MAYO CLINIC

INTRODUCTION TO POINT-OF-CARE ULTRASOUND

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Indianapolis, IN

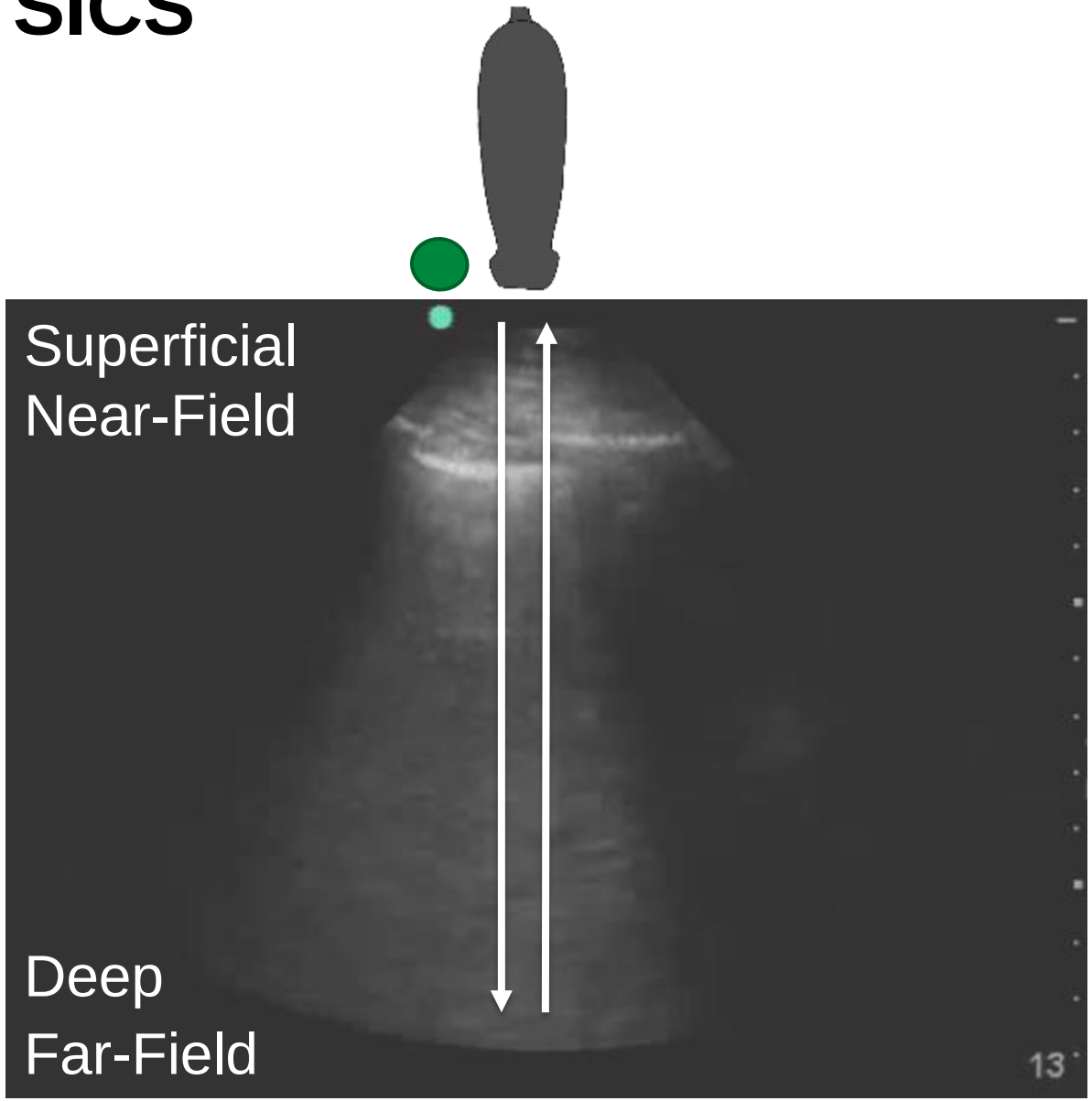
DISCLOSURES

None

LEARNING OBJECTIVE

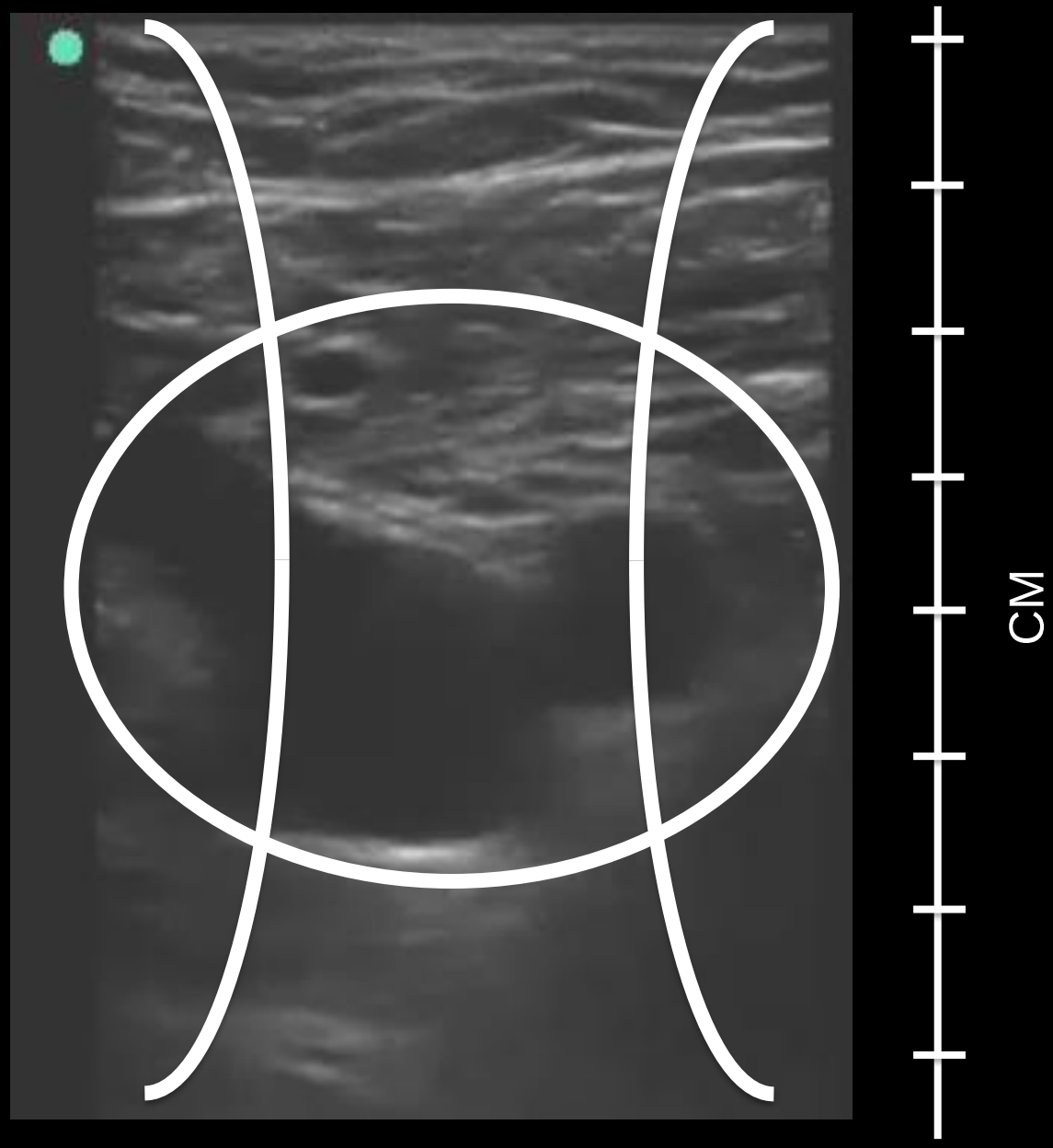
- Explain the basics of ultrasound physics and orientation.
- Summarize scope, indications, and evidence for Point-of-Care Ultrasound (POCUS) of the heart, lungs, peripheral vasculature, and soft tissues.
- Interpret POCUS images of the heart, lungs, peripheral vasculature, and soft tissues.
- Contrast evidence for standard of care with POCUS.

POCUS PHYSICS



POCUS PHYSICS

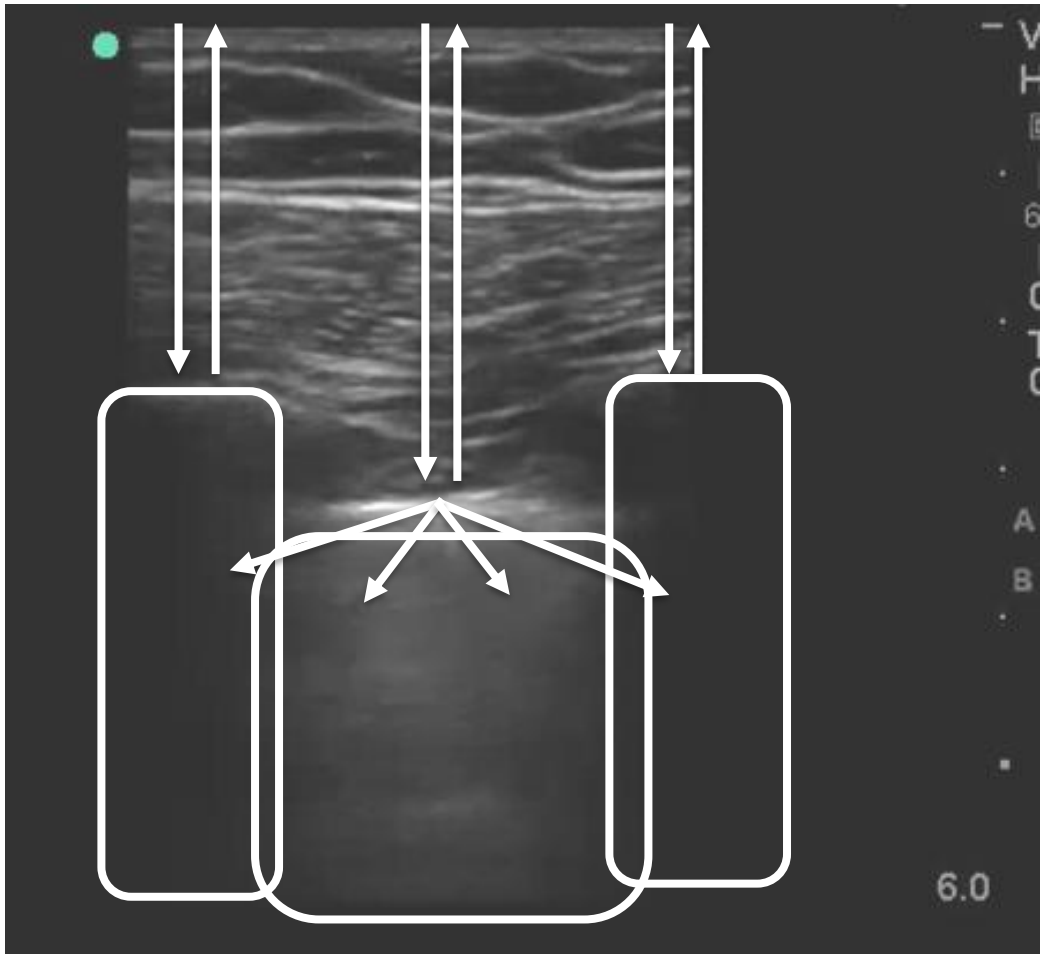
- Depth
- Focal Zone

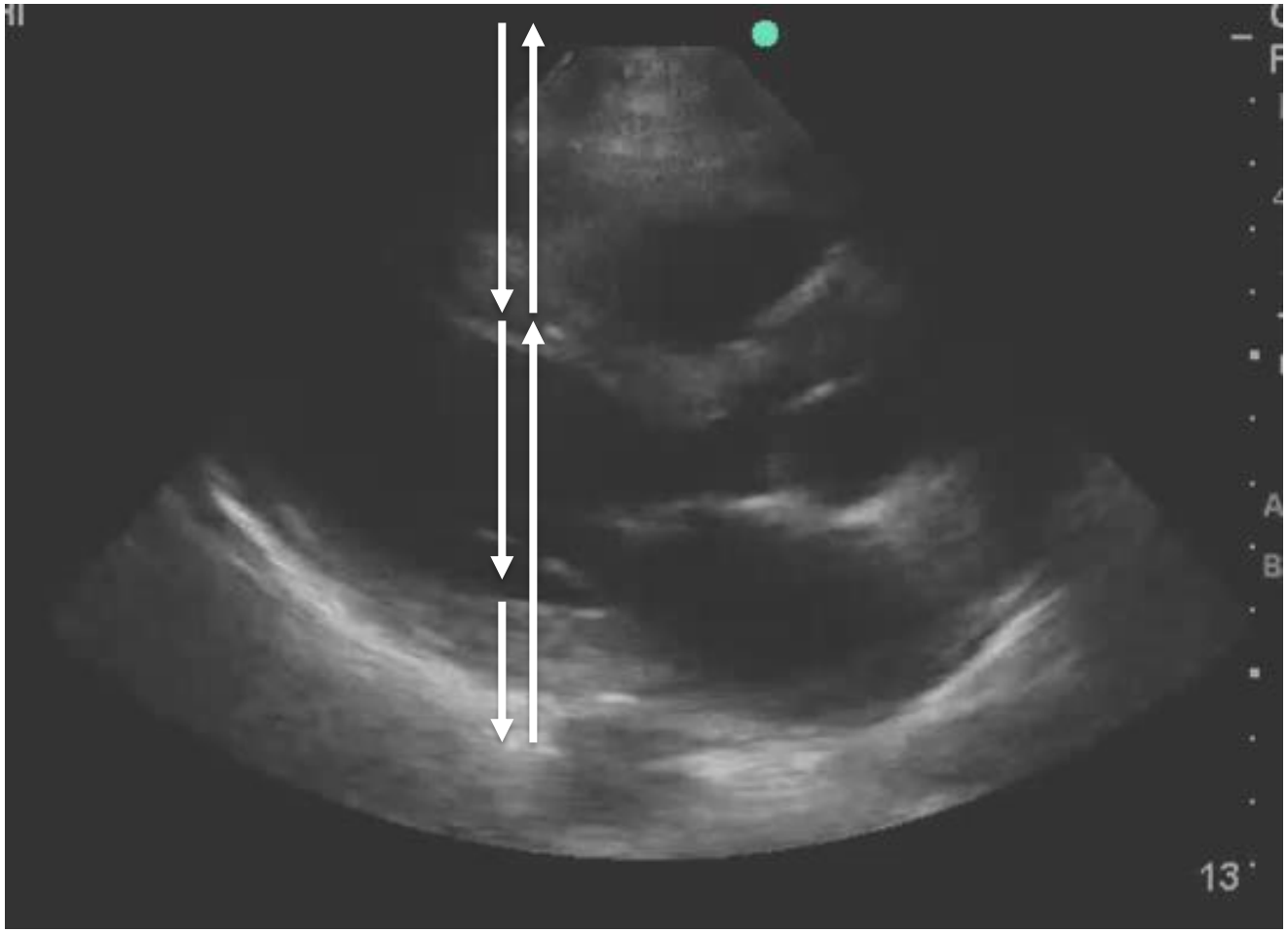


POCUS PHYSICS

- Acoustic Impedence
- Gray Scale
  - Black (anechoic) = Fluid or loss of echos
  - White (hyperechoic) = Strong reflectors (pleura, bone, fascia, etc).
  - Gray (isoechoic) = organs, tissues.

POCUS PHYSICS

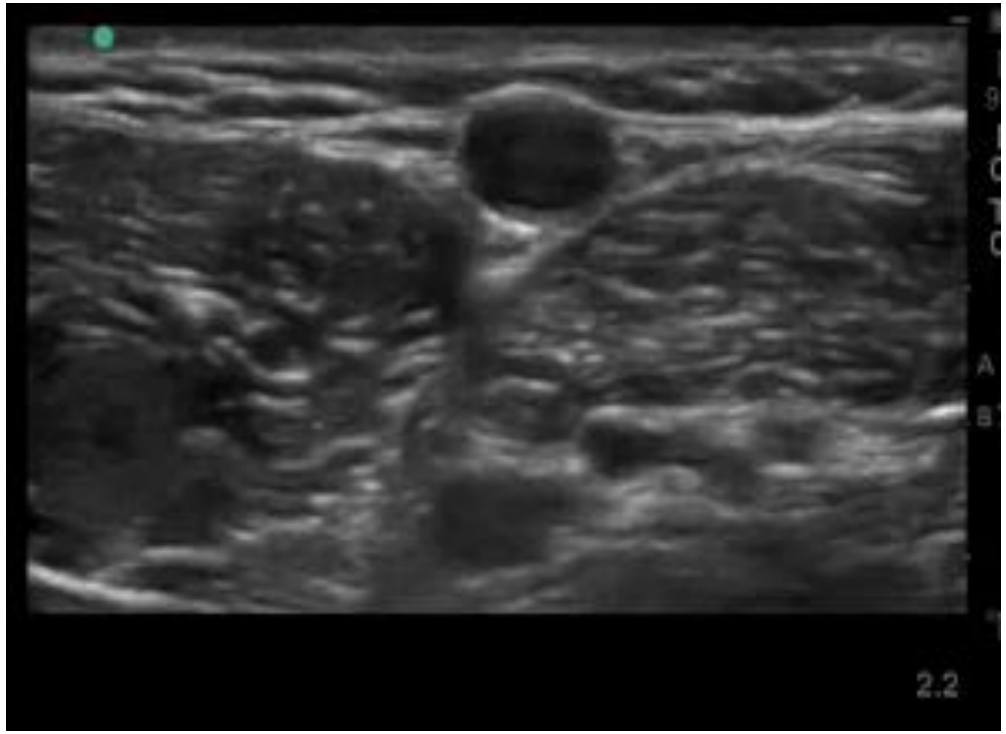


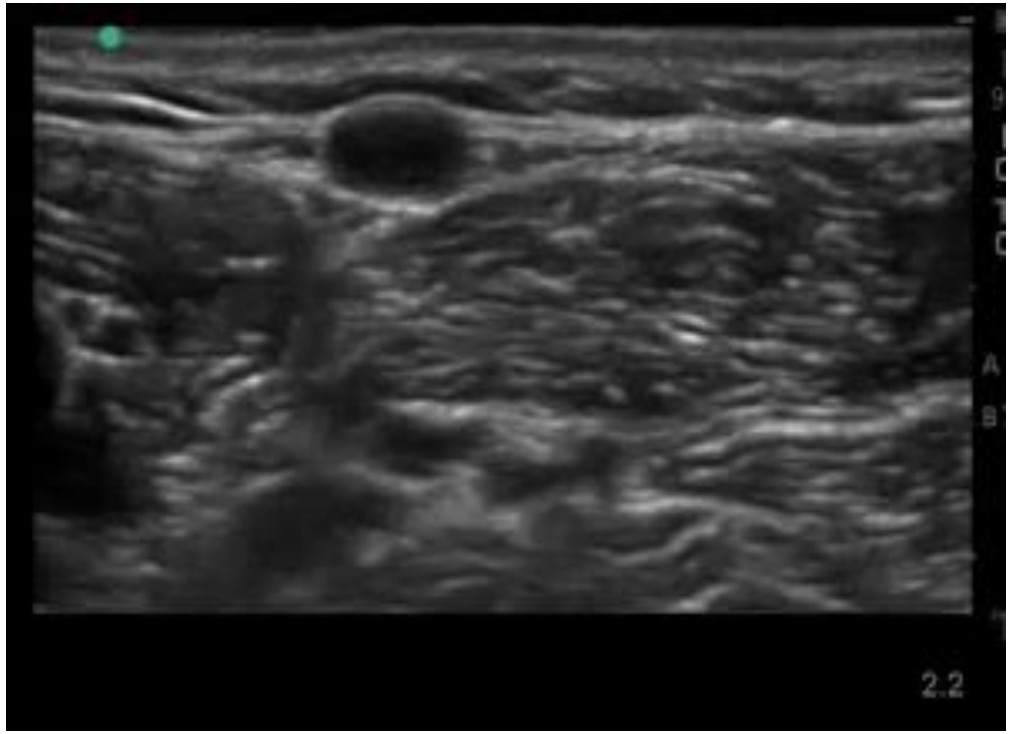


GAIN

- Amplitude of the ultrasound waves.

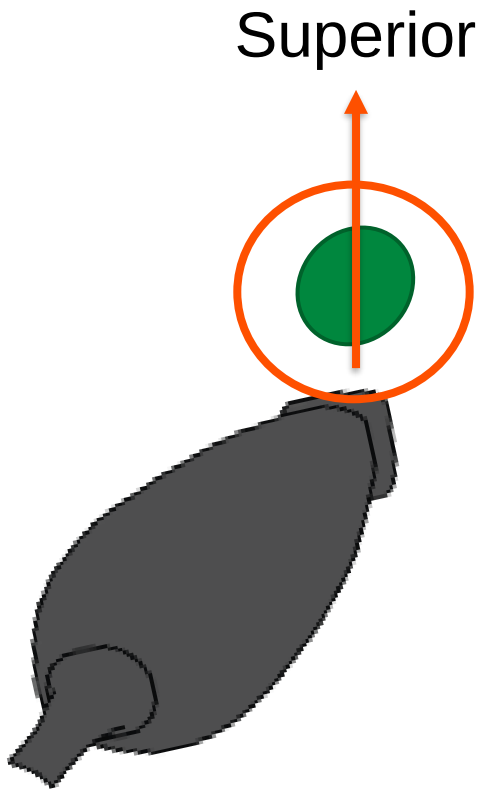
Down Gain

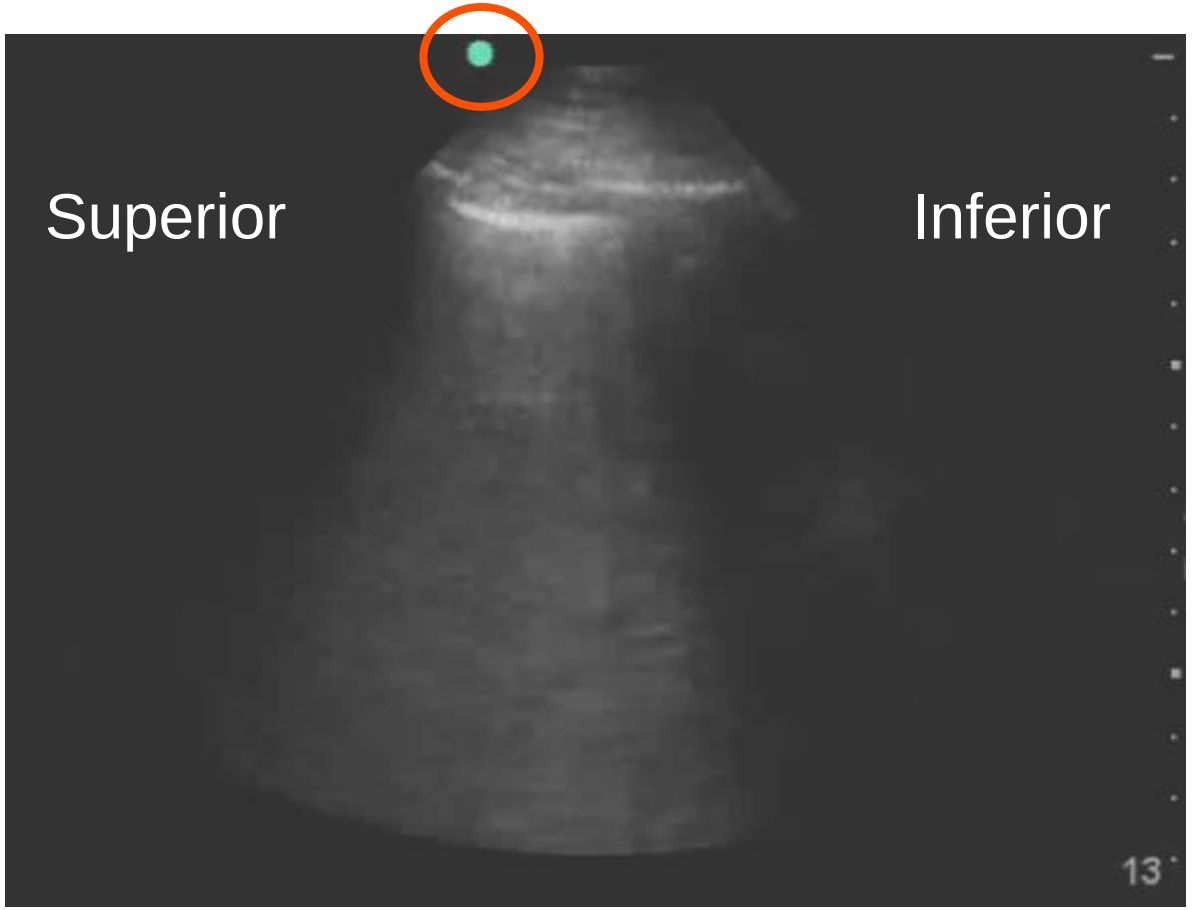




Up Gain

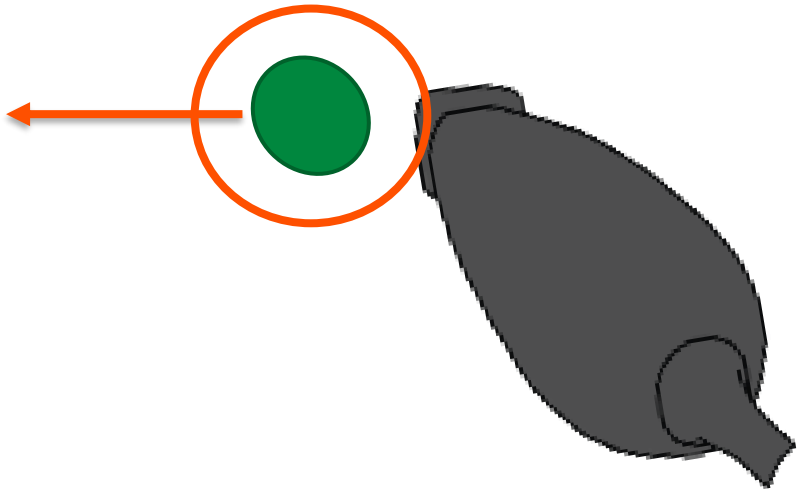
INDICATOR MARKERS





INDICATOR MARKERS

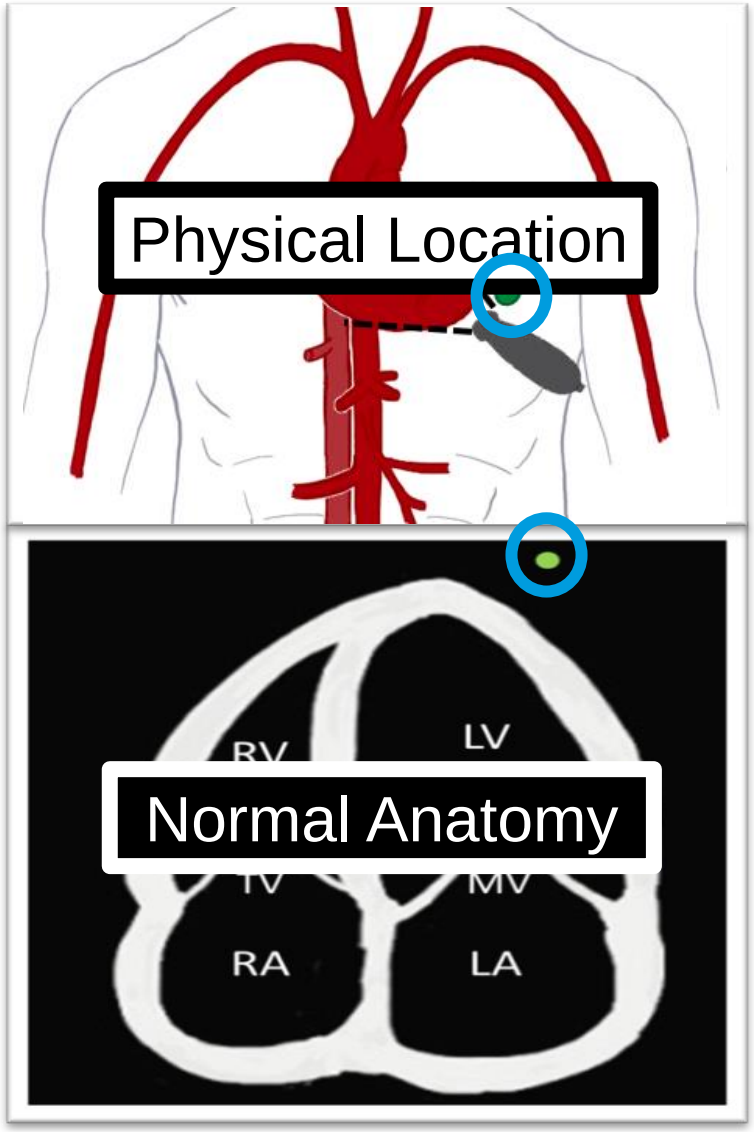
Patient's Right

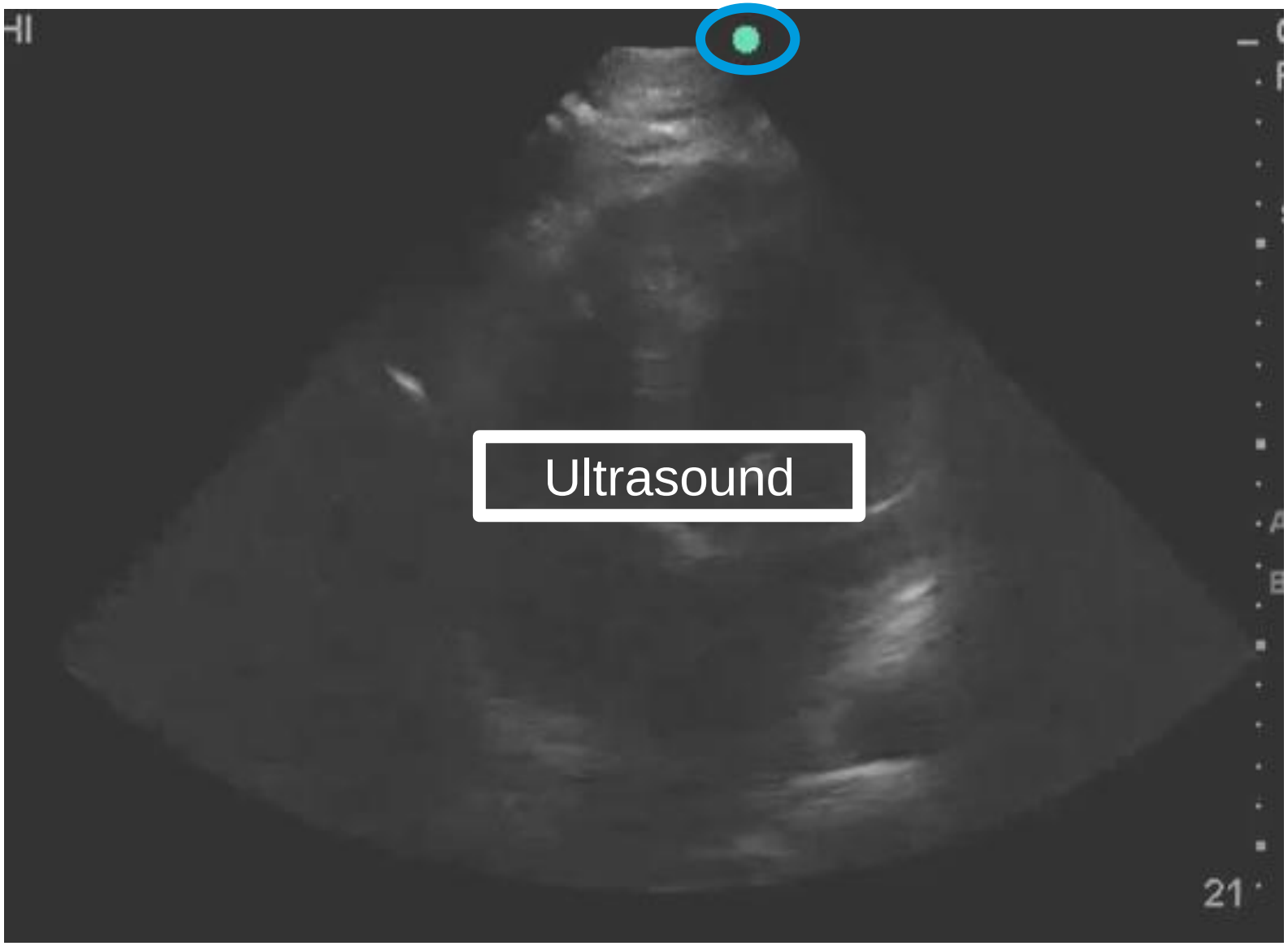


Patient's Right

Patient's Left

SLIDE CONVENTION





CASE 1

CASE 1

- A 78 year-old gentleman presents to the emergency department for evaluation shortness of breath, progressing over 3 – 4 days.
- He endorses cough, but denies sputum production. Denies fever or rigors. Denies hemoptysis.

- Past Medical / Surgical History:
  - COPD
  - Hypertension
  - Obesity
- Social History:
  - 60 pack year history of smoking
- Family History:
  - Father – Lung cancer

CASE 1

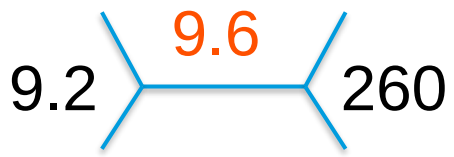
Vital Signs:

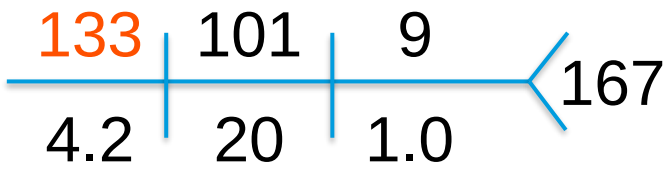
- HR 92
- BP 156/52
- SpO2 84%
- RR 28
- T 37.0 Celsius

Exam:

- Mild distress
- Body habitus impairs JVD
- Normal S1 and S2.
- Diffuse wheezing throughout all lung fields
- 2+ pitting “chronic” edema

CASE 1





Lactate 1.7

CASE 1

Presumptive Diagnosis:
COPD Exacerbation

DuoNebs
Prednisone
Levofloxacin

Admitted

FOCUSED CARDIAC ULTRASOUND (FoCUS)

- Scope:
  - LV size / systolic function
  - RV size / systolic function
  - IVC size and respiratory variation
  - Pericardial effusions / Cardiac Tamponade
- Indications:
  - Hypotension
  - Respiratory Failure
  - Intravascular volume assessment

Qualitative
(not Quantitative)

FoCUS

5 Cardinal Views of the Heart

- Parasternal Long Axis (PLAX)
- Parasternal Short Axis (PSAX)
- Apical 4 Chamber (A4C)
- Subcostal 4 Chamber (S4C)
- Inferior Vena Cava (IVC)

FoCUS

5 Cardinal Views of the Heart

- Parasternal Long Axis (PLAX)
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- Apical 4 Chamber (A4C)
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- Inferior Vena Cava (IVC)

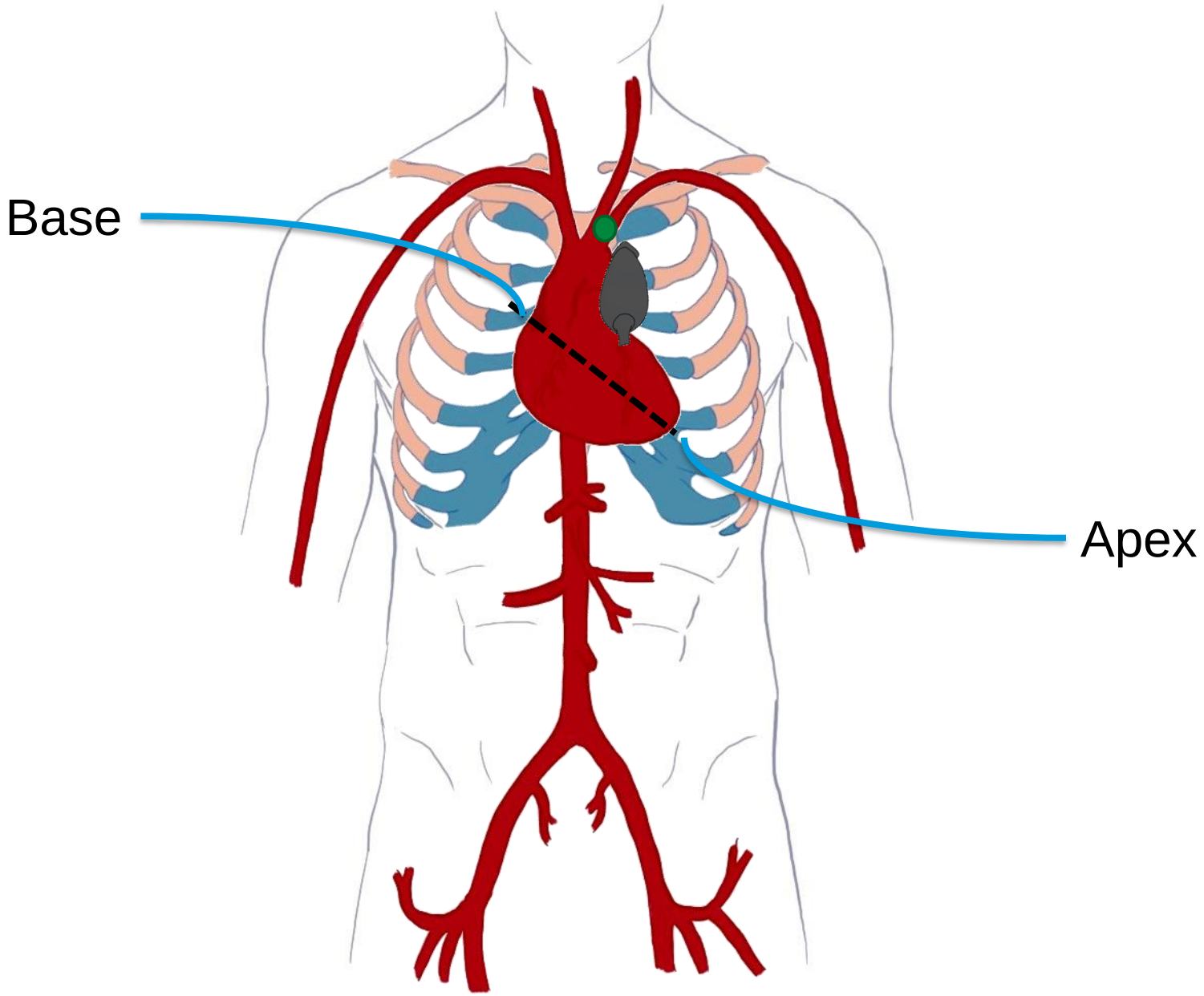
FoCUS

LV Systolic Function:

- Hyperdynamic
- Normal
- Reduced / Severely Reduced

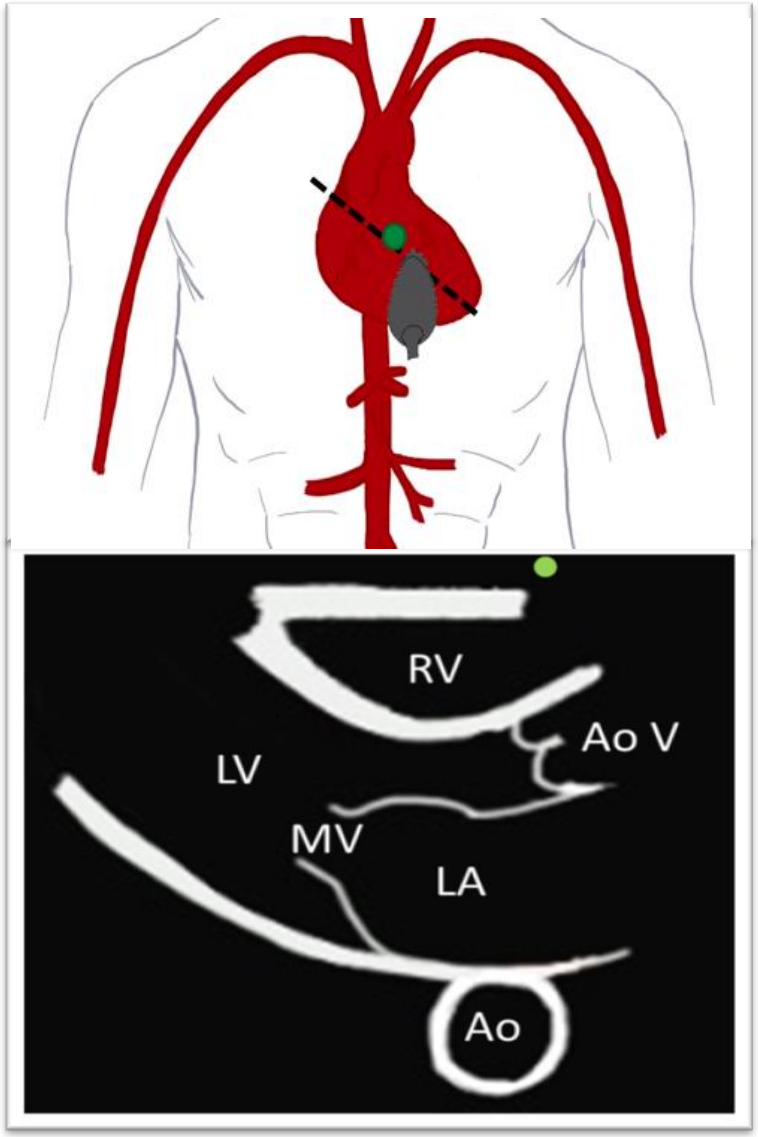
Soni NJ, Arntfiled R, Kory P (2015). Point of Care Ultrasound, Oxford: Elsevier Saunders.

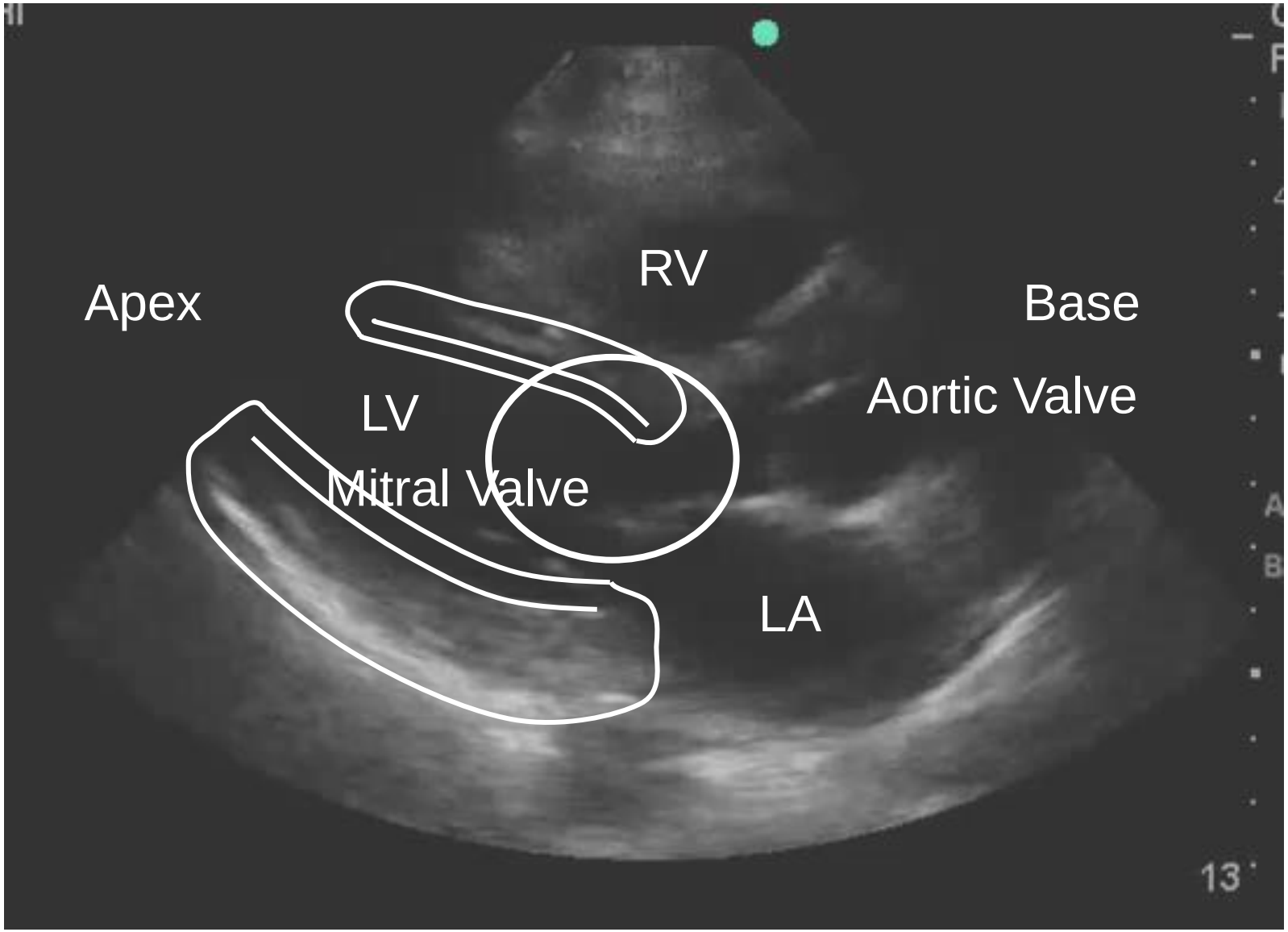
FoCUS
PLAX



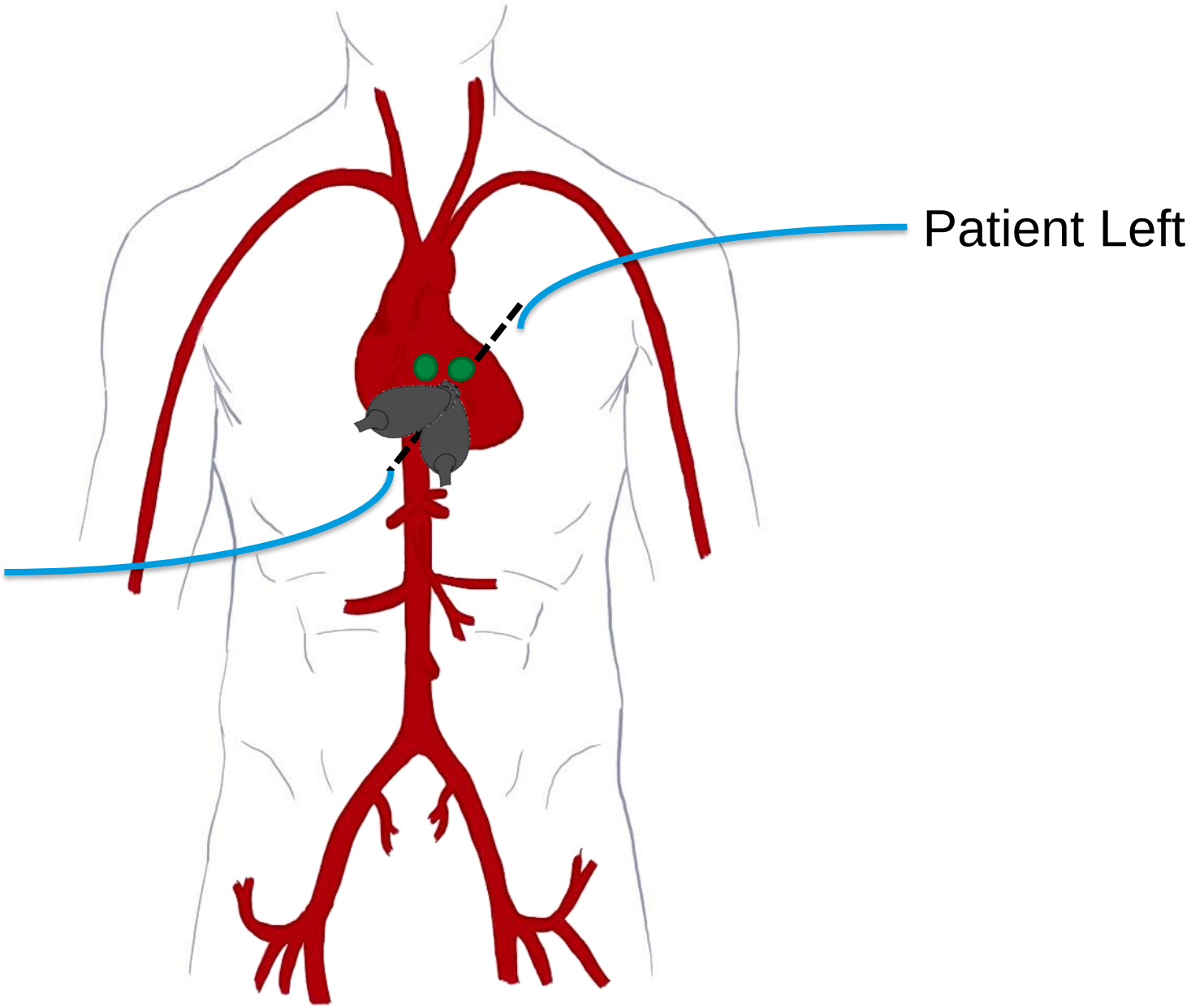
FoCUS
PLAX

1. Endocardial Excursion
2. Myocardial Thickening
3. E Point Septal Separation

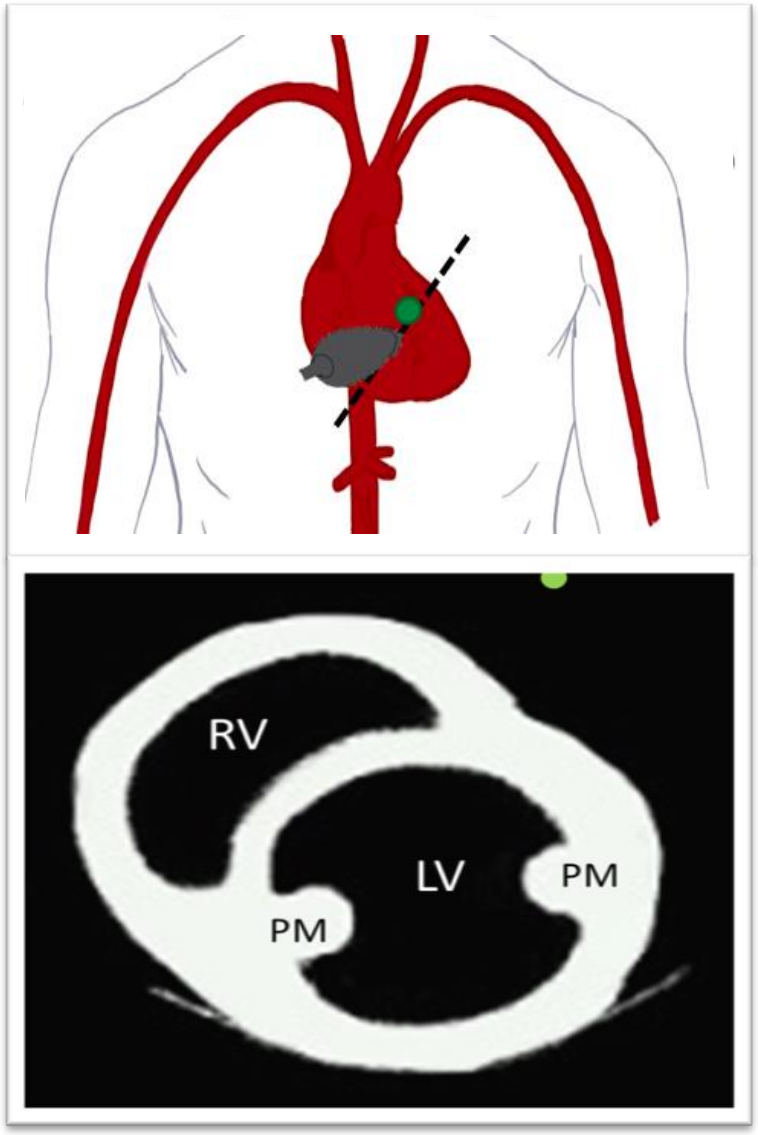


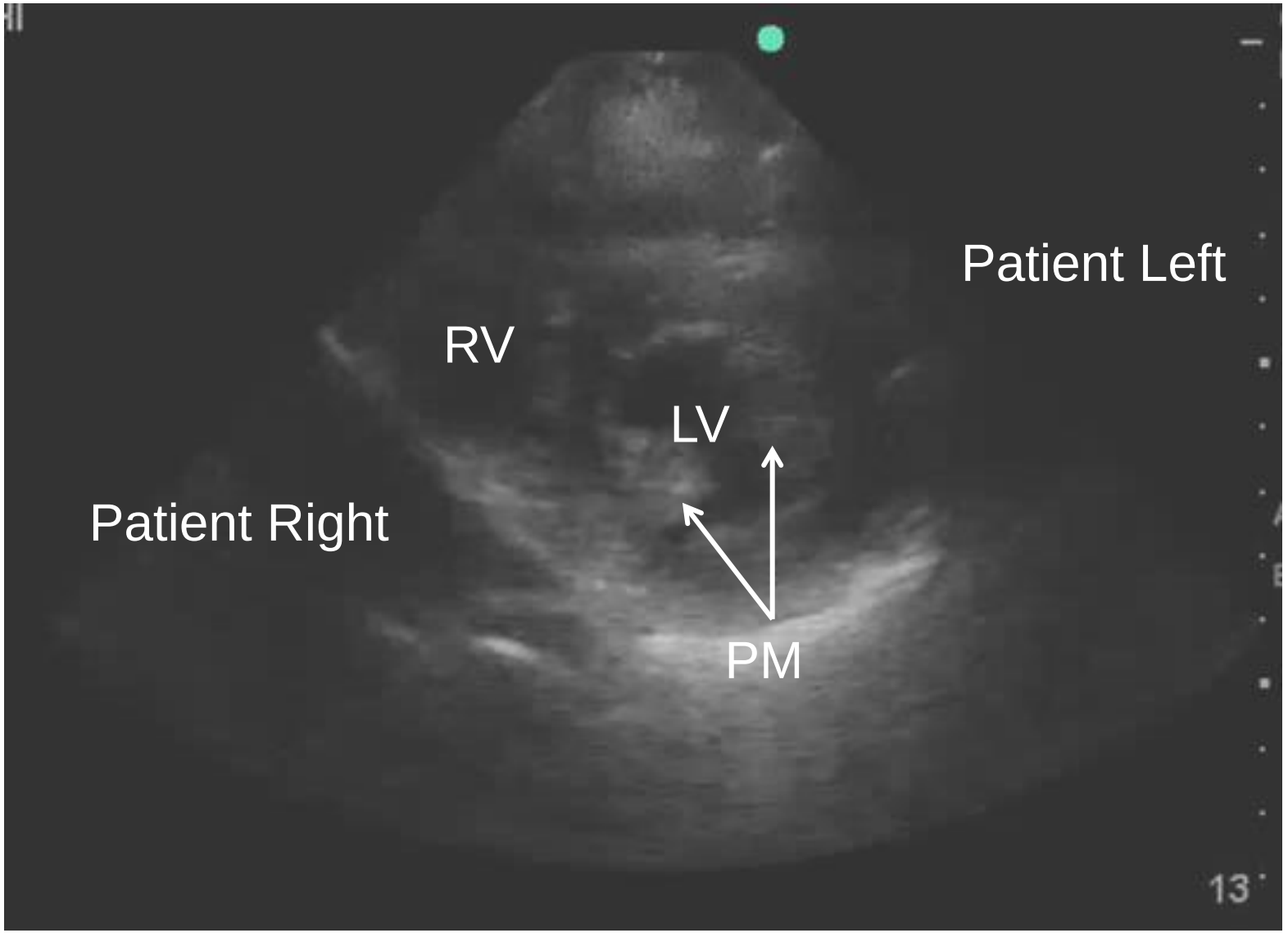


FoCUS
PSAX

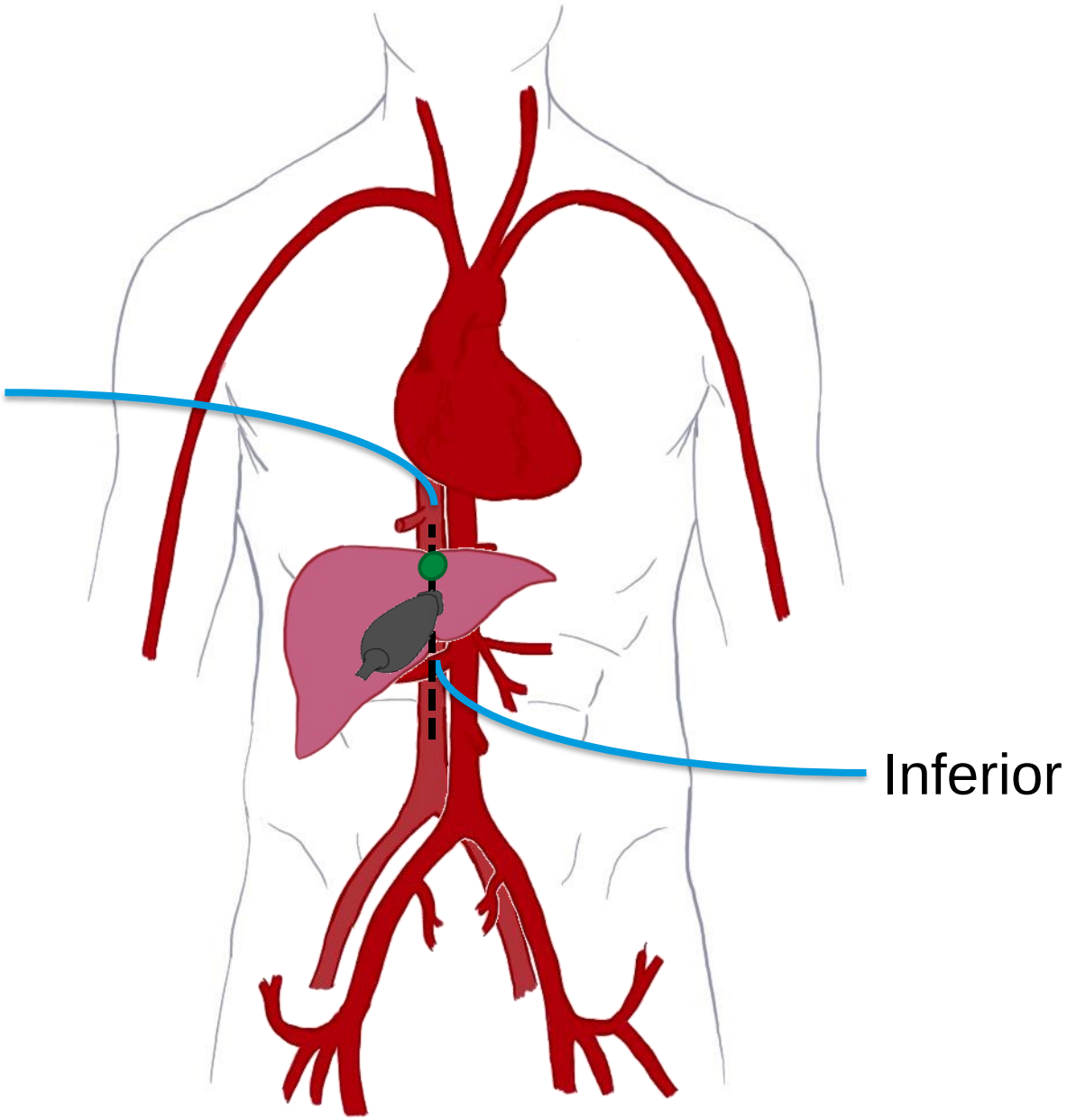


FoCUS
PSAX

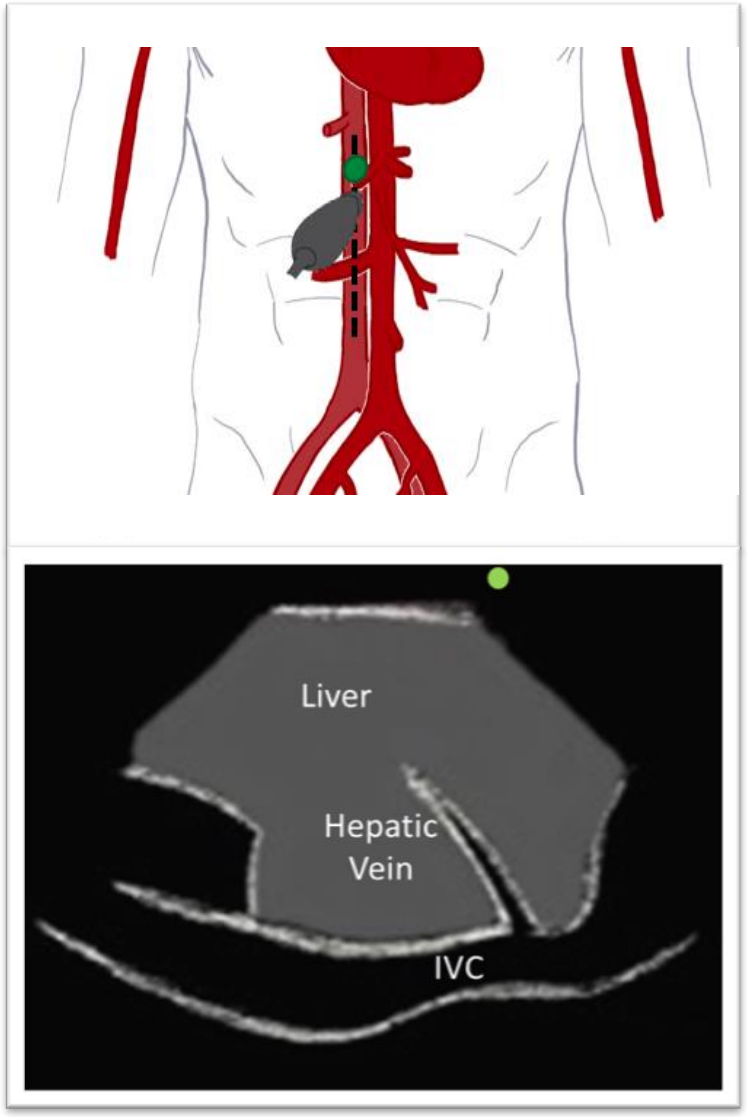


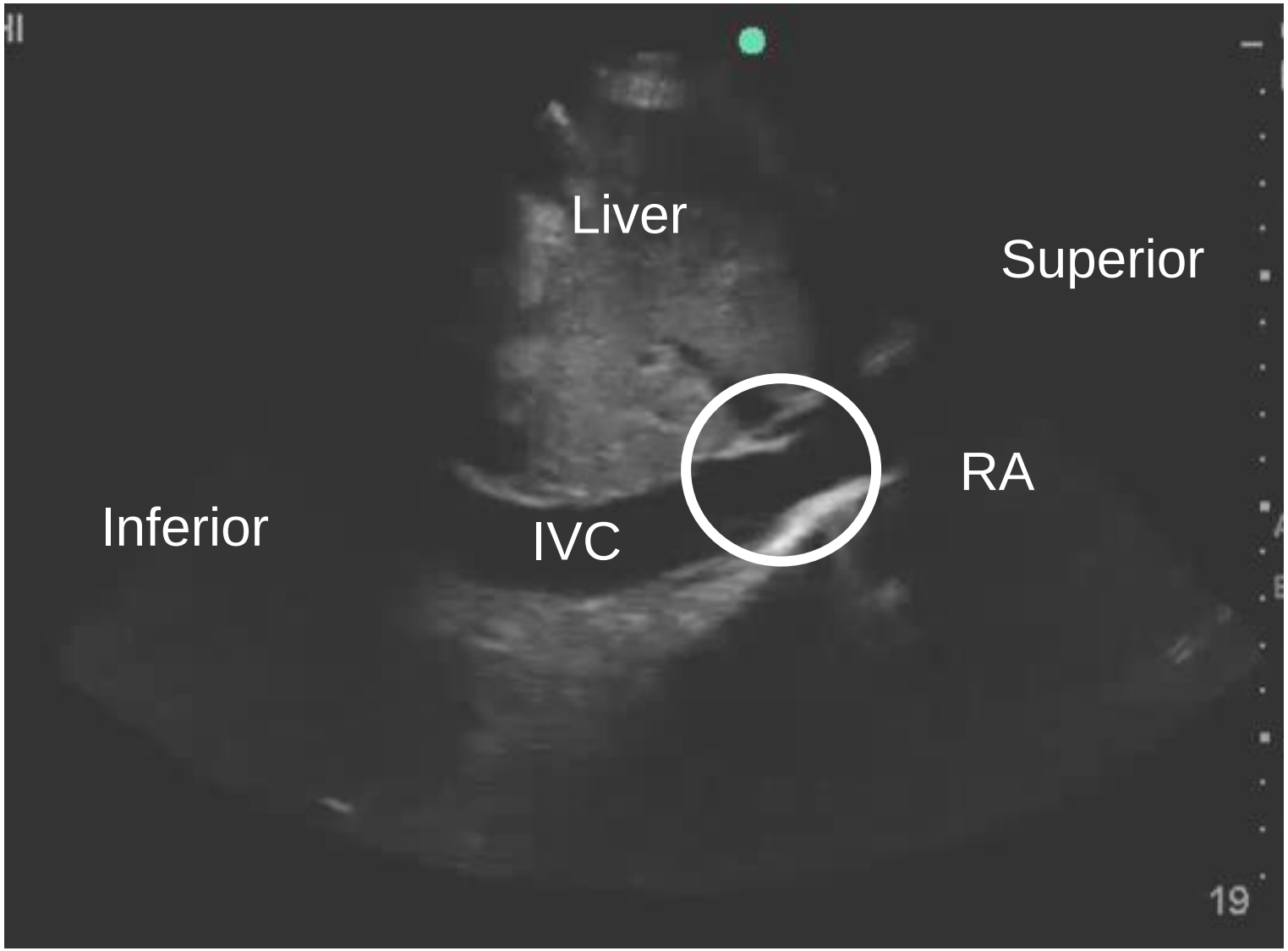


FoCUS
IVC



FoCUS
IVC





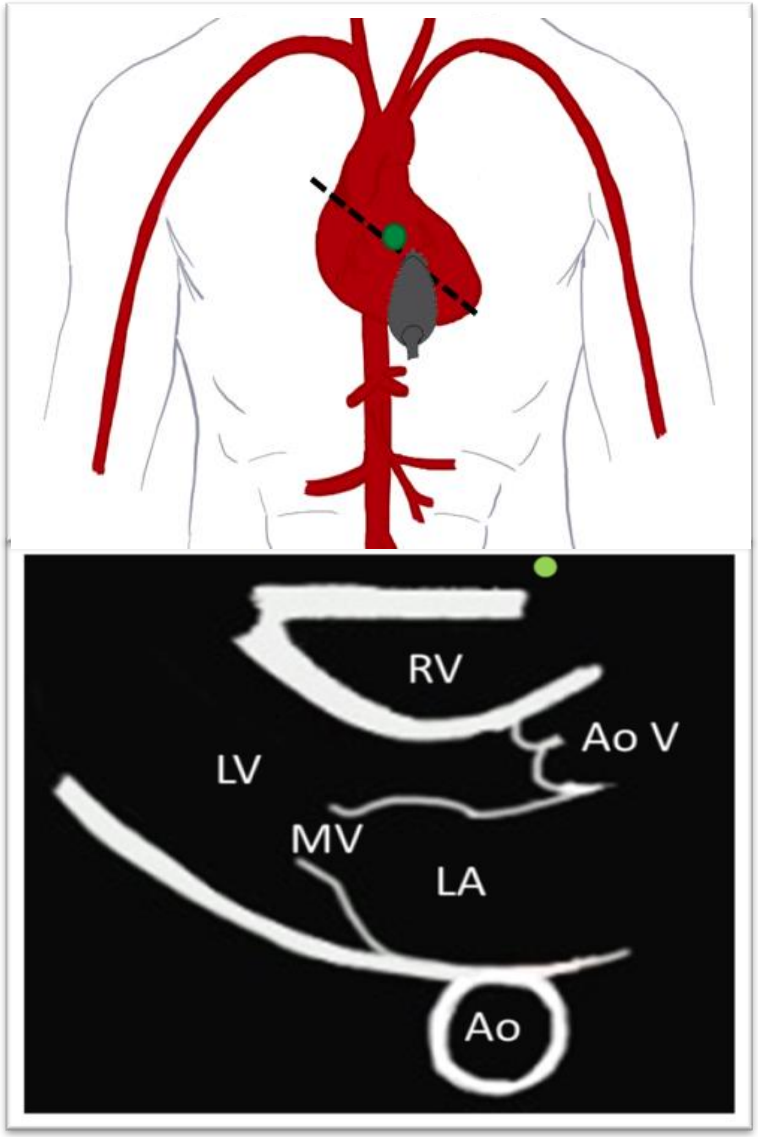
FoCUS

- Surrogate marker for RA Pressure / Central Venous Pressure
- JVP ≈ IVC

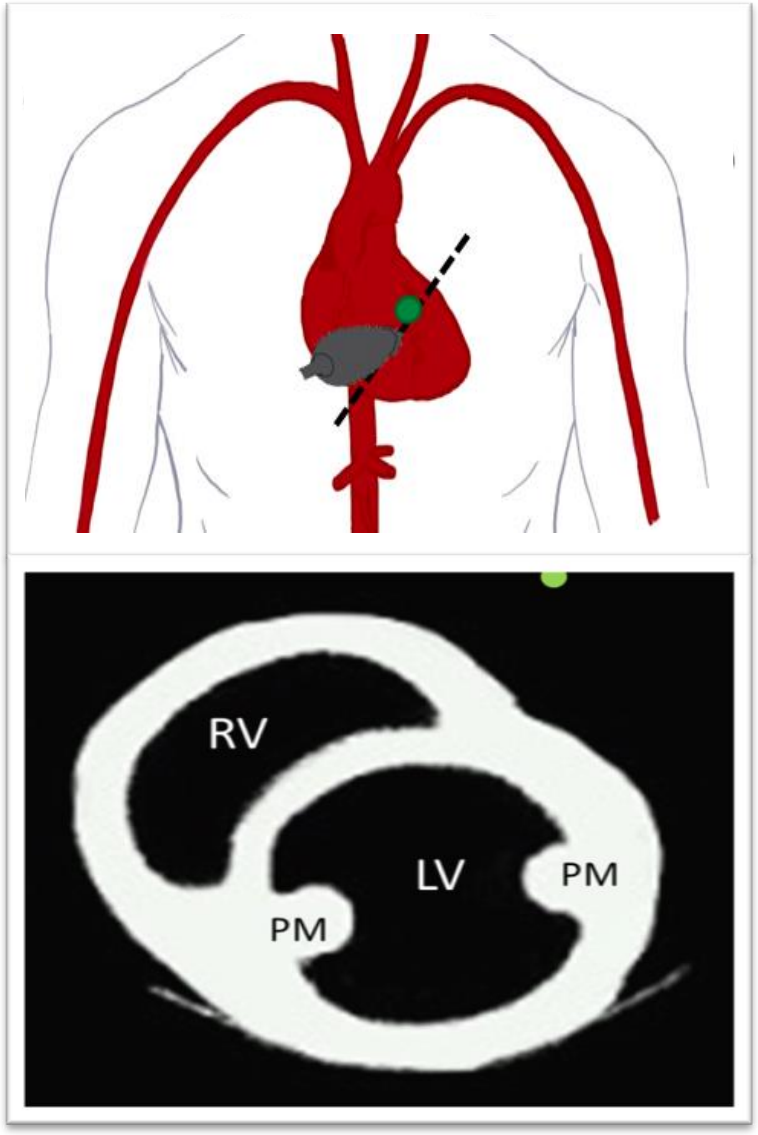
IVC Findings	CVP (mm Hg)	Clinical Correlation
IVC < 2.1 cm, with > 50% collapse	3 (range 0 – 5)	Probable hypovolemia
IVC < 2.1 cm, with < 50% collapse IVC > 2.1 cm, with > 50% collapse	8 (range 5 – 10)	
IVC < 2.1, with < 50% collapse	15 (range 10 – 20)	Possible hypervolemia

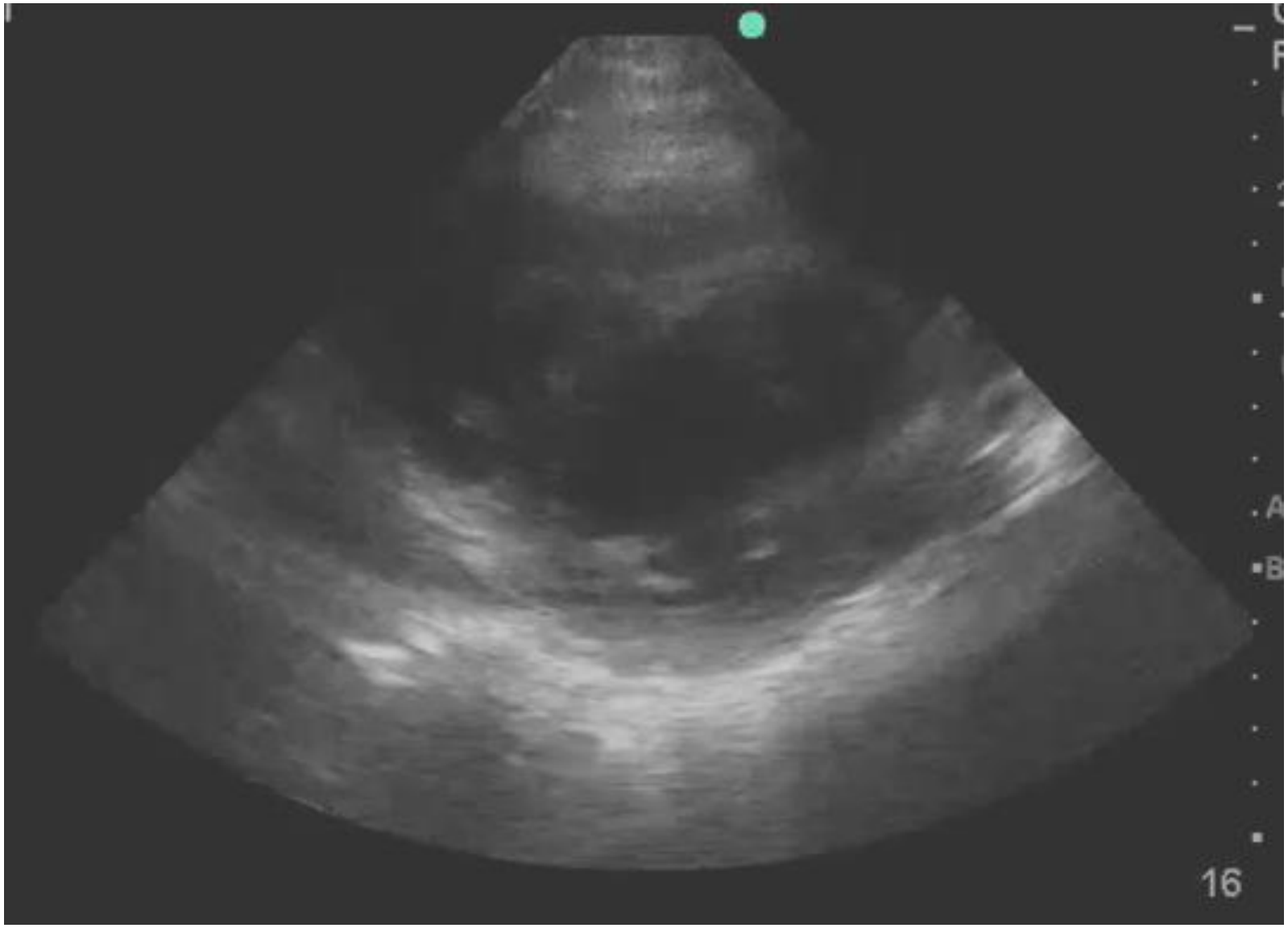
Soni NJ, Arntfiled R, Kory P (2015). Point of Care Ultrasound, Oxford: Elsevier Saunders.

CASE 1
PLAX

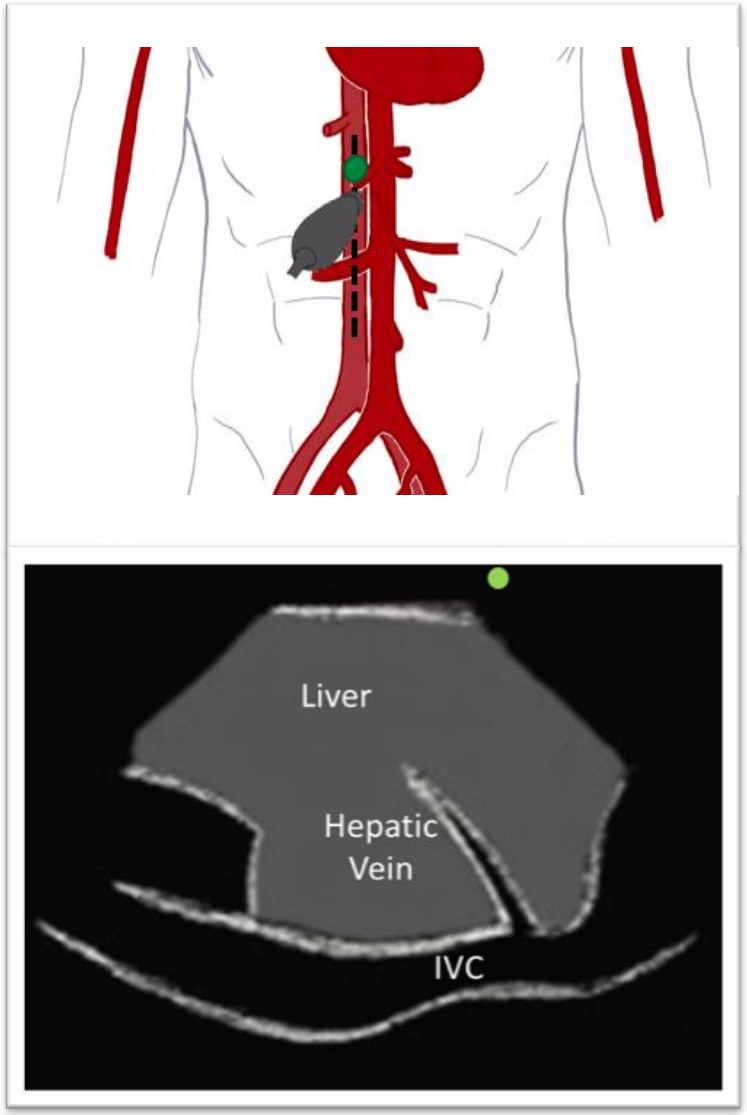


CASE 1
PSAX





CASE 1
IVC

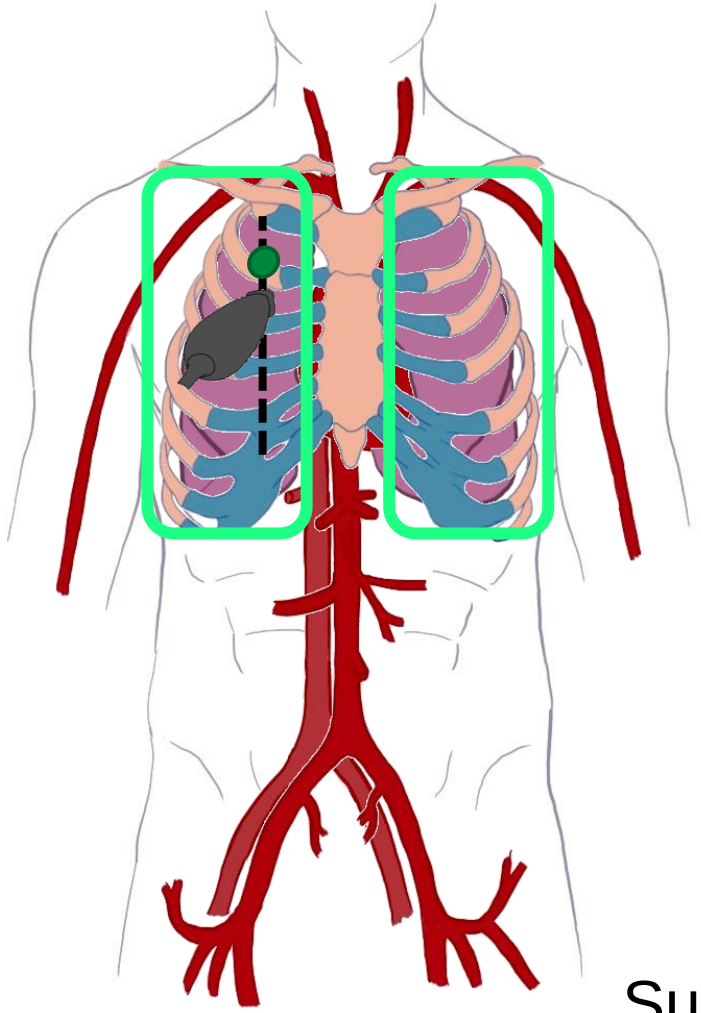


LUNG ULTRASOUND

- Scope:
  - Pulmonary Edema
  - Pneumonia (viral and bacterial)
  - Pleural effusions (simple vs complex)
  - Pneumothorax
- Indications:
  - Dyspnea
  - Hypoxia
  - Respiratory Failure
  - Intravascular volume assessment

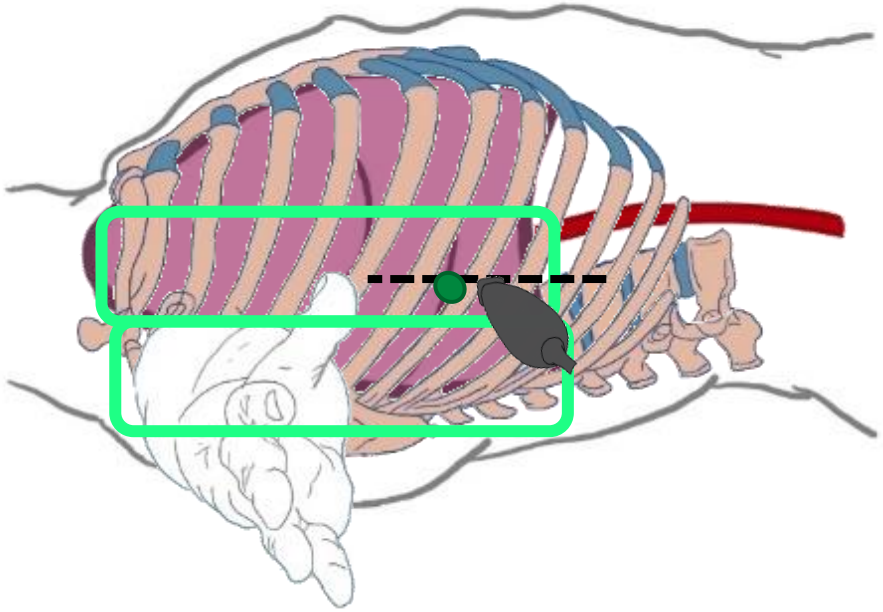
LUNG ULTRASOUND

Zone 1



Zone 2

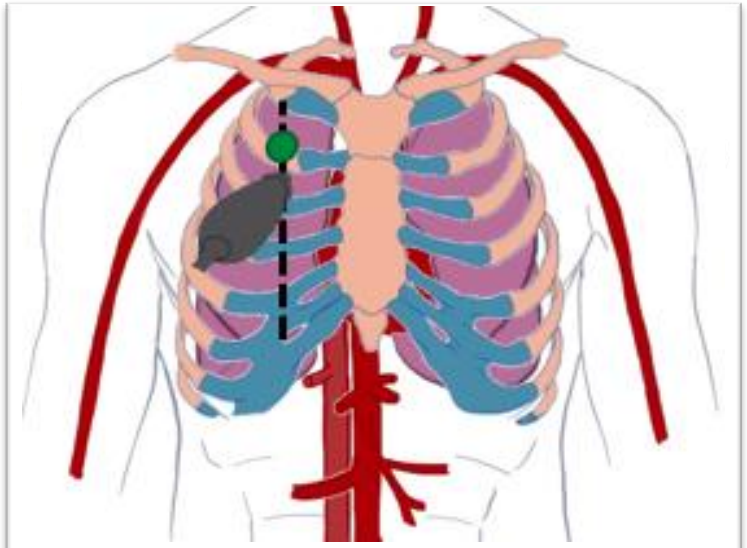
Zone 3

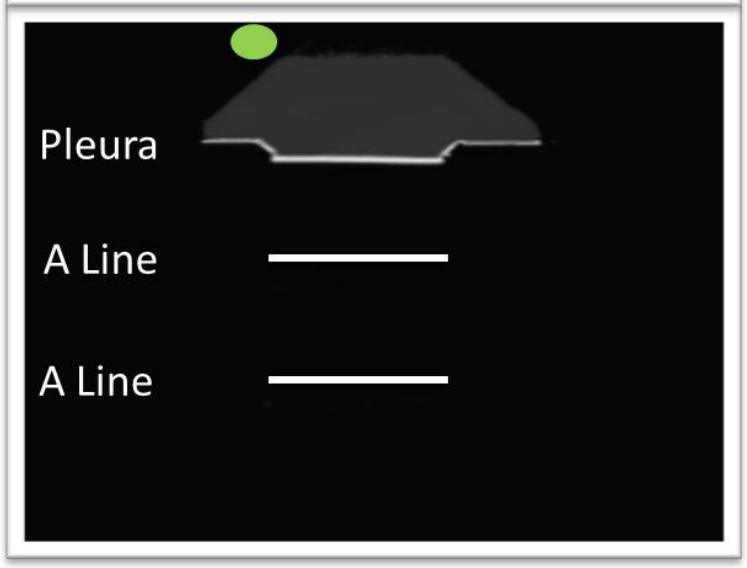


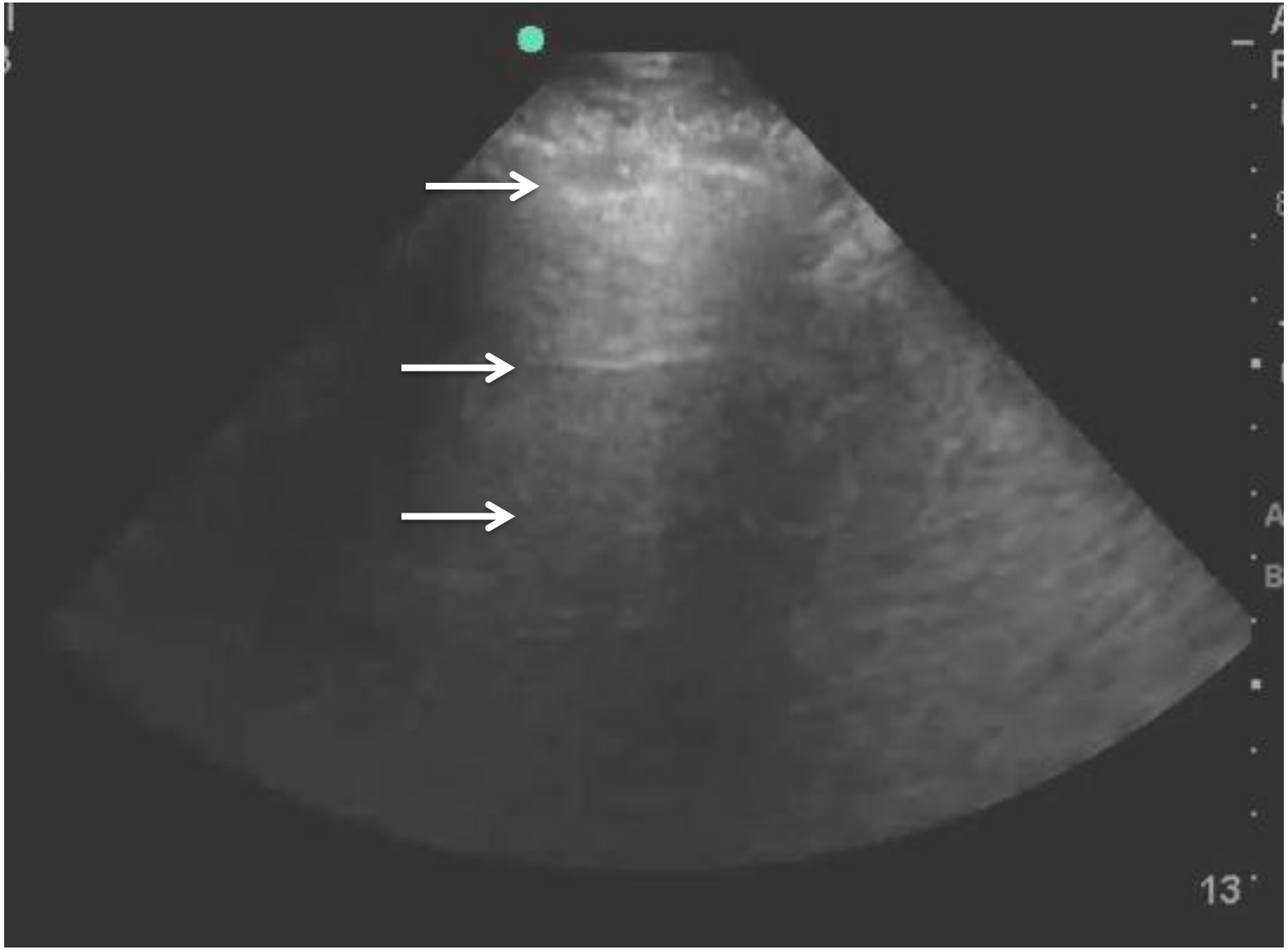
Superior + Inferior Points

LUNG ULTRASOUND

A LINES + LUNG SLIDING

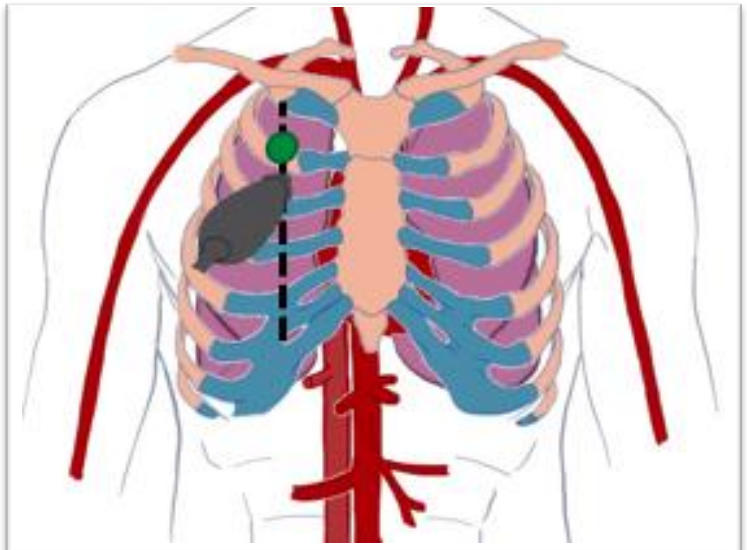


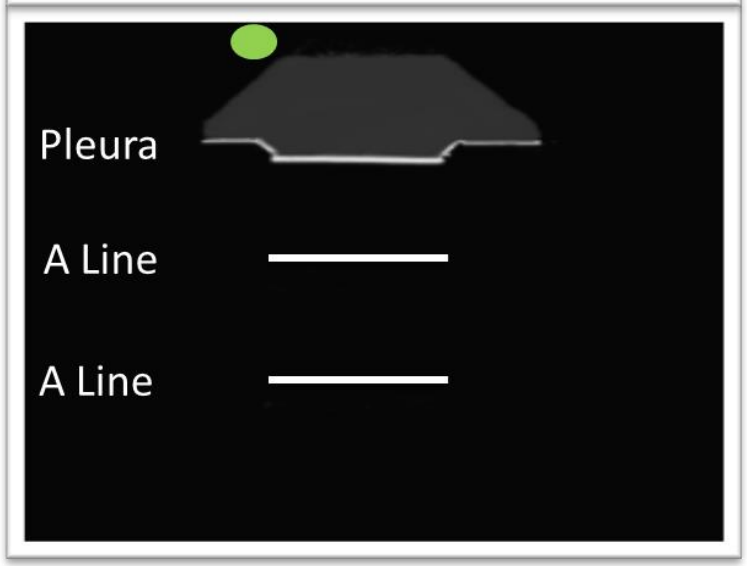


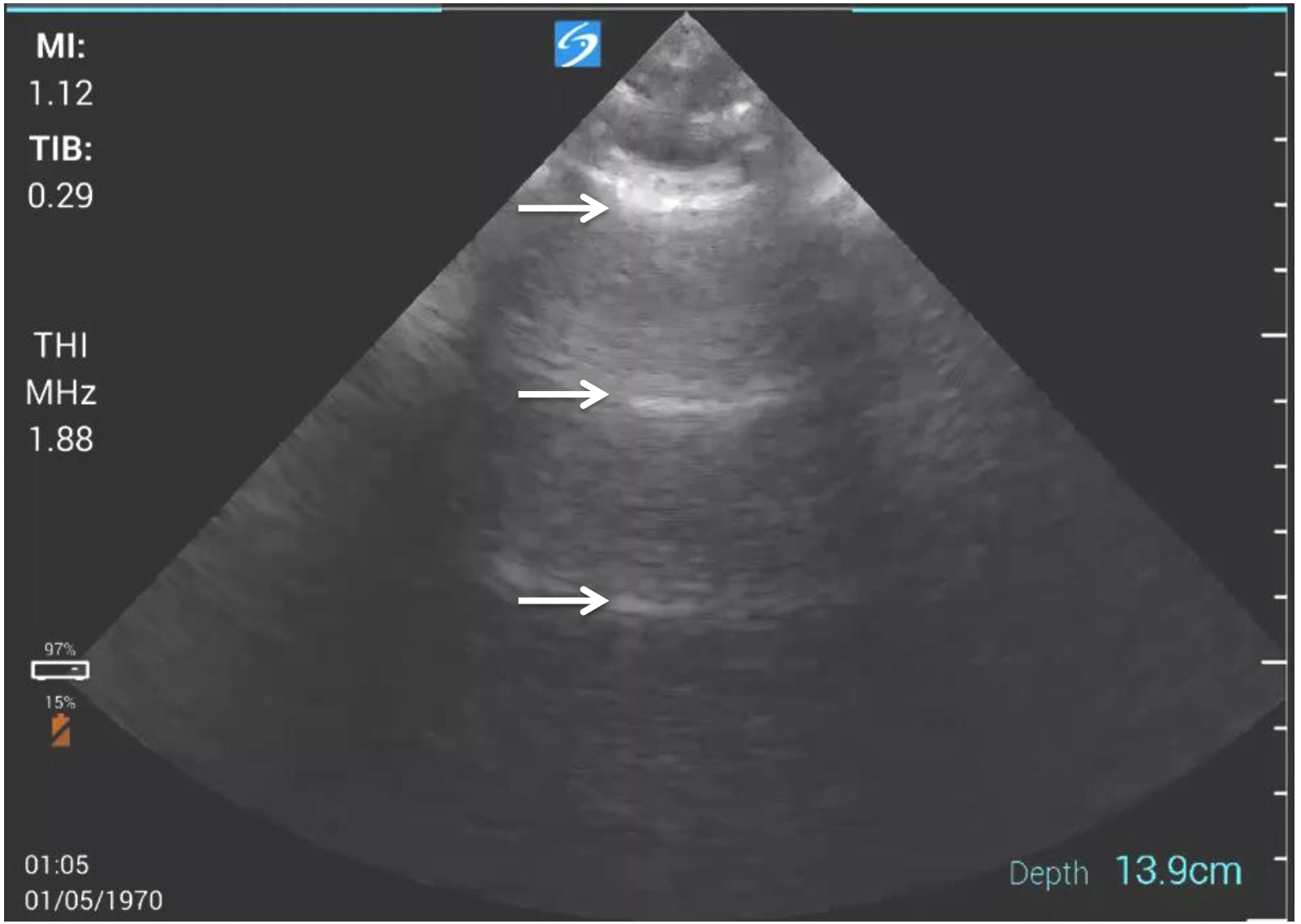


LUNG ULTRASOUND

ABSENT LUNG SLIDING

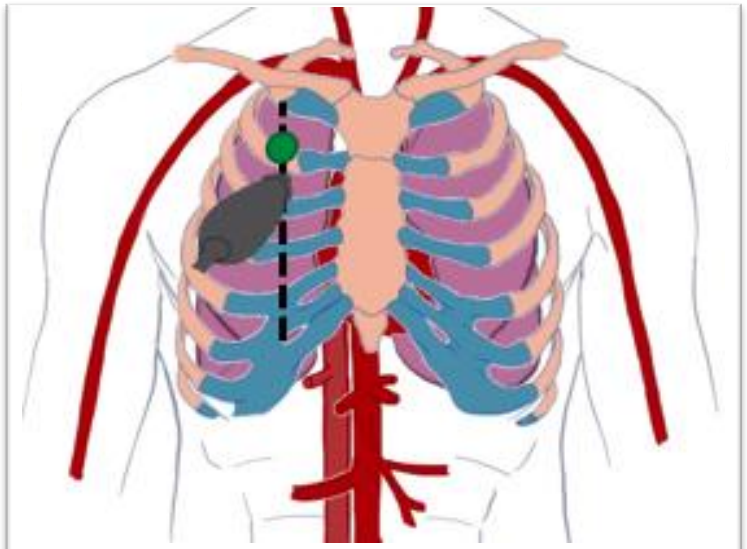


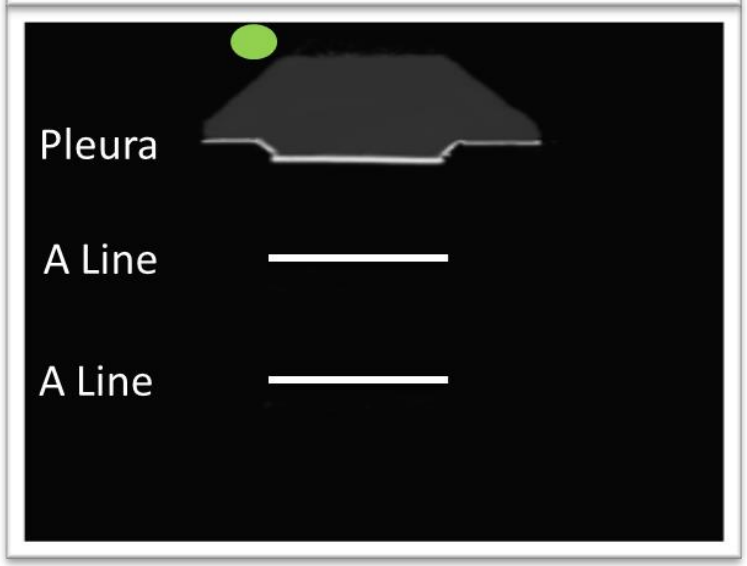


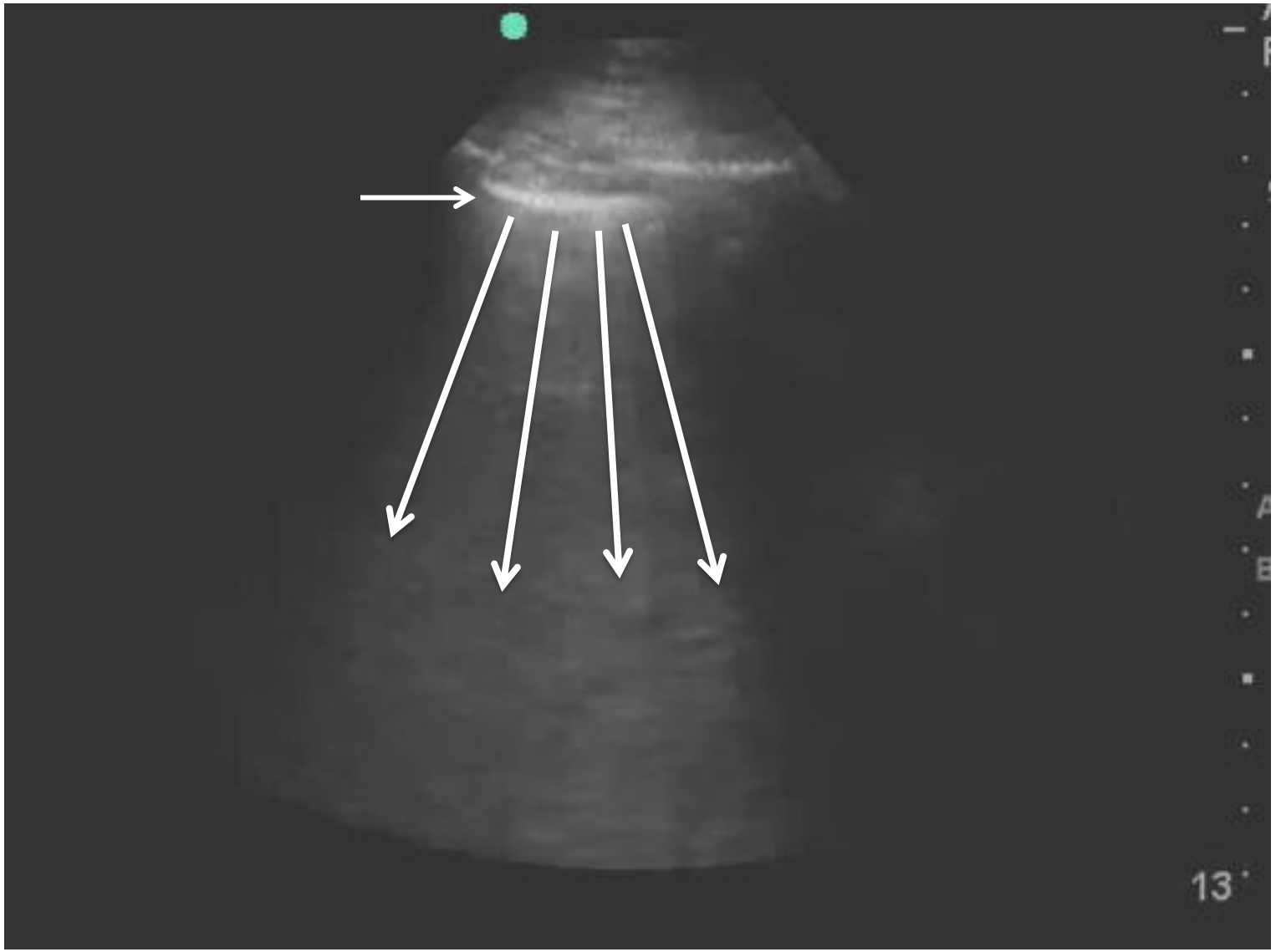


LUNG ULTRASOUND

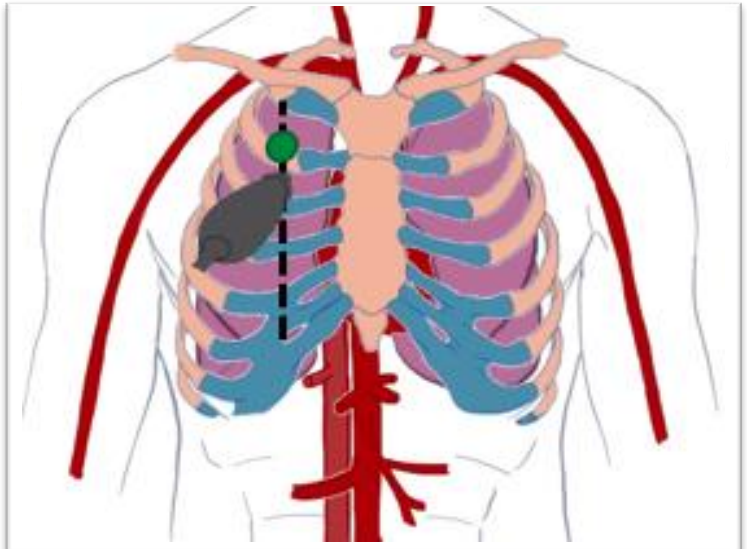
B LINES

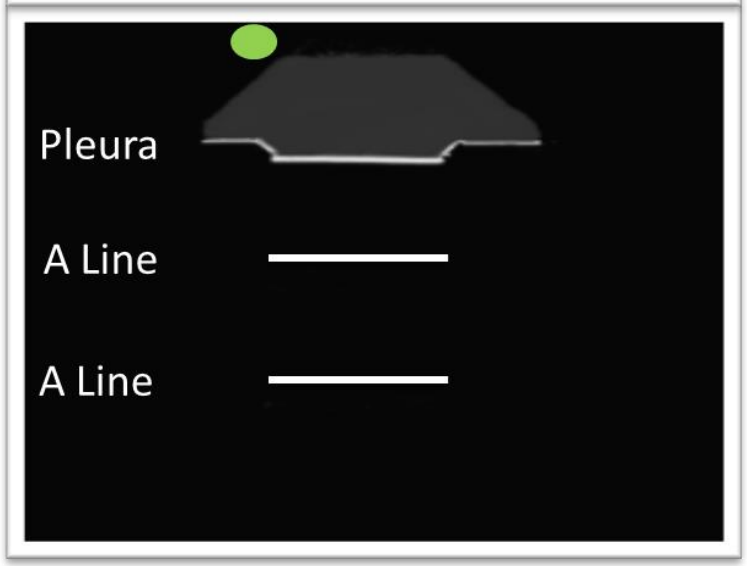


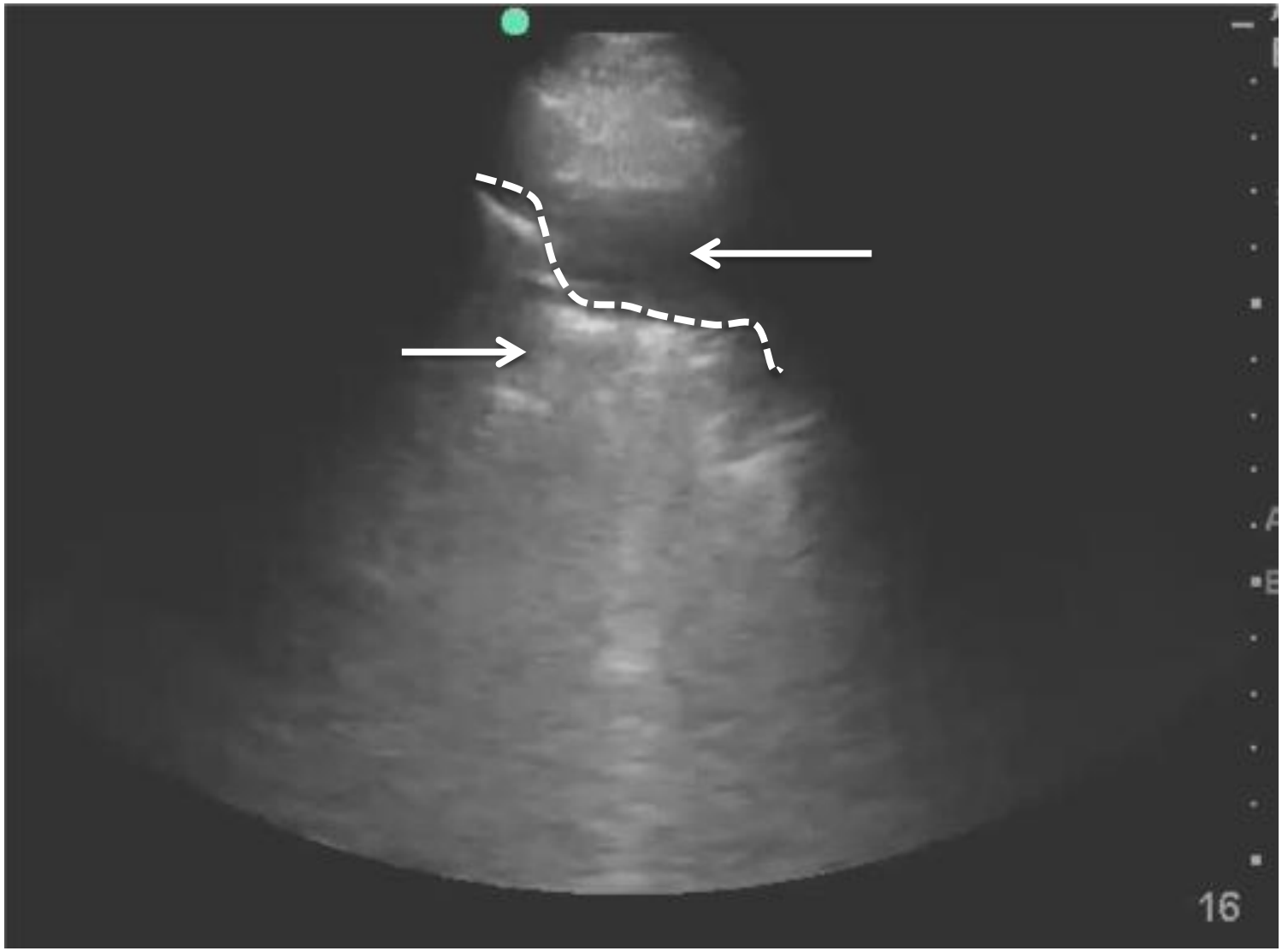




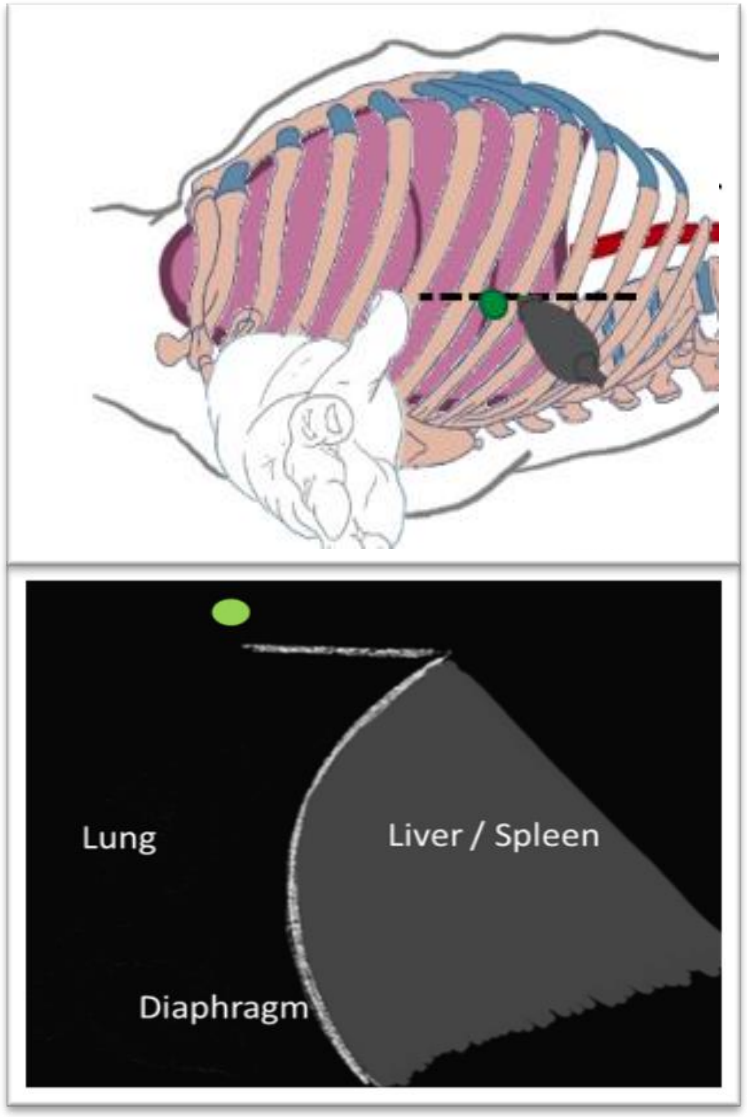
LUNG ULTRASOUND
CONSOLIDATION

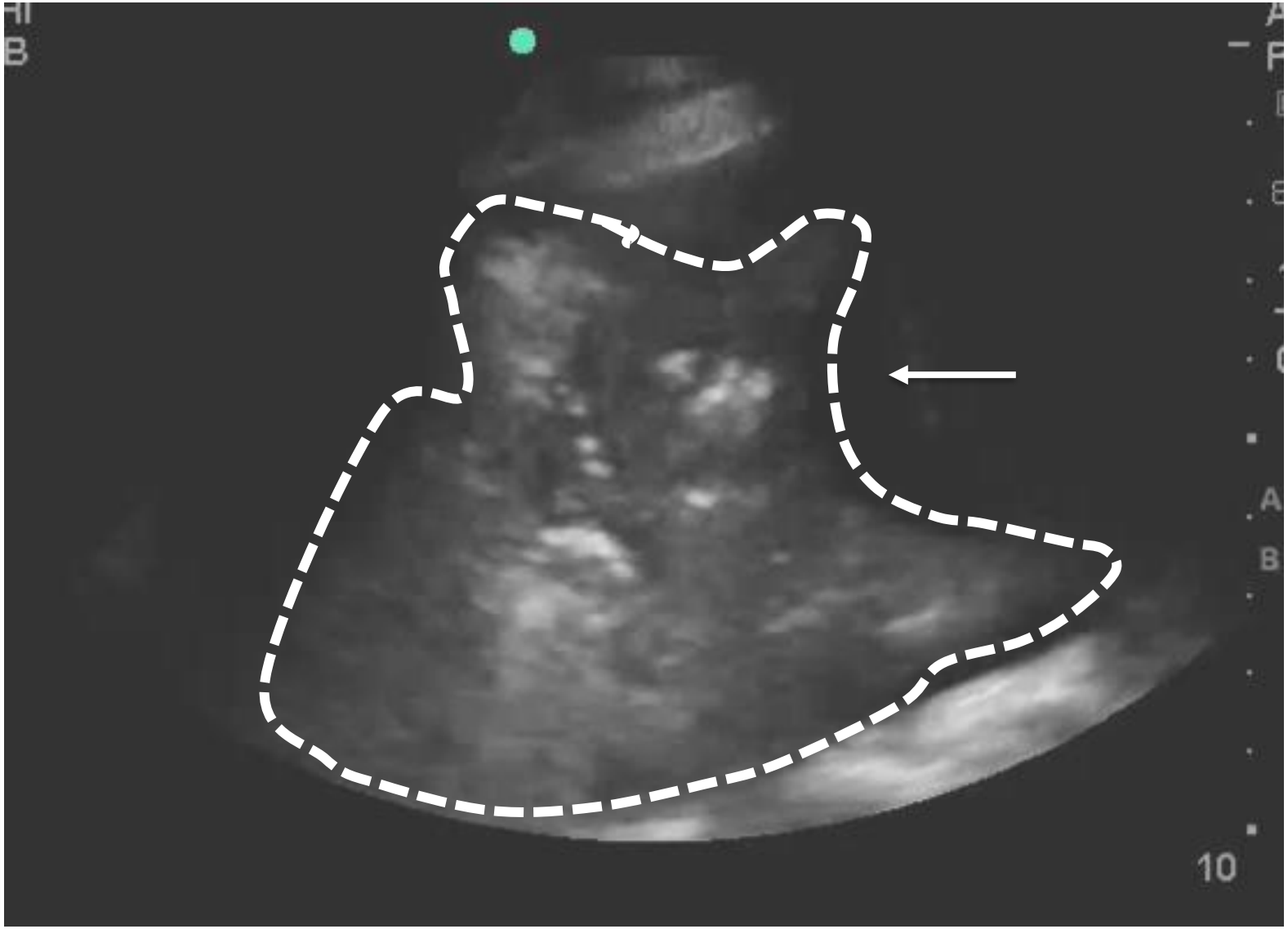




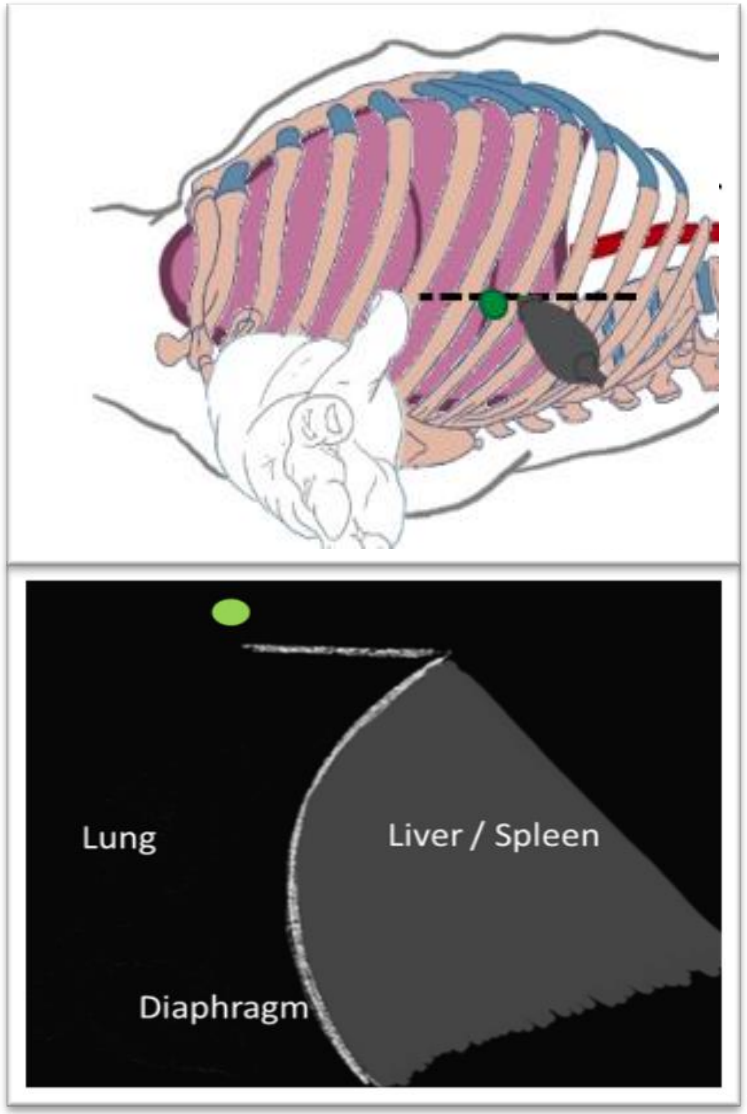


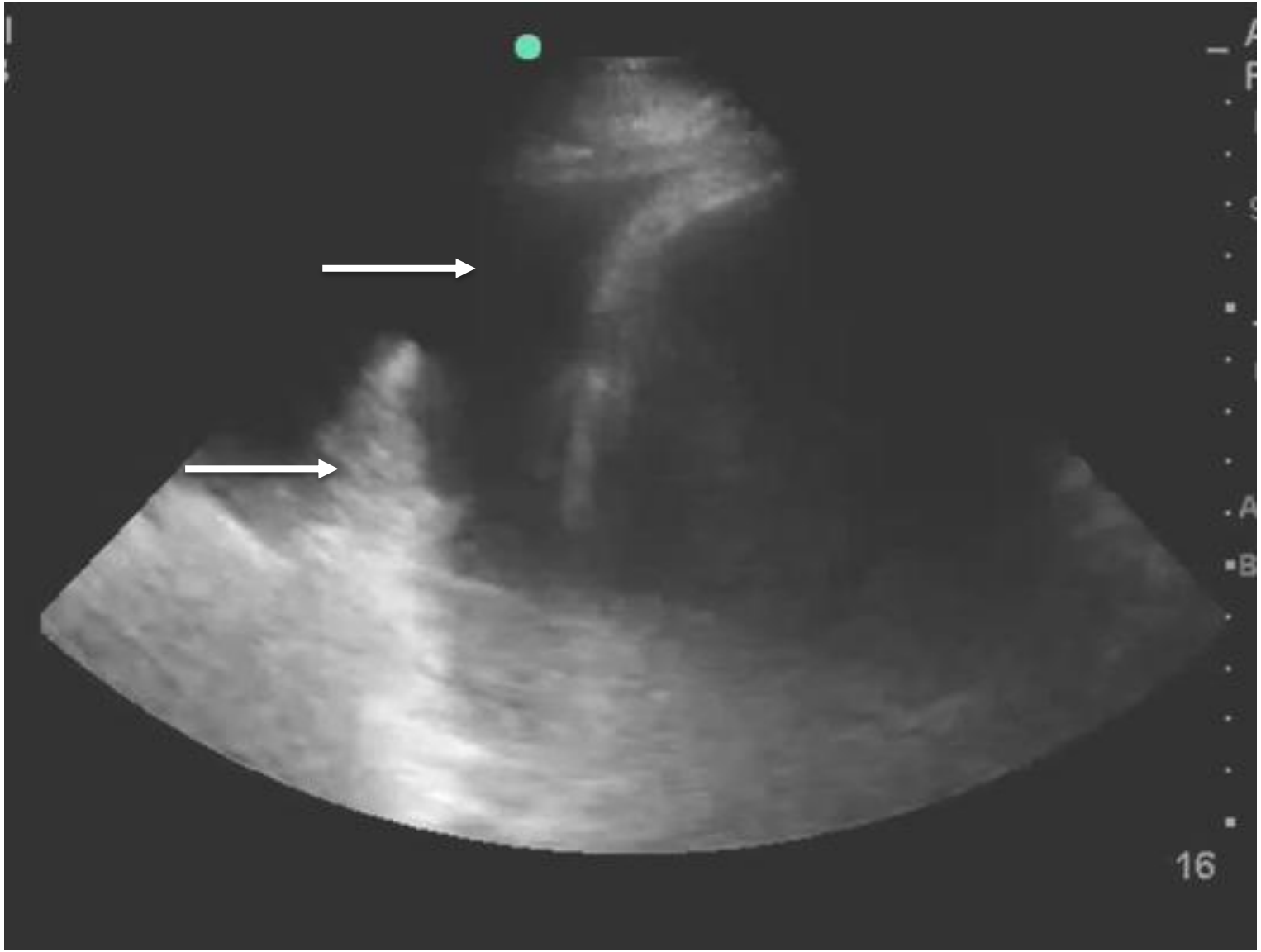
LUNG ULTRASOUND
CONSOLIDATION

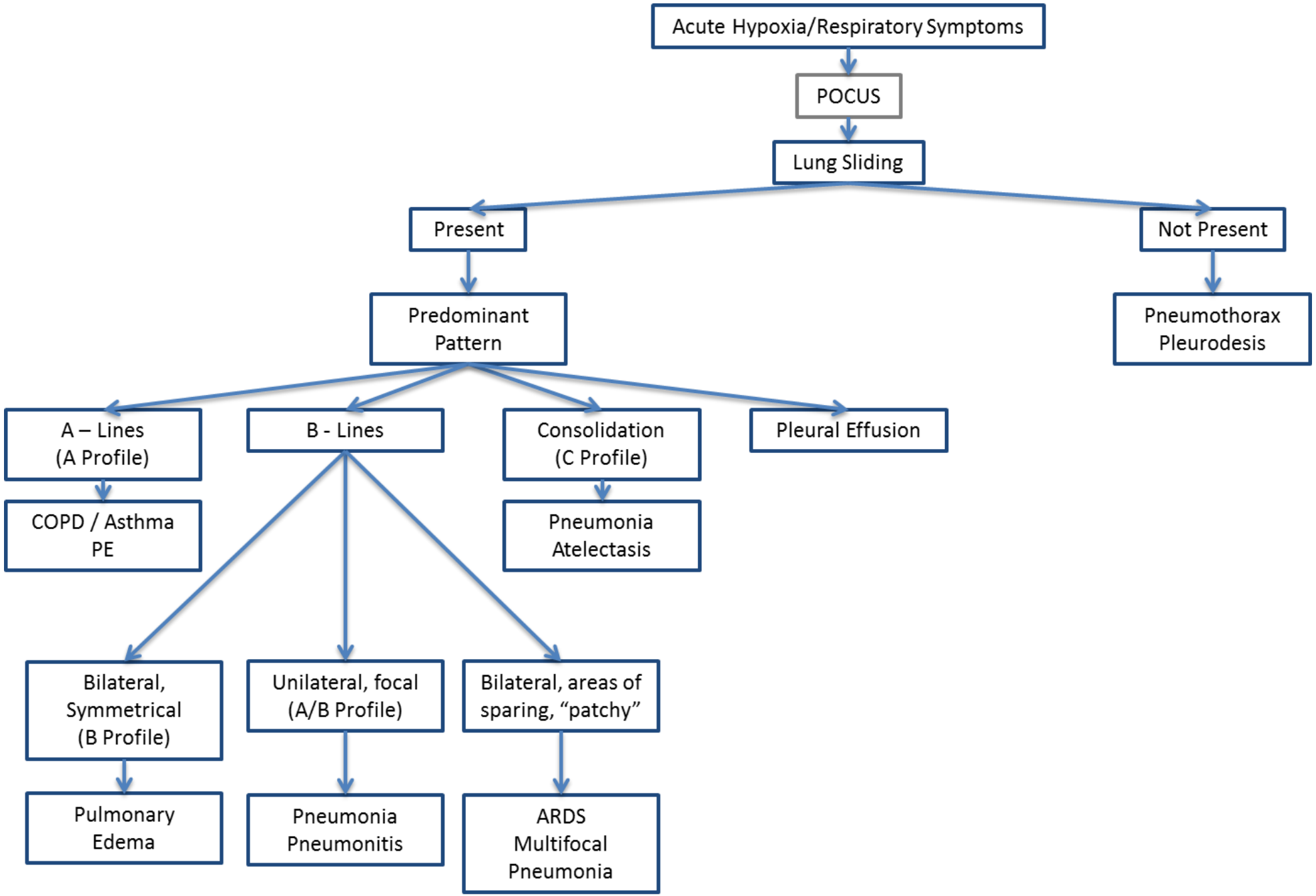




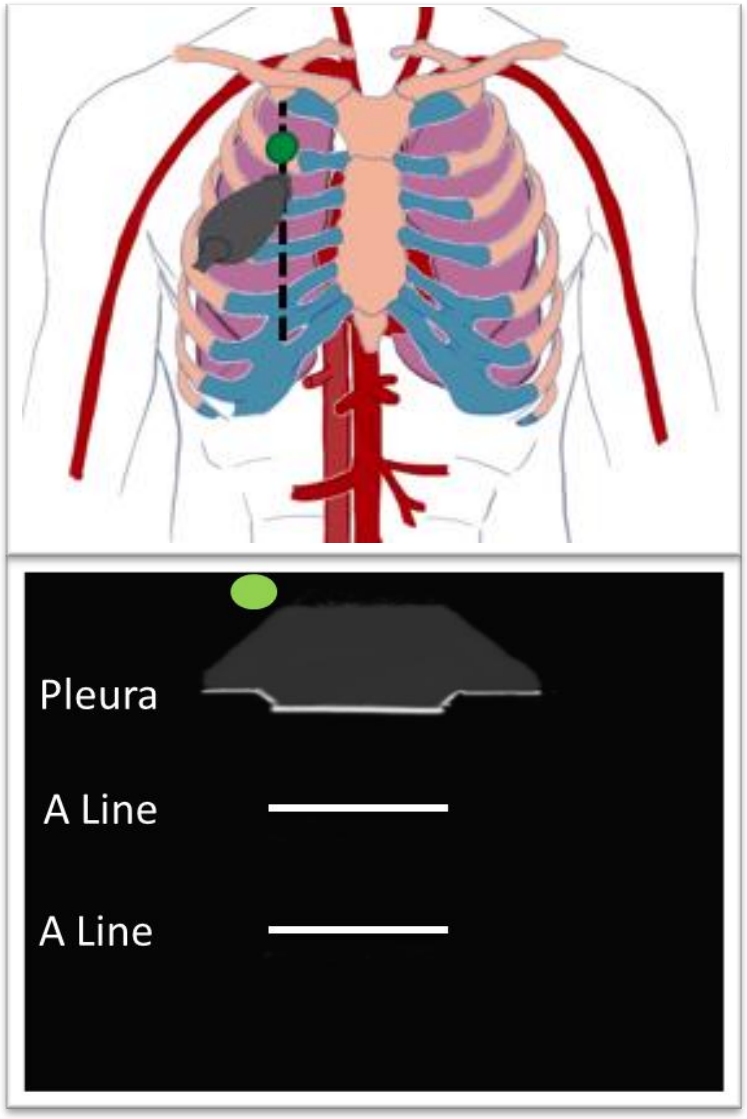
LUNG ULTRASOUND
PLEURAL EFFUSION

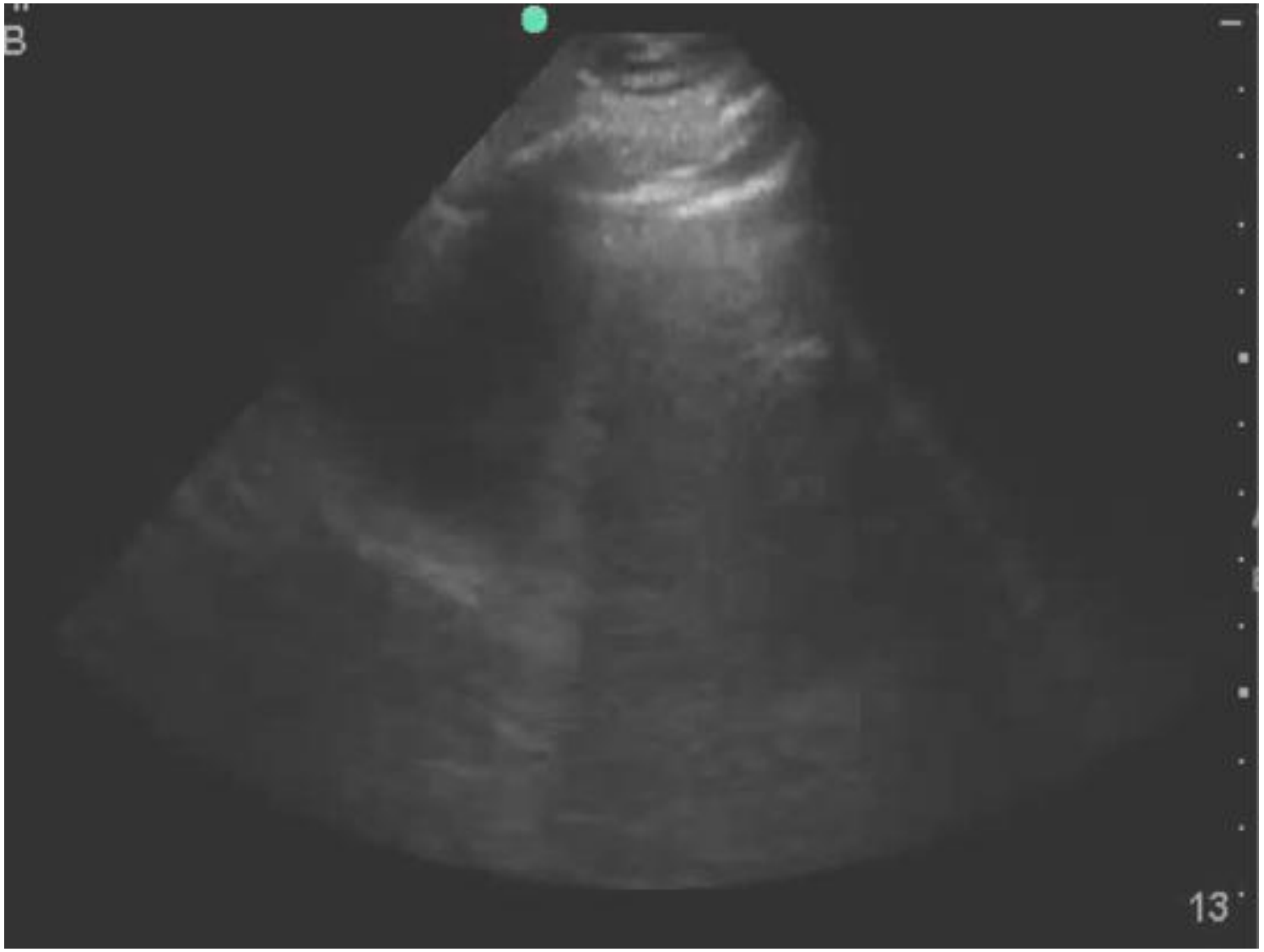




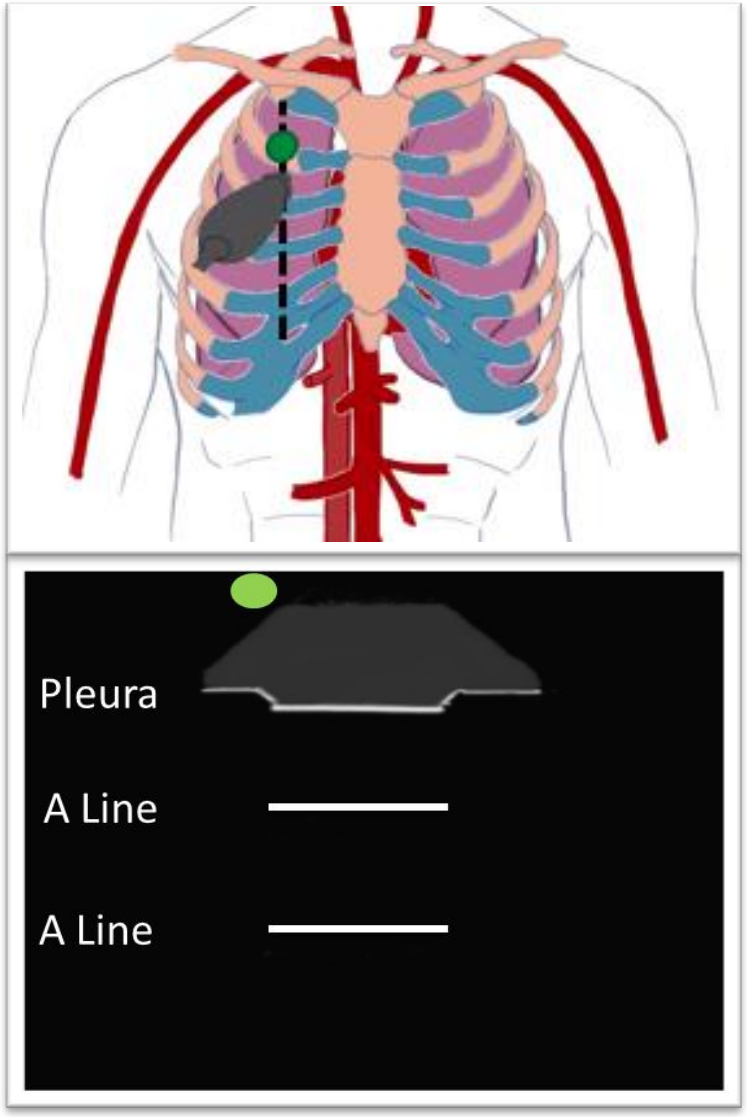


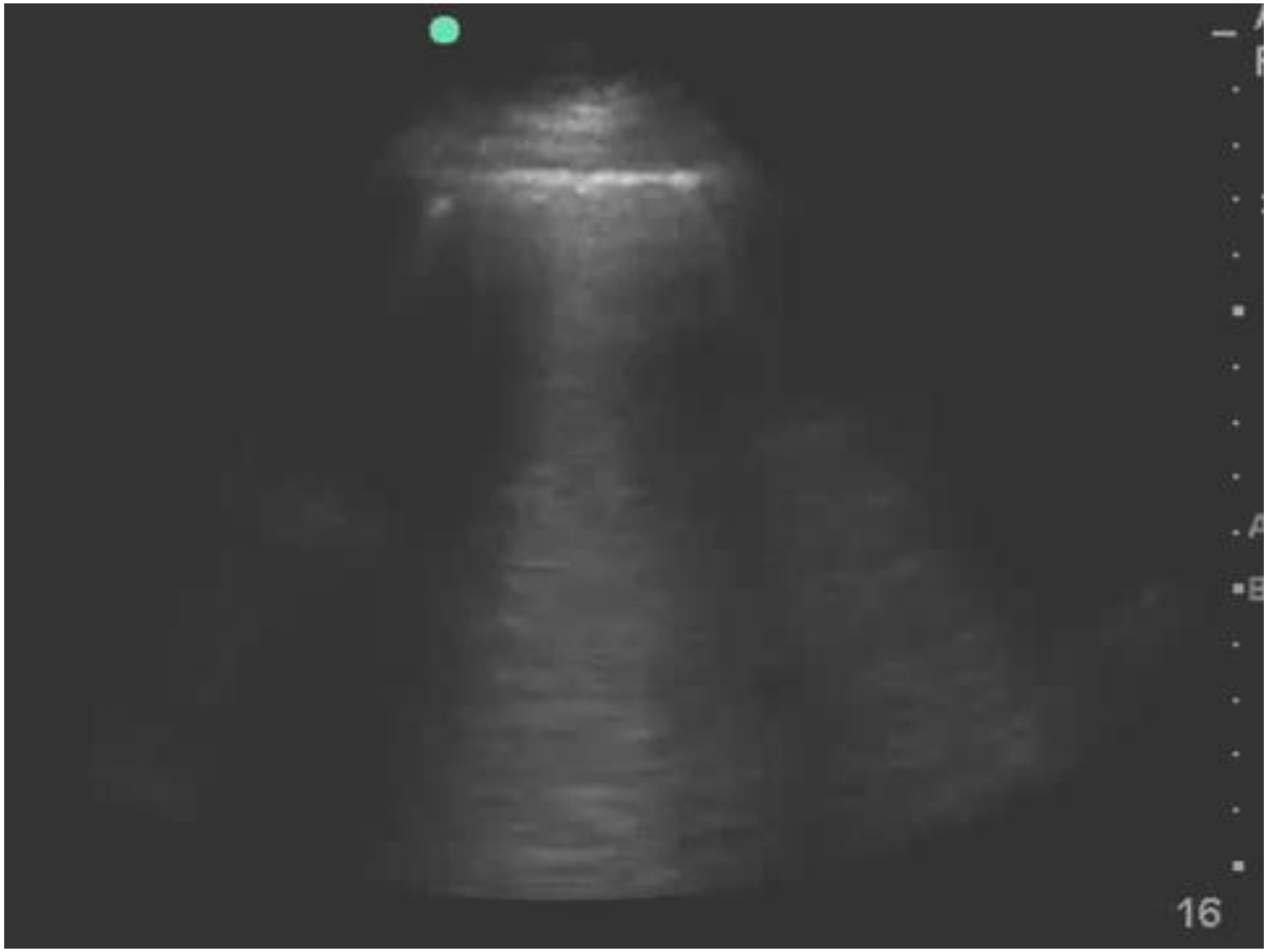
CASE 1
RIGHT APEX



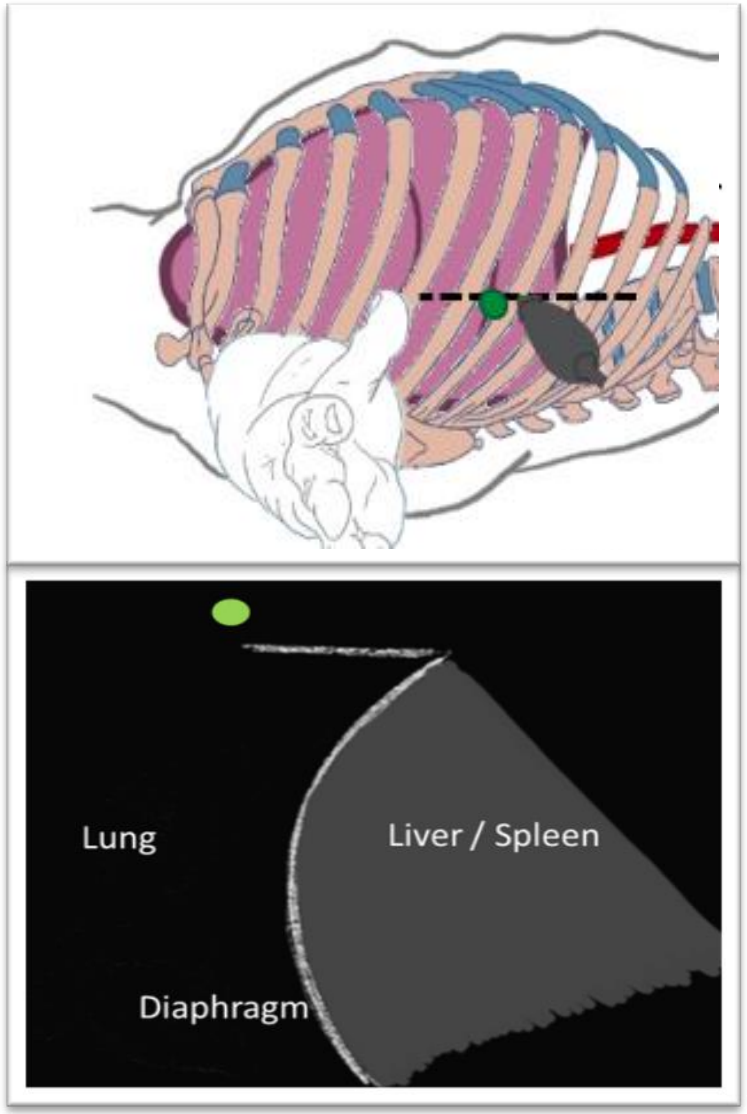


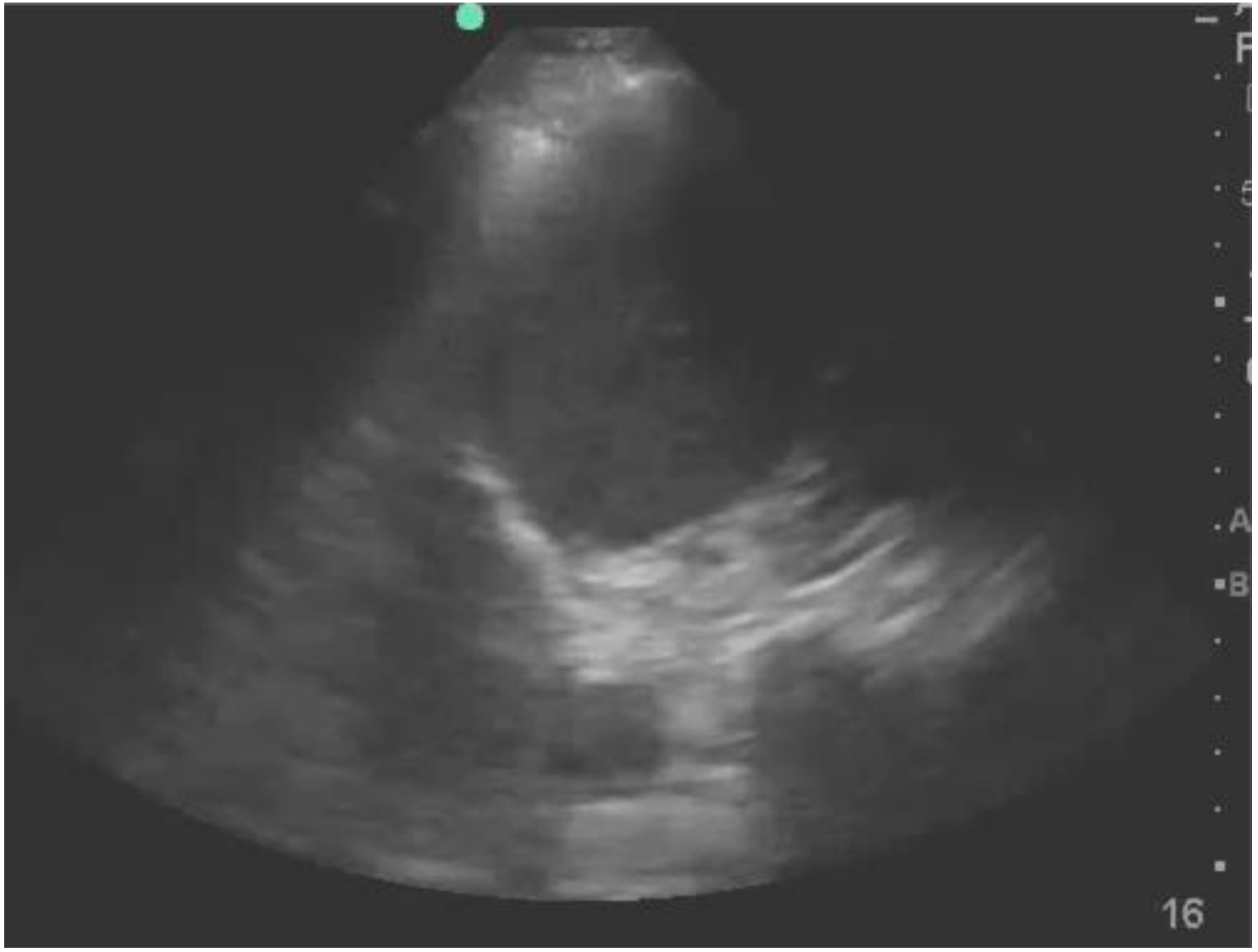
CASE 1
LEFT APEX



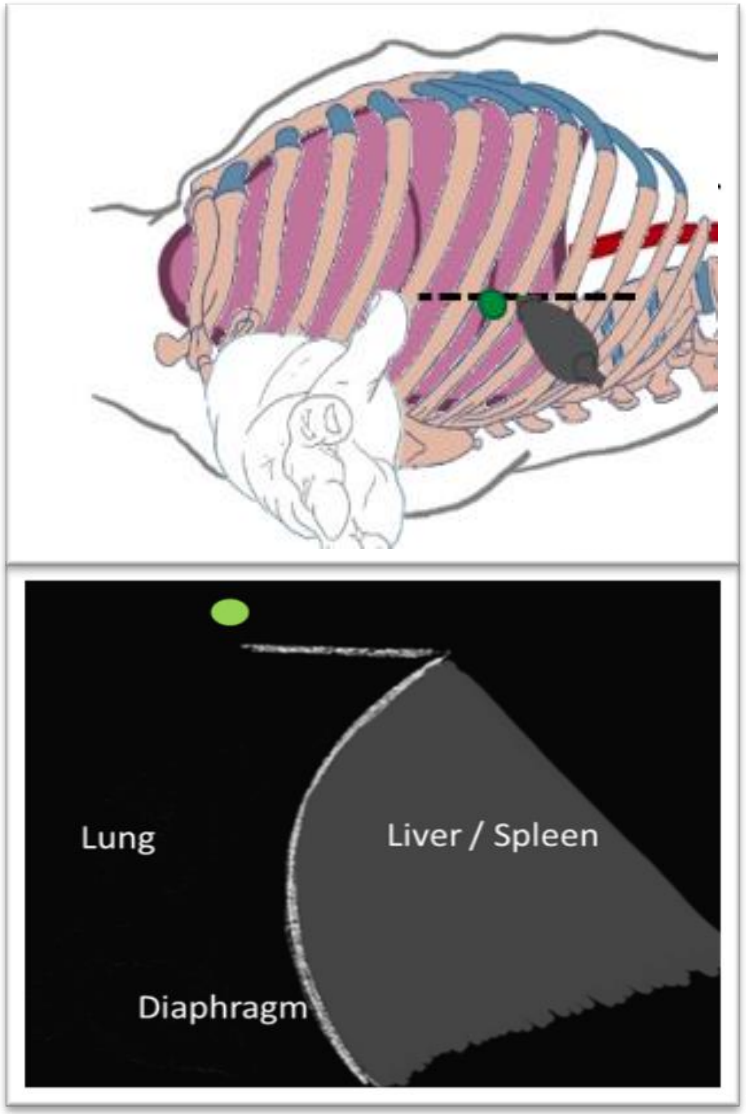


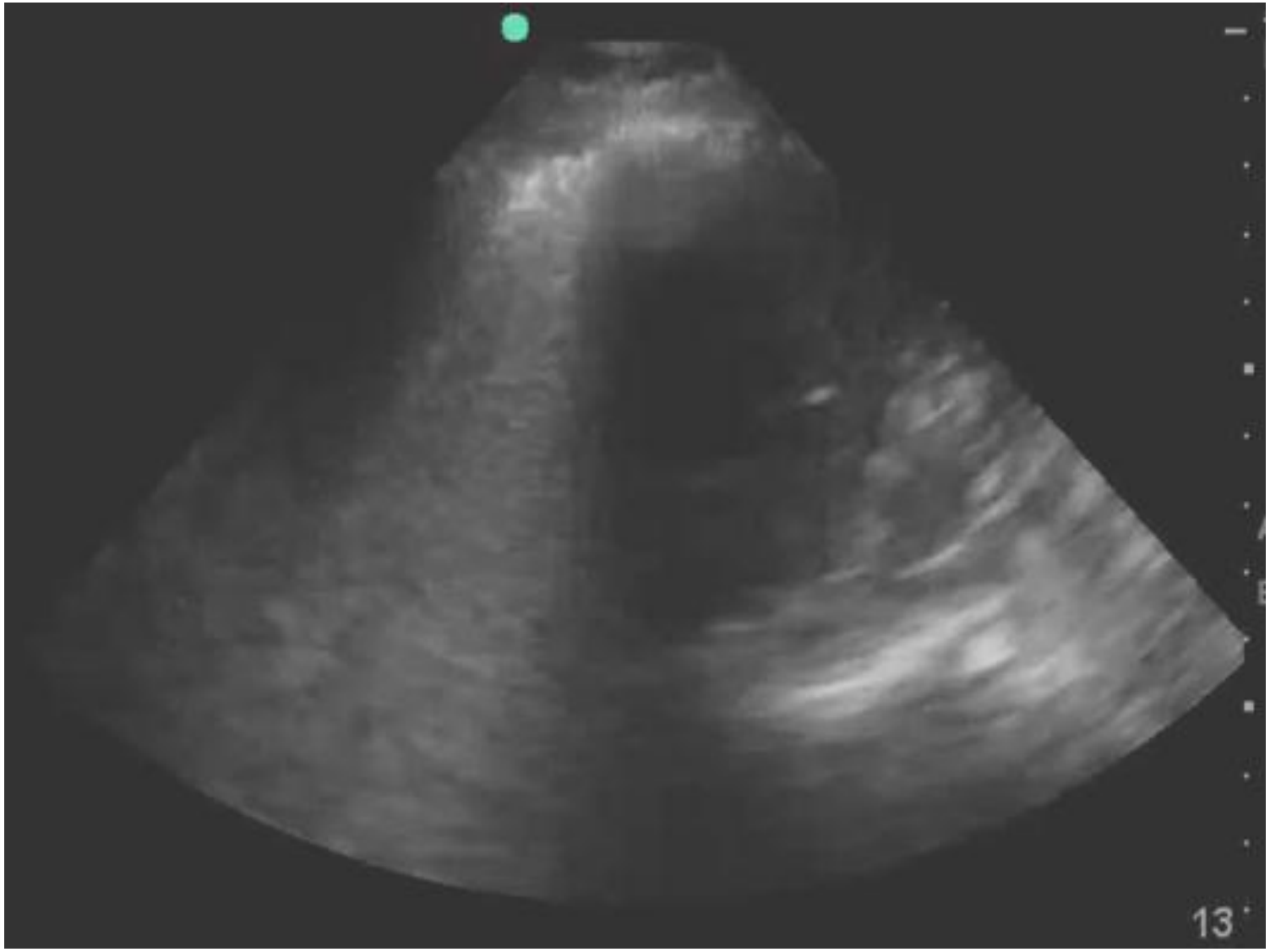
CASE 1
RIGHT BASE

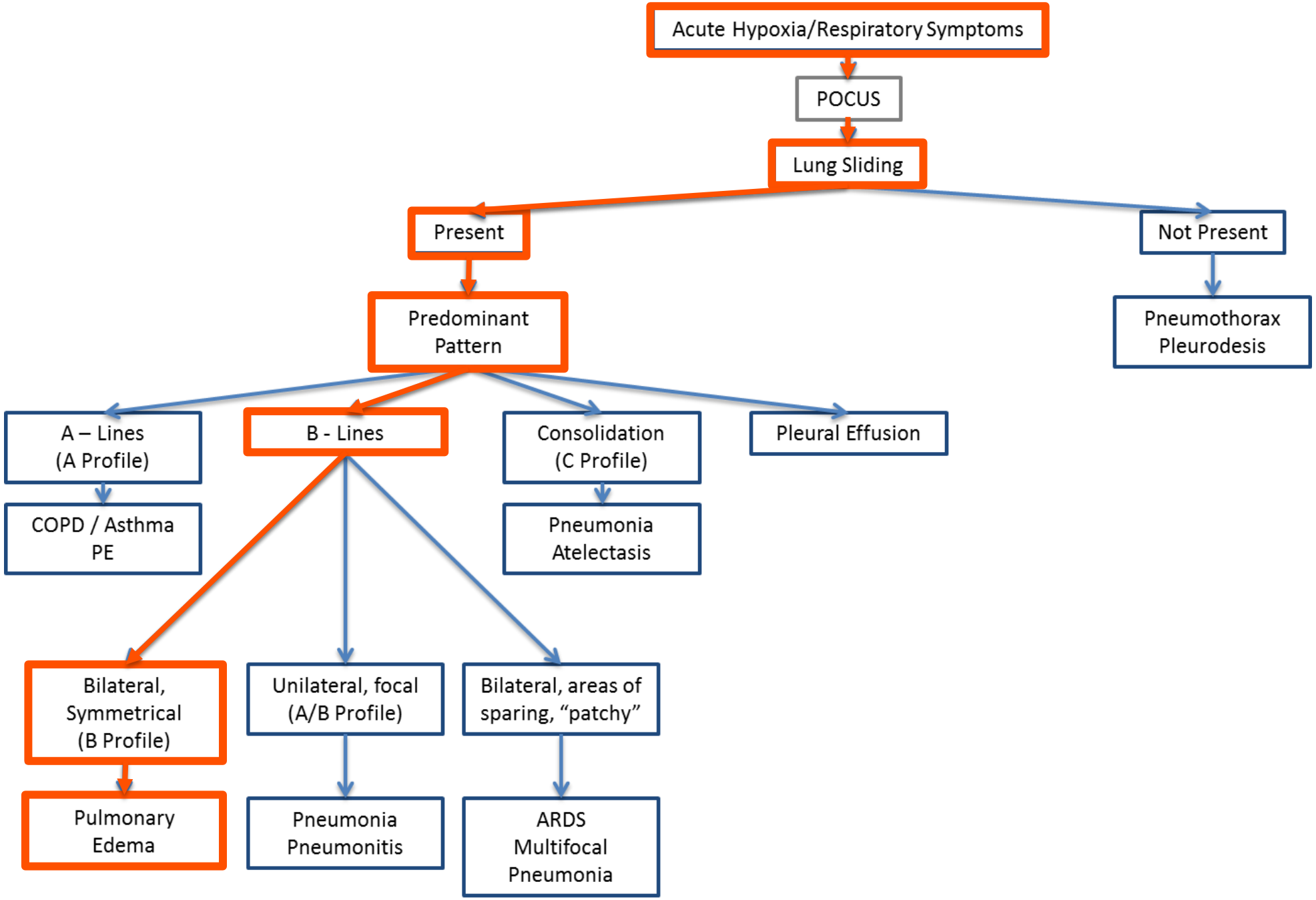




CASE 1
LEFT BASE







CASE 1

- Diagnosed with acute decompensated heart failure with reduced ejection fraction
  - NOT COPD
  - Diuretics started, steroids/antibiotics stopped
  - Echo
  - HFrEF meds started
  - Cardiology follow up

CHF

33.5% of patients with CHF exacerbation presenting to the ED with dyspnea are missed.[1]

"Bedside lung US and echocardiography appear to the most useful test for affirming the presence of AHF."[2]

1. Collins SP, Lindsell CJ, Peacock WF,Eckert DC, Askew J, Storrow AB. Clinical Characteristics of emergency depatrement heart failure patients initially diagnosed as non-heart failure. BMC Emergency Medicine. 2006;6:11. doi:10.1186/1471-227X-6-11.
2. Martindale JL, Wakai A, Collins SP, et al. Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-analysis. Acad Emerg Med. 2016 Mar;23(3):223-42. doi: 10.1111/acem.12878. Epub 2016 Feb 13.

	Chest X-ray		Lung Ultrasound	
	Sensitivity	Specificity	Sensitivity	Specificity
Pulmonary Edema	56.9%	89.2%	85.3 – 94.1%	92%

- Alrajab S, Yousef AM, Akkus N, Caldito G. Pleural ultrasonography versus chest radiography for the diagnosis of pneumothorax: review of theliterature and meta-analysis. Critical Care 2013, 17:R208.
- Martindale JL, Wakai A, Collins SP, et al. Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-analysis. Acad Emerg Med. 2016 Mar;23(3):223-42. doi: 10.1111/acem.12878. Epub 2016 Feb 13.
- Al Deeb M, Barbic S, Featherstone R, Dankoff J, Barbic D. Point-of-Care ultrasonography for the diagnosis of acute cardiogenic pulmonary edema in patients presenting with acute dyspnea: a systematic review and meta-analysis. Acad Emerg Med . 2014 Aug;21(8):843-52. doi: 10.1111/acem.12435

	Chest X-ray		Lung Ultrasound	
	Sensitivity	Specificity	Sensitivity	Specificity
Pulmonary Edema	56.9%	89.2%	85.3 – 94.1%	92%
Pneumonia	38 – 64%	93%	85 – 96%	93 – 96%
Pneumothorax	39.8 – 50.2%	99%	90.9%	99%
Pleural Effusion	51%	91%	94%	98%
COVID-19	51.9%		88.9%	

- Alrajab S, Yousef AM, Akkus N, Caldito G. Pleural ultrasonography versus chest radiography for the diagnosis of pneumothorax: review of theliterature and meta-analysis. Critical Care 2013, 17:R208.
- Martindale JL, Wakai A, Collins SP, et al. Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-analysis. Acad Emerg Med. 2016 Mar;23(3):223-42. doi: 10.1111/acem.12878. Epub 2016 Feb 13.
- Al Deeb M, Barbic S, Featherstone R, Dankoff J, Barbic D. Point-of-Care ultrasonography for the diagnosis of acute cardiogenic pulmonary edema in patients presenting with acute dyspnea: a systematic review and meta-analysis. Acad Emerg Med . 2014 Aug;21(8):843-52. doi: 10.1111/acem.12435

CASE 2

CASE 2

- A 72-year-old female presents to the emergency department for evaluation of right lower extremity redness and swelling.
- She endorses:
  - Generalized malaise
  - Flushing
  - Dyspnea and dyspnea on exertion
  - Bilateral lower extremity swelling, right greater than left.
- Past Medical History:
  - CAD
  - Hypertension
  - Hyperlipidemia
  - Diabetes mellitus type II.
  - HFpEF
- Past Social History:
  - Smoker (50 pack years).
  - Daily alcohol use.

CASE 2

Vital Signs:

- HR 98
- BP 105/52
- SpO2 90%
- RR 24
- T 37.6 Celsius

Exam:

- Mental – A&O x 3. CAM negative
- Heart – Regular rhythm and rate.
- Lungs – CTAB
- Lower extremities –

  2+ pitting edema noted on the left
  3+ pitting edema noted on the right.

  Erythema and tenderness from the right thigh distally to just below the knee.

  No noted fluctuance

DVT POCUS

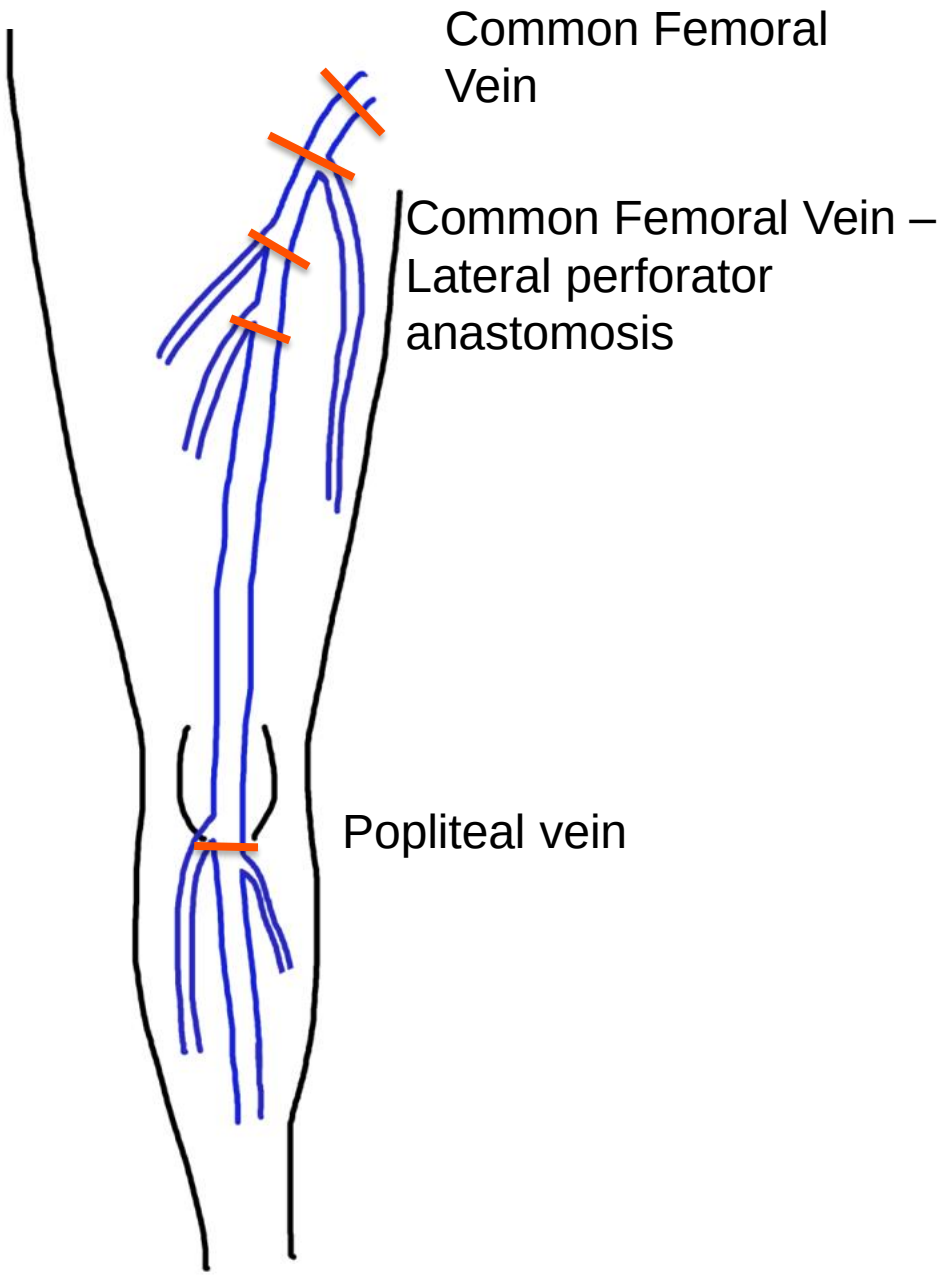
- Scope
  - DVT → Compressive Ultrasonography
- Indications
  - Swelling
  - Redness
  - Pain

DVT POCUS

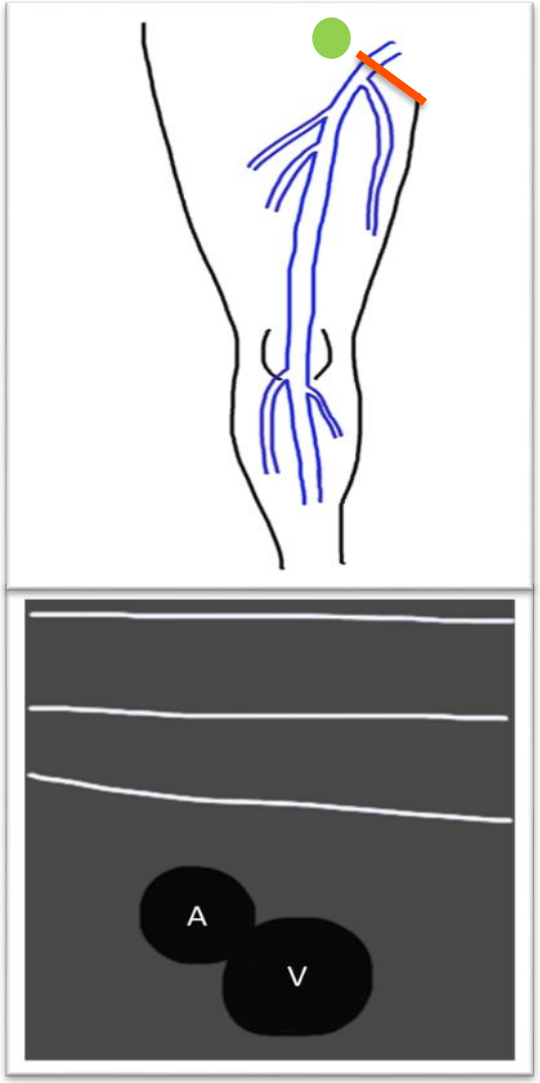
- 5 Point Exam

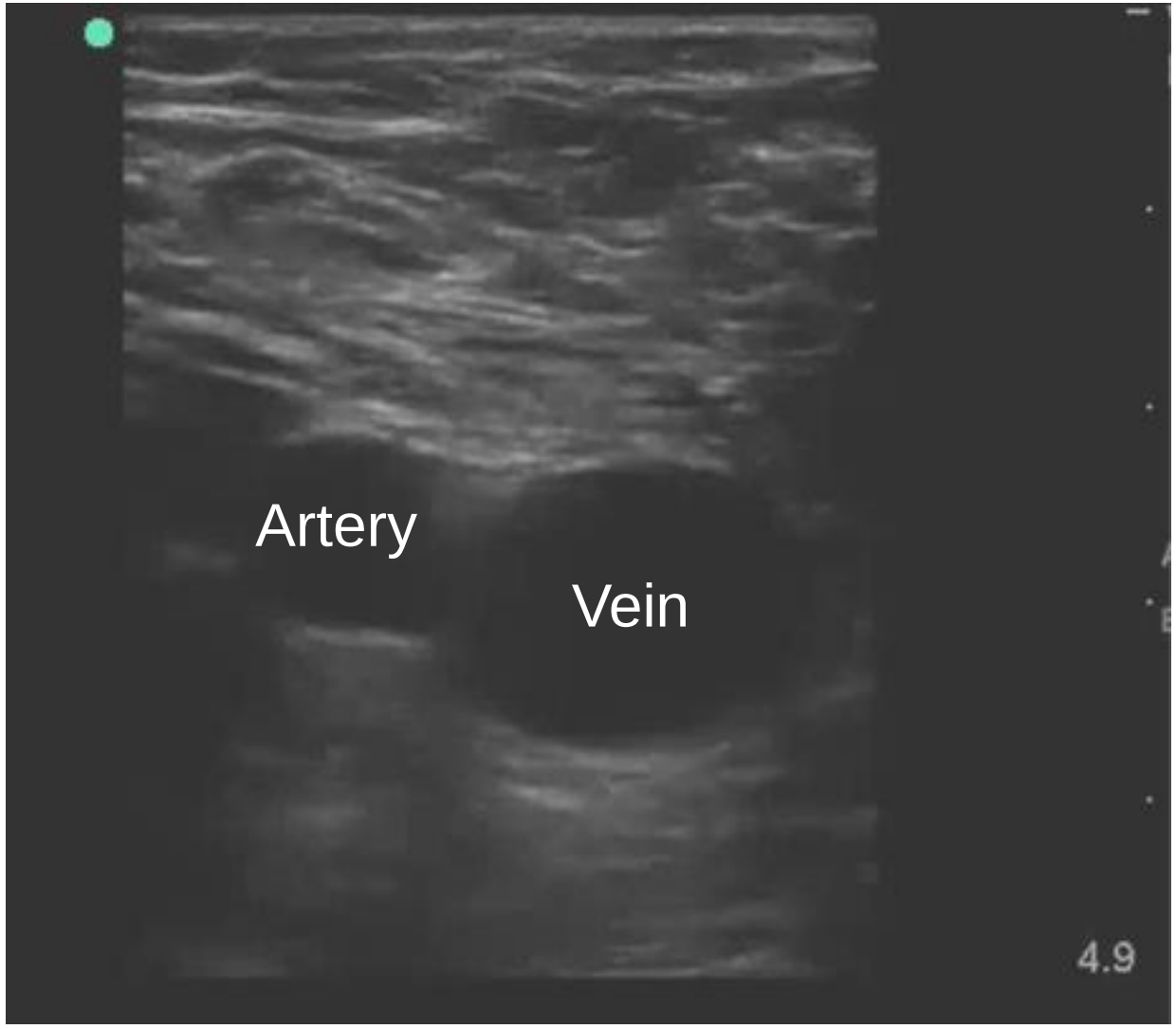
Common Femoral Vein – Greater saphenous vein anastomosis

Bifurcation of the Common Femoral Vein into the superficial and deep femoral veins

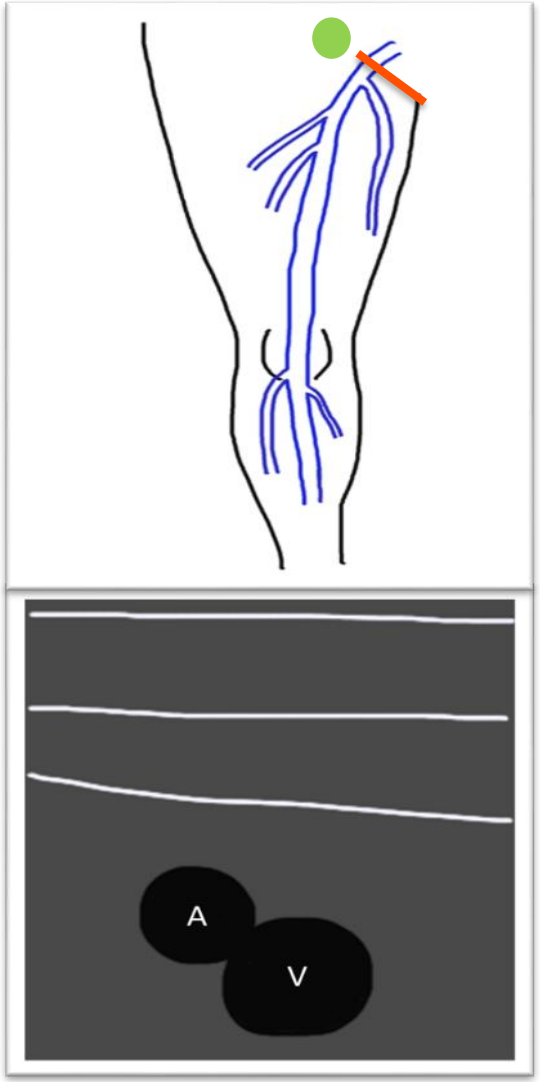


DVT POCUS – NORMAL





DVT POCUS – DVT



DVT POCUS

- DVT
  - Sensitivity: 96.1%
  - Specificity: 96.8%

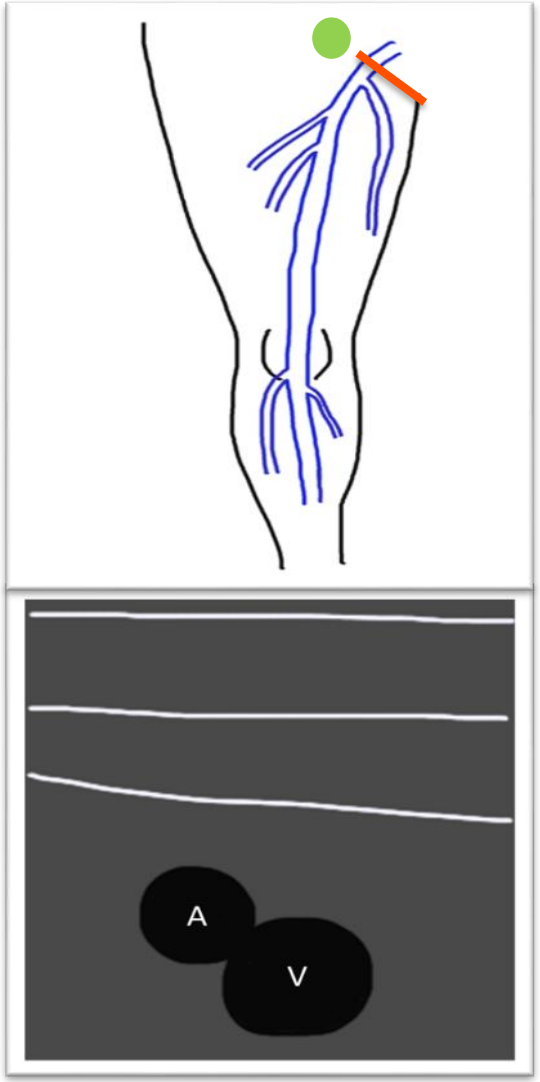
- Multi-organ (Heart, Lung, DVT) POCUS for PE
  - Sensitivity: 90 - 92%
  - Specificity: 64 - 86.2%

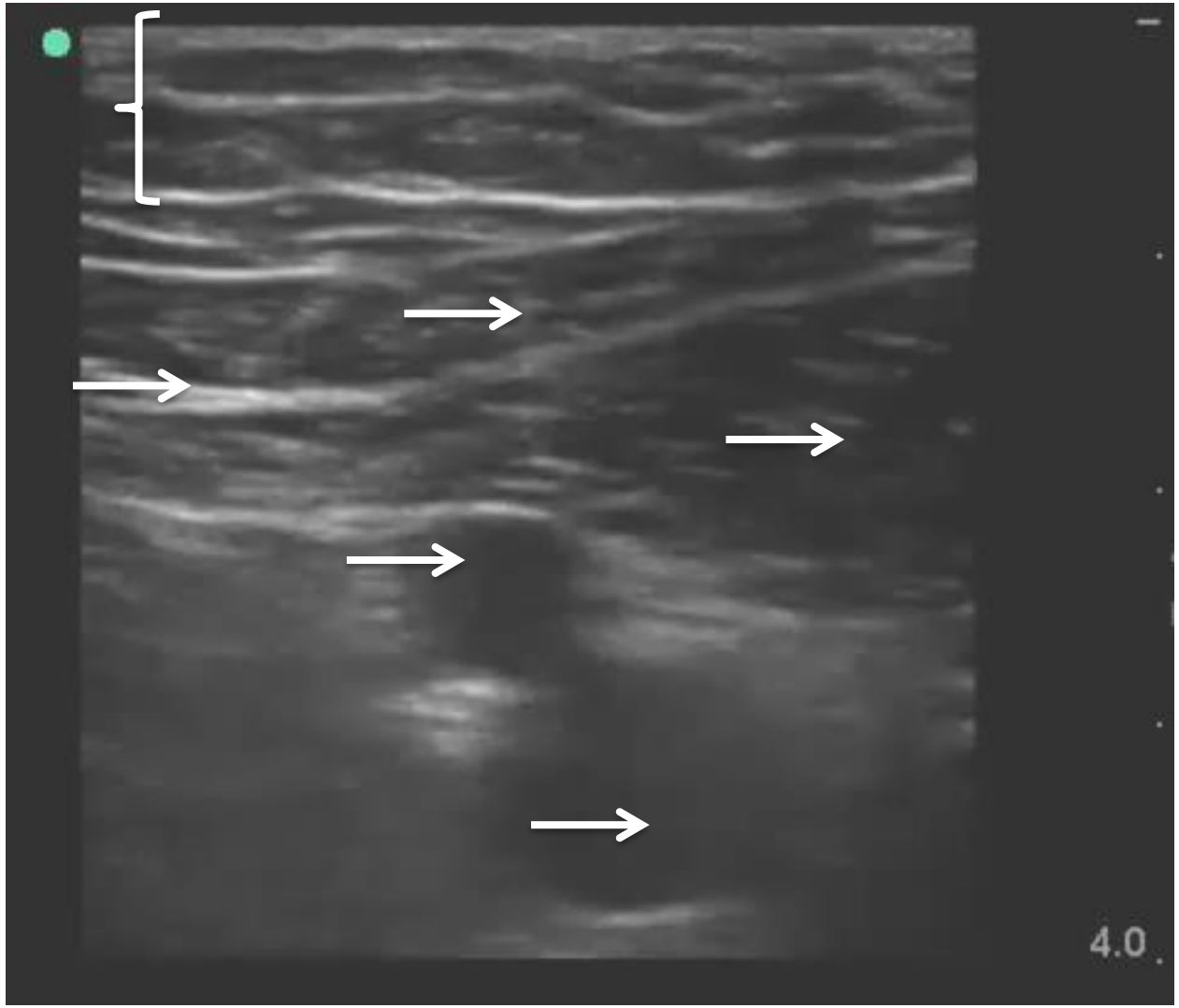
- Pomero F. Dentali F, Borretta V, Bonzini M, Melchio, Douketis, JD, Fenoglio. Accuracy of emergency physician-performed ultrasonography in the diagnosis of deep-vein thrombosis: a systematic review, meta-analysis. Thromb Haemost 2013; 109(01): 137-145.
- Nazerian P, Vanni S, Volpicelli G, et al. Accuracy of point-ofcare multiorgan ultrasonography for the diagnosis of pulmonary embolism. *Chest.* 2014;145(5):950-957.
- Dwyer DJ, Grunwal Z. Increased sensitivity of Focused Cardiac Ultrasound for Pulmonary Emobolism in Emergency Departrment Patients with Abnormal Vital Signs. Academic Emergency Medicine. 2019; 26(11):1211-1220

SOFT TISSUE POCUS

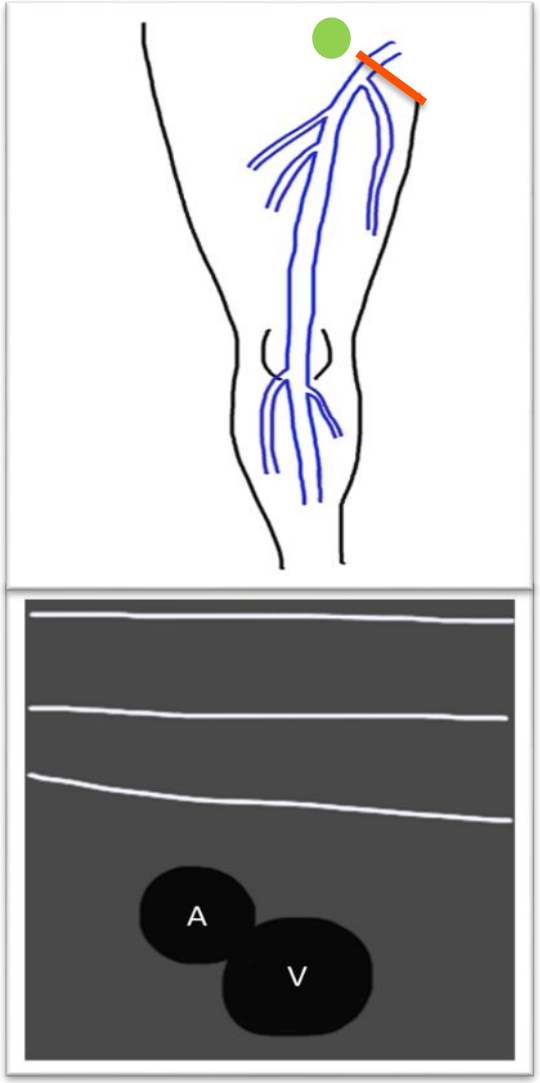
- Scope
  - Skin and Soft Tissue Infection (SSTI)
  - Foreign body identification
- Indications
  - Swelling
  - Redness
  - Pain

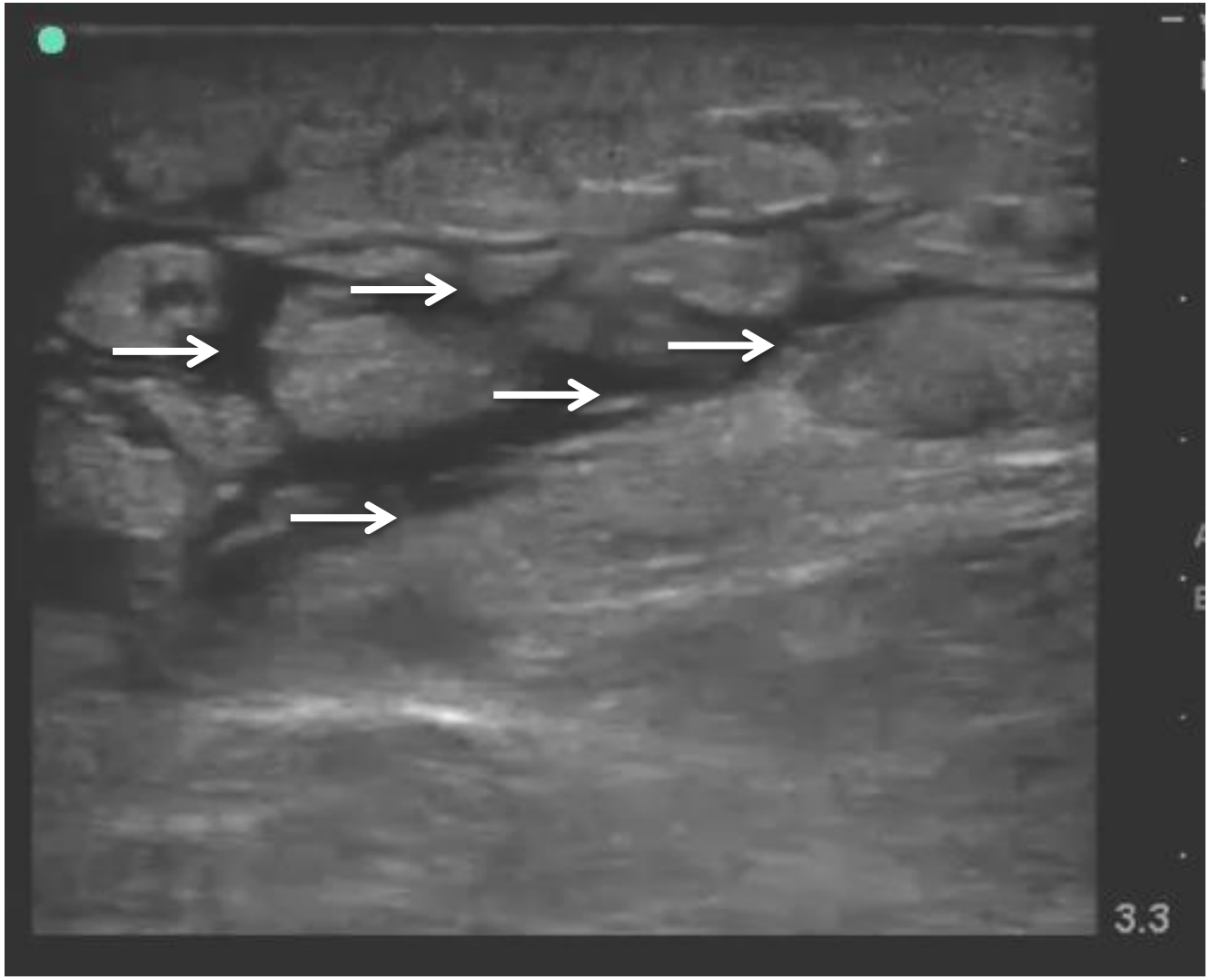
SOFT TISSUE POCUS – NORMAL



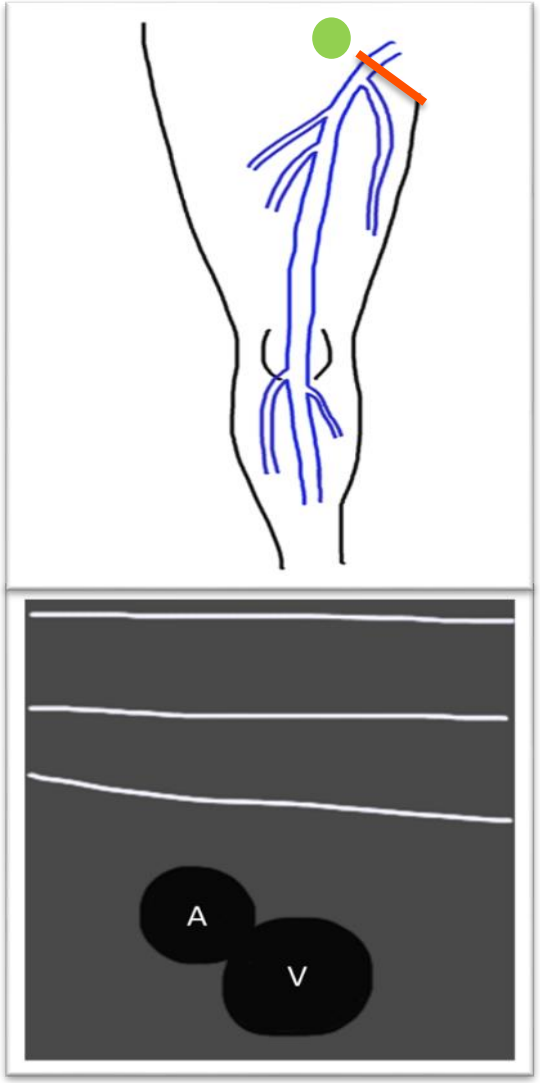


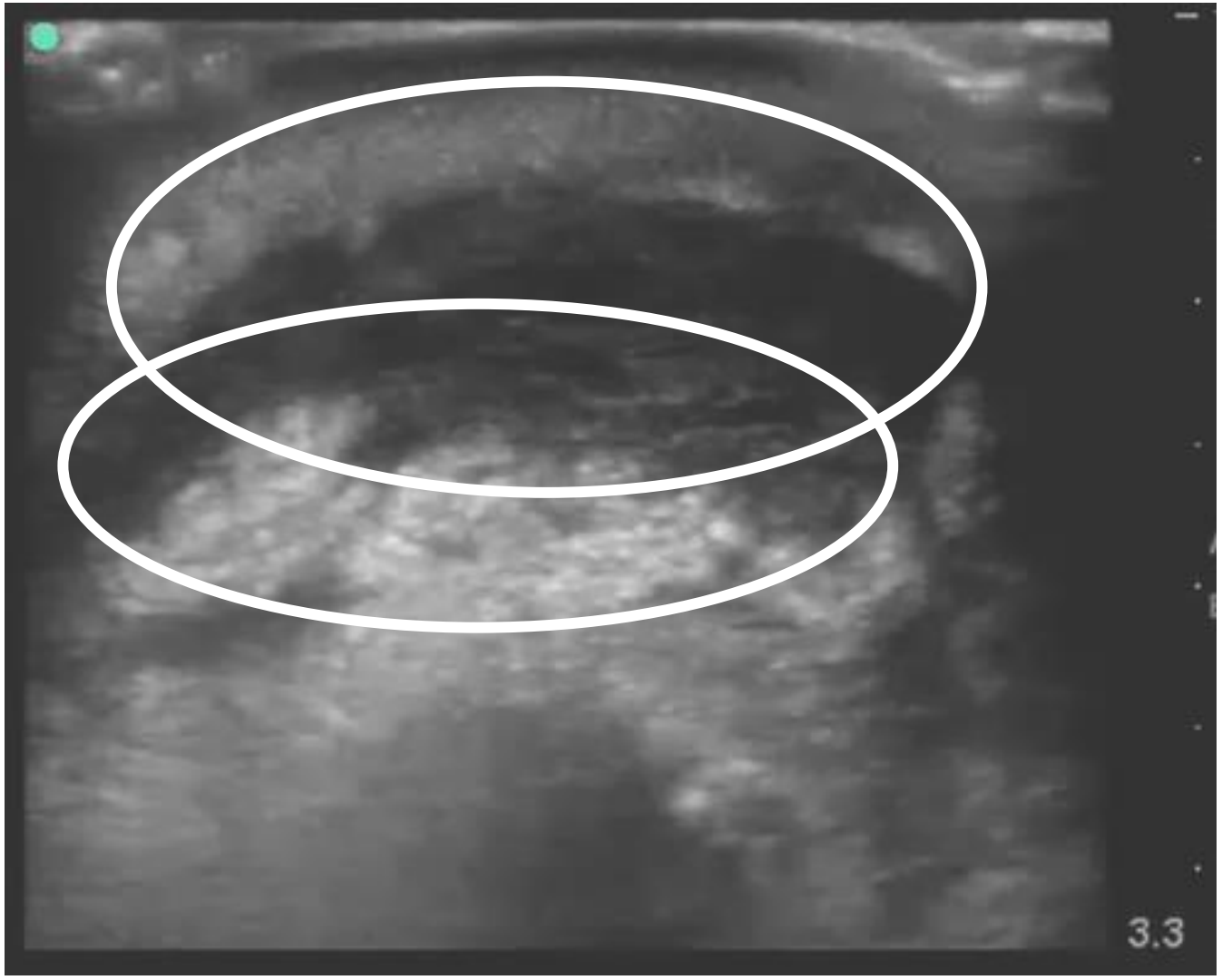
SOFT TISSUE POCUS – COBBLESTONING





SOFT TISSUE POCUS – ABSCESS





SOFT TISSUE POCUS

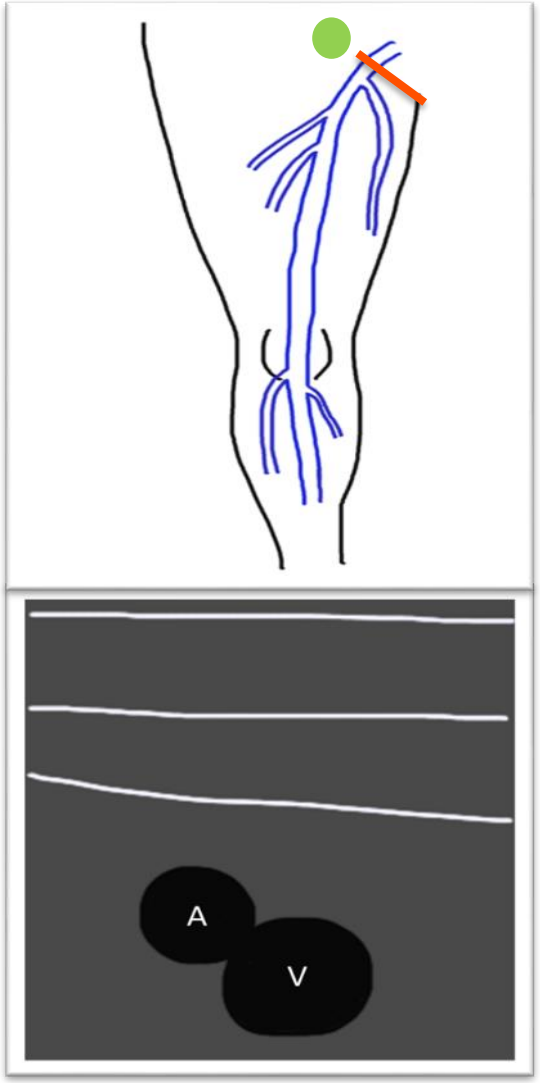
- Cellulitis vs Abscess

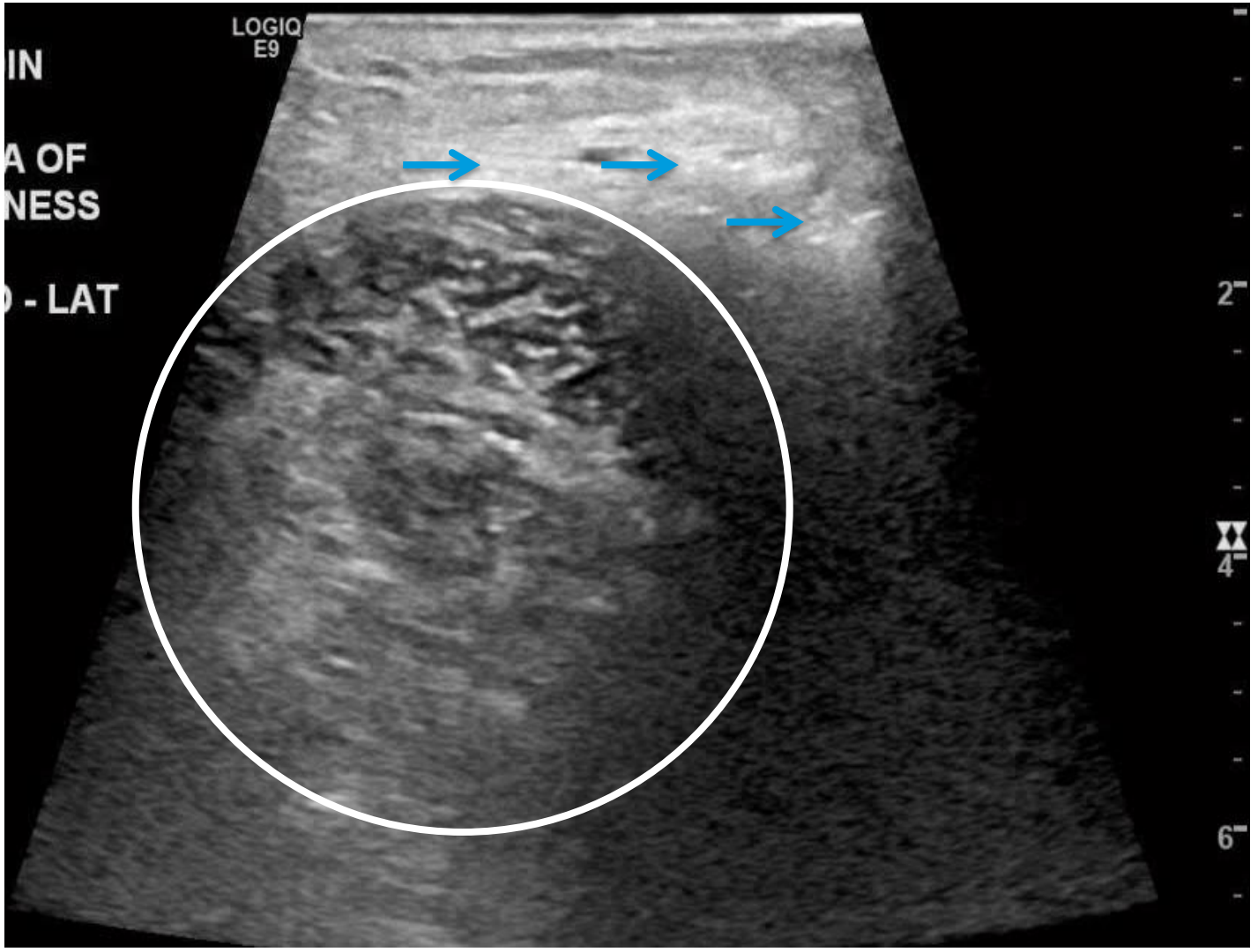
	Sensitivity	Specificity
Physical Exam	75 – 95%	60 – 84%
POCUS	95.5 – 97%	80.3 – 83%

- Changes management (up to 50% of patients)
- Reduces treatment failure rates (17% to 3.7%)
- Shorter ED Length of stay.

- Barbic D, Chenkin J, Cho DD, et al. In patients presenting to the emergency department with skin and soft tissue infections what is the diagnostic accuracy of point-of-care ultrasonography for the diagnosis of abscess compared to the current standard of care? A systematic review and meta-analysis. *BMJ Open*. 2017;7(1):e013688.
- Subramaniam S, Bober J, Chao J, Zehtabchi S. Point-of-care ultrasound for diagnosis of abscess in skin and soft tissue infections. *Acad Emerg Med.* 2016;23(11):1298-1306.
- Tayal VS, Hasan N, Norton HJ, Tomaszewski CA. The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. *Acad Emerg Med*. 2006;13(4):384-388
- Gaspari RJ, Sanseverino A, Gleeson T. Abscess incision and drainage with or without ultrasonography: a randomized controlled trial. *Ann Emerg Med.* 2019;73(1):1-7

CASE 2





CASE 2

CASE 2

Presumptive Diagnosis:
Nec Fasc

CT
Antibiotics
Stat Surgery
Consult

OR

SOFT TISSUE POCUS

- Necrotizing Fasciitis

	Sensitivity	Specificity
POCUS	88.2%	93.3%

  - Caveat
    - Study: Single center (Taiwan), 62 patients, abnormally high rate of nec fasc (27.4% of patients) → limits generalizability.
  - Practical Use:
    - Does not replace standard of care
    - But… if you see air in the soft tissues, think necrotizing fasciitis

- Yen ZS, Wang HP, Ma HM, et al. Ultrasonographic screening of clinically-suspected necrotizing fasciitis. *Acad Emerg Med*. 2002;9(12):1448-1451.

SUMMARY

POCUS USES				
FOCUS	Lung	DVT	Cellulitis	Abscess

SUMMARY

POCUS USES				
FOCUS	Lung	DVT	Cellulitis	Abscess
Aorta	Bladder	Renal	OB	Ocular
SBO	Gallbladder	Appendicitis	Vascular Access	Testicular
AKI	Shock	Volume status	Trauma	MSK
Sepsis	Foreign body	Cardiac arrest	Procedural guidance	Nerve block

POCUS IN CRITICAL ILLNESS

Indiana Convention Center, 120-124
10:30 – 11:30

QUESTIONS AND DISCUSSION

Breunig.Michael@mayo.edu

Heart

Lungs

Soft Tissue

