VOLUME ASSESSMENT & 'FIND THE FLUID' –BY POCUS

Lokesh Yadav, MD
Assistant Professor,
Oregon Health & Science University

OHSU Health

No disclosures

Objectives:

- Review physical exam signs of volume overload
- Learn POCUS evidence for use in volume assessment
- Learn use of POCUS to find fluid in the body

VOLUME STATUS BY PHYSICAL EXAM

- JVP inspection
- Peripheral edema
- Auscultation
- Vitals including orthostatic
- Capillary refill time
- Skin turgor

Jugular venous pulse by inspection

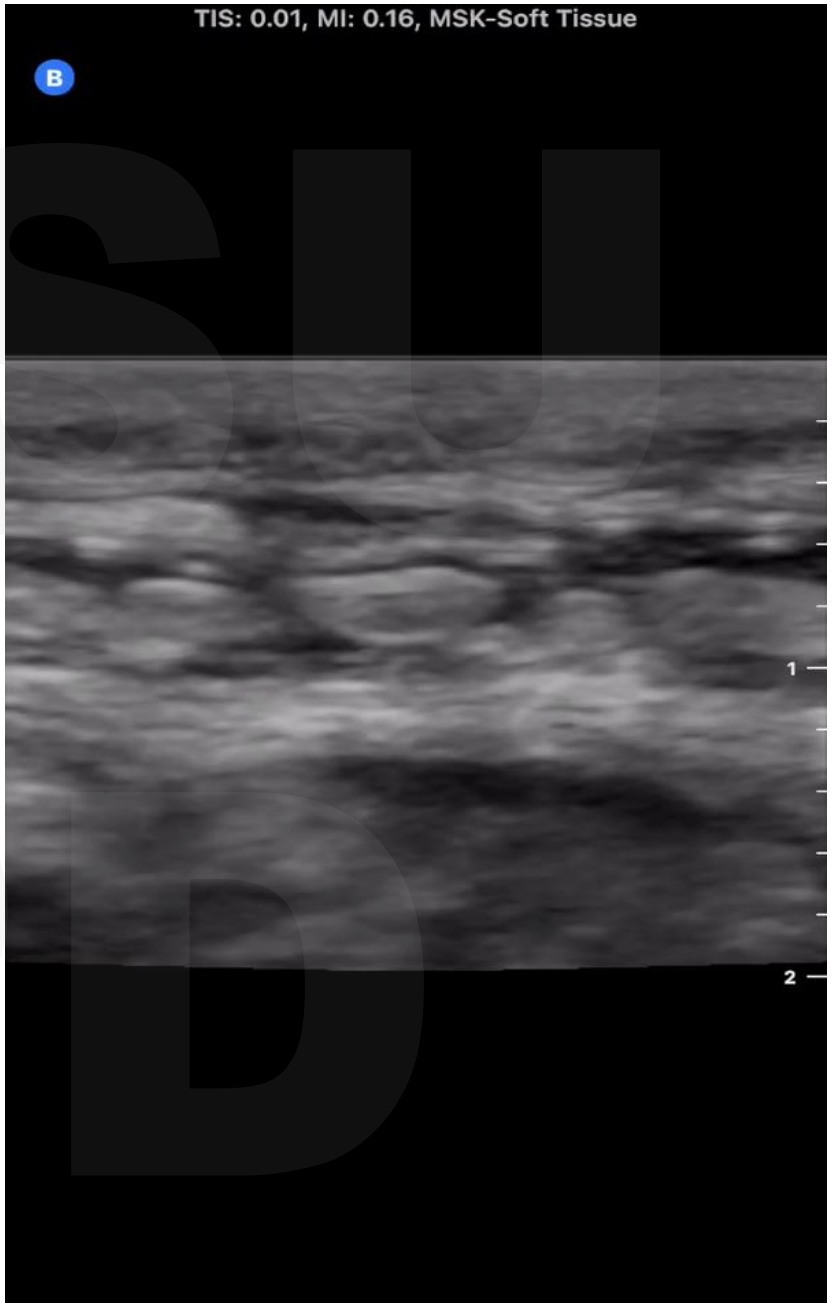
- **JVP: 10-80% failure to visualize accurately**
  - Factors: inexperience, high grade obesity, wide neck, EJ mistaken, Afib, TR
- **JVP measurement > 8 cm H2O**
  - Sensitivity 47-92%, specificity 93-96%, positive LR of 9.7 for an elevated central venous pressure (CVP).

JVP

- **JVP < 5 cm H2O**
  - 90% sensitivity, 89% specificity, and positive likelihood ratio (LR) of 8.4 for a low CVP
- **Hepatojugular reflux**
  - LR of 8 for an elevated CVP if positive

Edema

- High capillary hydrostatic pressure (**CHF**)
- low oncotic pressure (**hypoalbuminemia**),
- high interstitial hydrostatic pressure (**lymphatic obstruction**)
- high capillary permeability (**cellulitis**)



- *Study on patients with ESRD:*

pedal edema correlated with age, body mass index, and left ventricular mass, but *did not reflect intravascular volume status*.

CHEST

- 20% congested patients -> normal radiograph.

CHEST

- **Lung crackles + peripheral edema + elevated JVP -> sensitivity 58% to detect elevated pulmonary capillary wedge pressure**

Leopold Auenbrugger, who first described diagnostic percussion in 1761, was inspired by observing his father, an innkeeper who percussed wine barrels.

Auscultation

- Sensitivity is 51% (43-60%)
- Specificity is 79 % (73-84)
- Diagnostic accuracy is 69% (64-74%)

  ->For detection of alveolar-pulmonary edema (crackles).

What is POCUS?

Scan performed & interpreted by same clinician:

- At bedside
- To answer a focused or binary question

VOLUME BY POCUS

Basic - IVC, IJ, Lungs

Intermediate - focused Cardiac

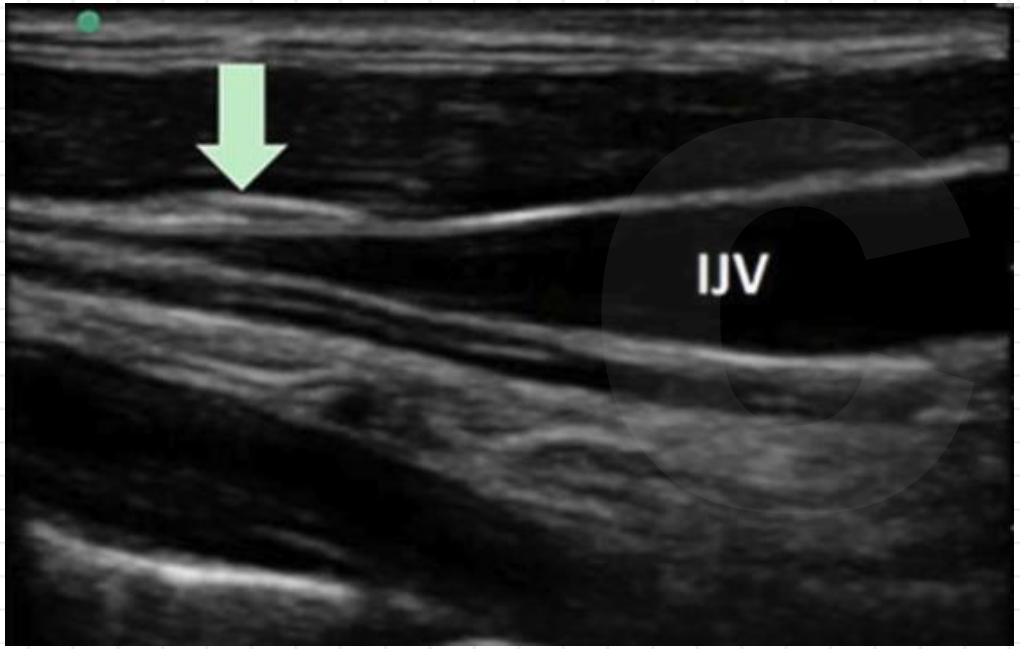
Advanced – VExUS

Why POCUS?

- Non-invasiveness
- Wide availability
- Low cost
- Relative ease of use
- Repeatability
- Safety

Internal Jugular vein

IJ is visualized and the 'point of narrowing'/meniscus is noted.
Vertical height from sternal angle is measured.
5cm is added to report CVP in cm of water.



Other measurements:

Diameter (small study - 7 mm correlated w a CVP <10 mmHg, 12.5 mm w CVP >10 mmHg)

Cardiac US (PLAX view) to estimate RA to sternal notch distance (Istrail et al.)

Inferior vena cava (IVC)

- 85% of plasma volume in venous circuit-> 2/3 in IVC
- Measurements: maximum diameter + decrease with sniff

IVC

American and European guidelines,

- Diameter ≤2.1 cm, >50% inspiratory collapse -> RAP 0–5 mm Hg
- Diameter >2.1 cm, <50% inspiratory collapse -> RAP 10–20
- If one of the above, RAP 8 mmHg (mean)

Other considerations

- Lateral diameter
- Round vs oval shape

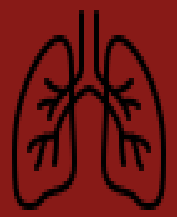
PITFALLS

- Severe dyspnea -> unable to 'sniff', lateral movement (off axis)
- Inspiratory collapse can be craniocaudal and/or mediolateral
- Increased intra-abdominal pressure (pregnancy).

OTHER CONSIDERATIONS

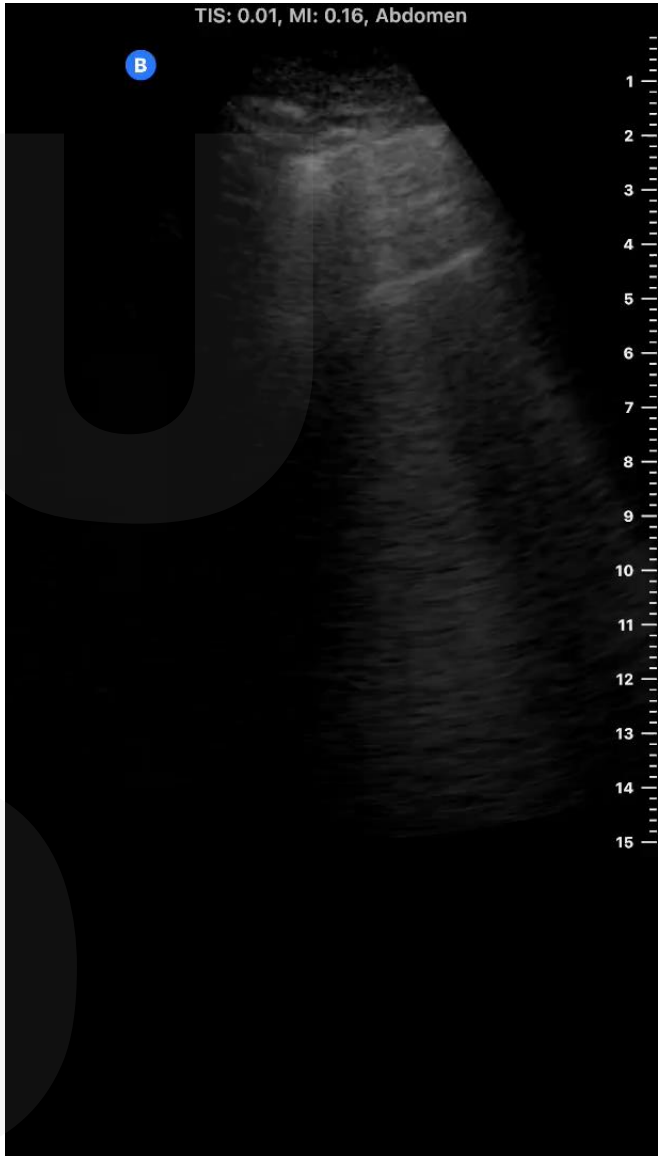
- Chronically dilated IVC (young athletes)
- Direct vasoplegic effect of drugs or sepsis
- Severe TR, RV failure, pulm HTN
- IVC thrombosis/stenosis/filters

Lung Ultrasound (LUS)



B-lines and effusions-> interstitial-alveolar syndrome or lung water

IVC + lung US has been proposed to estimate dry weight in hemodialysis patients



Focused Cardiac Ultrasound (FoCUS)

- Access **LVEF, chamber sizes, pericardial effusion** (and IVC)
- Low LV internal diameter at end-diastole -> hypovolemia (Lang et al.)

- RV/LV ratio -> RV pressure and volume overload
- Volume Responsiveness - Increase in stroke volume by >15% after 500 cc of fluid challenge. Needs doppler.

Data

- Integrated **cardiopulmonary ultrasound** (cardiac contractility + IVC assessment + lung US) -> diagnosis of pulmonary edema (17 vs 104 min)

  Wang et al, Integrated Cardiopulmonary Sonography

- High '**B-line score**' at discharge -> higher 30-day **rehospitalization** w acute HF. Not IVC, discharge weight or NT-Pro-BNP

  Prospective observational study, Martins et al. J Clin Med (2005) PMID 4072557

Data continued…

- **Increased in-hospital mortality if** >19 B-lines in 8 zone exam. (PMID: 33151302)

- **IVC collapsibility**, but not pedal edema or lung crackles, has shown to predict **readmission or ED visit** after discharge in patients hospitalized for **acute decompensated HF**. Scans done by IM residents. Study by Laffin et al.

Accuracy of lung ultrasound

Diagnosis	US Sensitivity (%)	US Specificity (%)	CXR sensitivity (%)	CXR specificity (%)
Pulmonary edema (≥3 B-lines in two bilateral lung zones)	94.1	92.4	56-73	69-90
Pleural effusion (anechoic fluid above diaphragm)	94	98	Supine: 39-65 Erect: 82	Supine: 76-89 Erect: 81

Gold standard: CT, data based on meta analysis of cohort studies

VExUS – Venous Excess Ultrasound

- Marker of systemic venous congestion.
- Dilated IVC + doppler flow alterations in **hepatic, portal, intra-renal veins**
- Elevated RAP + cardio-renal complications

Final words

POCUS is superior to clinical exam but not perfect.

Perform **'multiorgan assessment'** w POCUS

Integrate POCUS w **clinical and laboratory data**

Re-access w POCUS after intervention.

Consider **individual physiology, fluid responsiveness/ tolerance**

References

- Meyer R, Lin C, Yenokyan G, Ellen M. Diagnostic Utility of Ultrasound Versus Physical Examination in Assessing Knee Effusions: A Systematic Review and Meta-analysis. J Ultrasound Med. 2022
- Lichtenstein, D.A. Lung ultrasound in the critically ill. *Ann. Intensive Care* **4,** 1 (2014).
- Amir Qaseem, Itziar Etxeandia-Ikobaltzeta, Reem A. Mustafa, et al; Clinical Guidelines Committee of the American College of Physicians. Appropriate Use of Point-of-Care Ultrasonography in Patients With Acute Dyspnea in Emergency Department or Inpatient Settings: A Clinical Guideline From the American College of Physicians. Ann Intern Med.2021;174:985-993.
- *Koratala et al.* Point of Care Ultrasonography for Objective Assessment of Heart Failure: Integration of Cardiac, Vascular, and Extravascular Determinants of Volume Status. *Cardiorenal Med* (2021)
- Kearney et al. Integrative Volume Status Assessment. *POCUS Journal (2022)*
- *Nicolo et al.*Inferior Vena Cava Ultrasonography for Volume Status Evaluation: An Intriguing Promise Never Fulfilled. *Journal of Clinical Medicine (2023 Mar)*
- *Argaiz et al.* Comprehensive Assessment of Fluid Status by Point-of-Care Ultrasonography. *Kidney 360 (2021 Aug)*
- *Kattan et al.* The emerging concept of fluid tolerance: A position paper. *Journal of Critical Care, (2022 June)*
- *Beaubien-Souligny et al.* Quantifying systemic congestion with Point-Of-Care ultrasound: development of the venous excess ultrasound grading system. *Ultrasound Journal (2020 Dec)*

FIND THE FLUID

FIND THE FLUID

Fluid is **anechoic (= black)** on ultrasound. Does not reflect waves.

If '**complicated or complex**' -> bright material (loculations or septations or 'echogenic' material).

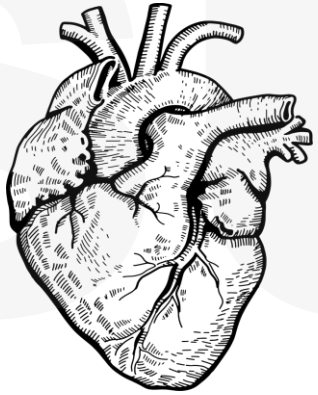
Learn to find fluid in/around:

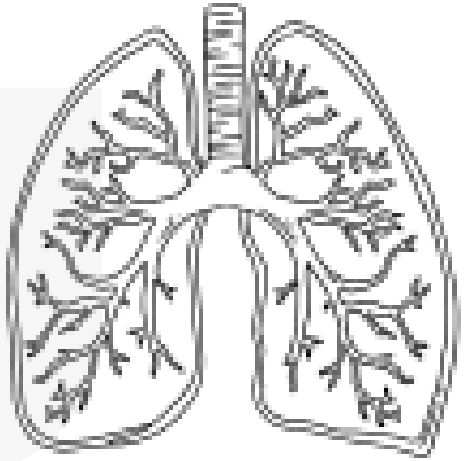
Lungs - pleural effusion

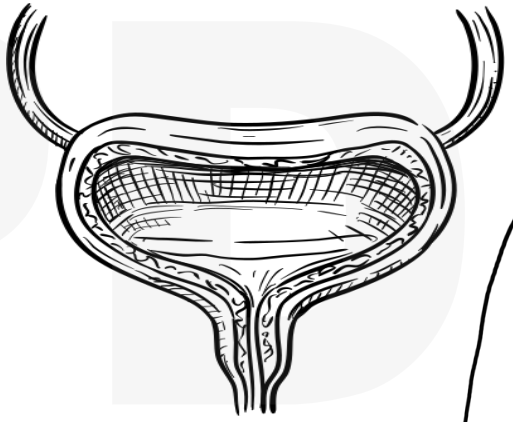
Abdomen - ascites

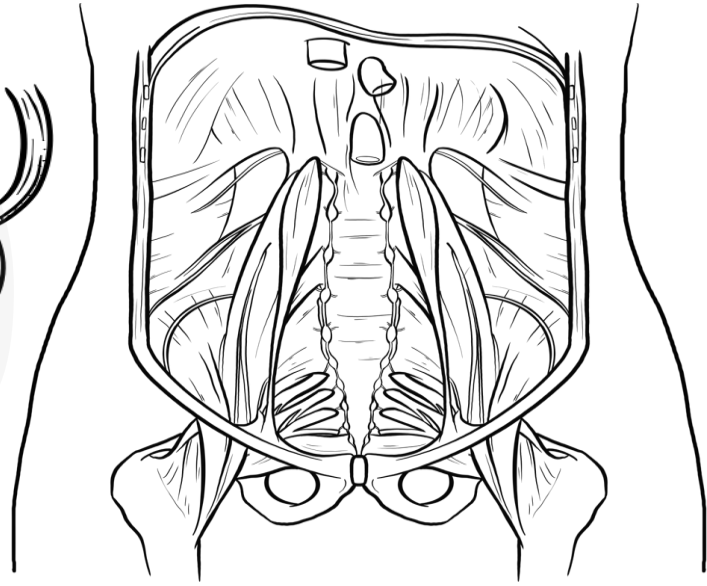
Heart - pericardial effusion

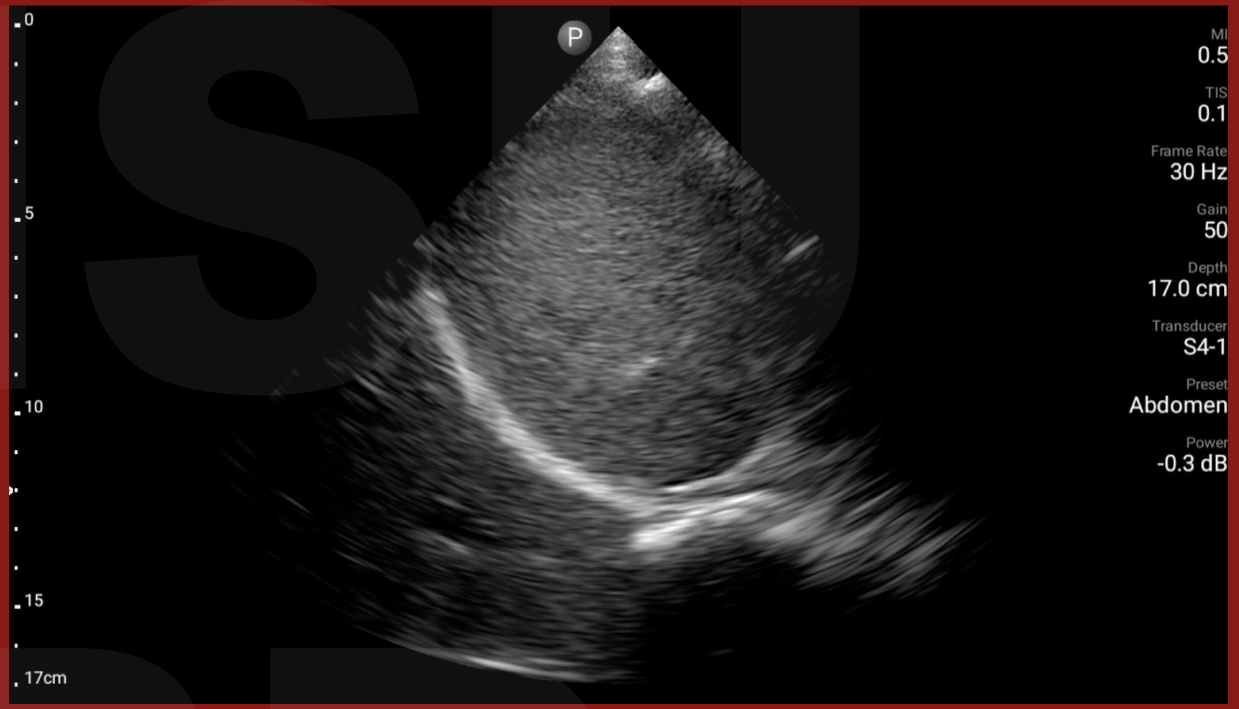
Bladder - urine (retention)



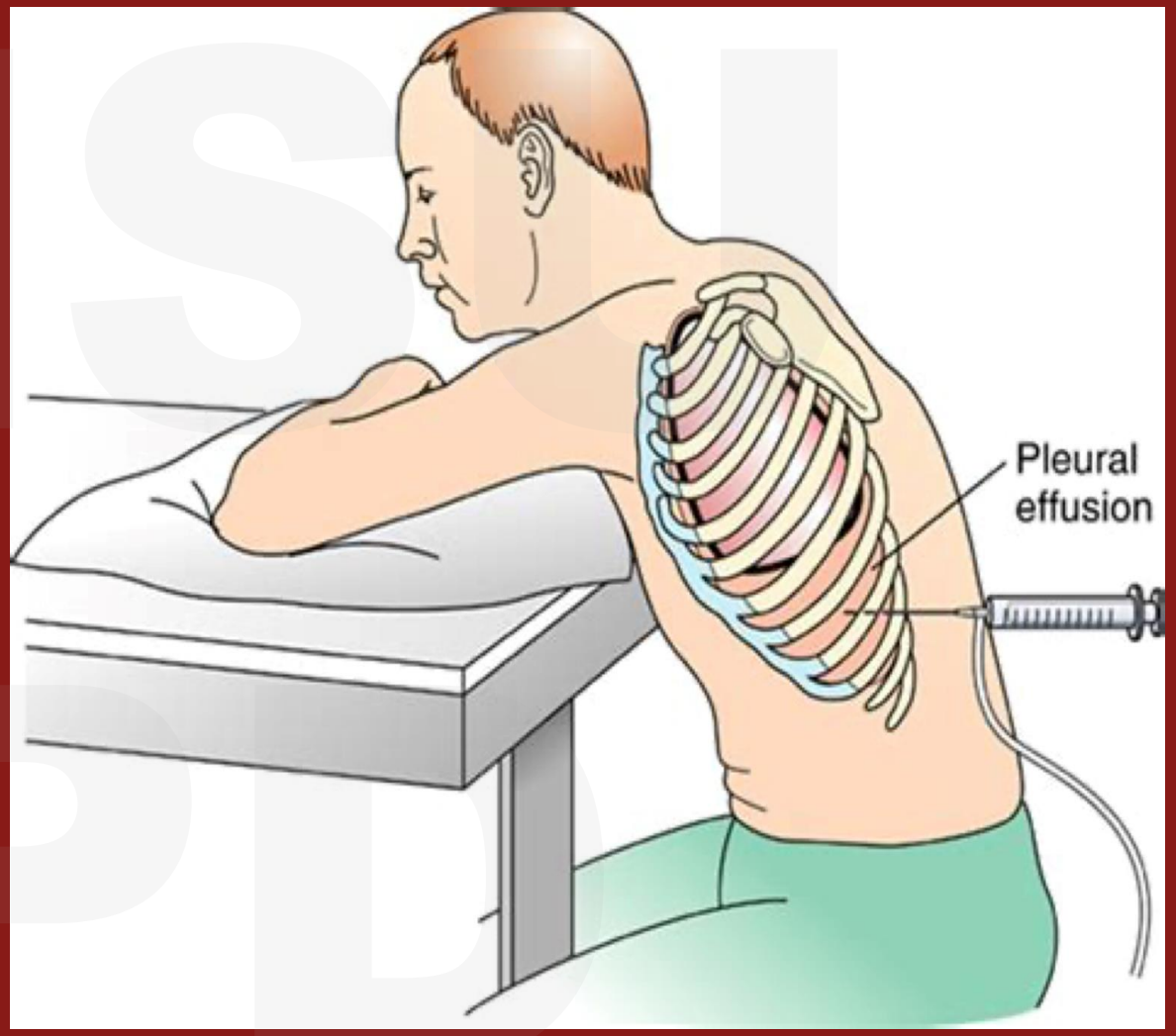








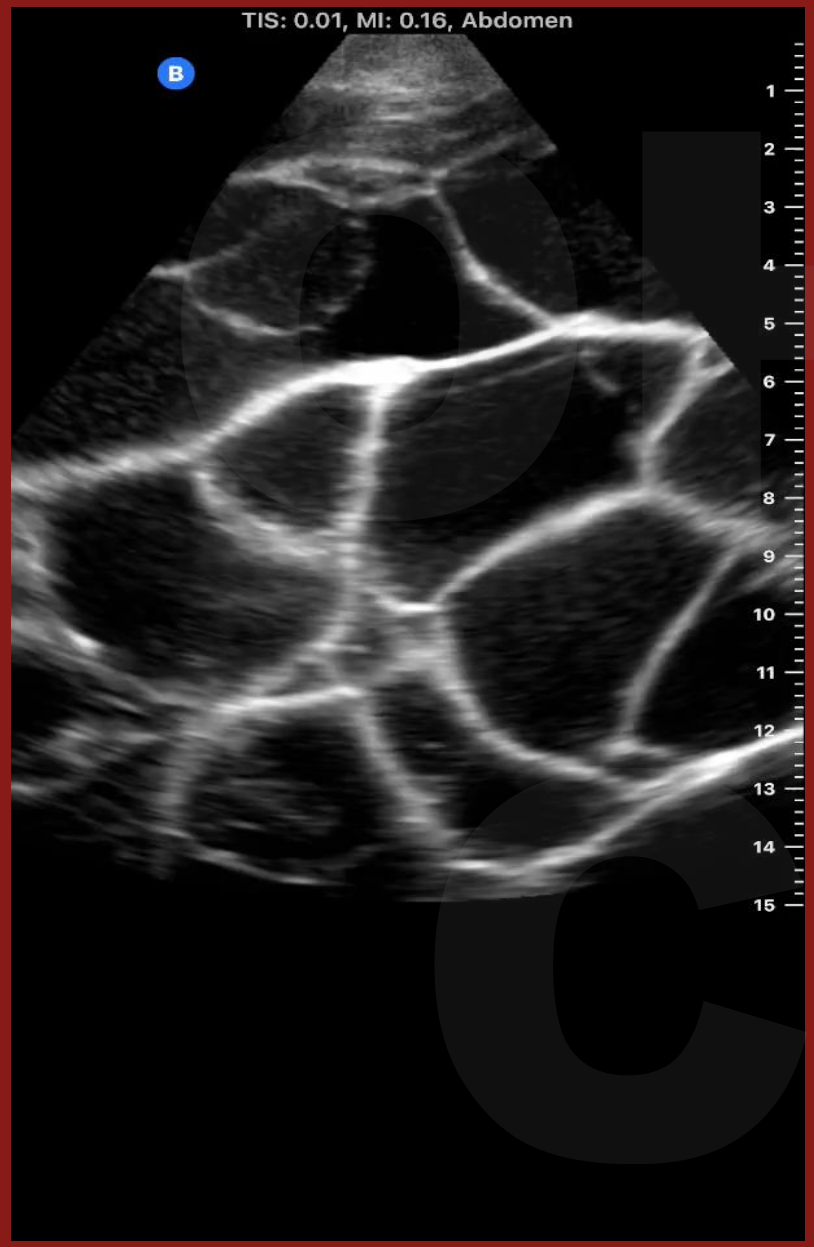
Find diaphragm - Use Largest Probe (curvilinear). Mid -axillary line.



For Thoracentesis

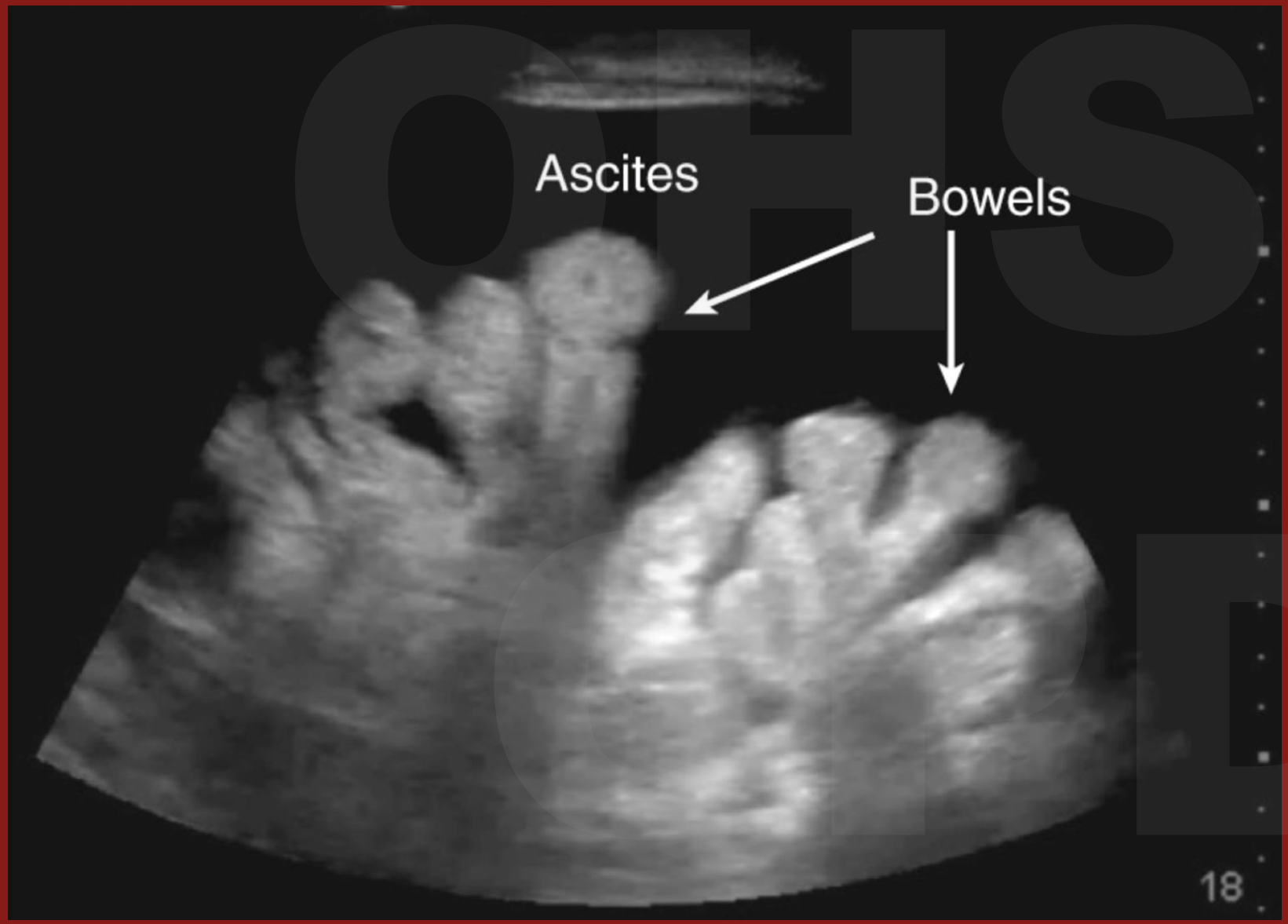
Ascites

Ascites (same patient)



Loculated ascites

- hemoperitoneum and peritonitis. Recent liver Tx.



Sea Ane..body (?mone)

Pleural Effusion

Pleural Effusion - complicated

Para-Sternal Long Axis (PLAX) View, Left

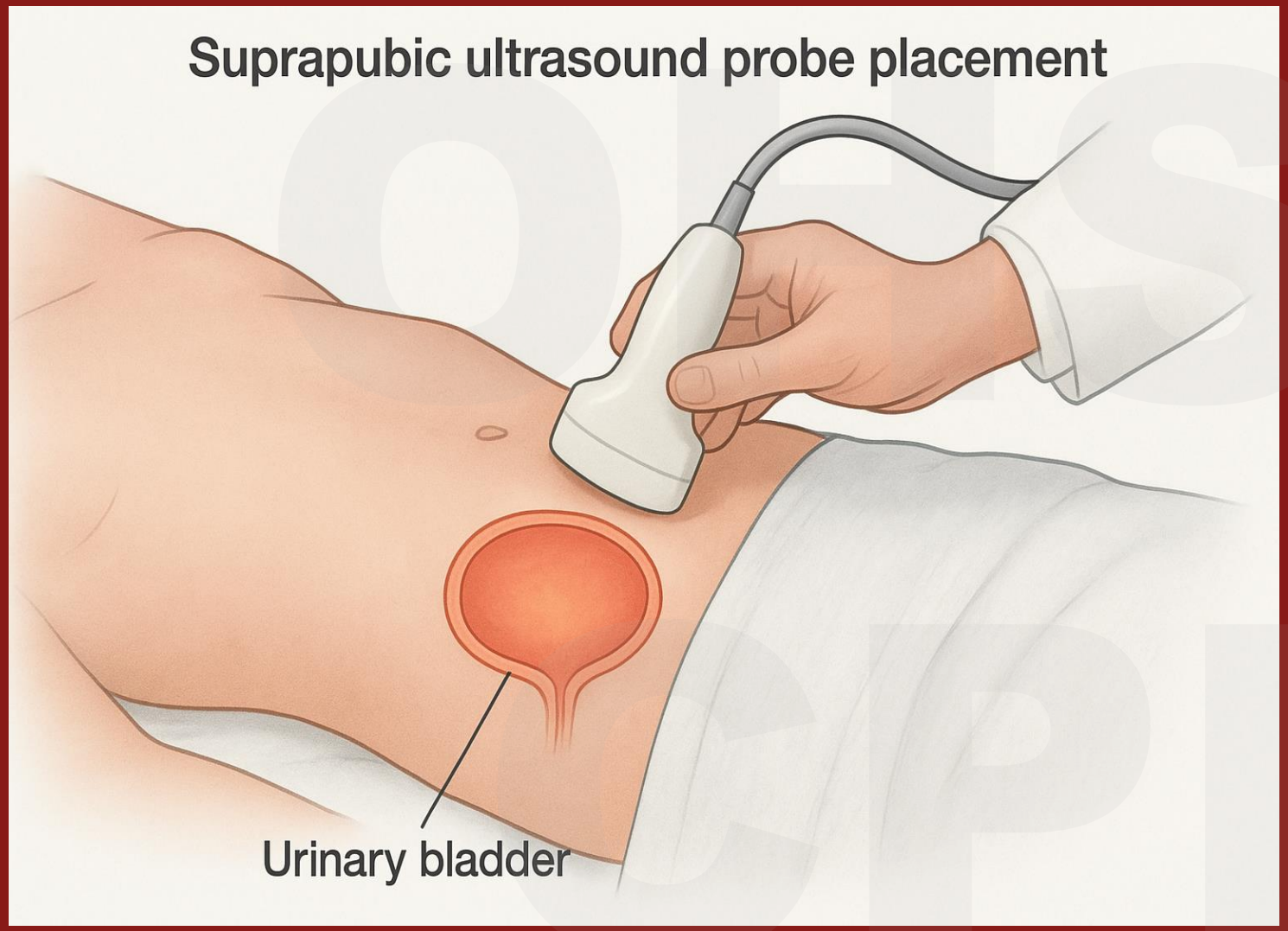
Sub-xiphoid View, Right

Pericardial Effusion (loculated), malignant

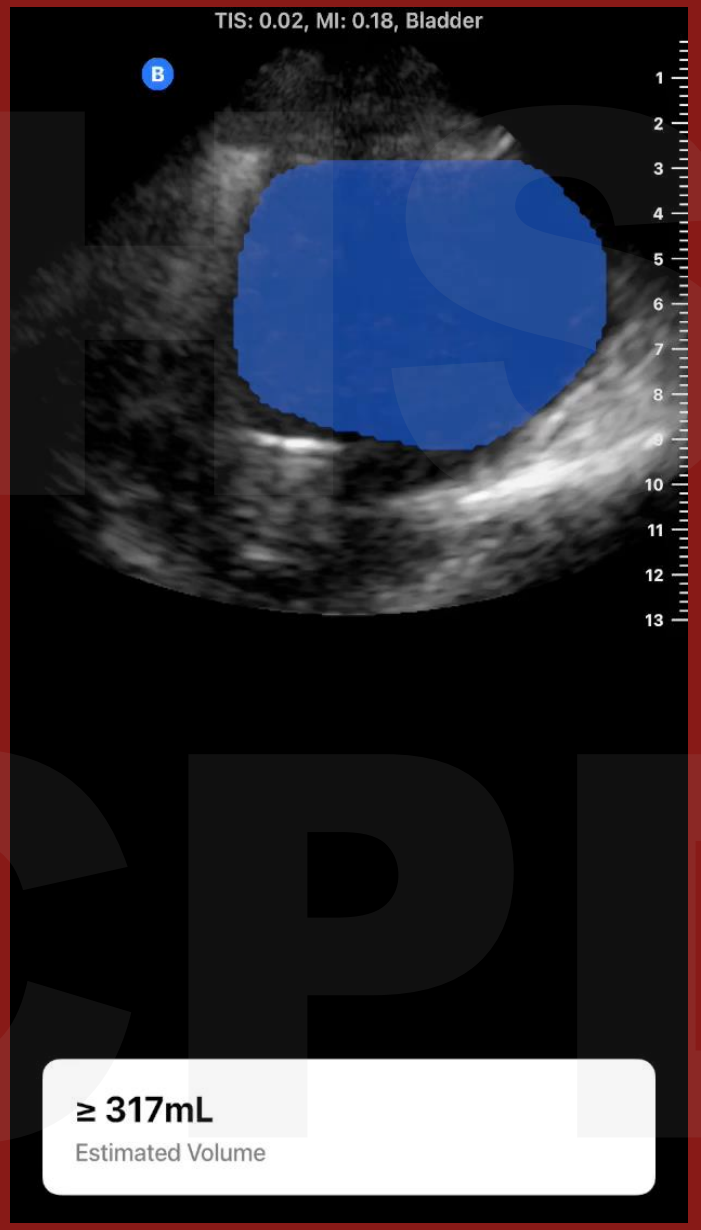
Subacute fever, wasting, CHF -> TB pericarditis

Image courtesy:
Gordon Johnson MD

Pericardial Effusion



Longitudinal or transverse

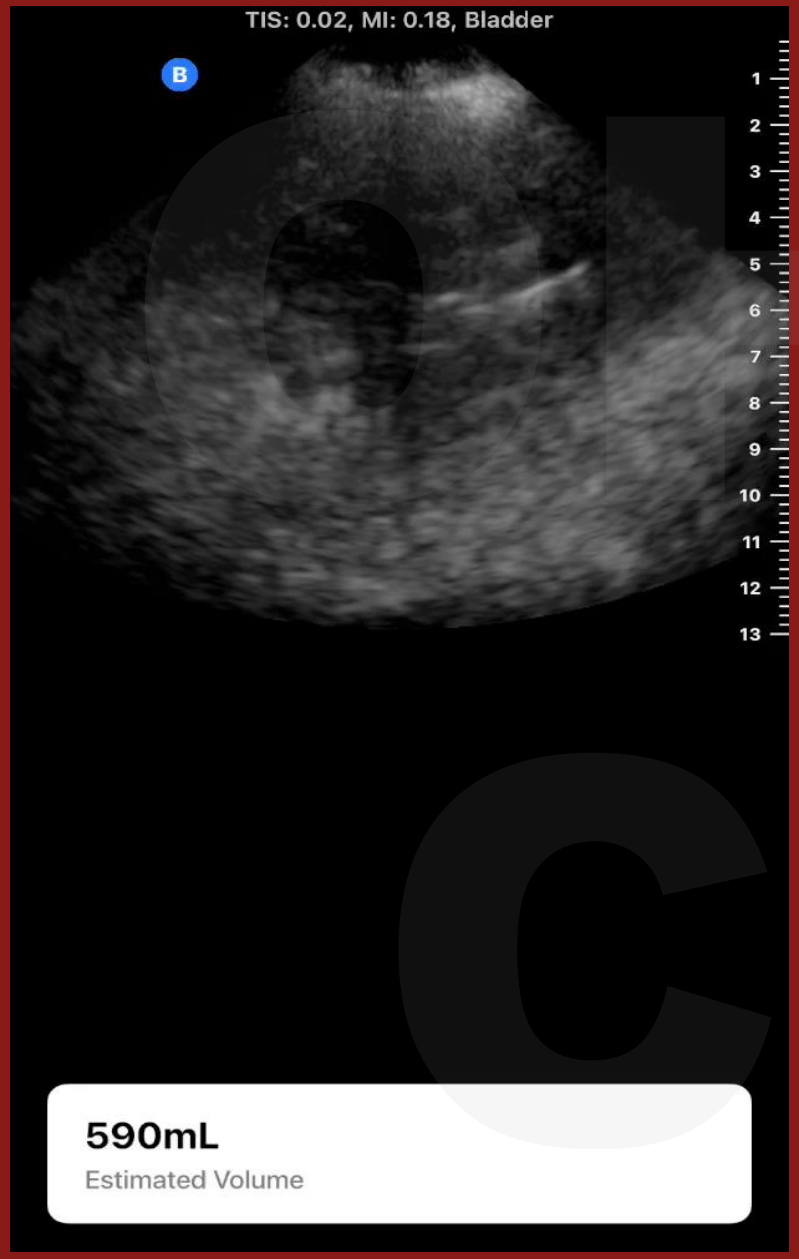


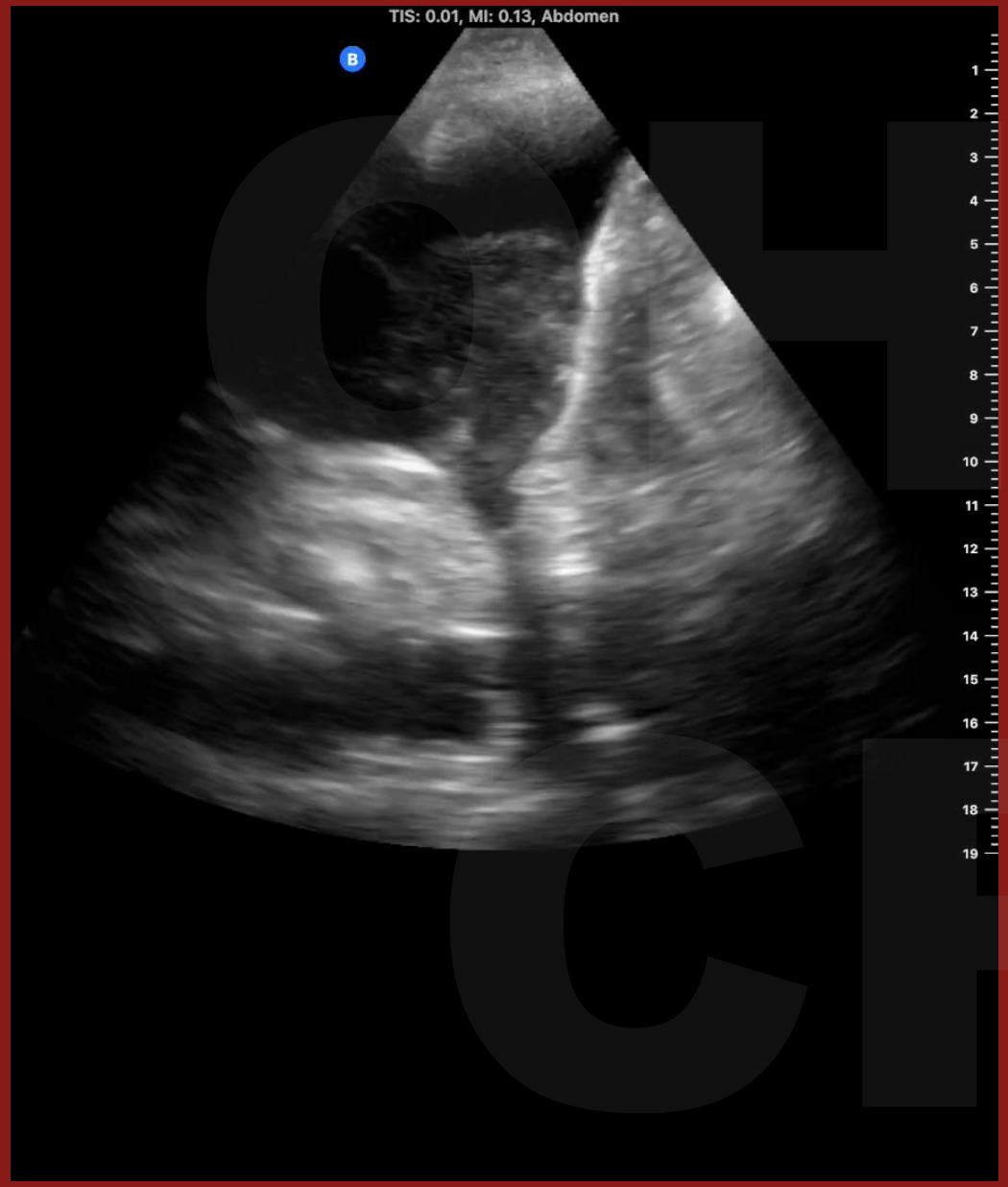
Bladder volume, ascites

Bladder (+Ascites)

Pleural effusion & Ascites

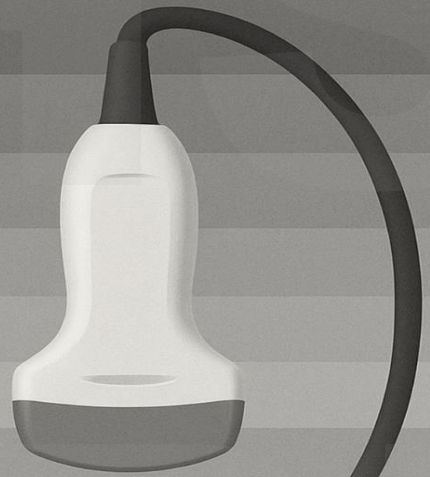
Malignant ascites (CholangioCa)


TIS: 0.02, MI: 0.18, Bladder
B
1
2
3
4
5
6
7
8
9
10
11
12
13
590mL
Estimated Volume



Hemothorax

POINT-OF-CARE ULTRASOUND



Because 50 shades of grey are not enough.