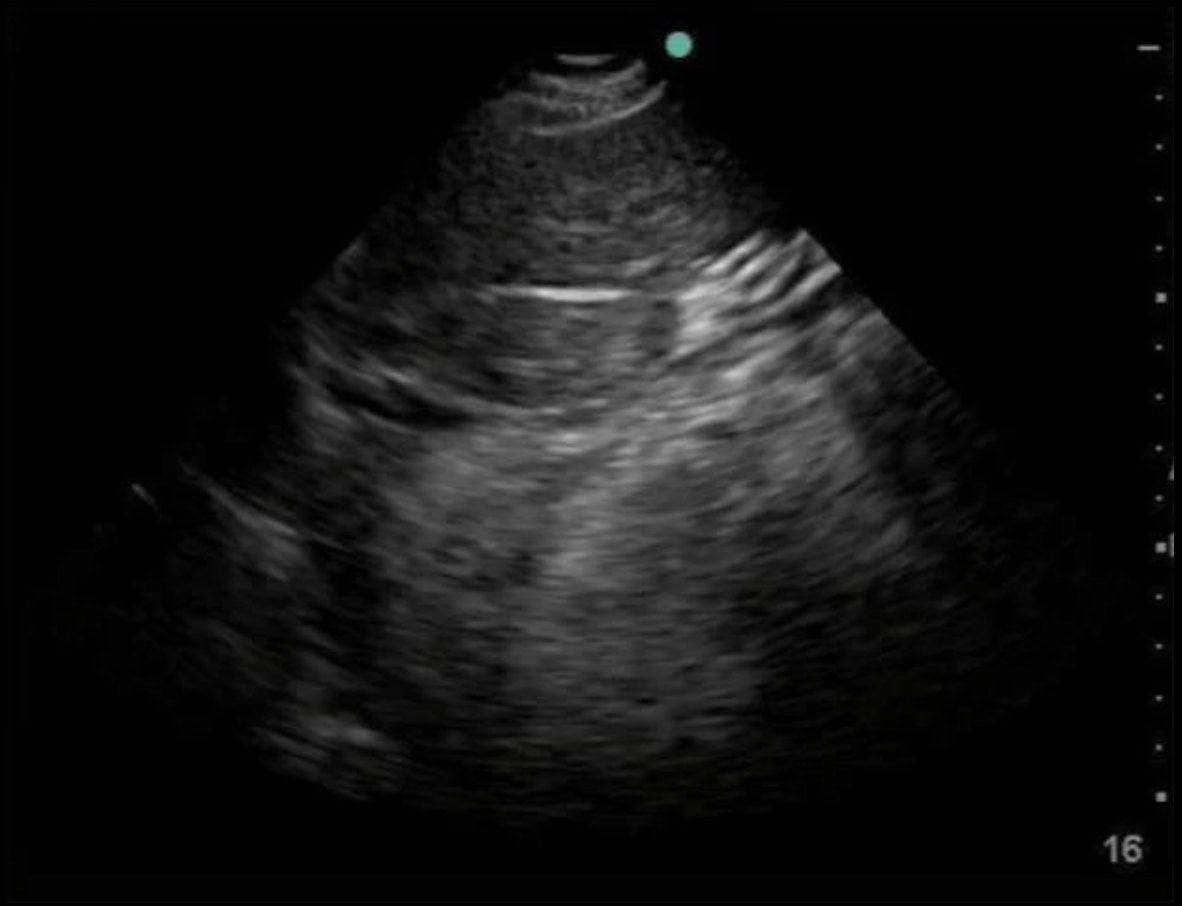
Subcostal Long Axis





Normal and Pathologic Findings

IVC

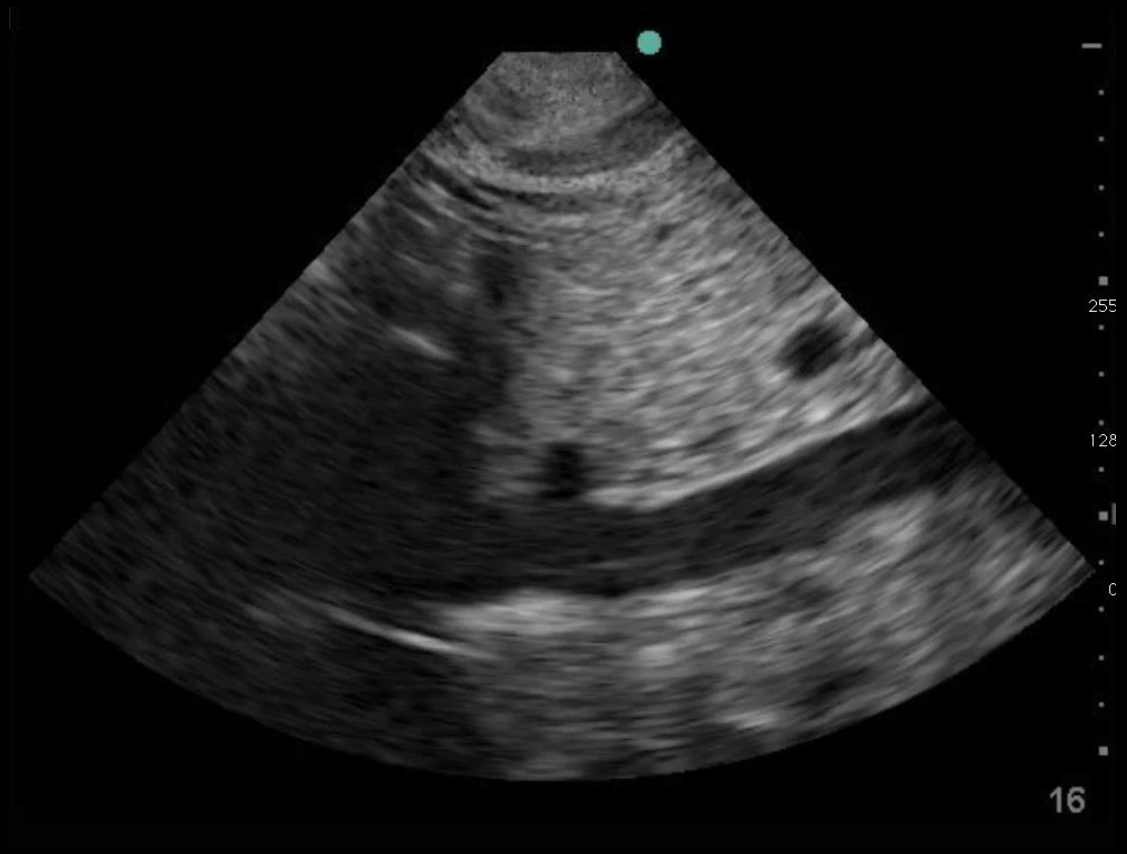


flat IVC

In trauma: severe hemorrhage?

Normal and Pathologic Findings

IVC



distended IVC

In trauma: tamponade?

tension pneumothorax?

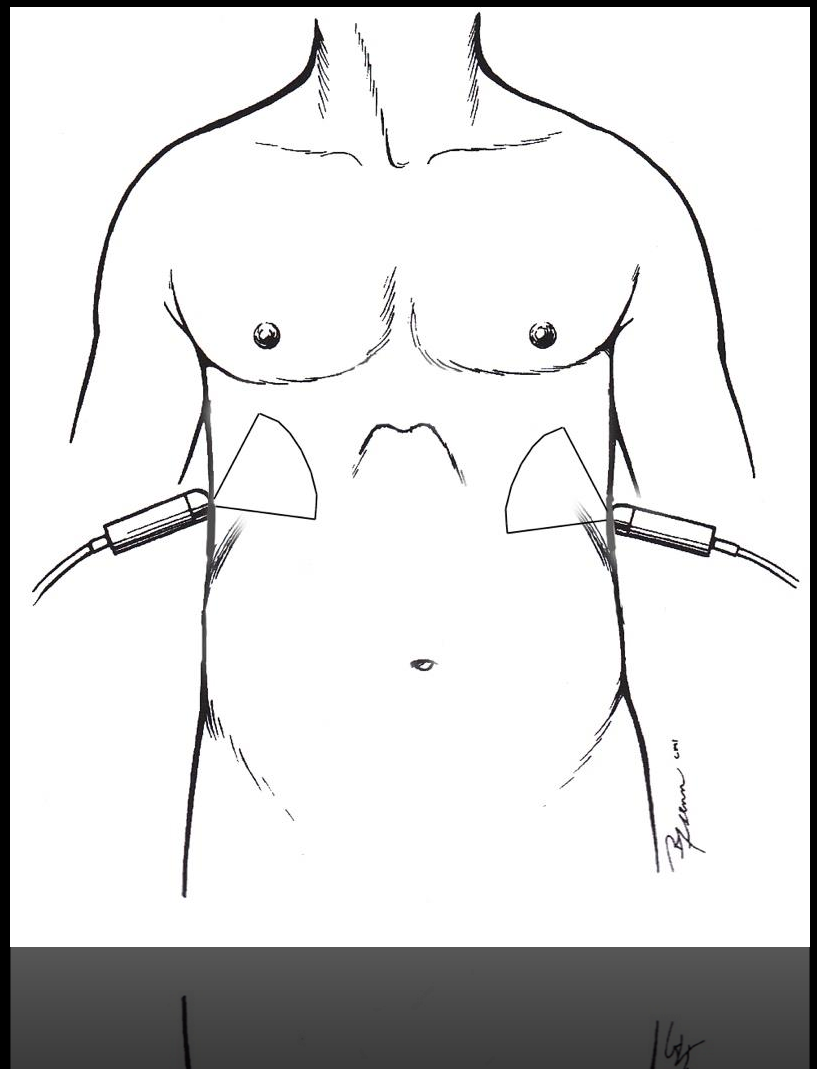
Thoracic Evaluation

Normal Sonographic Findings

Solid Organs

Use solid organs

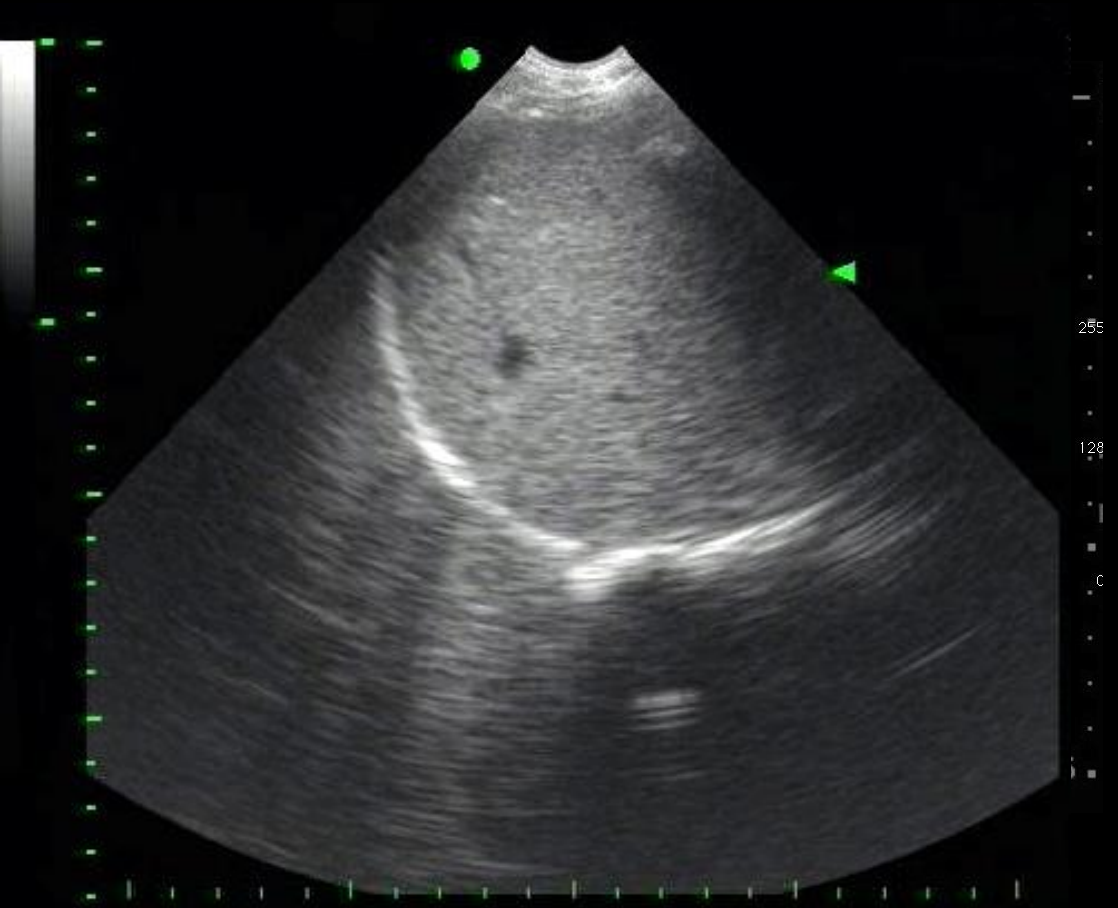
- liver and spleen as sonographic windows
- can see left and right costophrenic angles
- Exam may be done concurrently with abdominal imaging



Normal Sonographic Findings

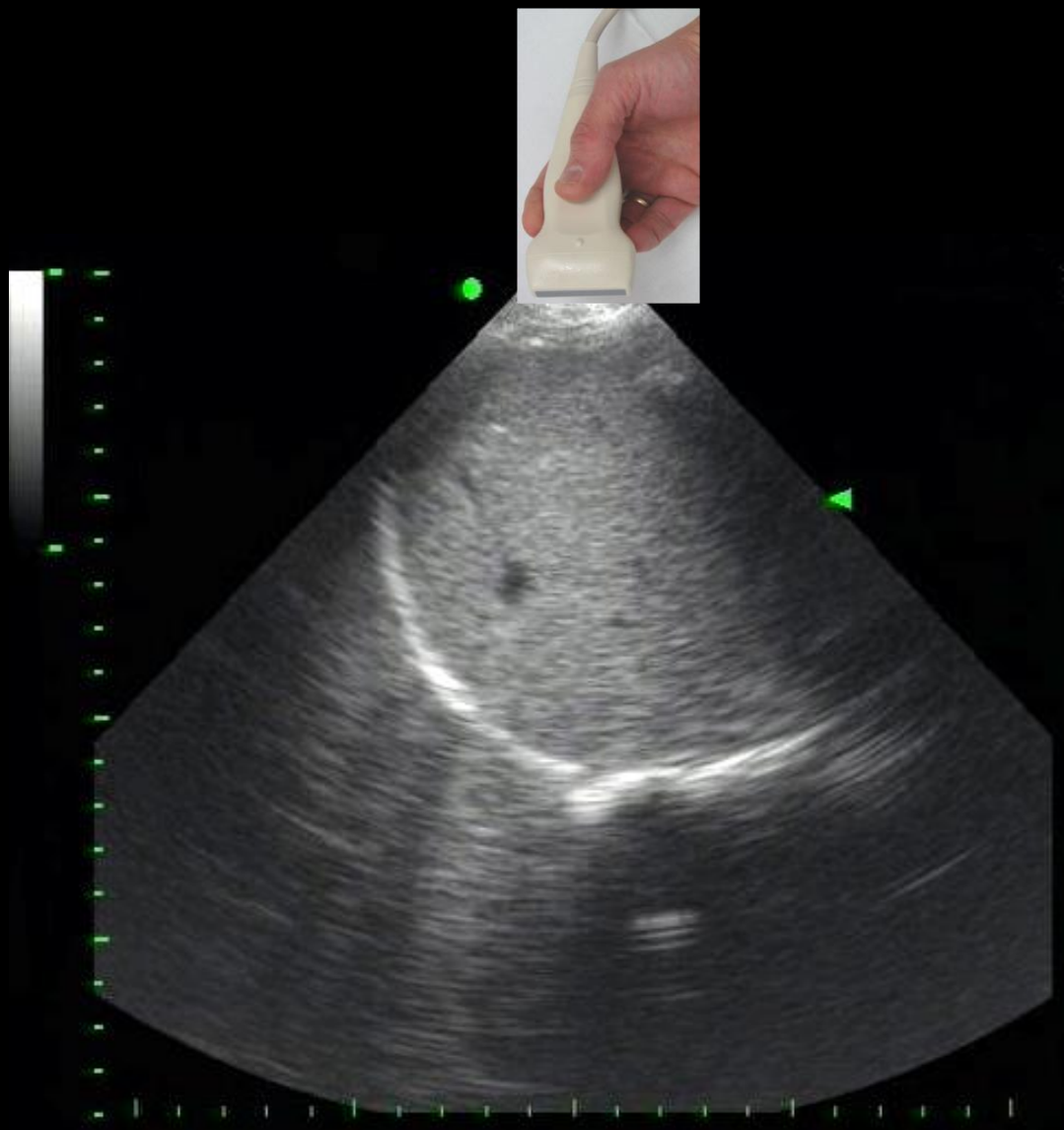
Right Costophrenic Angle

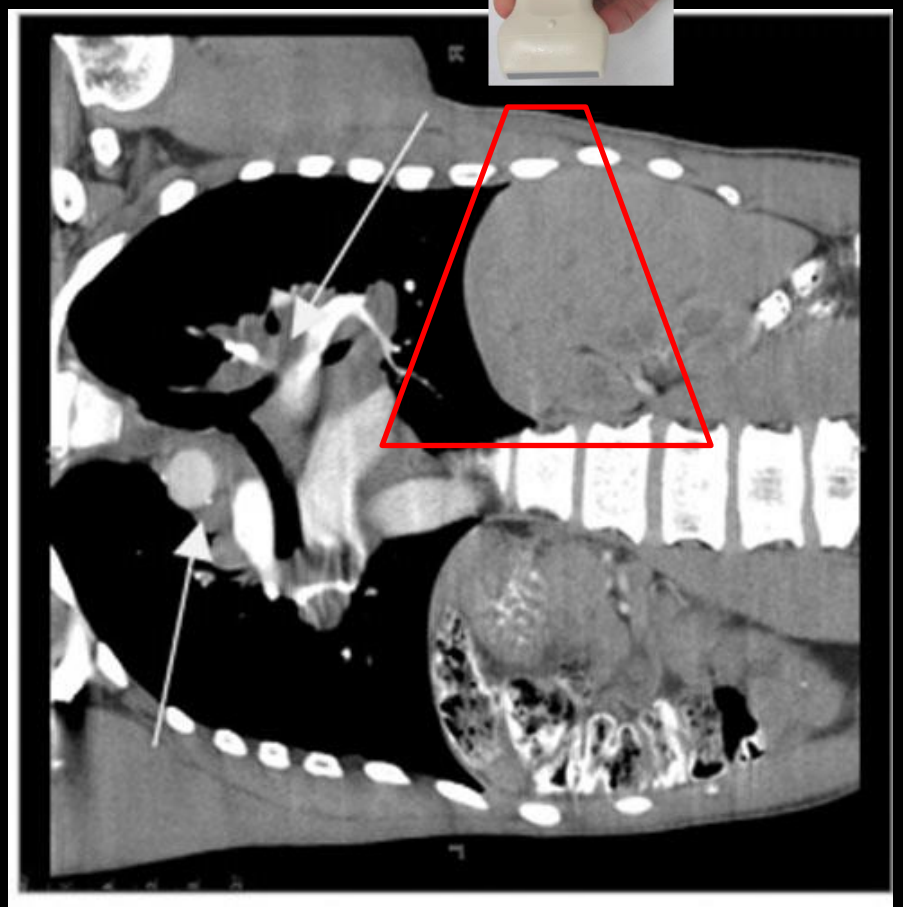
right CFA



Perihepatic

- Subphrenic recess, Pleural Space





Normal Sonographic Findings

Left Costophrenic Angle

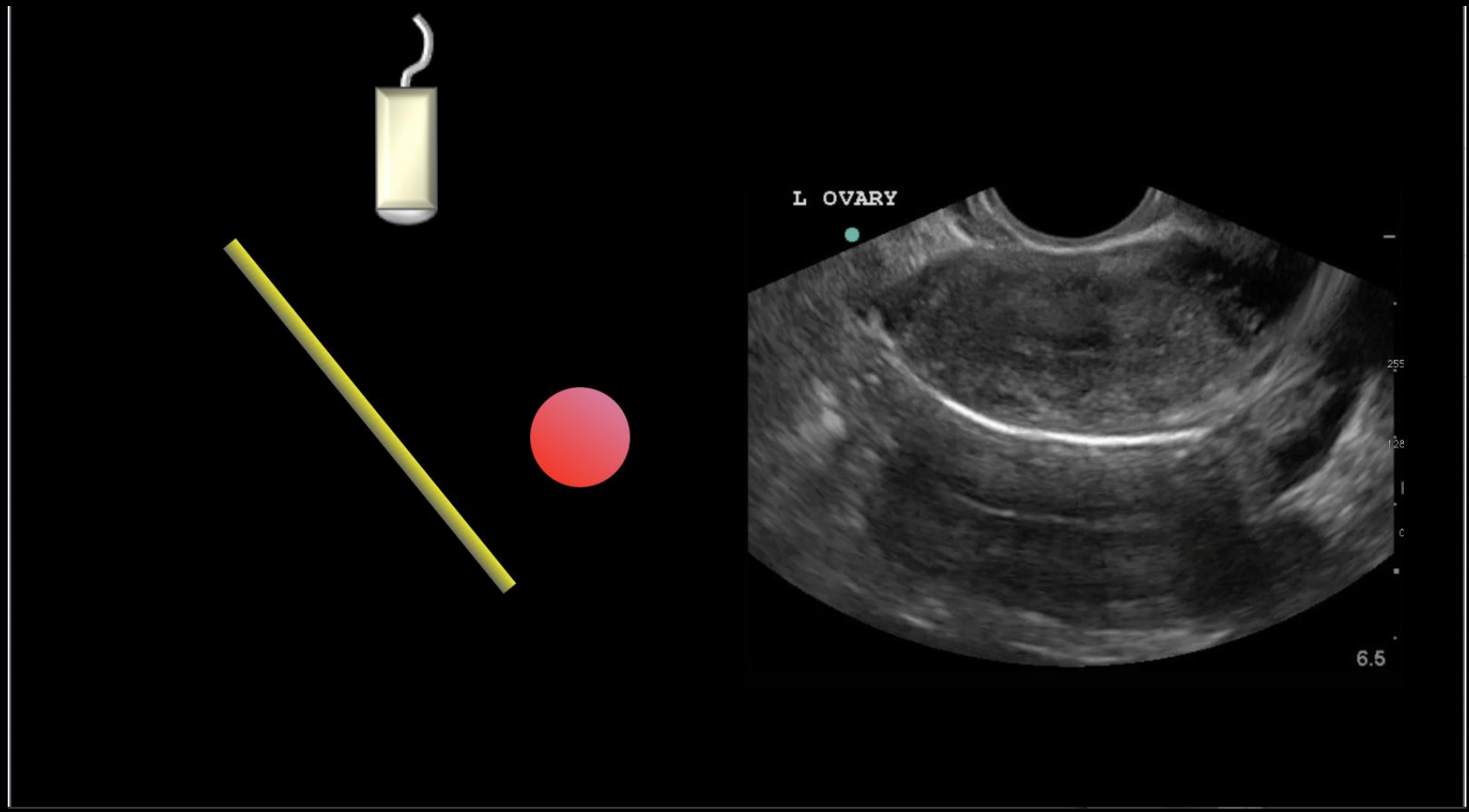
left CFA

Normal Sonographic Findings

Left Costophrenic Angle

Anatomy and Artifacts

- Mirror artifact



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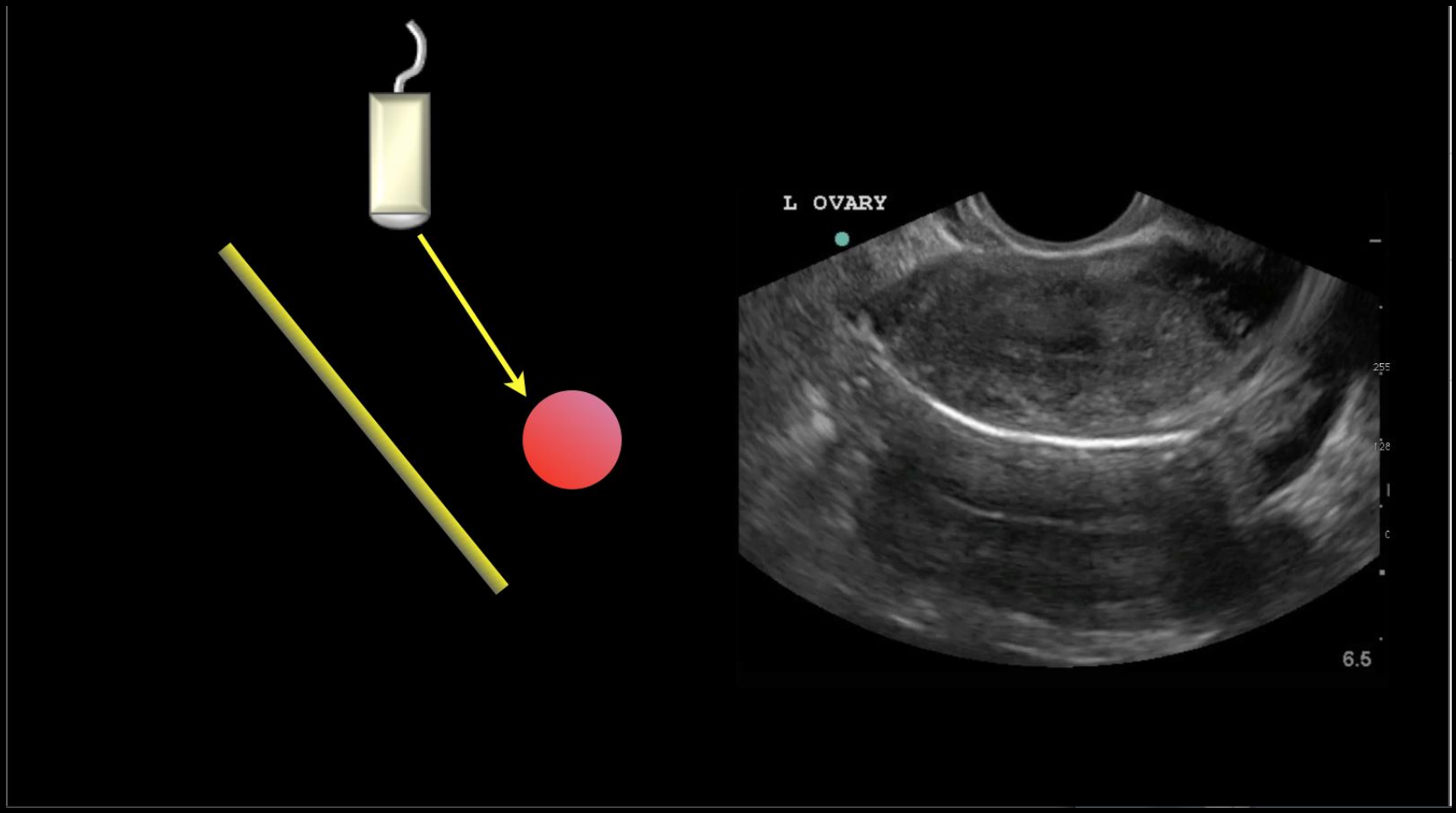

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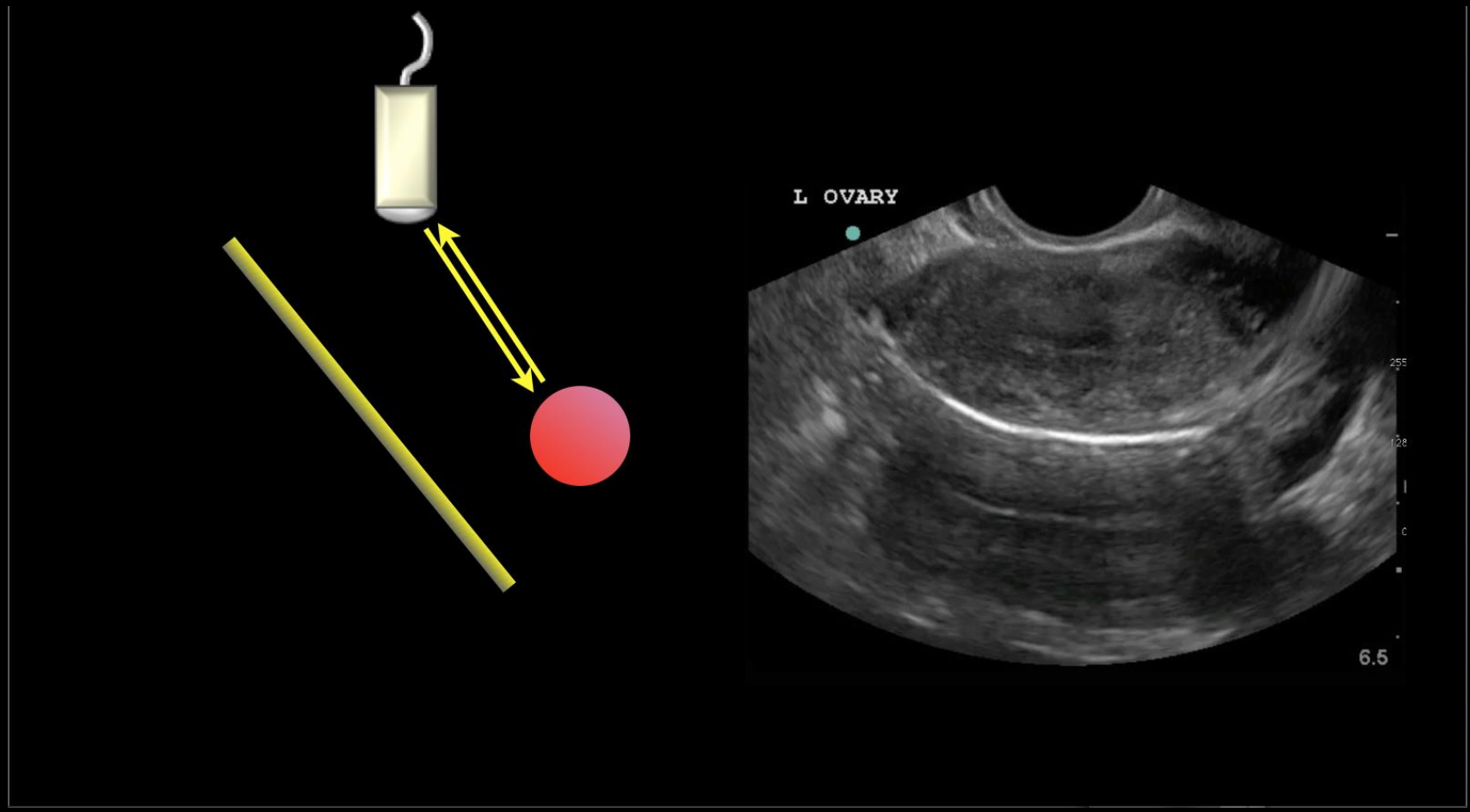

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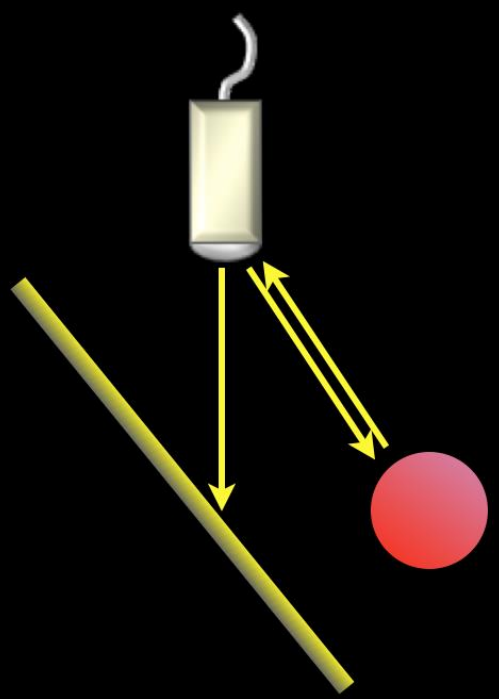

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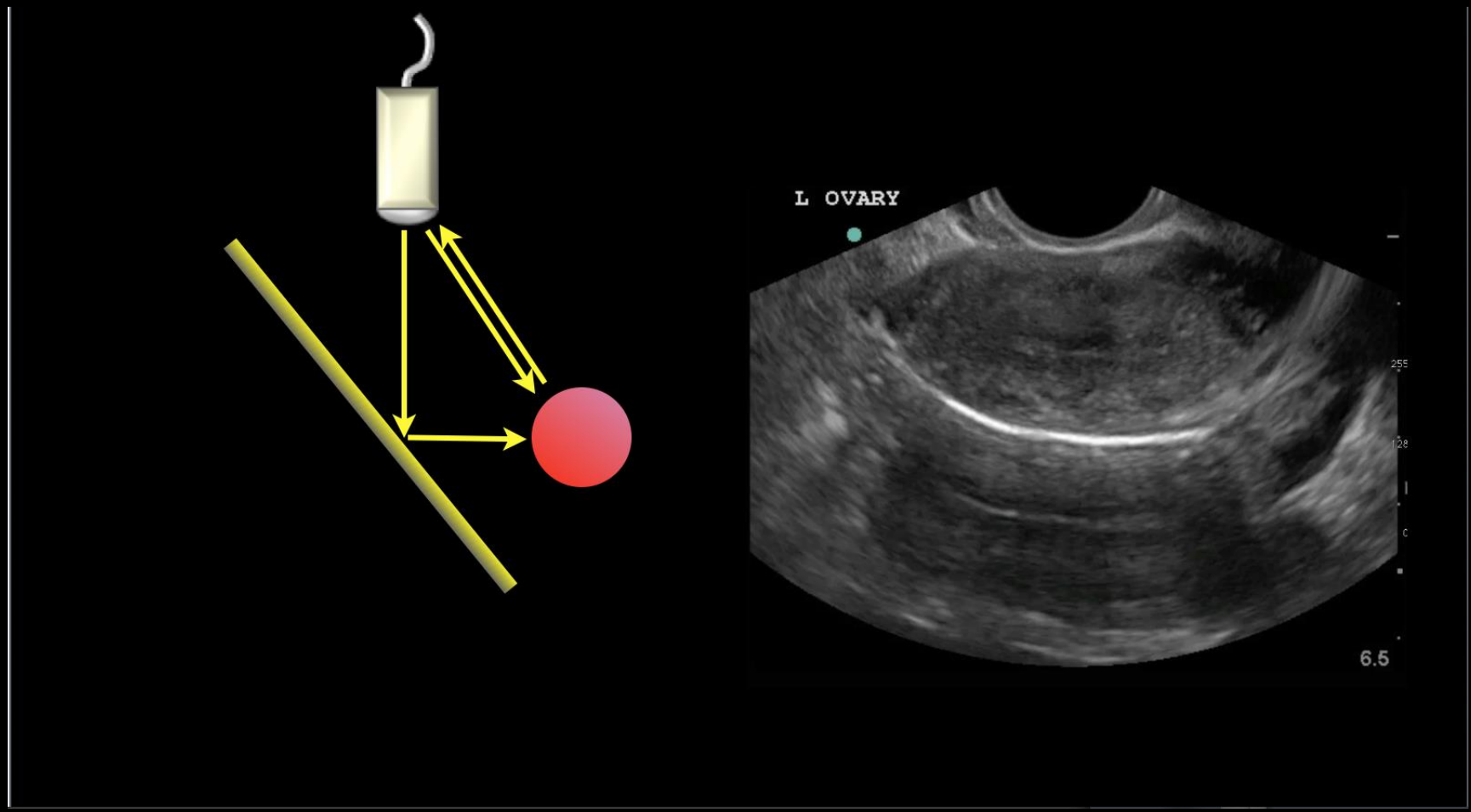

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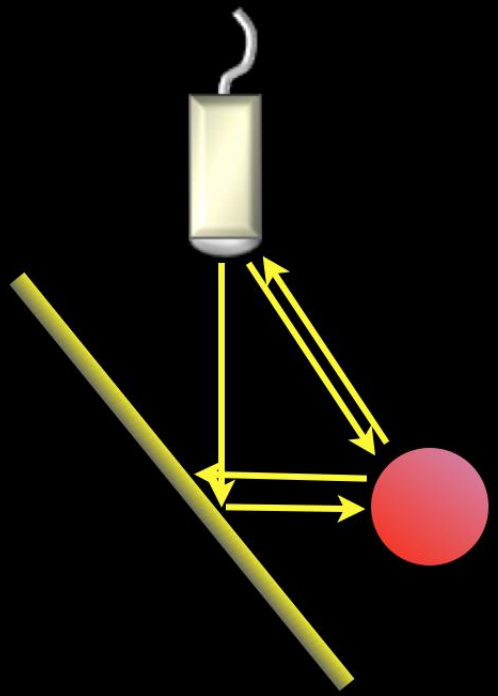

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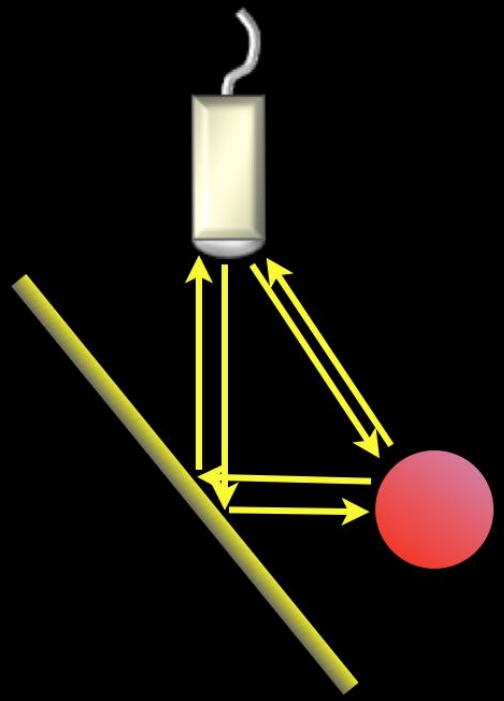

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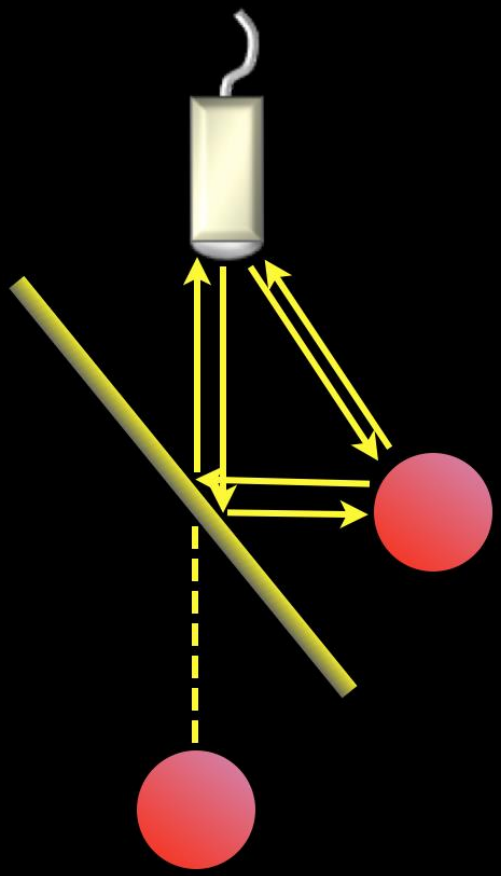

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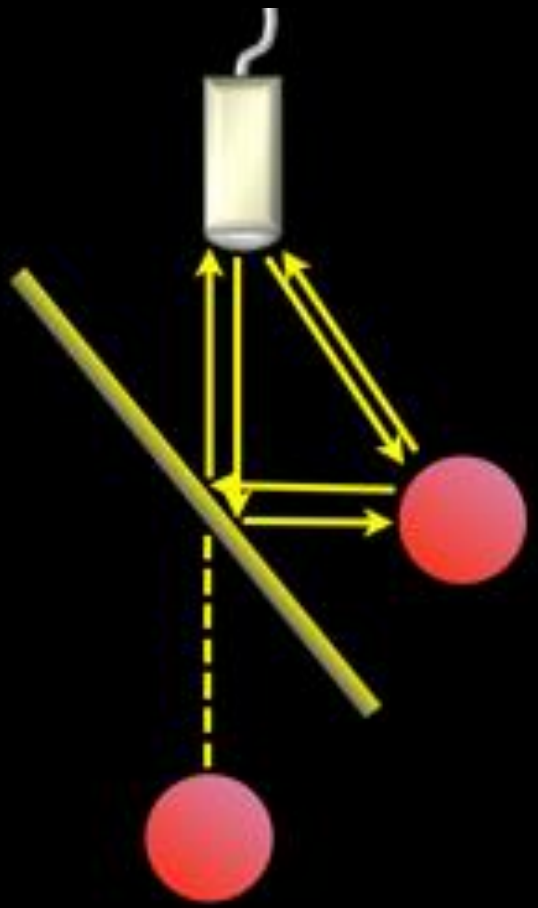
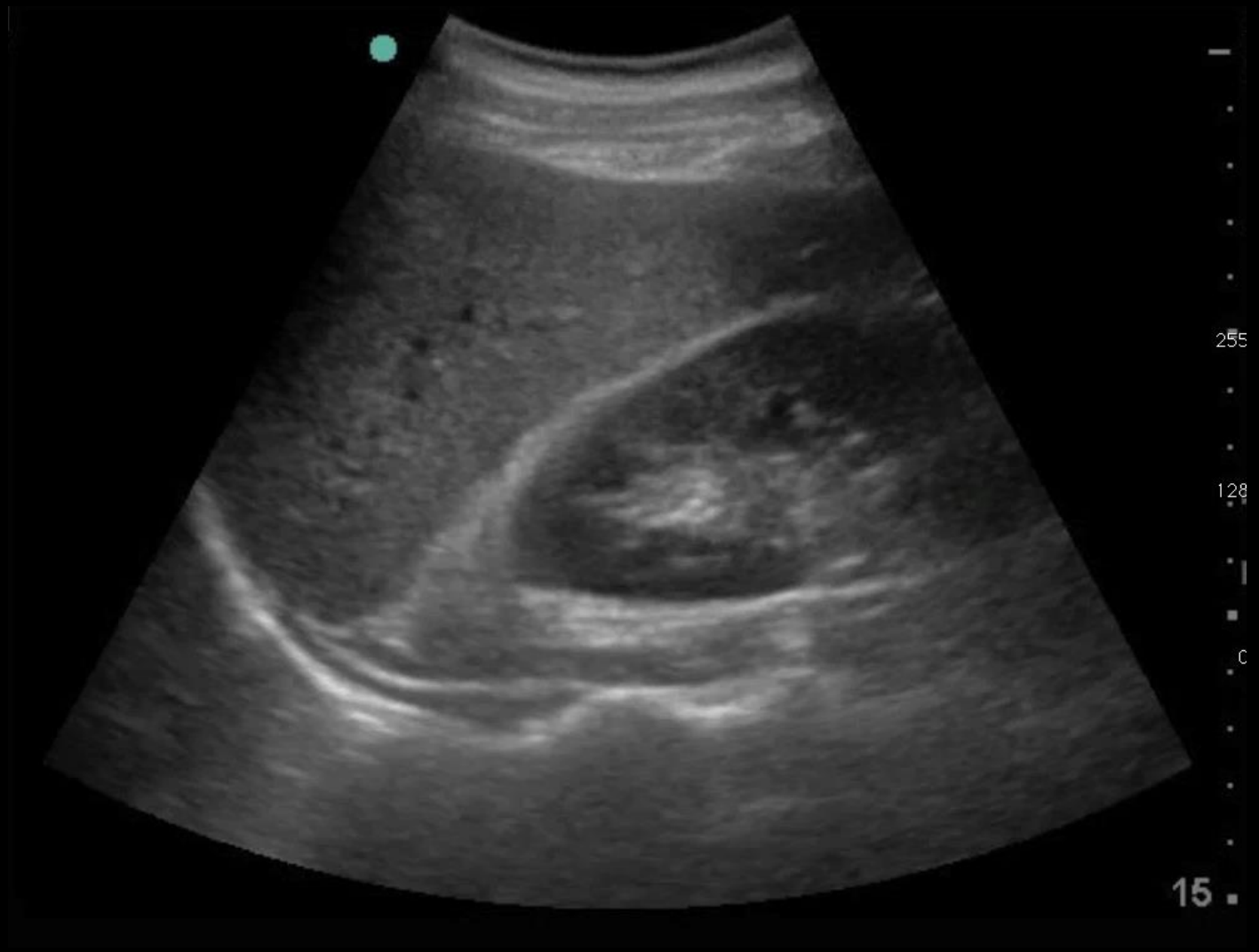


Normal Sonographic Findings

Mirror Artifact



Sonographic Pathology

Pleural Fluid

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

Sonographic Pathology

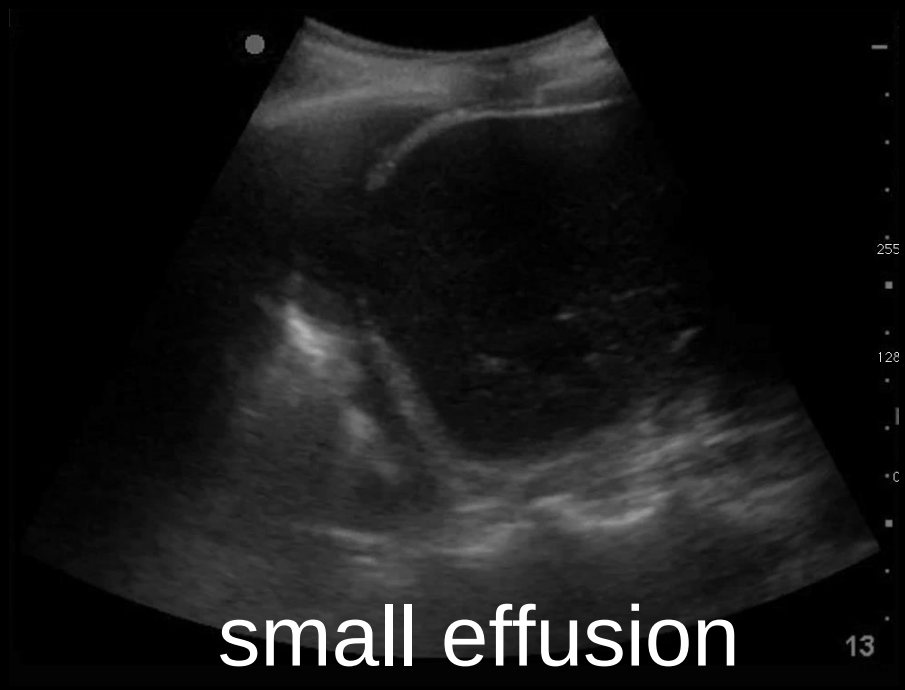
Pleural Fluid

Sonographic Pathology

Pleural Fluid

Sonographic Pathology

Pleural Fluid



small effusion

large effusion

Two scenarios:
Trauma = Hemothorax
Medical = Pleural Effusion

Sonographic Pathology

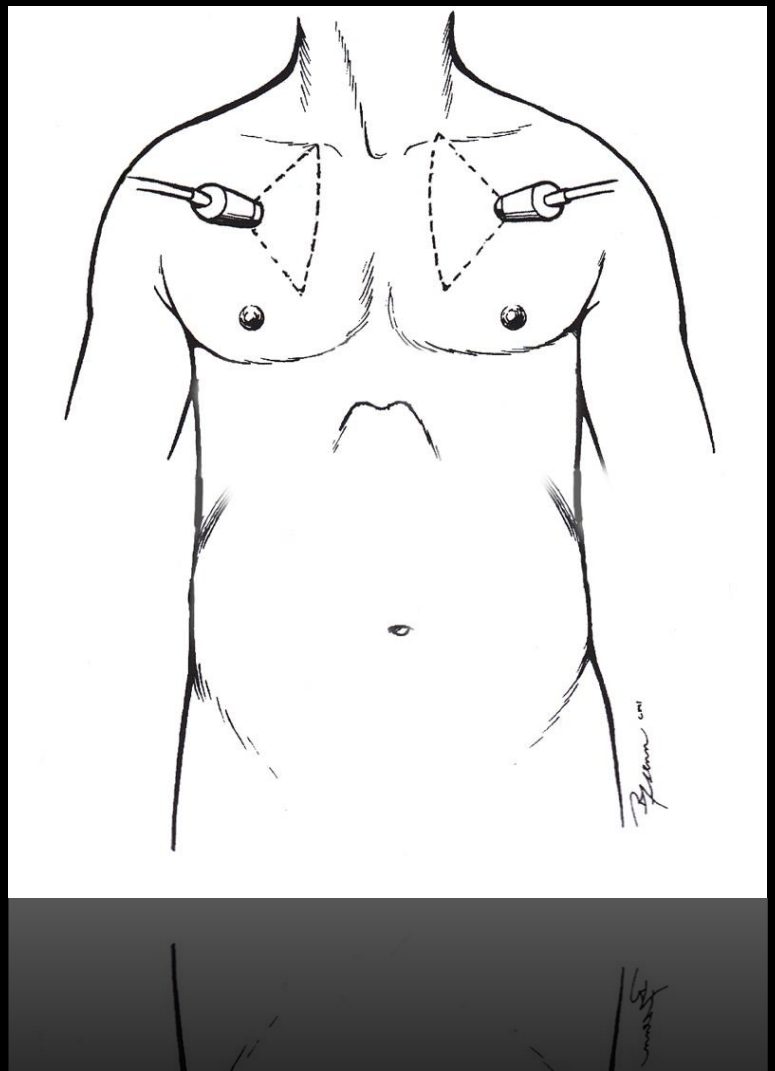
Pleural Fluid

- More sensitive than chest radiography
  - CXR: 200 mL
  - Sonography: 20 mL

Normal Sonographic Findings

Pleural Interface

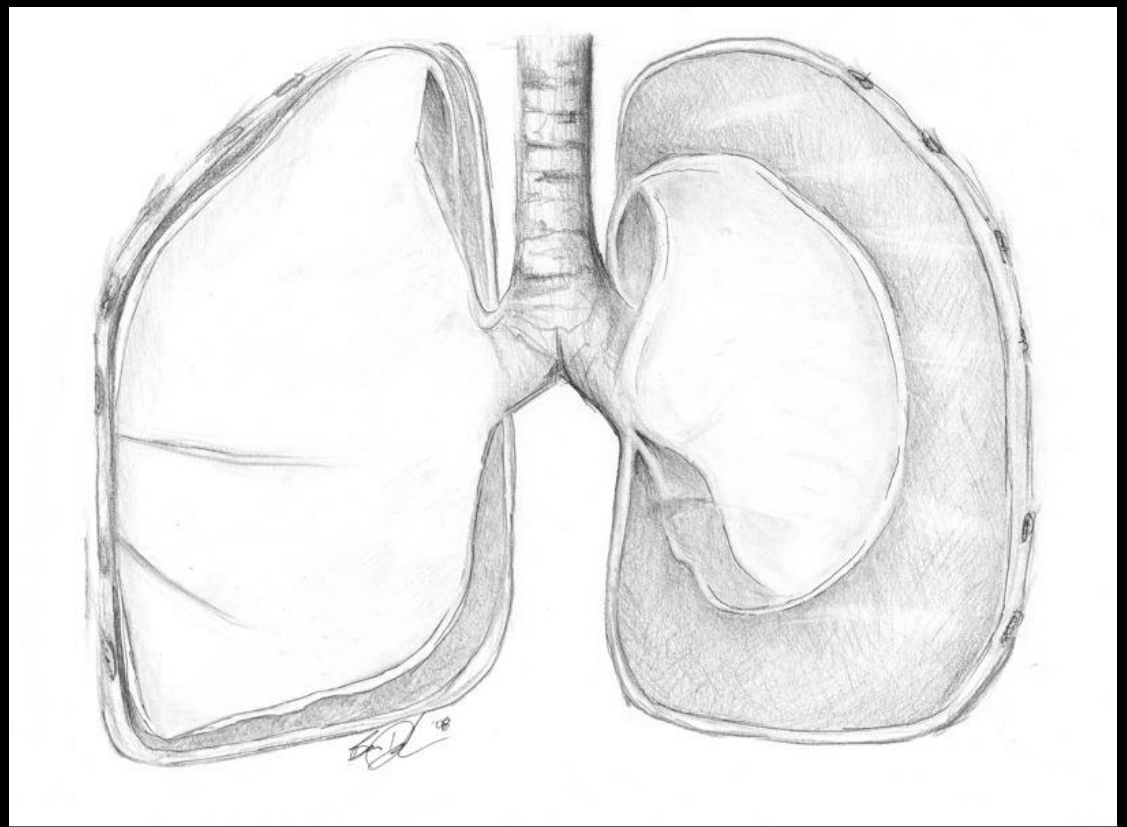
- Evaluation for pneumothorax
  - Visceral and parietal pleura
  - Assess for lung sliding

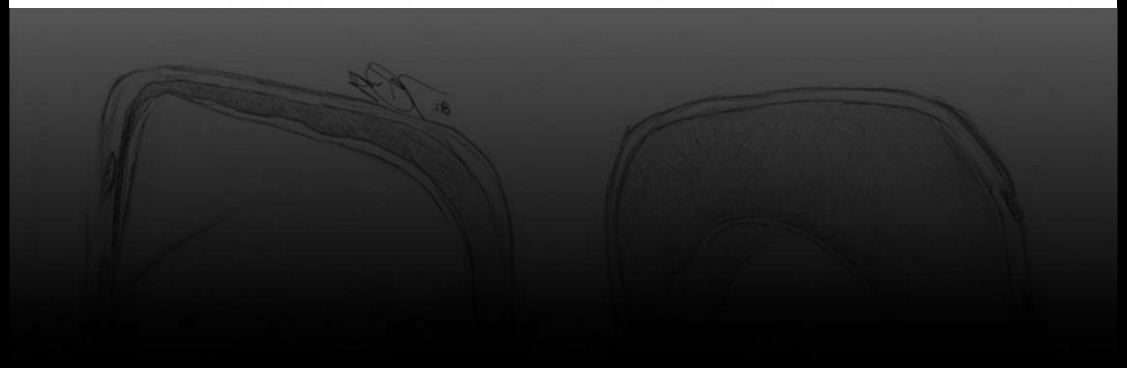


Sonographic Pathology

Pneumothorax

- Separation of visceral and parietal pleura





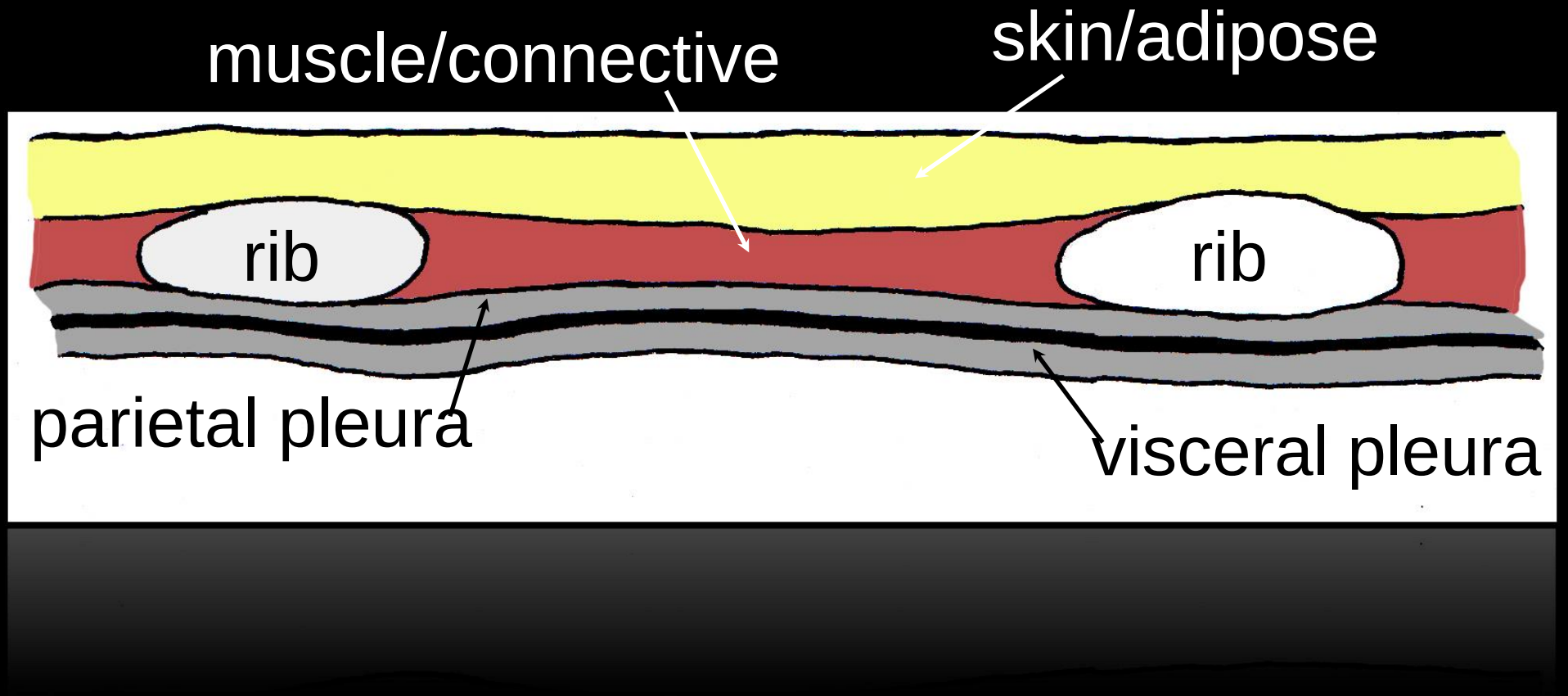
Normal Sonographic Findings

Pleural Interface

High frequency linear probe usually used to examine area just below skin

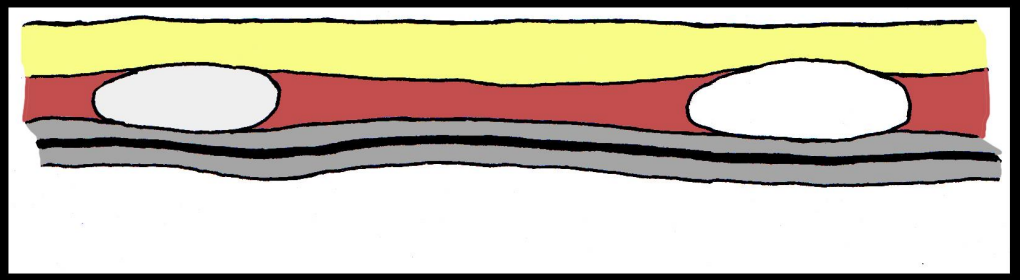
Normal Sonographic Findings

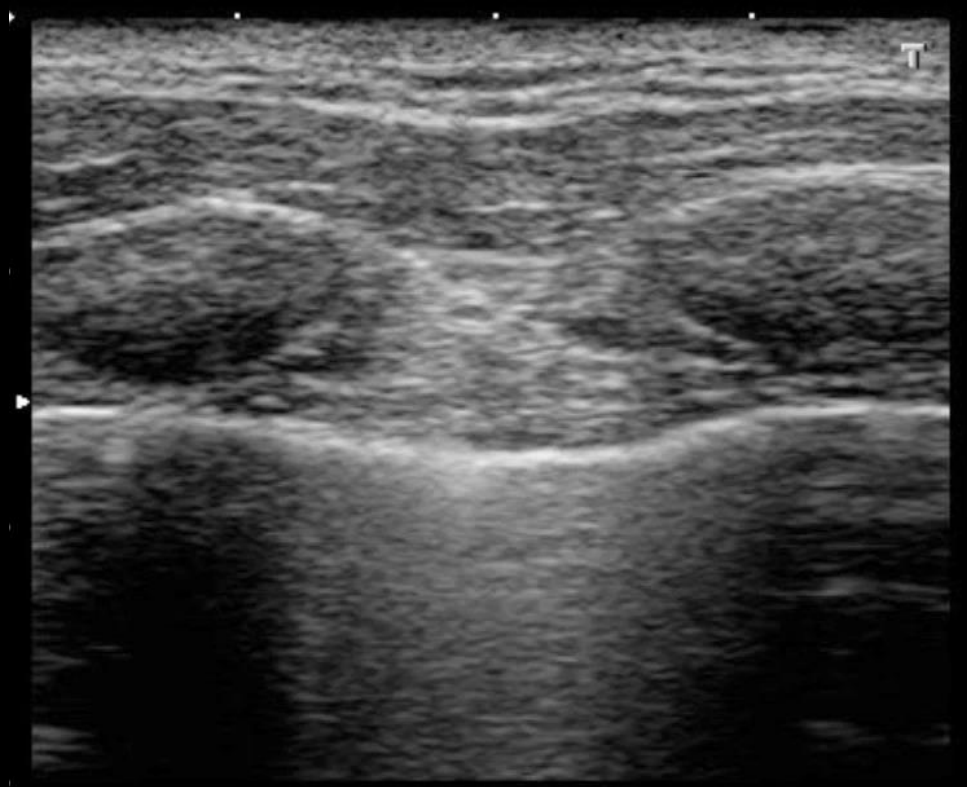
Pleural Interface



Normal Sonographic Findings

Pleural Interface

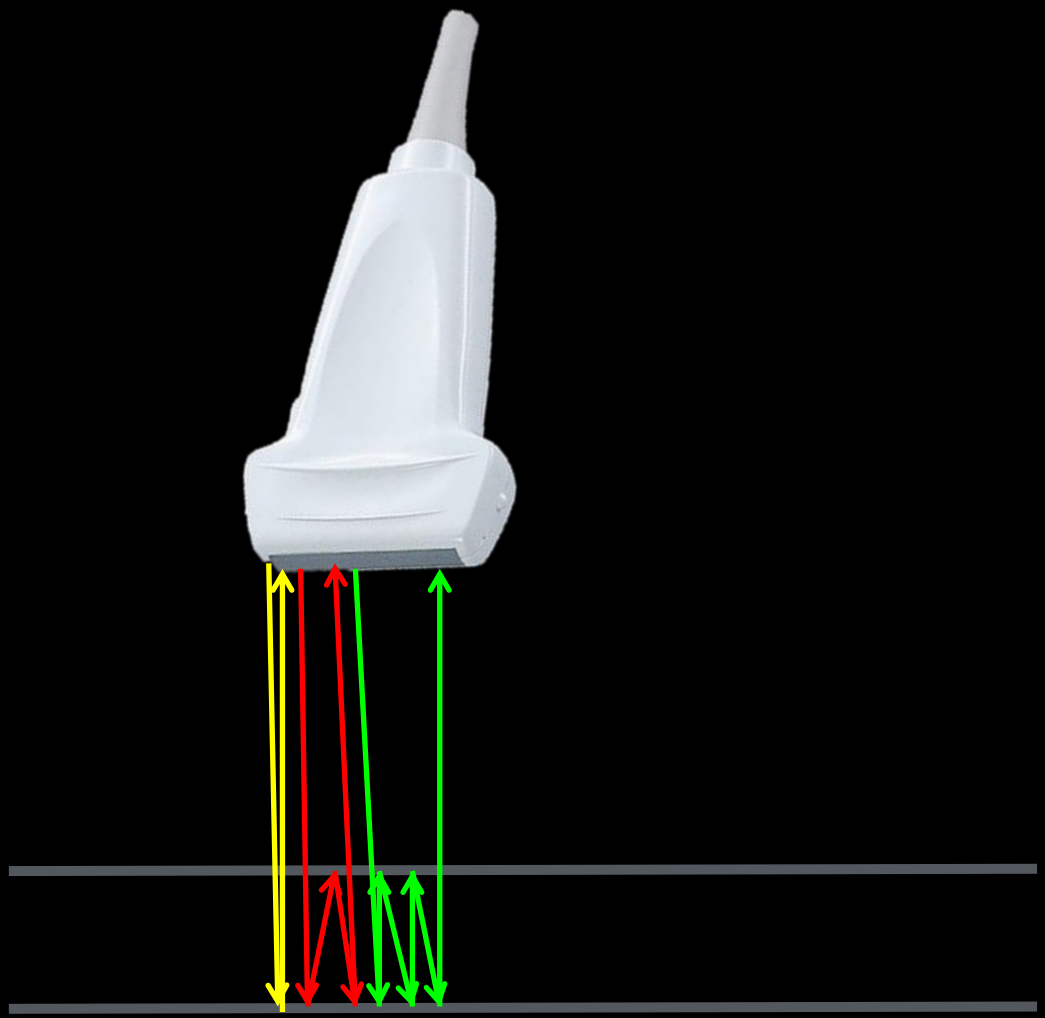




- Ring-down artifact and lung sliding are normal findings

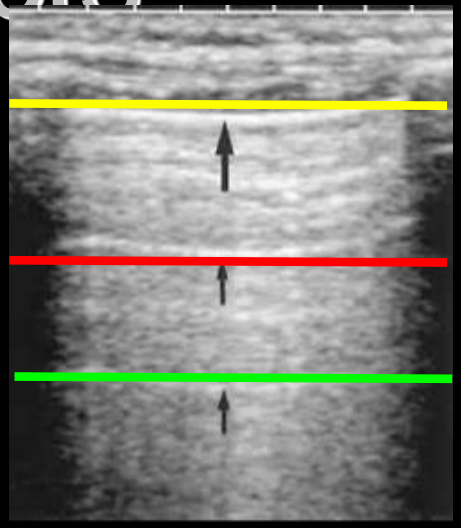
Anatomy and Artifacts

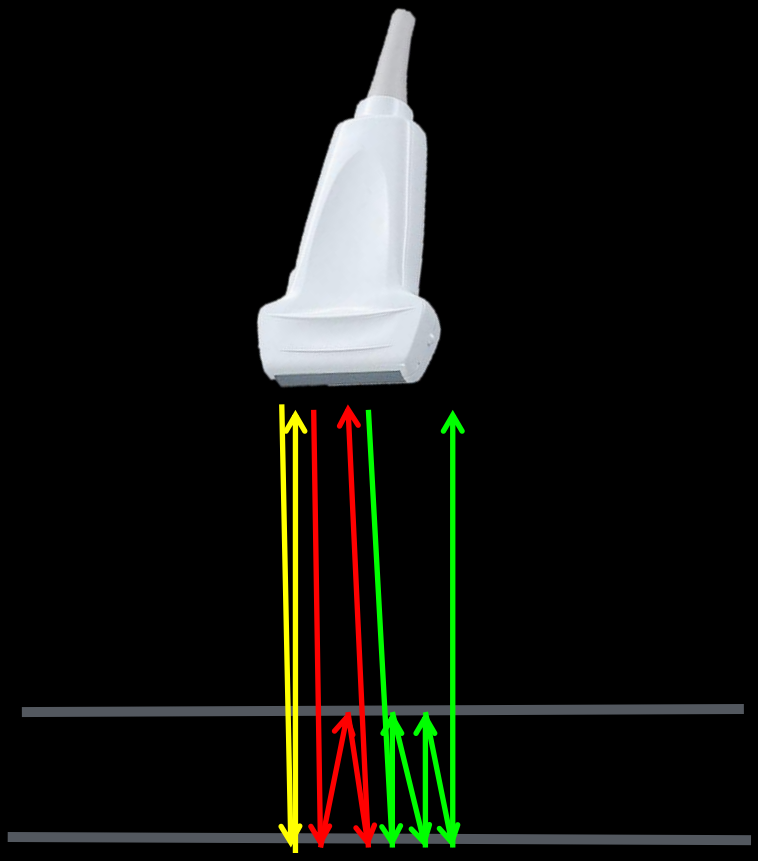
- Reverberation artifact

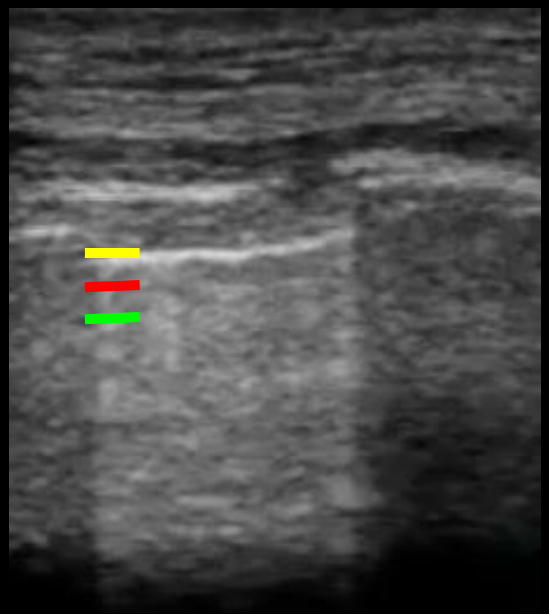


Anatomy and Artifacts

- Reverberation artifact
  - A-lines
  - Ring-down (comet tails)

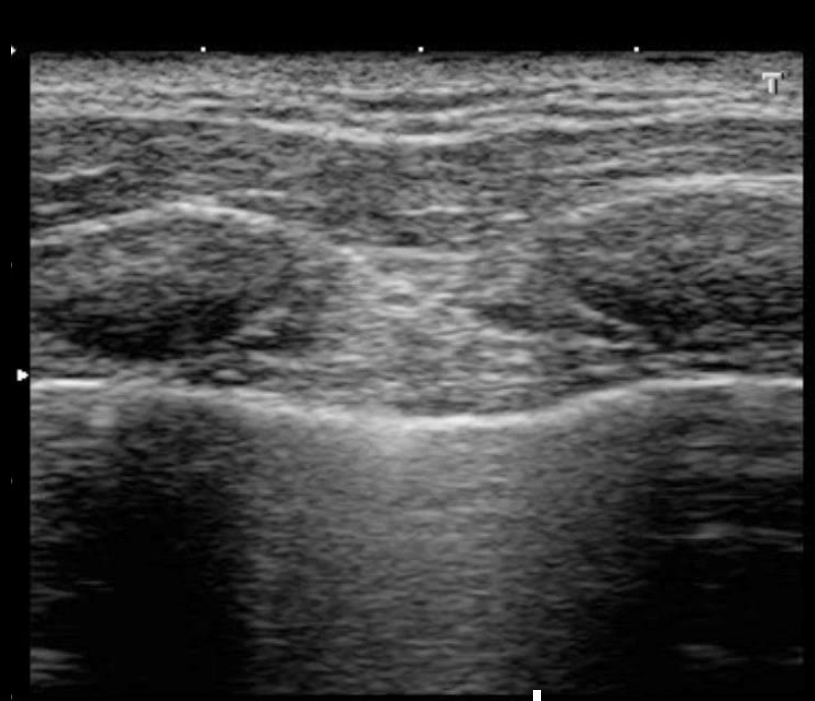






Sonographic Pathology

Pneumothorax



normal

no sliding

absence of lung sliding or ring-down artifact indicates pneumothorax

Sonographic Pathology

Pneumothorax

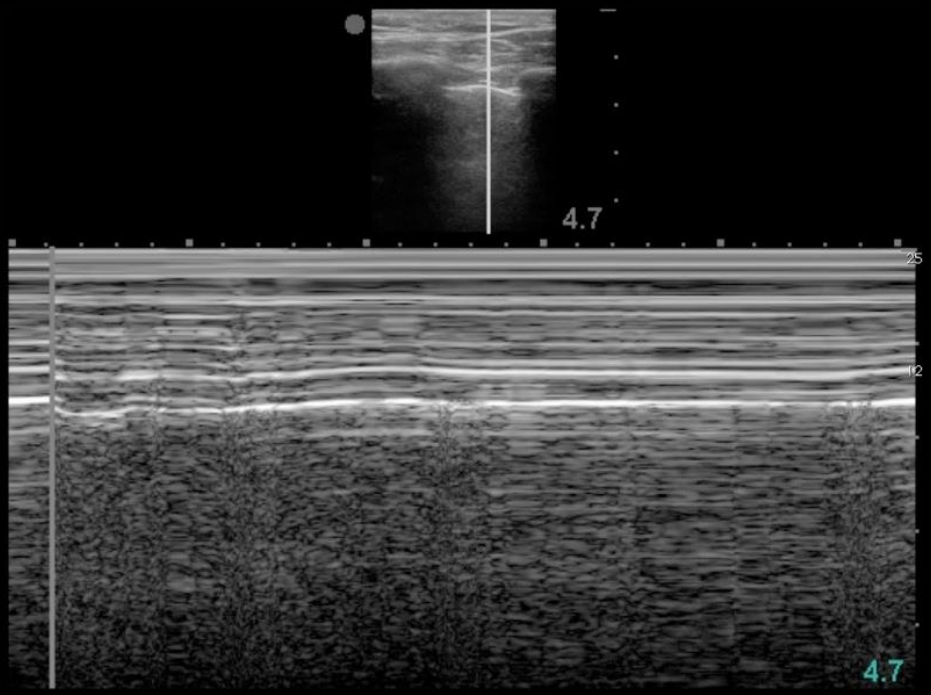
M-mode

may make detection of pneumothorax easier

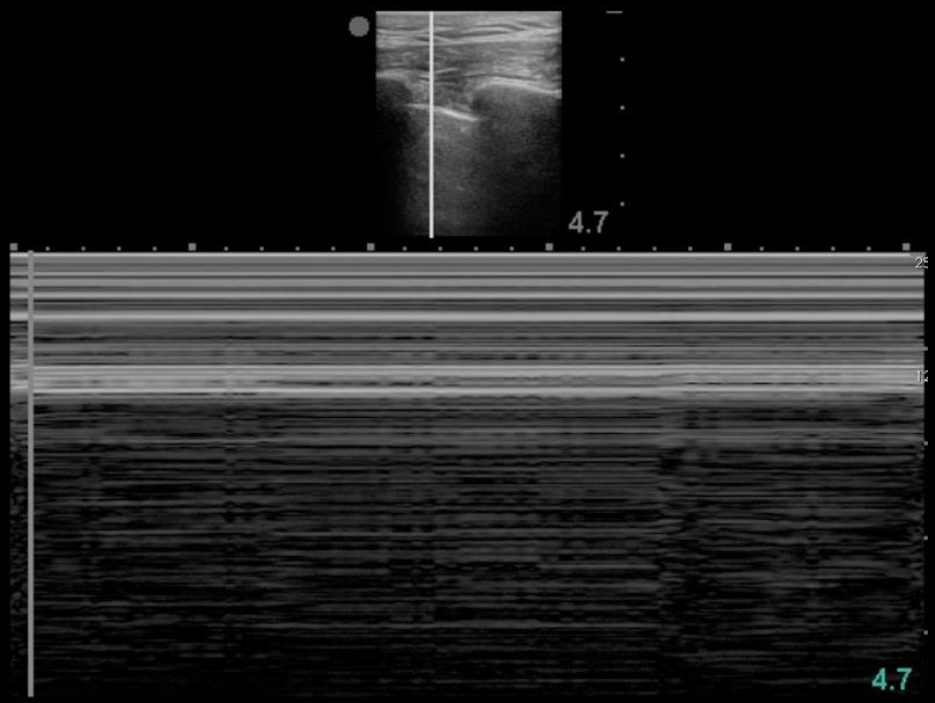
Sonographic Pathology

Pneumothorax

M-mode



normal

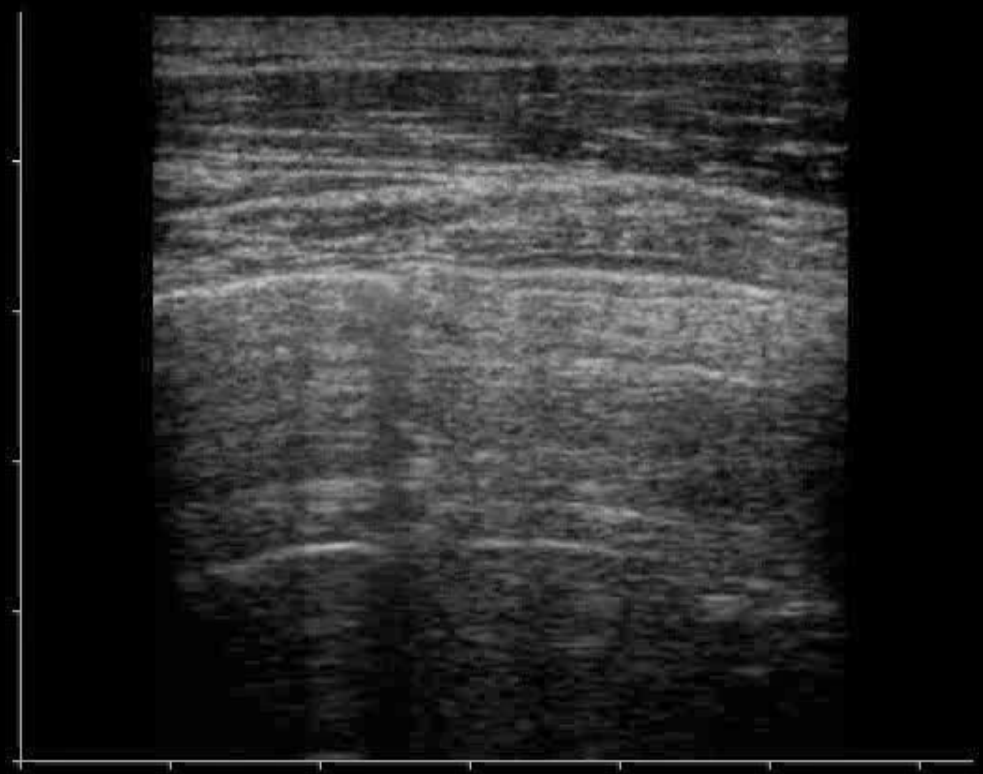


pneumothorax

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

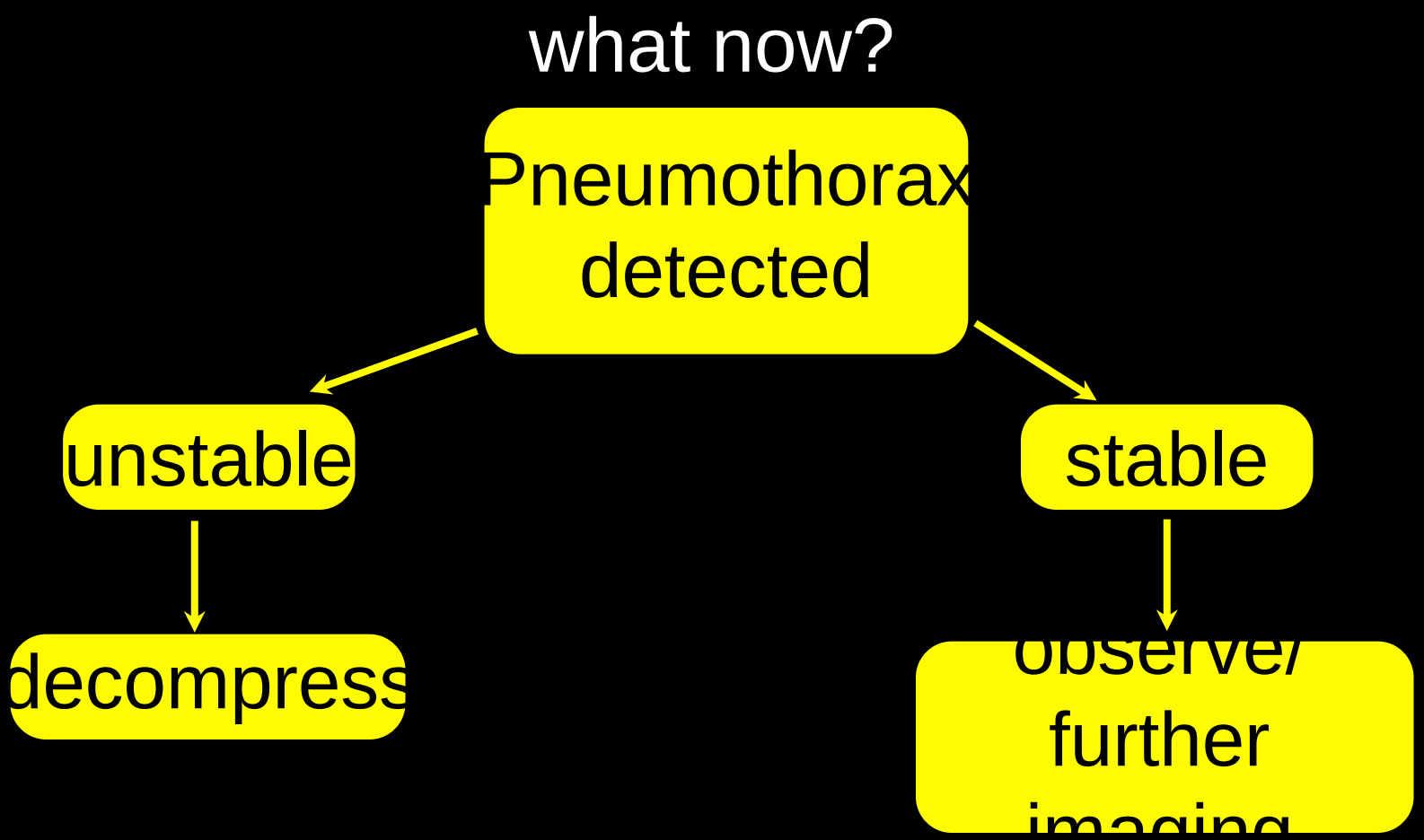
Sonographic Pathology

Pneumothorax

- Much more sensitive than chest radiography
  - CXR: 50-60%
  - Sonography: 90-96%
  - CT: 97-100%

Sonographic Pathology

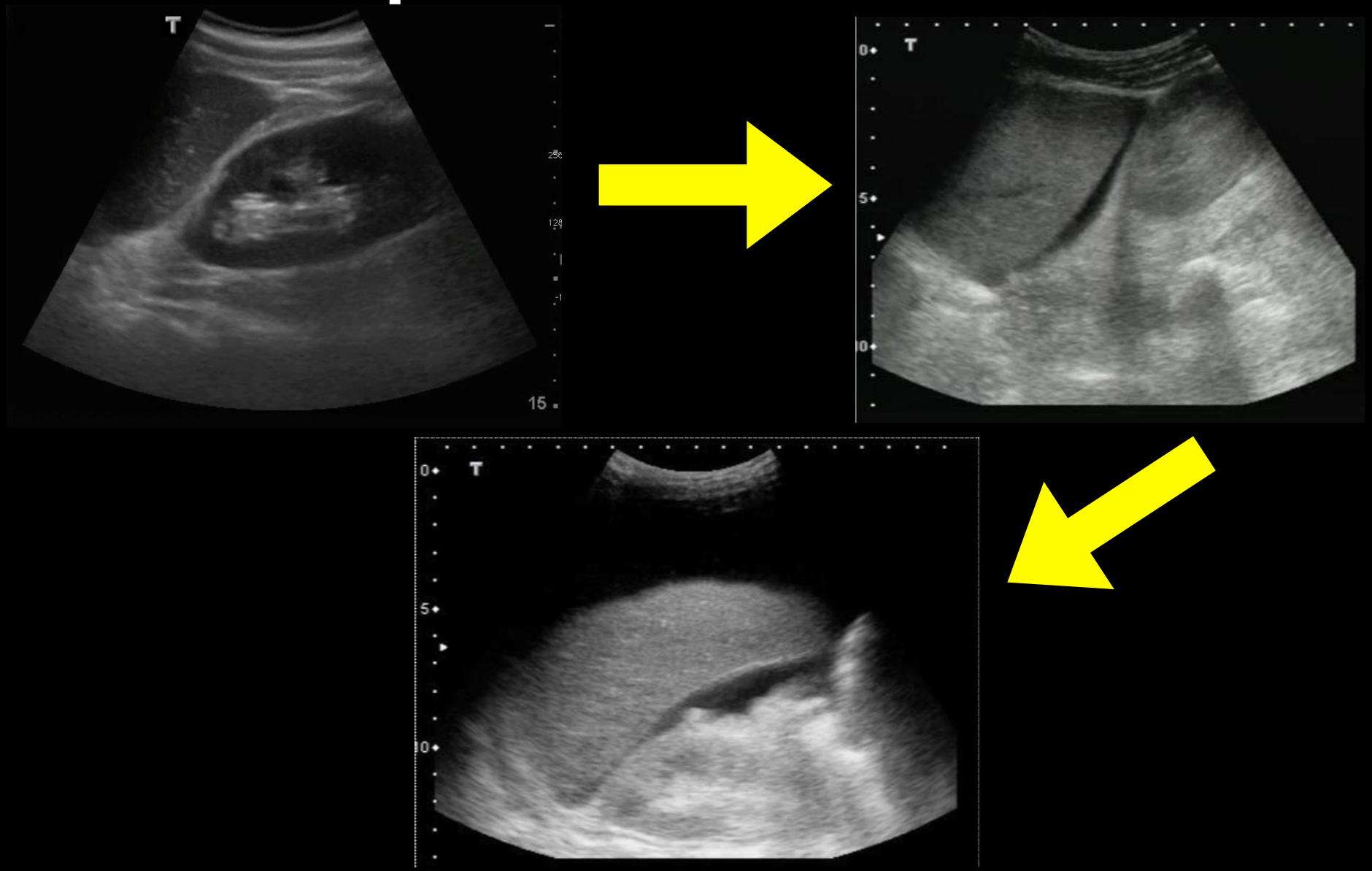
Pneumothorax



Pitfalls

Pitfalls

Repeat the exam



Pitfalls

Right Upper Quadrant

free fluid at liver tip

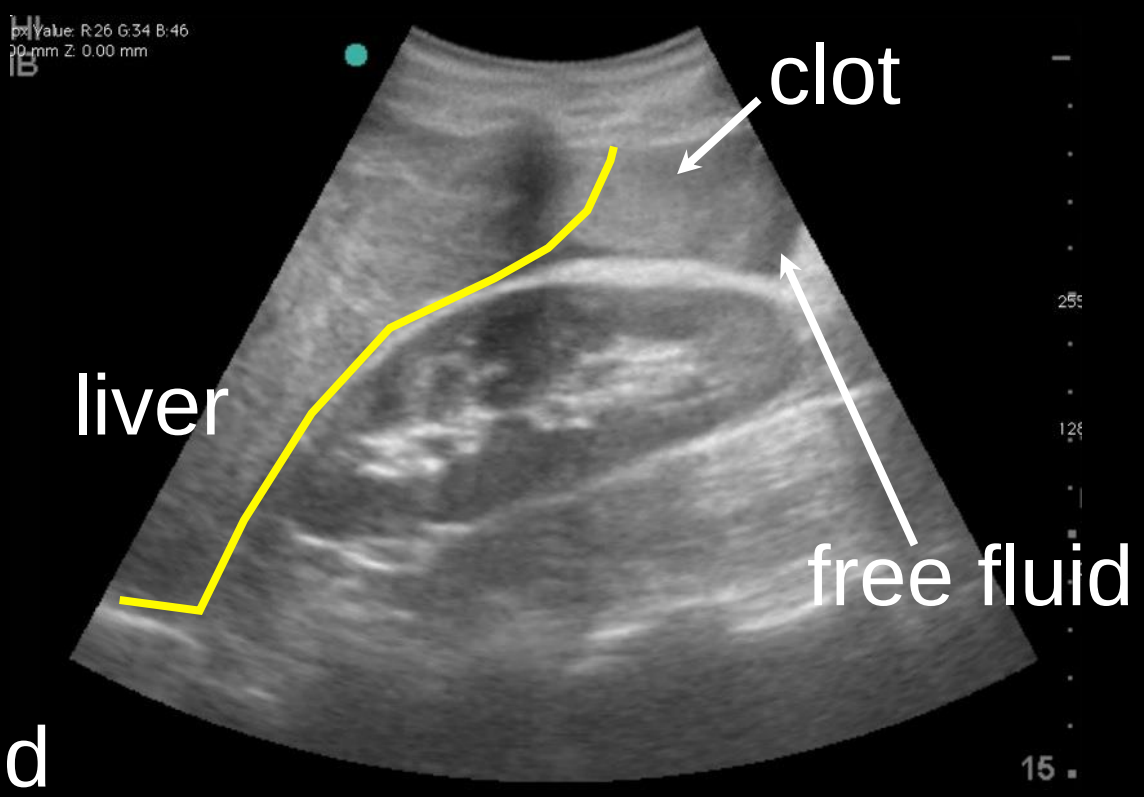
Pitfalls

Clotted Blood

may become isoechoic to tissue

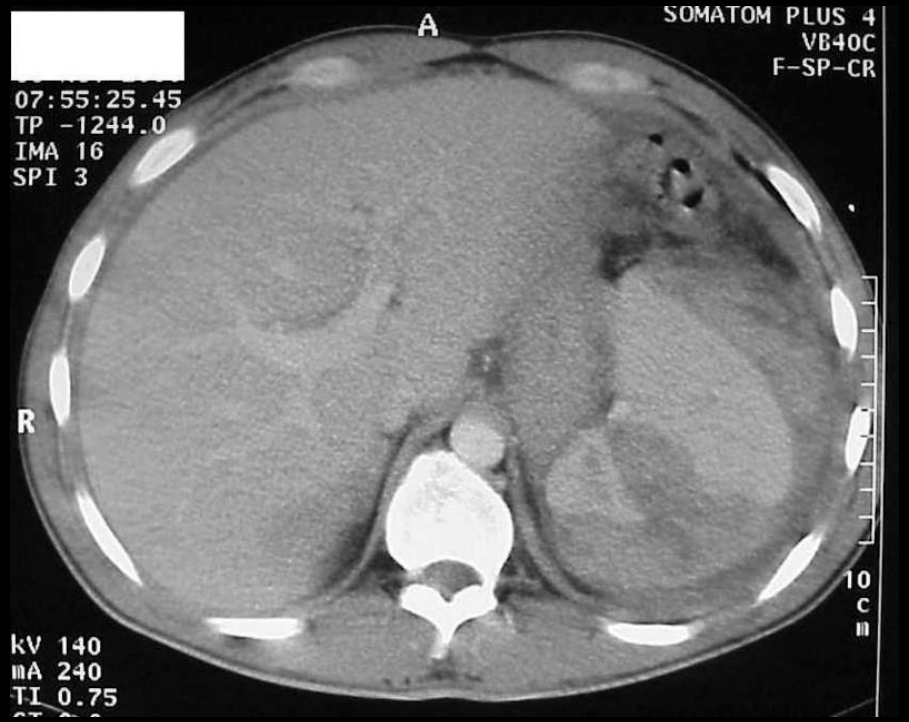
Pitfalls

Clotted Blood



Pitfalls

Solid Organ Injury



Ultrasound is not reliable for solid organ injury!

Pitfalls

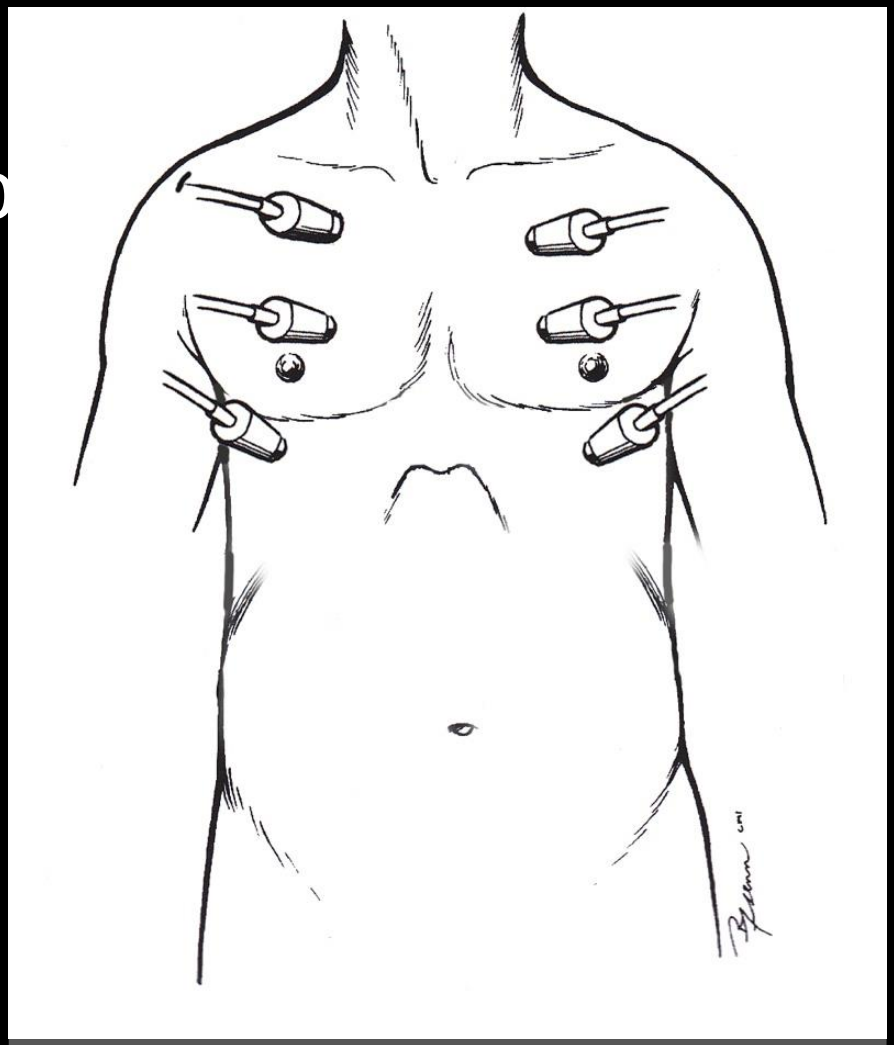
Retroperitoneal hemorrhage

- Ultrasound is not reliable for reliable for retroperitoneal bleeding!

Pitfalls

Scanning too Quickly

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

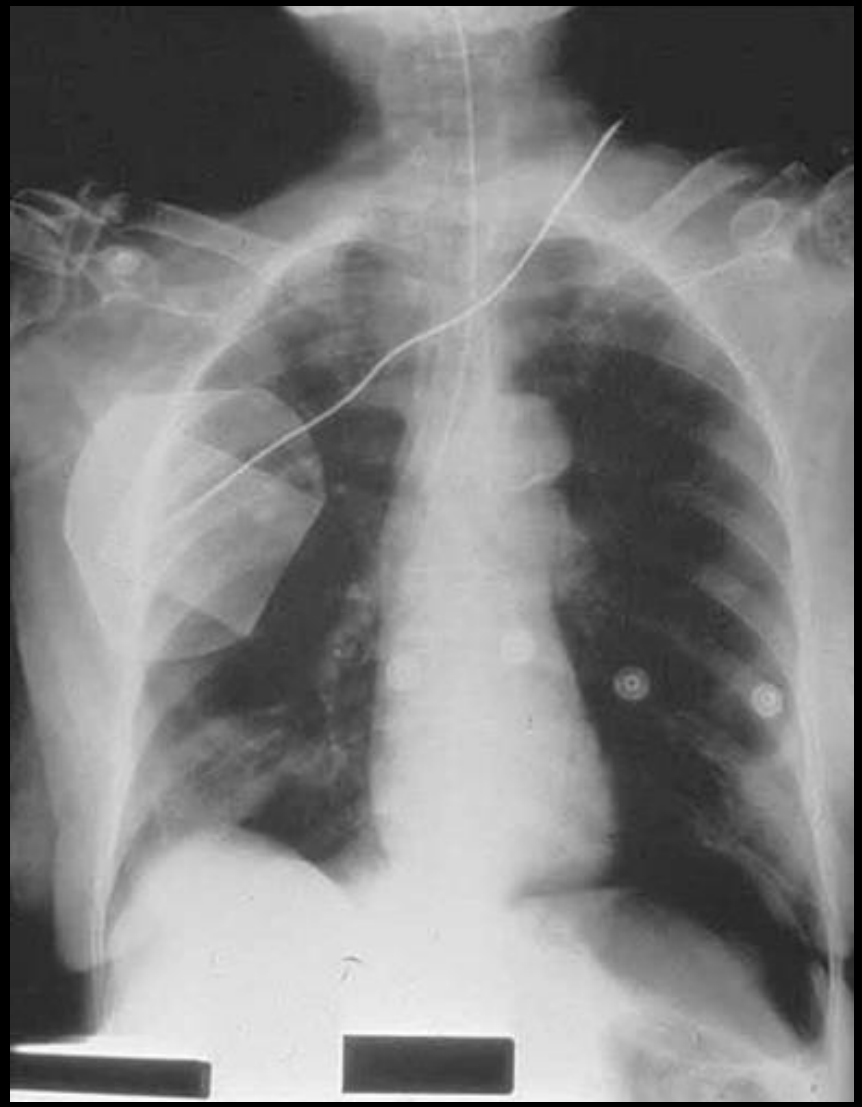


Pitfalls

False Positives

Lack of lung sliding may arise in several situations:

- mainstem intubation
- COPD
- pleural adhesions
- blebs



Pitfalls

Cardiac Movement

- Heart movement may imitate lung sliding

Cases

Cases

Penetrating Thorax Wound

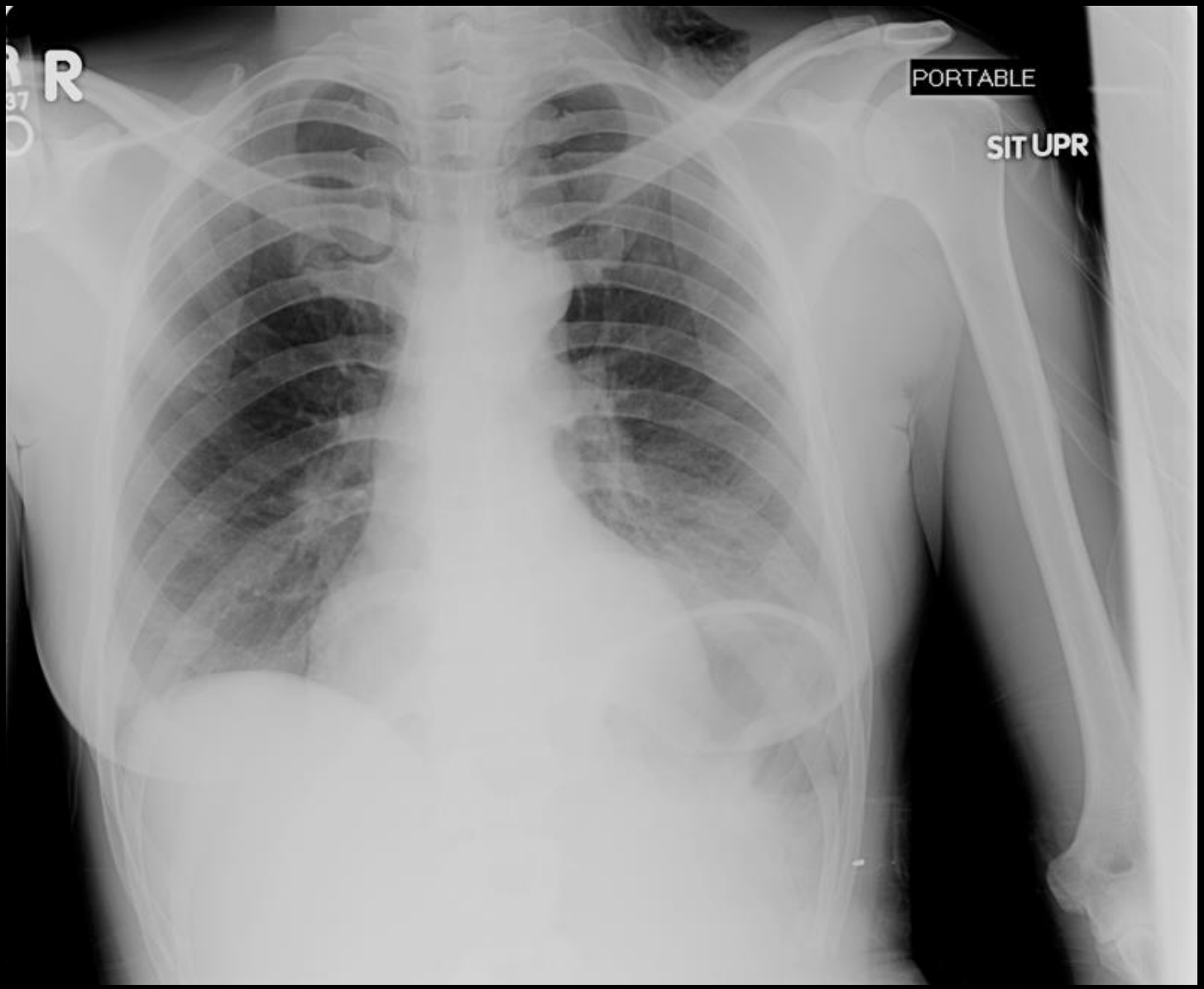
- 32 y/o female stabbed with a fork
- Vitals normal
- No respiratory distress
- Equal lung sounds

Cases

Penetrating Thorax Wound

Cases

Penetrating Thorax Wound



Cases

Penetrating Thorax Wound

right

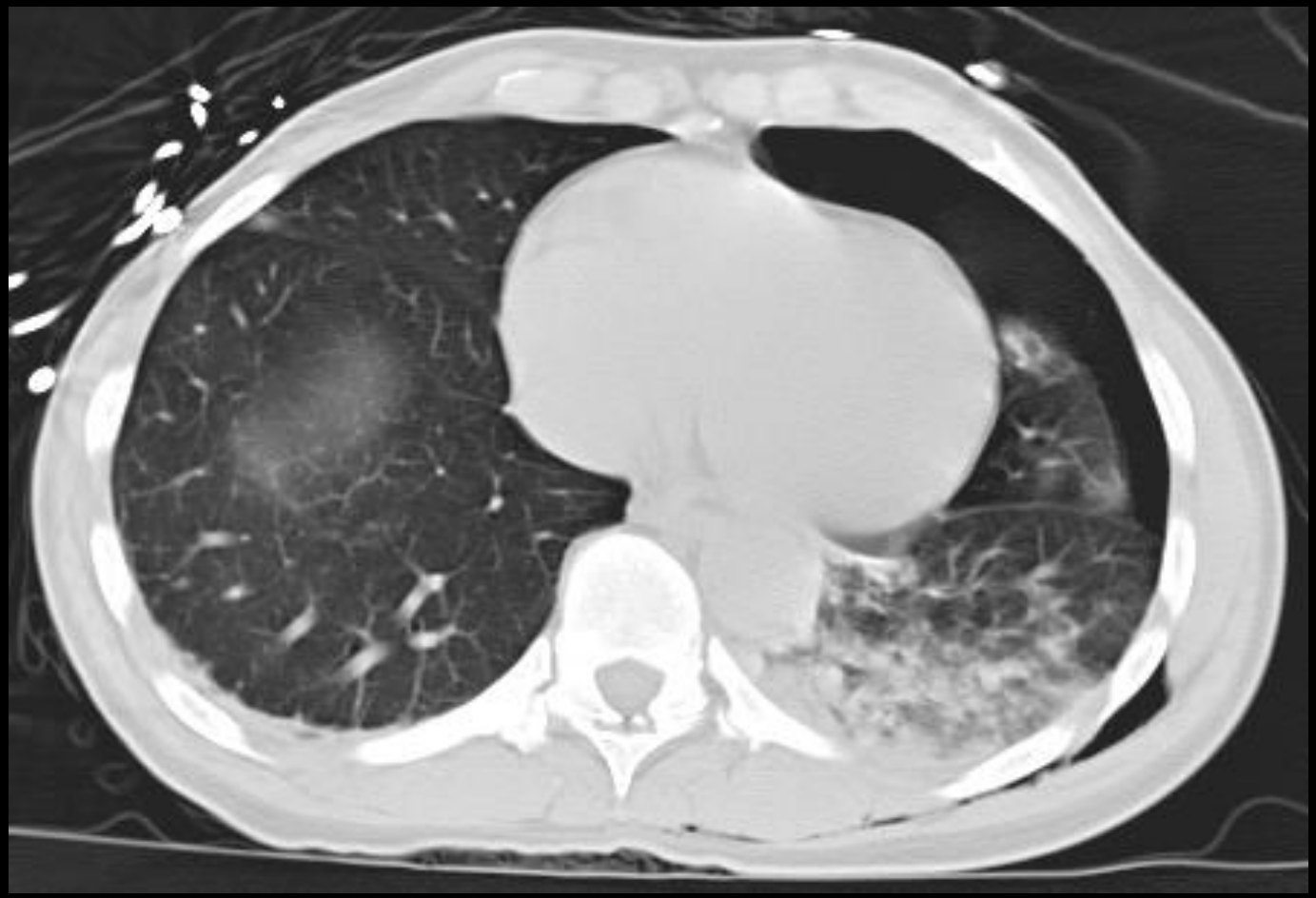
Cases

Penetrating Thorax Wound

left

Cases

Penetrating Thorax Wound



Cases

Penetrating Thorax Wound

- Ultrasound more sensitive than chest x-ray
- Guides treatment in event of decompensation

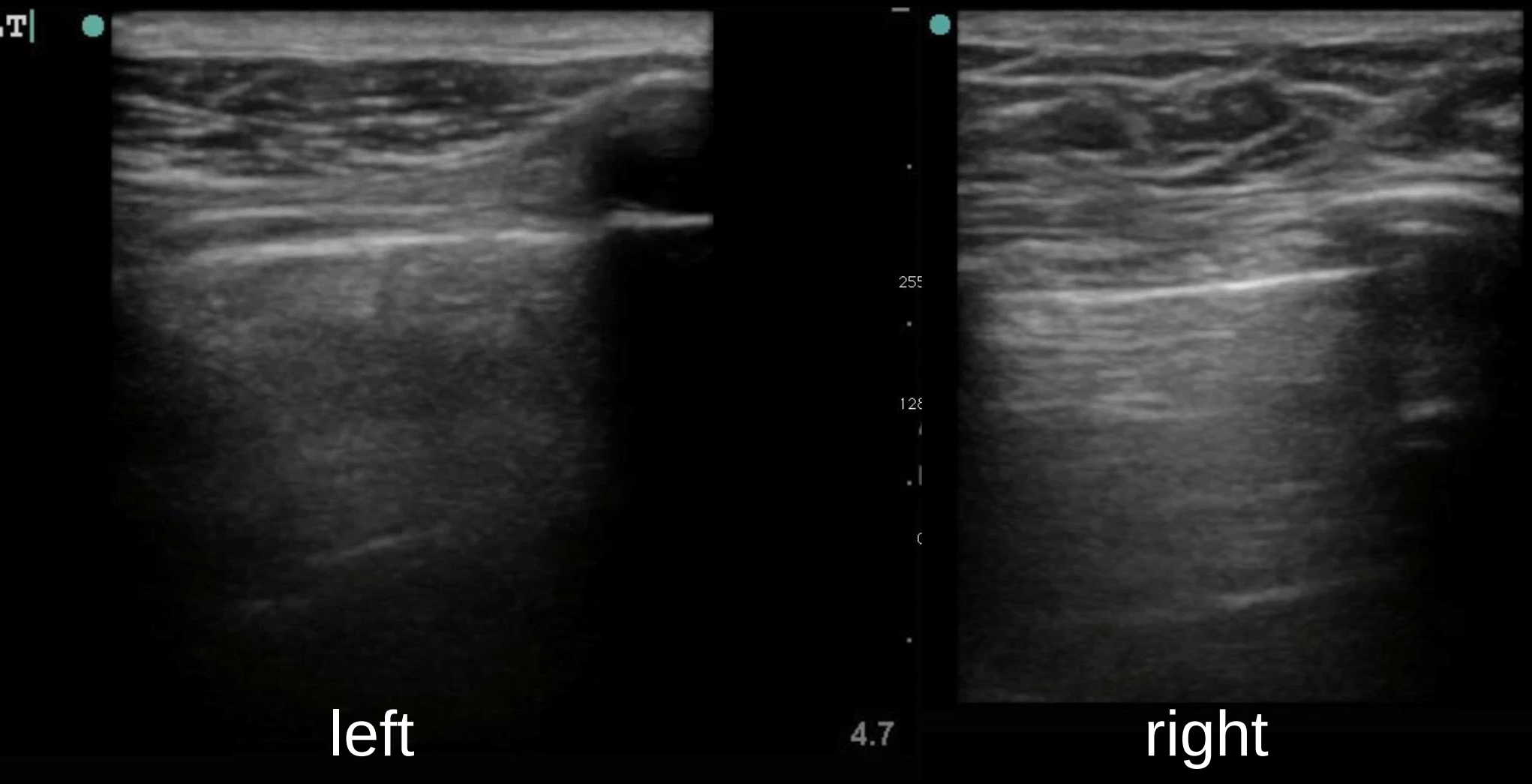
Cases

Hit by a Train

- 29 y/o male whose car was struck by a train
- hypotensive, agonal respirations, GCS <8
- Blood from L. ear, bruises L. chest/abdomen.
- Decreased L. breath sounds, abdomen soft
- Needle decompression L. chest
- Intubated

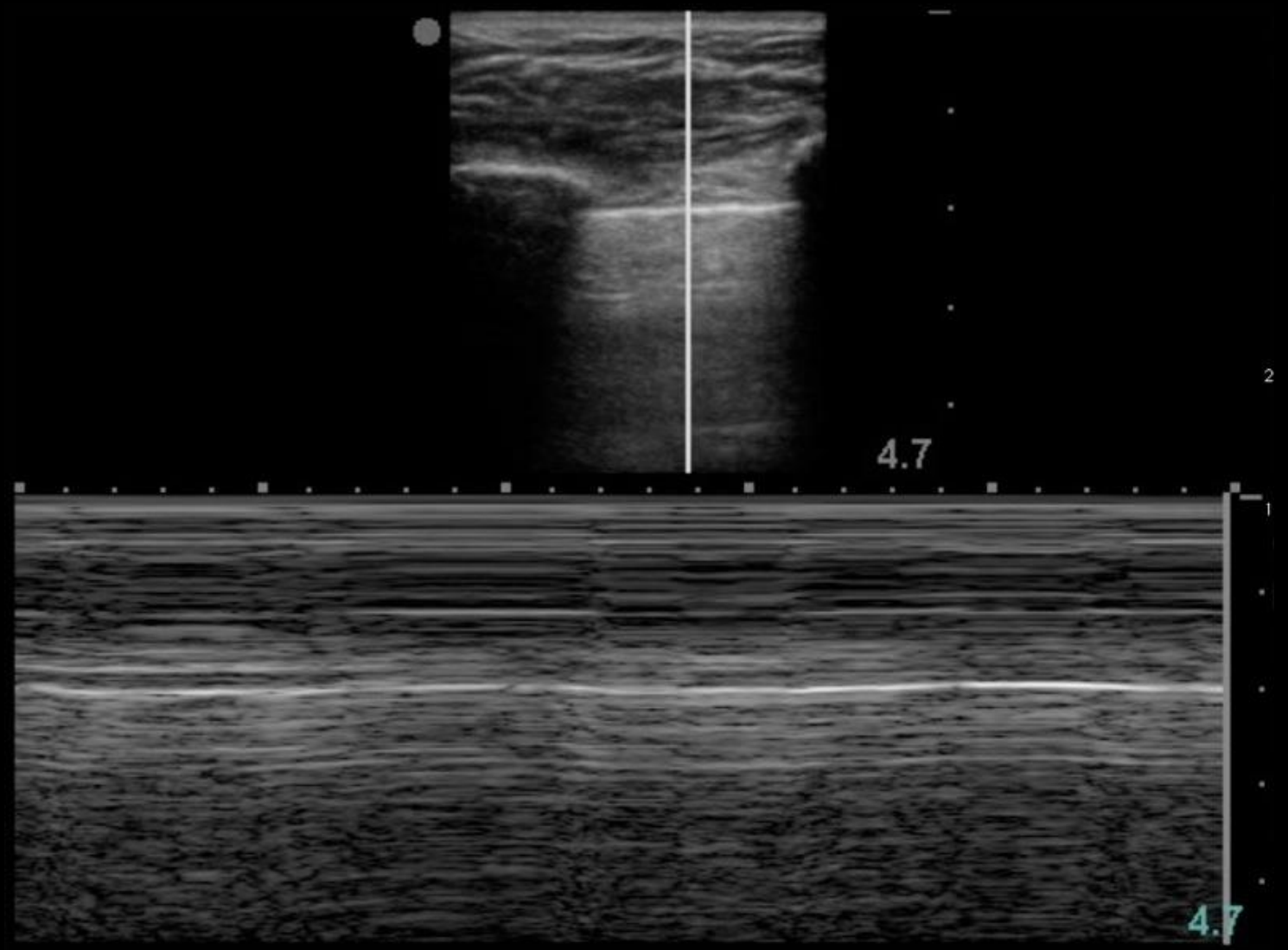
Cases

Hit by a Train



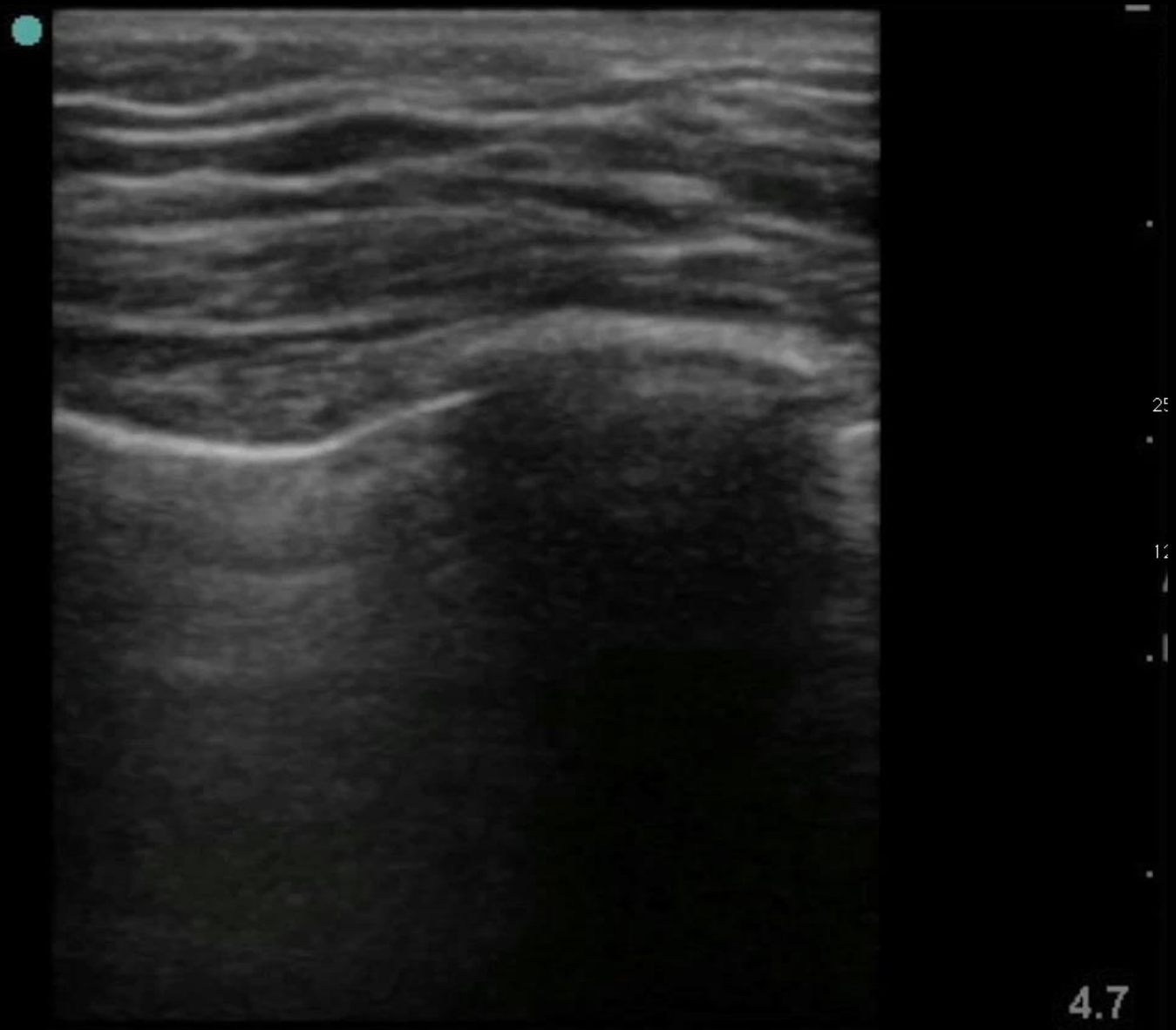
Cases

Hit by a Train



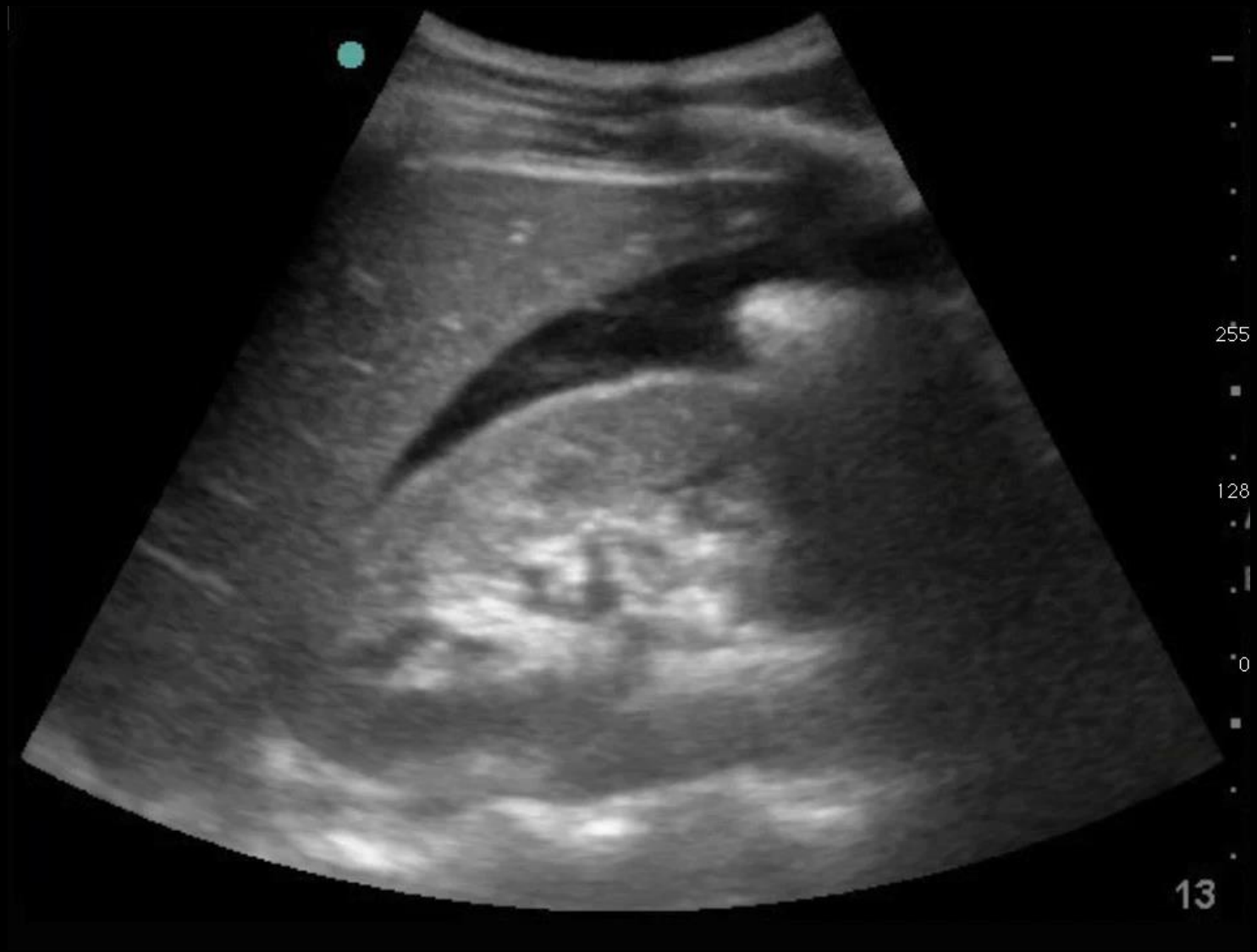
Cases

Hit by a Train



Cases

Hit by a Train



Cases

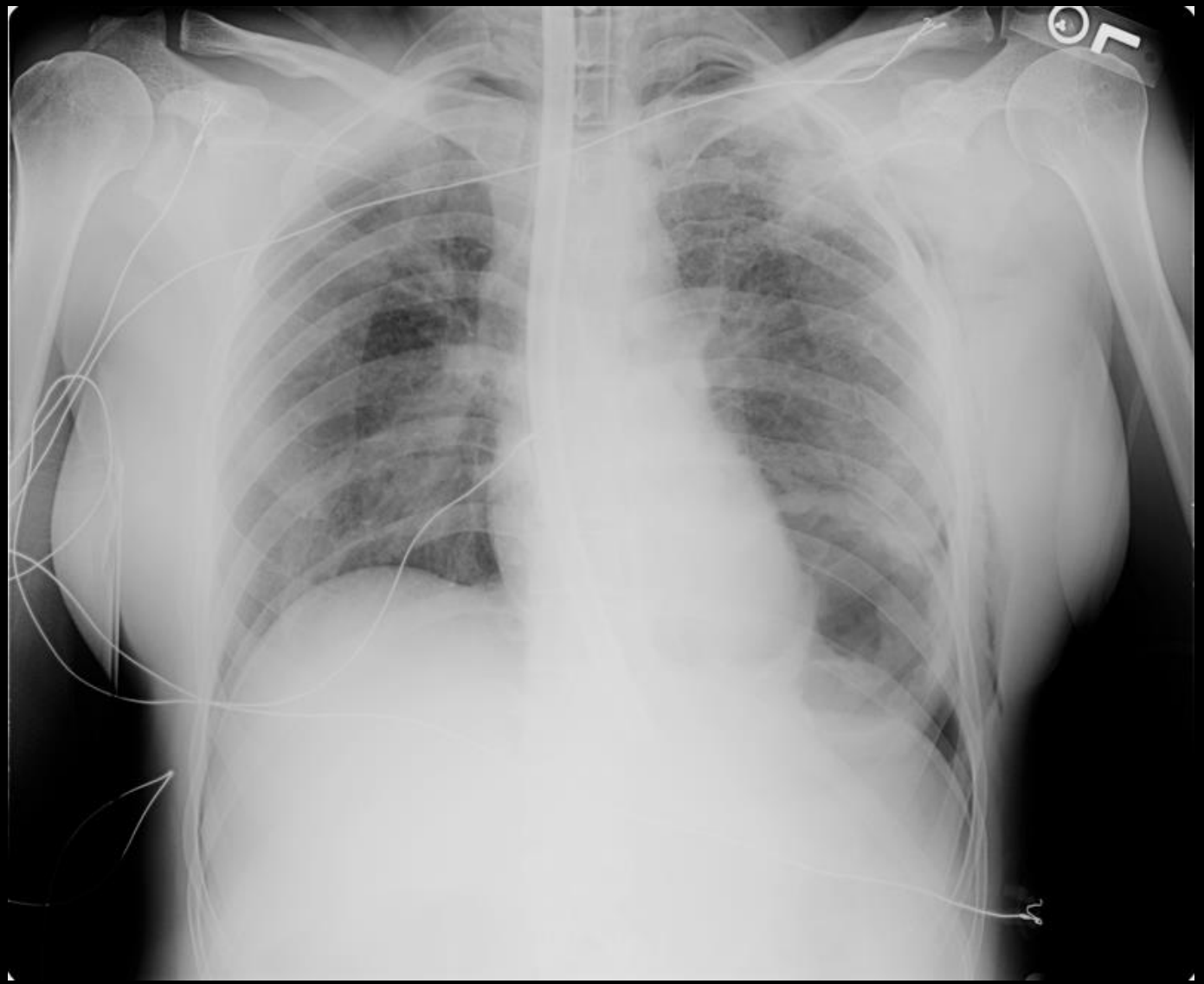
Hit by a Train

Cases

Hit by a Train

Cases

Hit by a Train



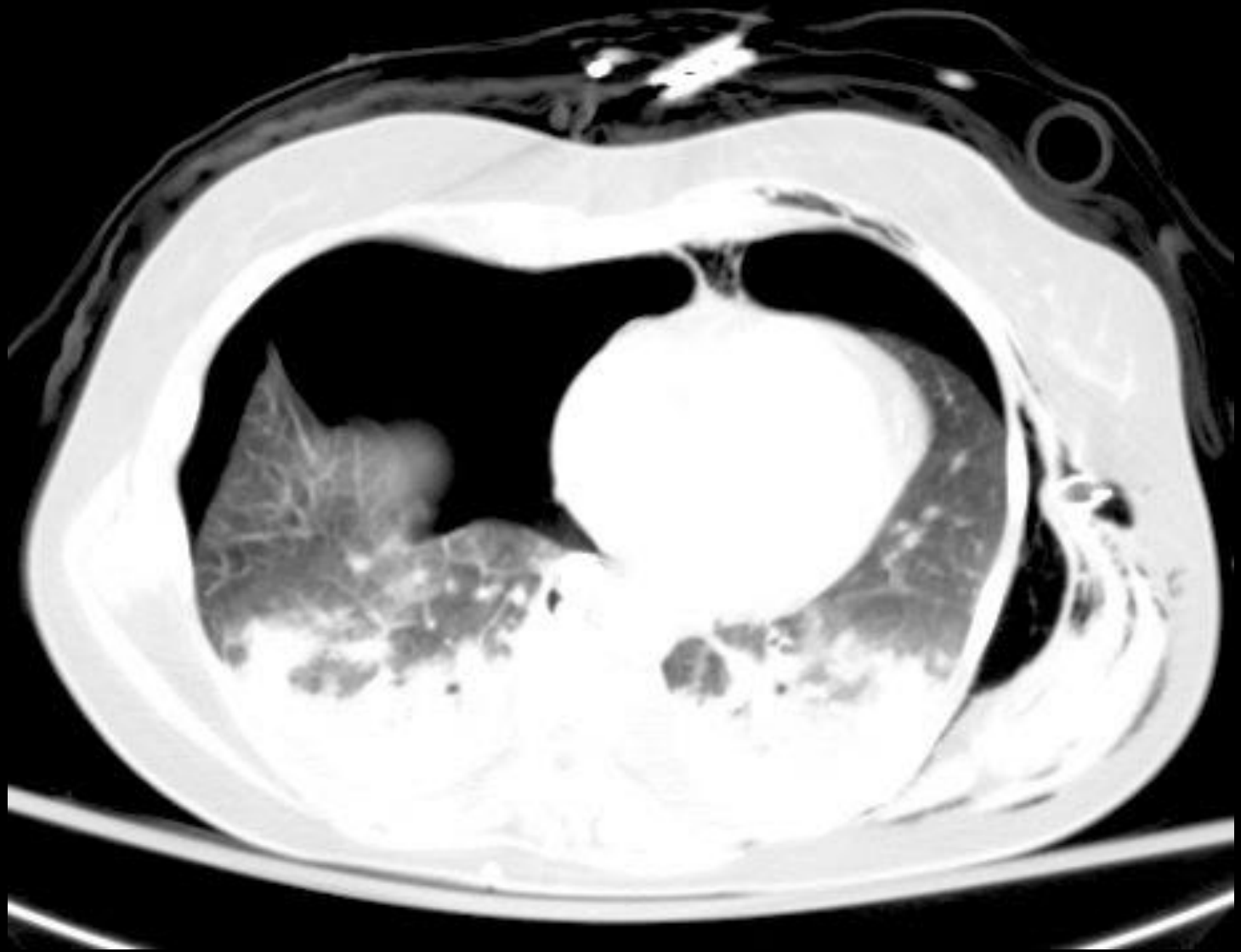
Cases

Hit by a Train

- After bilateral chest tubes and IV fluids,vitals stabilized and patient sent to CT

Cases

Hit by a Train



Cases

Hit by a Train

Cases

Hit by a Train

- Case highlights ability of CT to localize injury above and/or below the diaphragm and guide treatment

Conclusion

EFAST in Non-Trauma

- spontaneous pneumothorax
- pleural effusions
- pericardial effusions
- ascites
- ruptured ectopic
- ruptured AAA

Conclusion

Advanced Trauma Applications

- Evaluation and treatment of shock
- Confirmation of intubation - ETT depth
- Procedural guidance
- Fracture diagnosis and reduction
- Eye trauma, head injury, foreign bodies, others...

Summary

Main Goals

- Obtain information:
  - Is there a pericardial effusion?
  - Is there a pneumothorax?
  - Is there a hemothorax?
  - Is there intraperitoneal bleeding?
  - What is relative volume status?

Summary

Ultrasound

- Obtain useful information in seconds
- Now used for blunt and penetrating abdominal AND thoracic injury
- Remember limitations
  - inability to localize source of bleeding
  - does not rule out abdominal injury
  - exam may evolve with time