Advanced Point-of-Care Ultrasound

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Disclosures:

None

Intro to POCUS

Learning Objectives

- Summarize scope and indications for Point-of-Care Ultrasound (POCUS) of the heart, lungs, kidneys and soft tissues.
- Interpret POCUS images of the heart, lungs, kidneys and soft tissues, in the setting of acute, critical illness.
- Contrast evidence for standard of care with POCUS.
- Discuss the effect POCUS has on diagnostic evaluation and treatment of acute, critical illness.

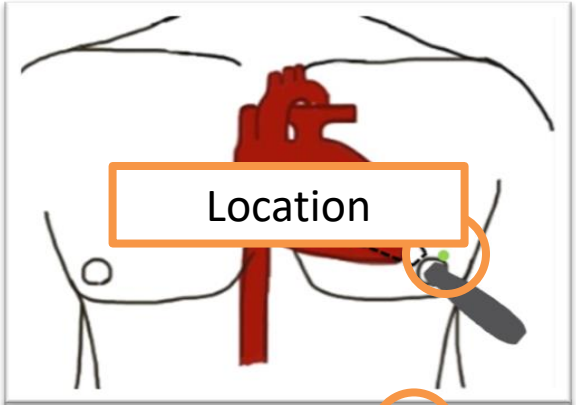
Case Based
(3 Real Patients)

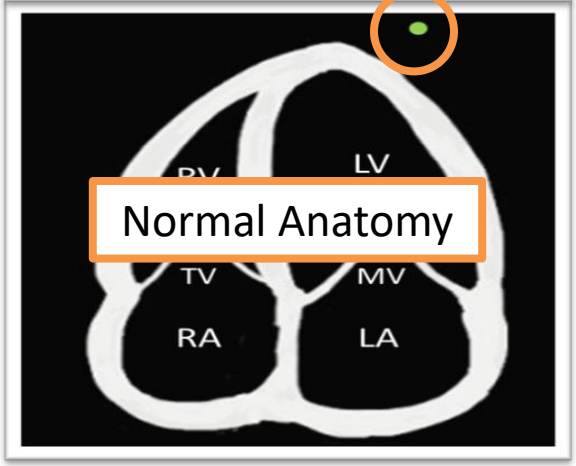
POCUS Basics

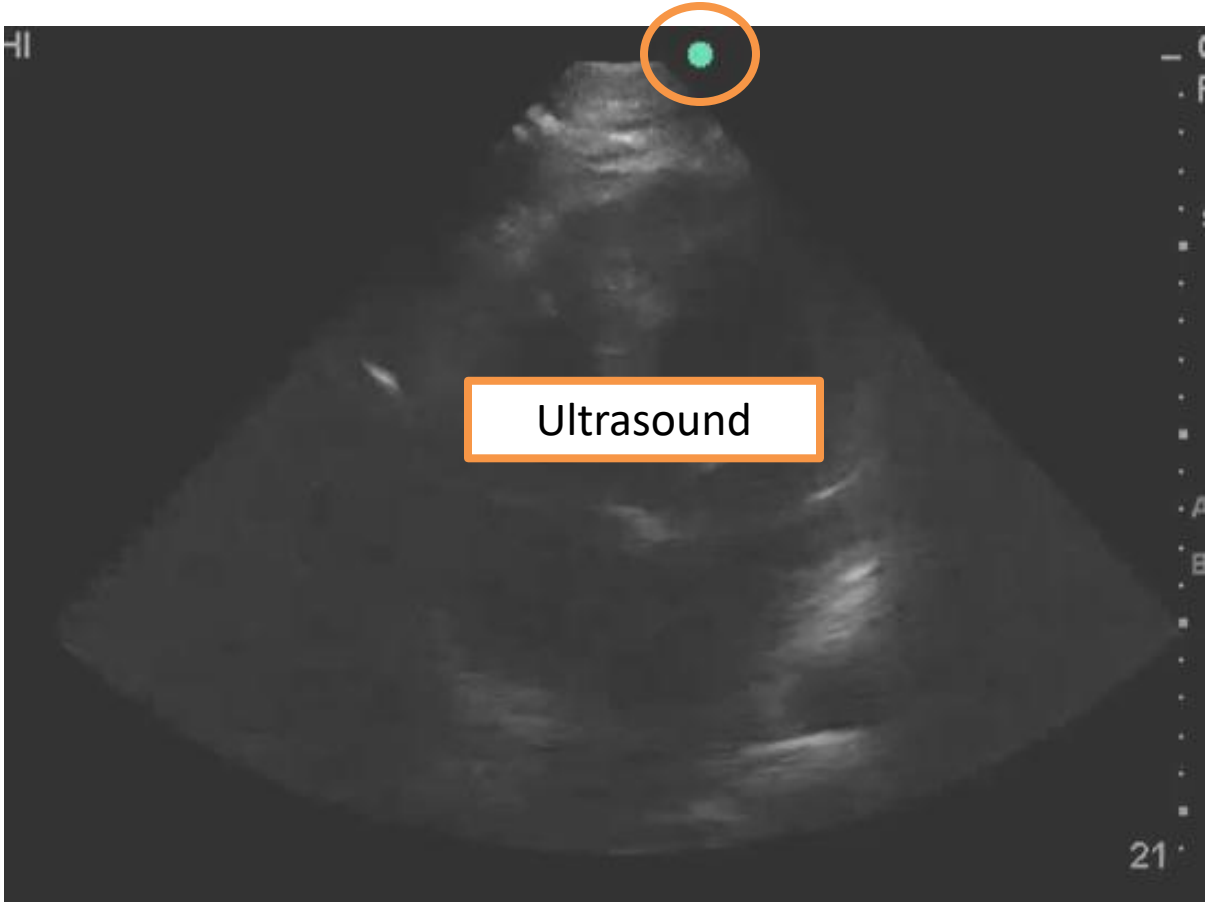
Orientation

POCUS Basics

Orientation







Case 1

HPI

- Asked to urgently evaluate a 74 year-old gentleman for confusion and hypotension.
  - Unable to provide history.
- Hospital Course:
  - Admitted for osteomyelitis of the left lower extremity, status post BKA
  - Diagnosed with critical limb ischemia of the right upper extremity and started on a heparin infusion.
  - Dialyzed earlier that day.

Case 1

HPI

- Past Medical History:
  - ESRD on HD
  - Diastolic left ventricular heart failure.
  - Diabetes mellitus type II.
- Past Social History:
  - Smoker (50 pack years).
  - Daily alcohol use.

Case 1

HPI

- Vital Signs:
  - HR 98, BP **84/55** (from 148/90), SpO2 98% on room air, RR 18, Tmax 36.8 Celcius.
- Physical Exam:
  - Mental – Alert to person, not place or time. Lethargic. **CAM positive**.
  - Heart – Regular rhythm and rate.
  - Lungs – **Faint crackles at the left base**.
  - Abdomen – Mildly tender to palpation.

Case 1

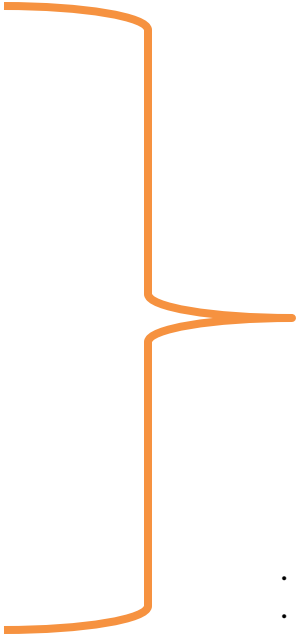
Differential Diagnosis

- Hypovolemia (dialyzed that day)
- Sepsis
  - Hospital acquired pneumonia (crackle in left base)
  - Wound Infection
  - Blood stream infection
- Hemorrhage (on heparin)
- Cardiogenic (extensive risk factors)

POCUS Evaluation of Hypotension

Systematic Evaluation

- Systematic POCUS protocol
  - RUSH: HI-MAP, RUSH: Pumps/Pipes/Tank, EGLS, FREE
- Central to every protocol:
  - LV size and function
  - RV size and function
  - IVC size and respiratory variation
- Additional:
  - Lungs
  - Aorta
  - Peripheral veins
  - Intra-abdominal cavity



Integrate POCUS findings

- Weingart SD, Duque D, Nelson B. The RUSH Exam: Rapid Ultrasound for Shock and Hypotension. https://emcrit.org/rush-exam/original-rush-article/
- Perera P, Mailhot, T, Riley D, Mandavia D. The RUSH Exam: Rapid Ultrasound in Shock in the Evaluation of the Critically Ill. Emerg Med Clin N Am 2010;28:29–56.
- Lanctot JF, Valois M, Beaulieu Y. EGLS: Echo-Guided Life Support – An algorithmic approach to undifferentiated shock. Crit Ultrasound J 2001;3:123-129.
- Ferrada P, Murthi S, Anand RJ, Bochicchio GV, Scalea T. Transthoracic Focused Rapid Echocardiographic Examination: Real-Time Evaluation of Fluid Status in Critically Ill Trauma Patients. J Trauma. 2011;70:56-64.

POCUS Evaluation of Hypotension

Goals

1. Quickly rule in / rule out specific pathology.
2. Narrow differential diagnosis.
3. Characterize type of shock / hypotension.

POCUS Evaluation of Hypotension

Systematic Evaluation

- Characterization of Shock

	Hypovolemic	Vasodilatory	Cardiogenic	Obstructive
Heart	Hyperdynamic LV function		Reduced / Severely Reduced LV fxn RV Dilation (MI)	+/- Dilated RV (PE) +/- Pericardial Effusion (Cardiac Tamponade)
IVC	Small IVC		Dilated IVC	Dilated IVC
Morrison's Pouch	+/- Abdominal free fluid (hemorrhage)	Normal	+/- Abdominal free fluid (ascites)	Normal
Aorta	+/- Aortic aneurysm / dissection	Normal	Normal	Normal
Pulmonary	Normal	+/- Consolidation (pneumonia)	B-Lines	+/- Absent lung sliding (pneumothorax)
Peripheral Veins	Normal	Normal	Normal	+/- DVT

Weingart SD, Duque D, Nelson B. The RUSH Exam: Rapid Ultrasound for Shock and Hypotension. https://emcrit.org/rush-exam/original-rush-article/

POCUS Evaluation of Hypotension

Practical Approach

- Use POCUS to target organs / organ systems based on clinical suspicion and pre-test probability.

Focused Cardiac Ultrasound

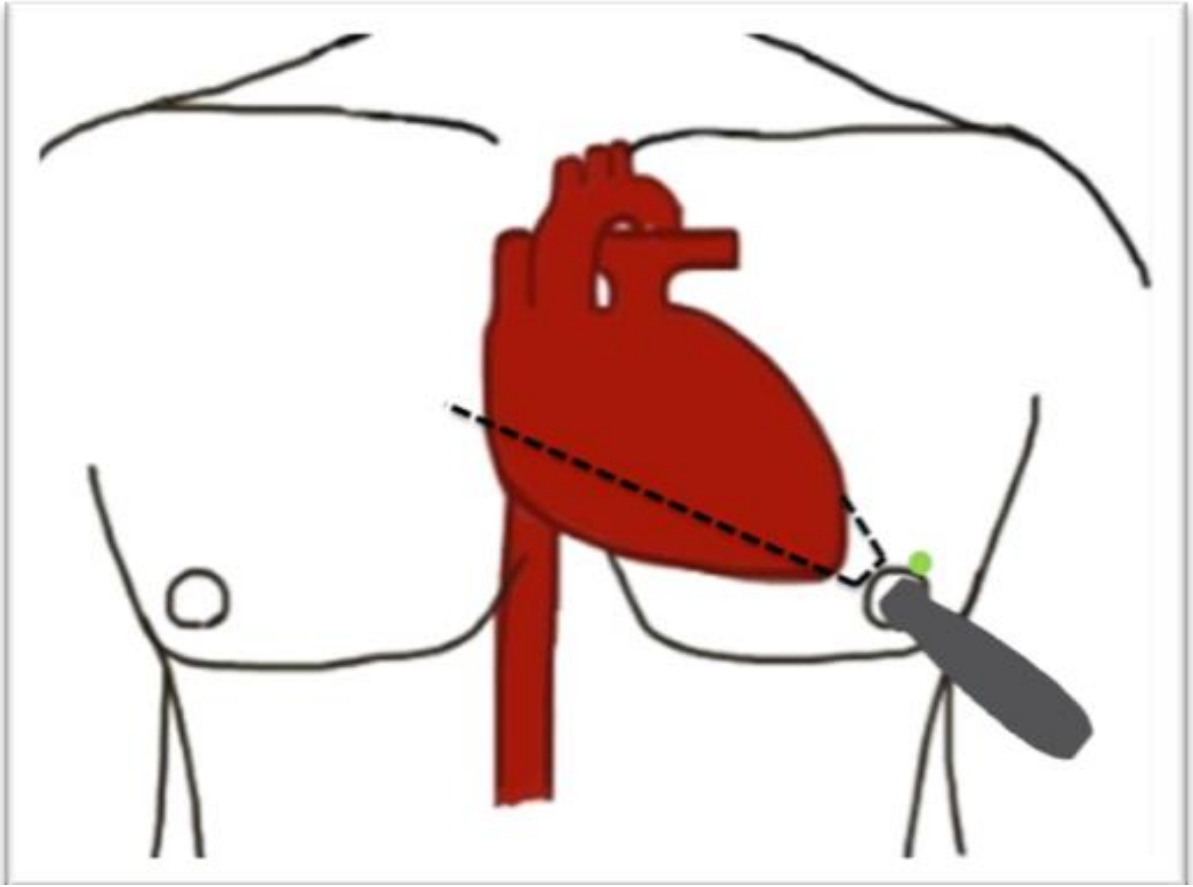
Introduction

- 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)

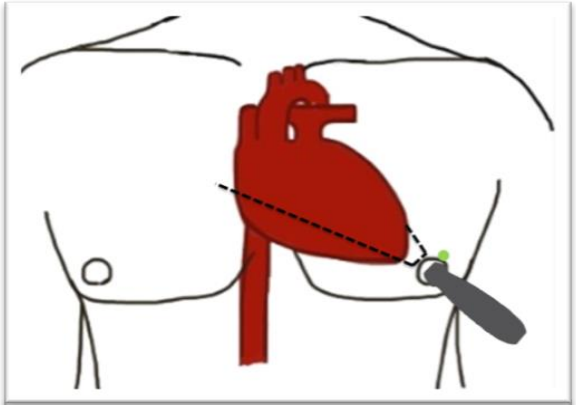
Focused Cardiac Ultrasound

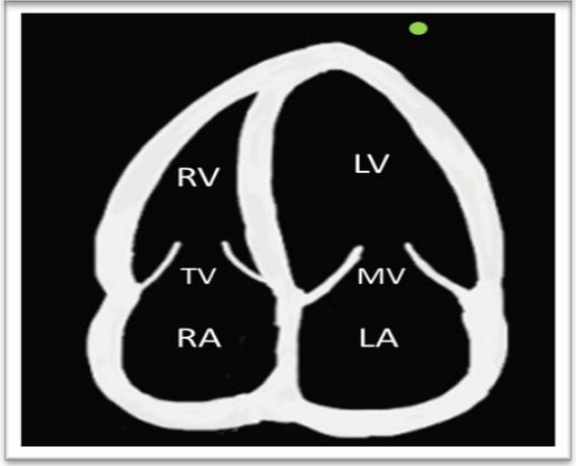
Apical Four Chamber (A4C)

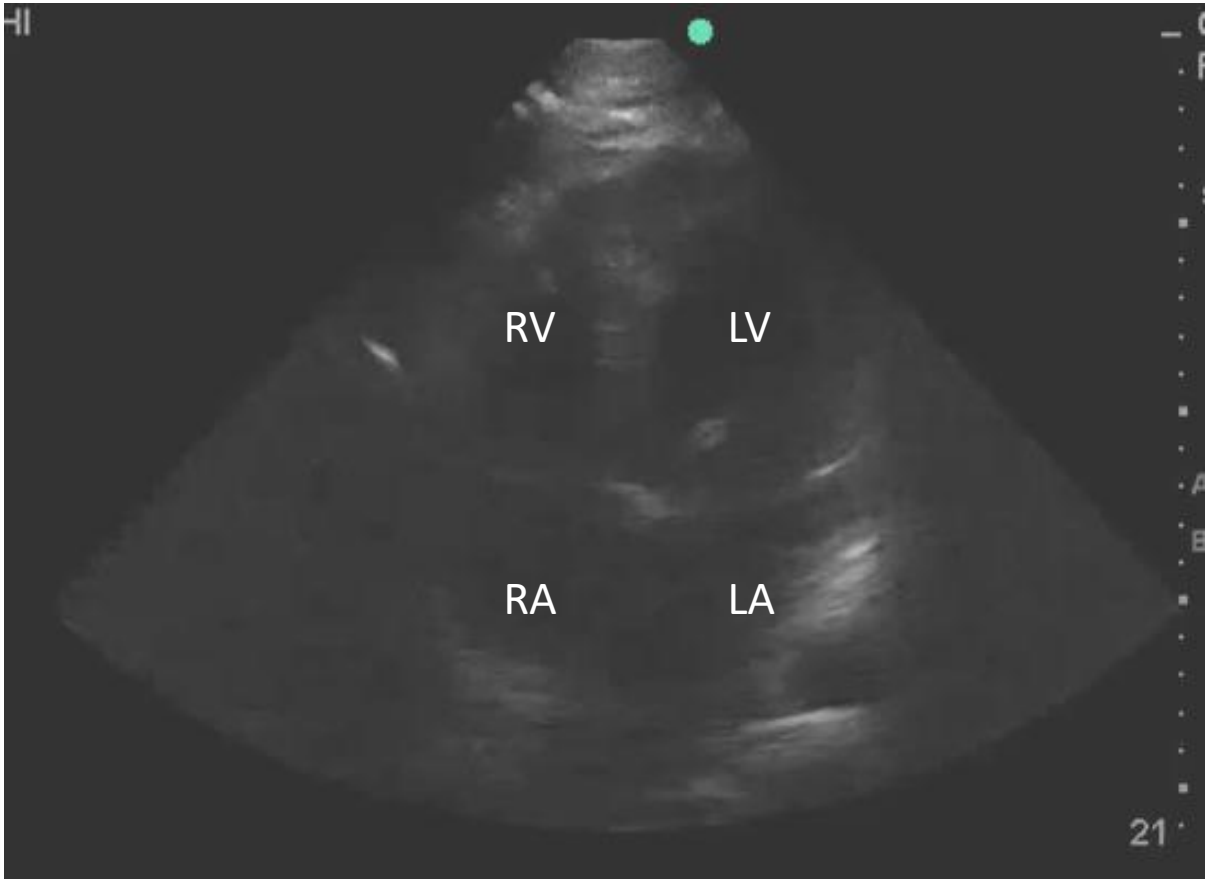


Focused Cardiac Ultrasound

Apical Four Chamber (A4C)

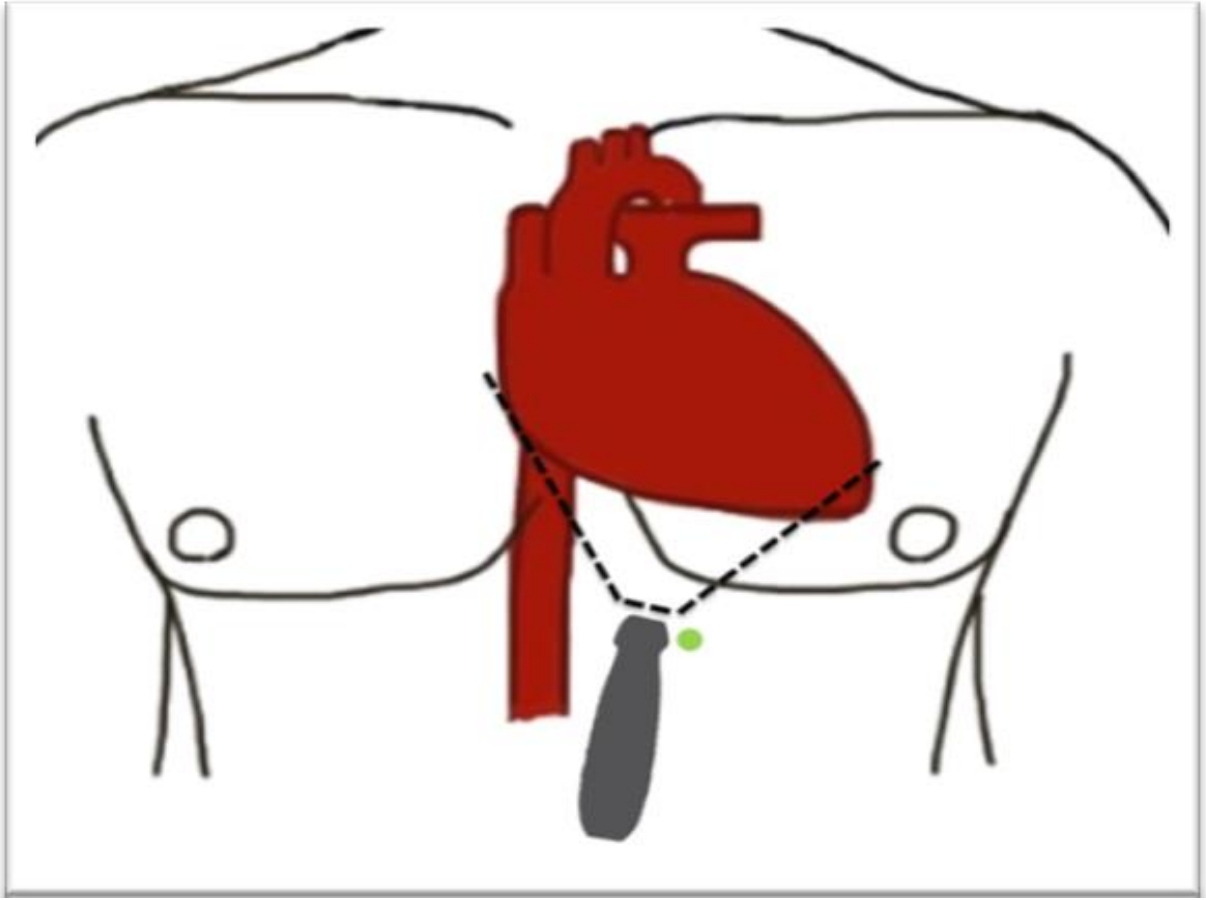






Focused Cardiac Ultrasound

Subcostal Four Chamber (S4C)



Focused Cardiac Ultrasound

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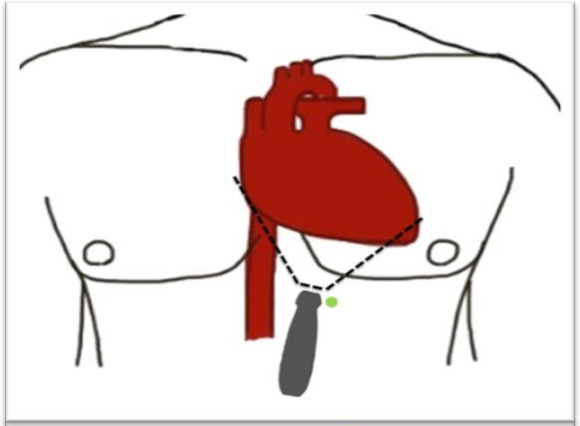
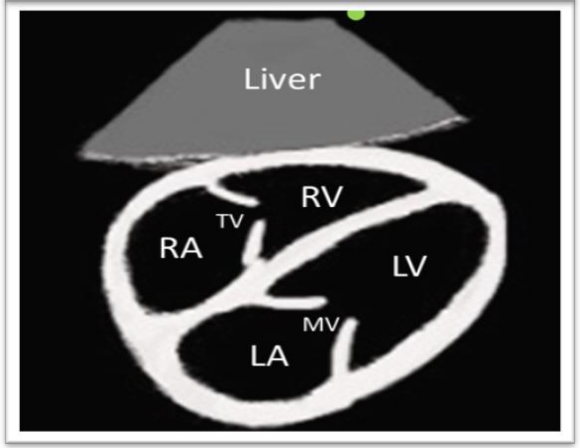
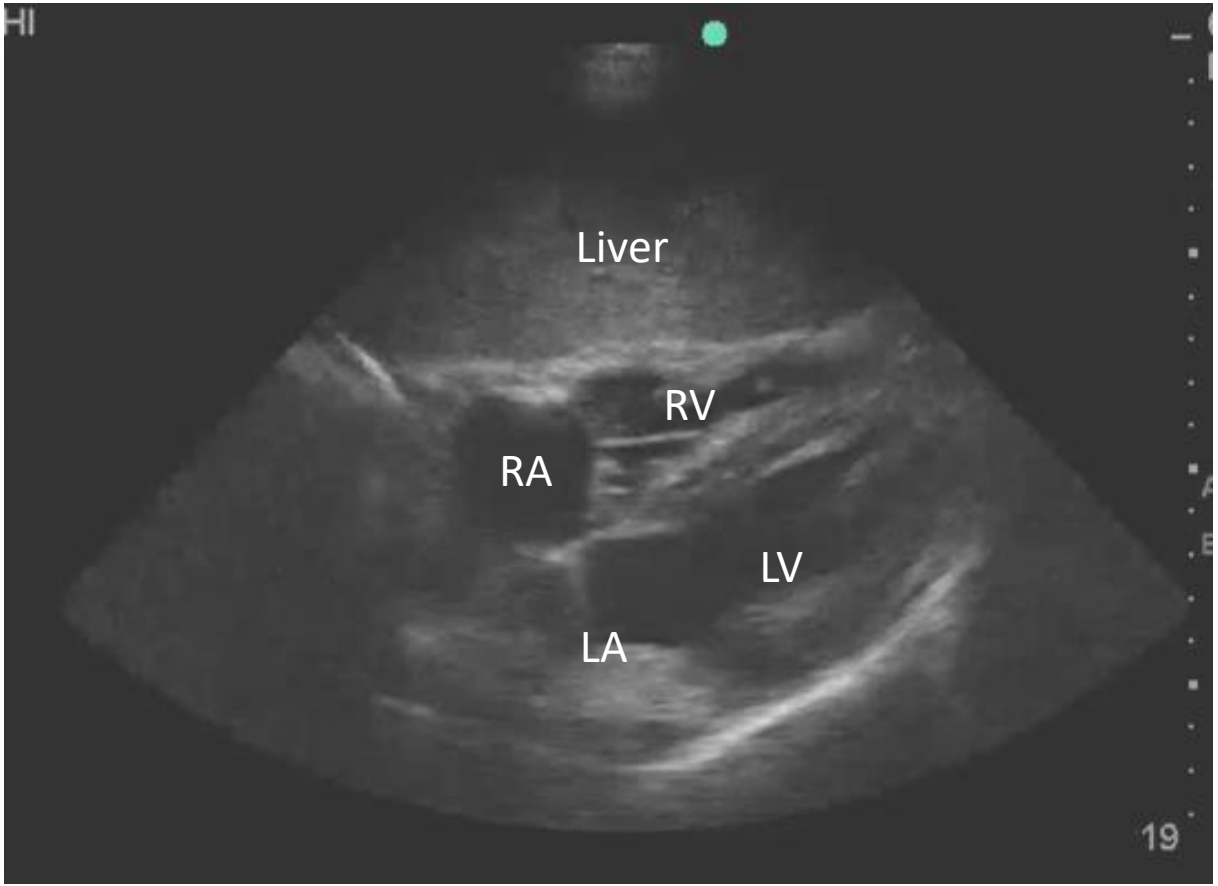
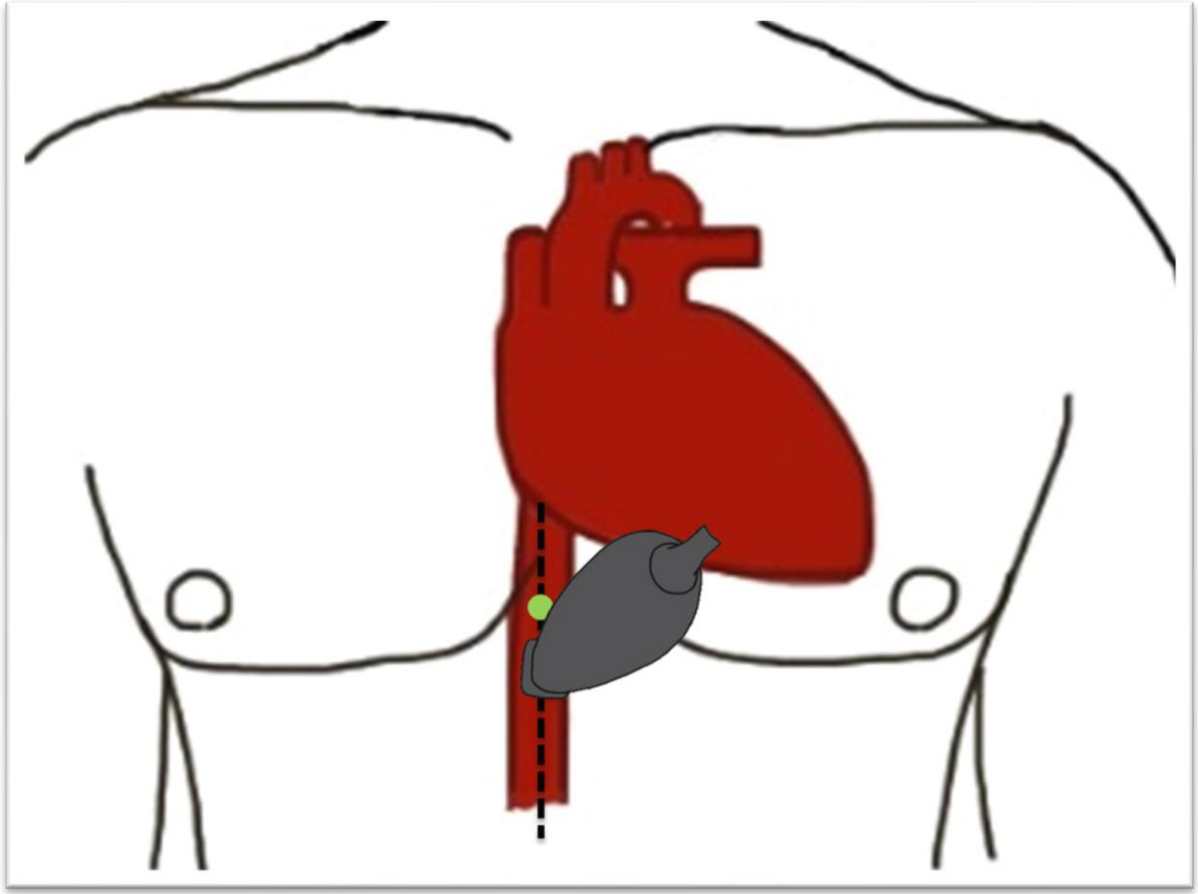






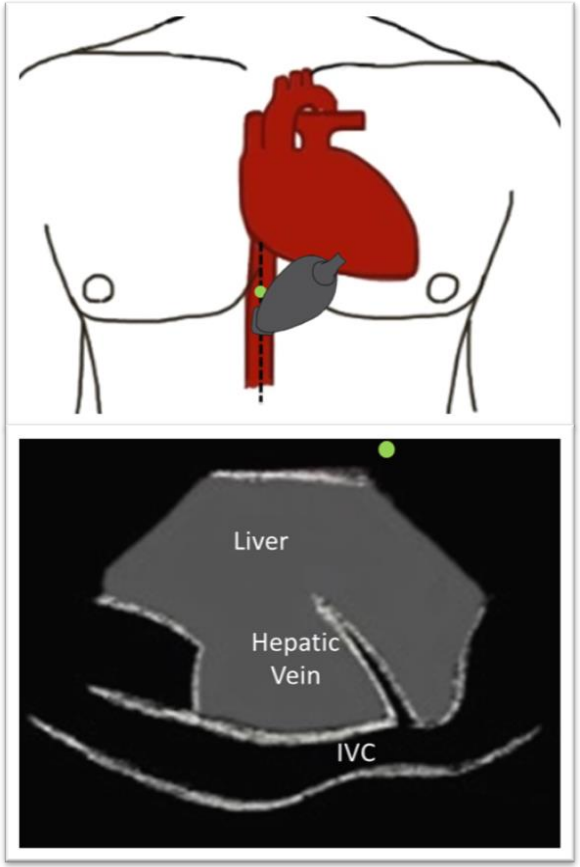
Focused Cardiac Ultrasound

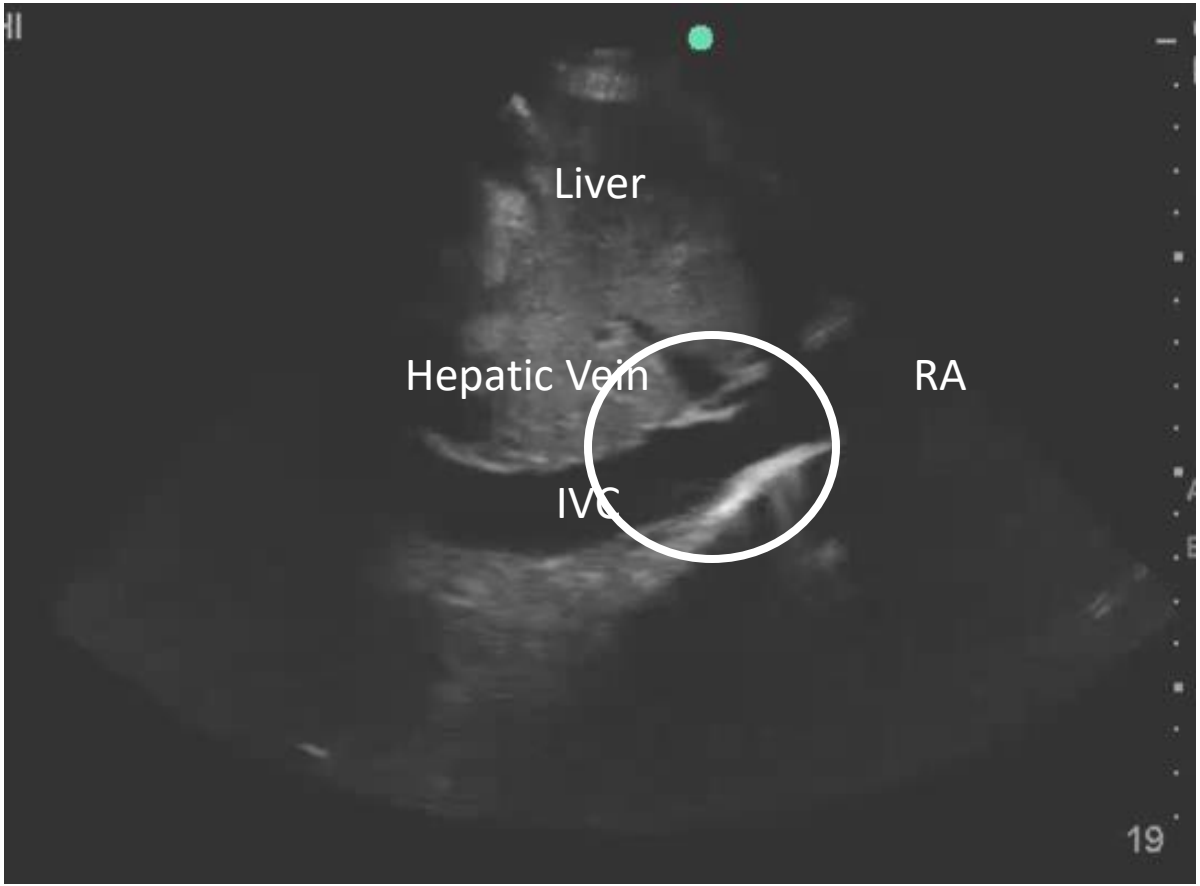
Inferior Vena Cava (IVC)



Focused Cardiac Ultrasound

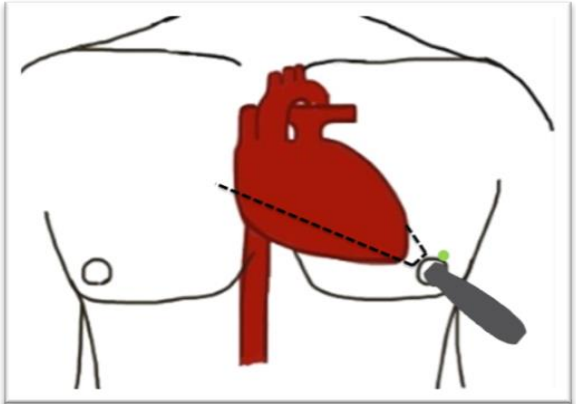
Inferior Vena Cava (IVC)

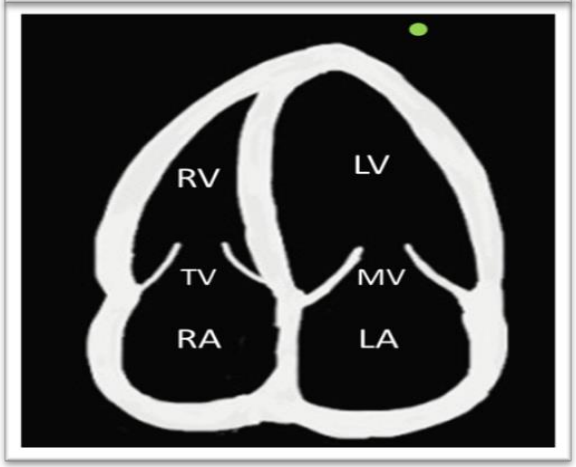


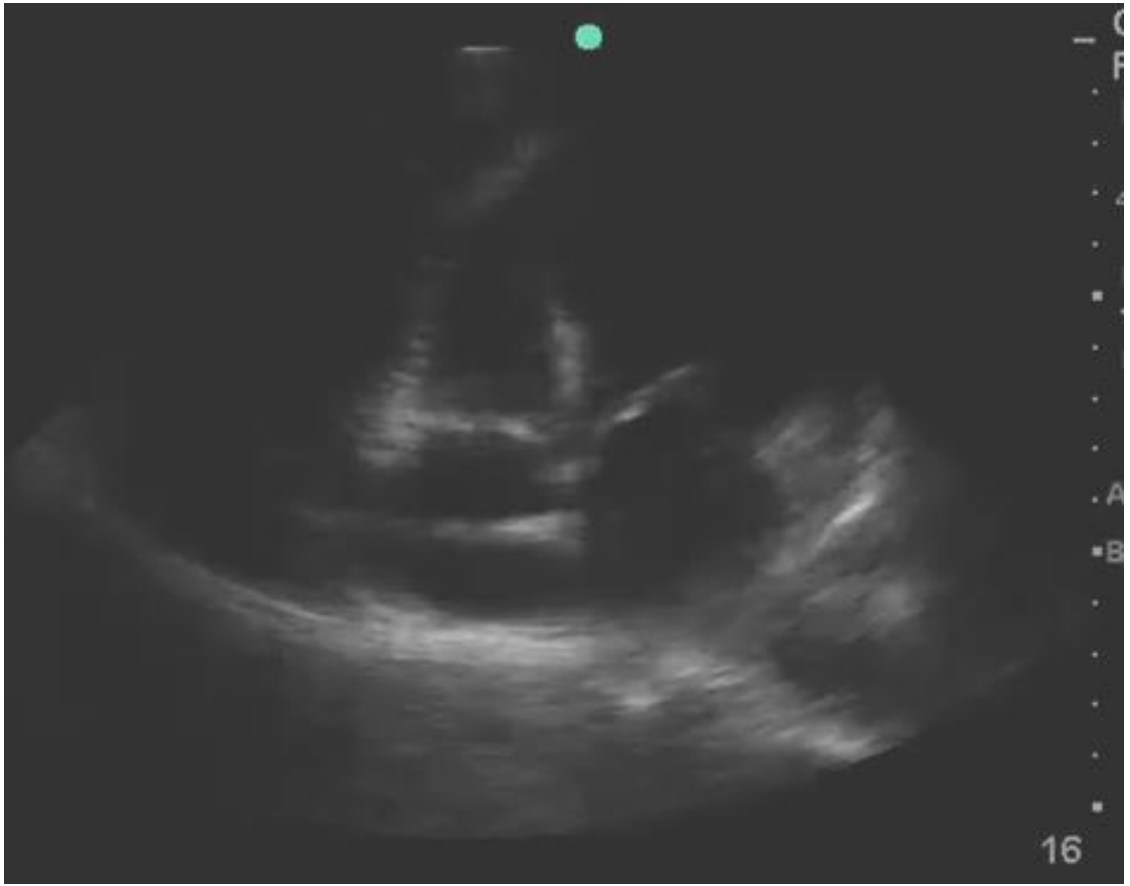


Case 1

Apical Four Chamber (A4C)

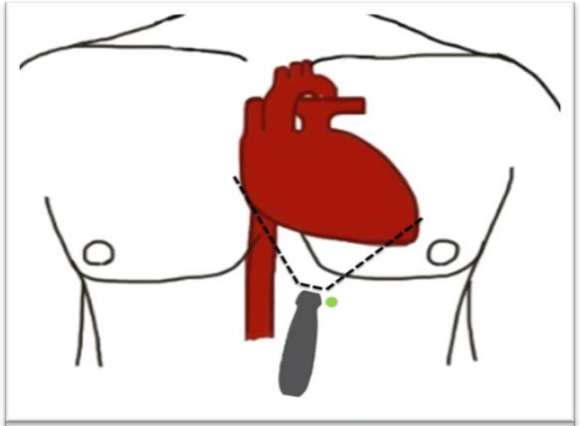


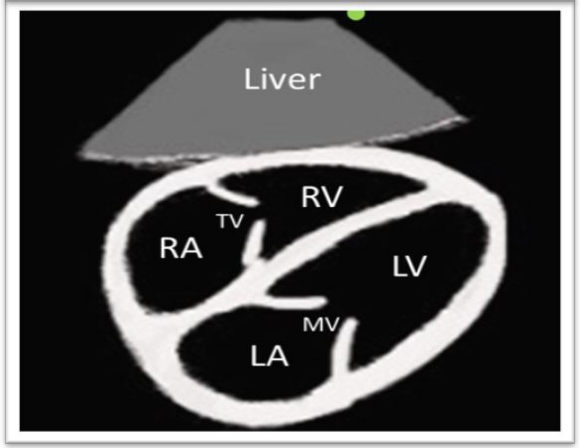


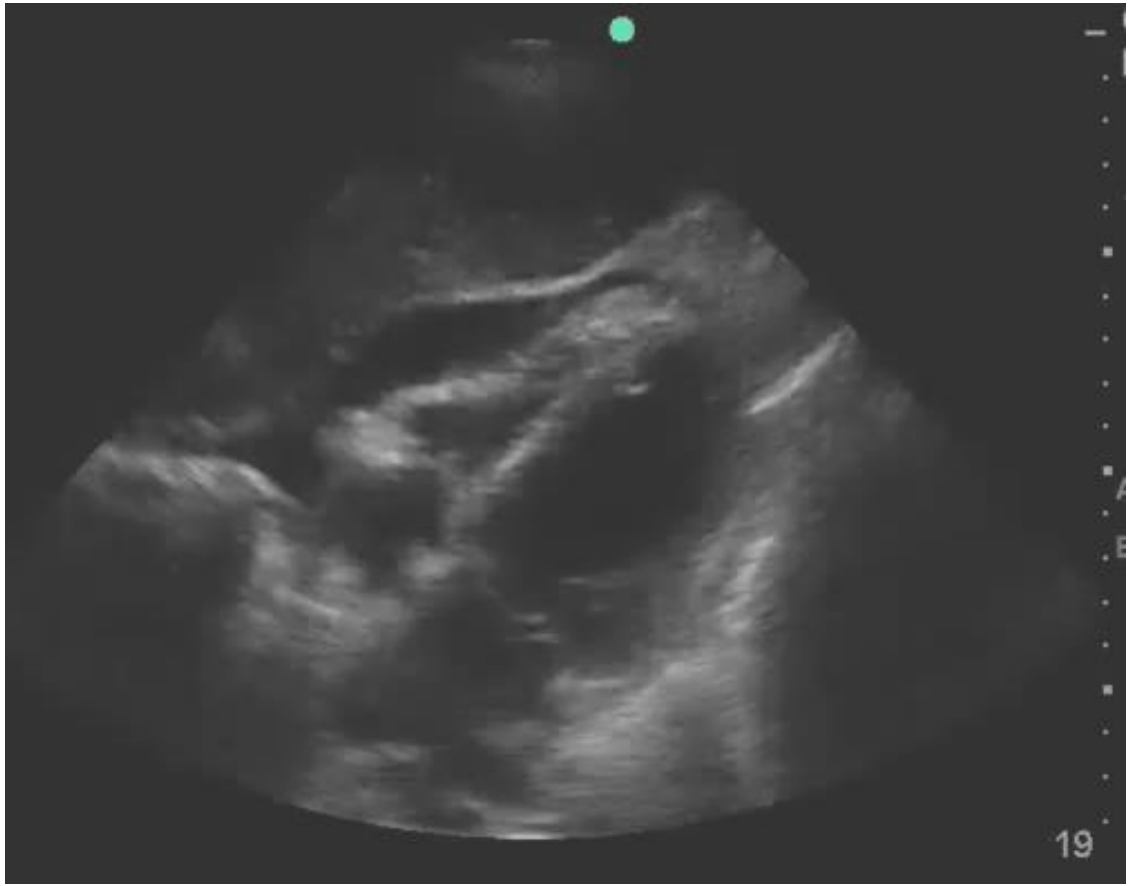


Case 1

Subcostal Four Chamber (S4C)

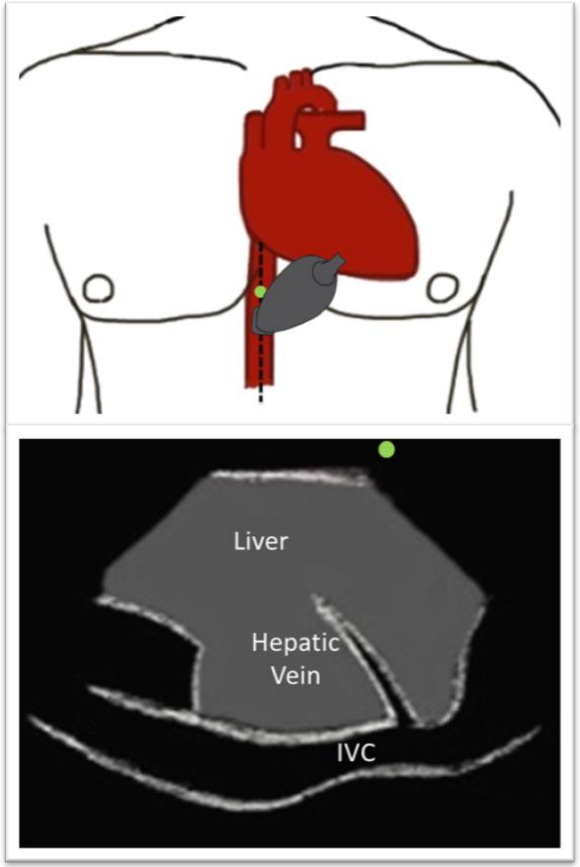






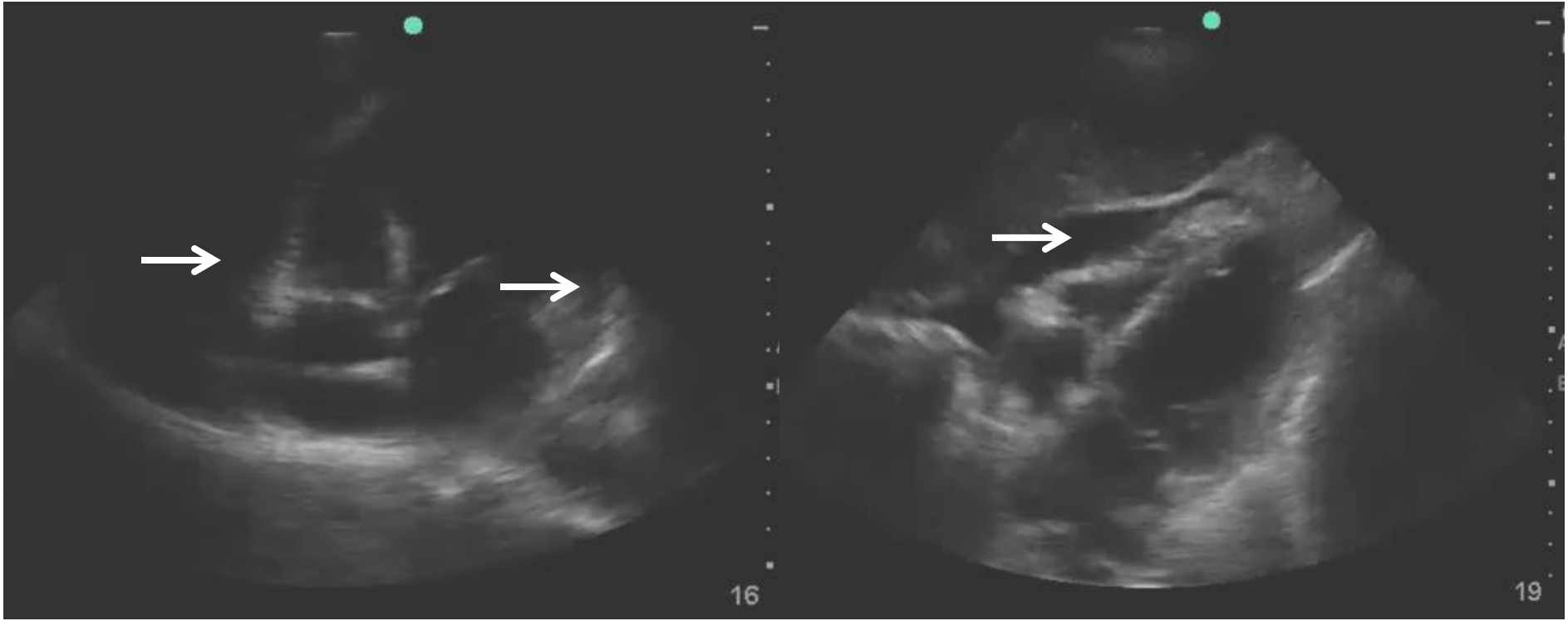
Case 1

Inferior Vena Cava (IVC)



Case 1

A4C + S4C



Case 1

Conclusion

- Findings **VERY** concerning for cardiac tamponade.
- Transferred to the Cardiac ICU for emergent pericardial drain placed.
- Diagnosed with hemorrhagic pericarditis causing cardiac tamponade.

POCUS Evaluation of Hypotension

Pericardial Disease

- Beck's Triad

	Sensitivity	Specificity	Frequency
Hypotension	26% (16-36%)	N/A	28%
Elevated JVP	76% (62-90%)	N/A	54%
Muffled heart sounds	28% (21-35%)	N/A	22%

- Pulsus Paradoxus
  - Sensitivity 82-98%, Specificity 83%, +LR 5.9, -LR 0.03.
  - Guberman BA, Folwer NO, Engel PJ, Gueron M, Allen JM. Cardiac tamopnade in medical patients. Circulation. 1981;64(3): 633-640.

cardial effusion impending
009;27:216-219.
Roy CL, Minor MA, Brookhart MA, Choudhry NK. Does this patient with a pericardial effusion have cardiac tamponade? JAMA. 2007;297(16): 1810 – 1818.

POCUS Evaluation of Hypotension

Pericardial Disease

- Pericardial Effusion
  - Sensitivity 96%, Specificity 98%
- Cardiac Tamponade

FoCUS Findings	Sensitivity	Specificity
RA Systolic Collapse	64-100%	82%
RV Diastolic Collapse	60-92%	85-100%
Normal IVC*	97%	N/A

- Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. Ann Emerg Med. 2001;38:377-382.
- Gillam LD, Guyer DE, Gibson TC, et al. Hydrodynamic compression of the right atrium: a new echocardiographic sign of cardiac tamponade. Circulation. 1983:68(2);294-301.
- Singh S, Wann LS, Schuchard GH, et al. Right ventricular and right atrial collapse in patients with cardiac tamponade – a combined echocardiographic and hemodynamic study. Circulation. 1984:70(6);966-971.

POCUS Evaluation of Hypotension

Literature Review

- Diagnostic Evaluation

Measurement	Standard of Care	Standard of Care + POCUS
Number of viable Diagnoses on initial eval	9	4
Provider confidence in diagnosis	50%	80%
Patient's with definitive diagnosis on initial eval	0.8%	12.7%

- Diagnosis by POCUS has excellent concordance with final consensus diagnosis (*k*=0.80).

- Shokoohi H, Boniface KS, Pouramand A, Liu YT, et al. Bedside Ultrasound Reduces Diagnostic Uncertainty and Guides Resuscitation in Patients With Undifferentiated Hypotension. Critical Care Medicine Journal 2015;43(12):2562-2569.
- Jones AE, Tayal VS, Sullivan DM, et al: Randomized, controlled trialof immediate versus delayed goal-directed ultrasound to identifythe cause of nontraumatic hypotension in emergency departmentpatients. Crit Care Med 2004; 32:1703–1708

POCUS Evaluation of Hypotension

Literature Review

- Evidence is mixed regarding POCUS effect on:
  - CT usage
  - IVF usage
  - Inotropes / Vasopressor usage

- Shokoohi H, Boniface KS, Pouramand A, Liu YT, et al. Bedside Ultrasound Reduces Diagnostic Uncertainty and Guides Resuscitation in Patients With Undifferentiated Hypotension. Critical Care Medicine Journal 2015;43(12):2562-2569.
- Jones AE, Tayal VS, Sullivan DM, et al: Randomized, controlled trialof immediate versus delayed goal-directed ultrasound to identifythe cause of nontraumatic hypotension in emergency departmentpatients. Crit Care Med 2004; 32:1703–1708
- Atkinson PR, Milne J, Diegelman L, Lamprecht H, StanderM, Lussier D, et al. Does Point-of-Care Ultrasonography Improve Clinical Outcomes in Emergency Department Patients With Undifferentiated Hypotension? An International Randomized Controlled Trial From the SHoC-ED. Annals of Emergency Medicine 2018.

POCUS Evaluation of Hypotension

Literature Review

Does Point-of-Care Ultrasonography Improve Clinical Outcomes in Emergency Department Patients With Undifferentiated Hypotension? An International Randomized Controlled Trial From the SHoC-ED Investigators

Conclusion: To our knowledge, this is the first randomized controlled trial to compare point-of-care ultrasonography to standard care without point-of-care ultrasonography in undifferentiated hypotensive ED patients. We did not find any benefits for survival, length of stay, rates of CT scanning, inotrope use, or fluid administration. The addition of a point-of-care ultrasonography protocol to standard care may not translate into a survival benefit in this group. [Ann Emerg Med. 2018;72:478-489.]

- POCUS has not been shown to improve patient centered outcomes…so far.

Atkinson PR, Milne J, Diegelman L, Lamprecht H, StanderM, Lussier D, et al. Does Point-of-Care Ultrasonography Improve Clinical Outcomes in Emergency Department Patients With Undifferentiated Hypotension? An International Randomized Controlled Trial From the SHoC-ED. Annals of Emergency Medicine 2018.

Case 2

HPI

- A 62 year-old female was admitted to your service overnight from the ED for complaints of fevers and rigors over the last 2 days.
- She endorses:
  - Dysuria
  - Urinary frequency
  - Urinary urgency

Case 2

HPI

- Past Medical / Surgical History:
  - Pseudomonas aeruginosa UTI (~3 months prior).
  - Hypertension
  - Left ventricular diastolic heart failure
- Social History:
  - No alcohol, tobacco or illicit drug use. Lives independently.
- Family History:
  - Noncontributory.

Case 2

Work Up

- Labs:
  - Hgb 15.2 g/dL.
  - WBC **16.7** x 109 /L
  - Creatinine **2.6** mg/dL
  - Lactate **3.1** mmol/L
- Urinalysis
  - Many gram negative bacilli on Gram stain.
  - WBC > 100 / hpf.

Case 2

Course

- Emergency Department Course:
  - Diagnosis: Sepsis due to UTI
  - IVF: LR 30 ml/kg.
  - Antibiotics: Cefepime.
- Hospital Admission:
  - Continued on cefepime.
  - Placed on maintenance fluids.

Case 2

Course

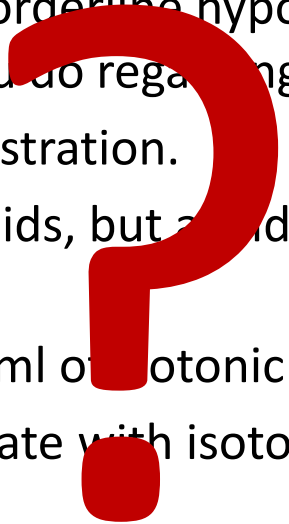
- AM Vital Signs:
  - HR **112**, BP **98/55**, RR **24**, SpO2 **88**% on room air, Tmax **39.0**.
- AM Labs:
  - WBC **15.9** x 10^9 /L
  - Creatinine **2.2** mg/dL
  - Lactate **2.4** mmol/L
- I/O's:
  - Net fluid +2.5 L
- Physical Exam:
  - No acute distress. CAM negative for delirium. Flushed and diaphoretic, warm to the touch.
  - Tachycardic, with a regular rhythm. Lungs clear to auscultation.
  - Abdominal exam normal, no CVA tenderness

Case 2

Reflection Question

In the setting of ongoing sepsis, borderline hypotension, and known CHF (net fluid positive 2.5L) what would you do regarding her fluid administration?

a. Avoid further fluid administration.
b. Continue maintenance fluids, but avoid further aggressive fluid resuscitation.
c. Give a small bolus of 500 ml of isotonic saline.
d. Aggressively fluid resuscitate with isotonic saline (i.e. 2 L).



Fluid Resuscitation

Standard of Care

- Hypovolemia

Exam Finding	Sensitivity	Specificity	-LR	+LR
Dry Axilla	50%	82%	0.6	2.8
Prolonged Capillary Refill	34%	95%	0.7	6.9
Dry Mucous Membranes	85%	58%	0.3	2.0
Postural Hypotension (non-bleeding)	29%	81%	0.9	1.5
Postural tachycardia (non-bleeding)	43%	75%	0.8	1.7
Postural tachycardia (bleeding)	22% (moderate loss) 97% (large loss)	98% -	0.8	11

- Simel DL, Goldberg K, Raja A. Make the Diagnosis: Hypovolemia, Adult. The Rational Clinical Exam.

Fluid Resuscitation

Standard of Care

- Hypervolemia
  - Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-analysis

Table 1
Pooled Test Performance Characteristics for History and Physical Examination Findings

	No. of Studies	No. of Patients	% AHF (95% CI)	Sensitivity, % (95% CI)	Specificity, % (95% CI)	LR+ (95% CI)	LR− (95% CI)
Symptoms							
Orthopnea[7,8,14,16,19,21,36,48,49,53–55,58,60,65]	15	5,430	45.5 (44.2–46.9)	52.1 (50.1–54.0)	70.5 (68.8–72.1)	1.9 (1.4–2.5)	0.74 (0.64–0.85)
PND[7,8,14,35,48,51,53,59,64]	9	2,216	44.8 (42.8–46.9)	46.2 (43.7–48.6)	73.9 (71.9–75.9)	1.6 (1.2–2.1)	0.79 (0.71–0.88)
Dyspnea at rest[20,51,55,61]	4	2,038	37.9 (35.9–40.0)	54.6 (51.2–58.0)	49.6 (46.9–52.3)	1.1 (0.9–1.4)	0.88 (0.74–1.04)
Absence of productive cough[7,8,12,36,49,59,62]	7	2,414	43.0 (41.0–45.0)	82.0 (79.6–84.4)	25.8 (23.5–28.2)	1.13 (1.02–1.26)	0.6 (0.5–0.8)
Examination findings							
S3[7,8,14,15,20,53–55,57–60,64,65]	14	5,900	45.2 (44.0–46.5)	12.7 (11.5–14.0)	97.7 (97.2–98.2)	4.0 (2.7–5.9)	0.91 (0.88–0.95)
JVD[7,8,12,14–16,18,19,21,25,36,48,51,53–55,57–61,64,65]	23	8,012	47.8 (46.7–48.9)	37.2 (35.7–38.7)	87.0 (85.9–88.0)	2.8 (1.7–4.5)	0.76 (0.69–0.84)
Hepatojugular reflex[56,59,61,65]	4	1,209	60.4 (57.6–63.1)	14.1 (11.9–16.6)	93.4 (91.2–95.2)	2.2 (1.3–3.7)	0.91 (0.88–0.94)
Leg edema[7,8,10,12,14,15,16,18,19–21,23,25,48,49,51,53–55,57–62,65]	26	9,626	47.2 (46.2–48.2)	51.9 (50.5- 53.4)	75.2 (74.0–76.4)	1.9 (1.6–2.3)	0.68 (0.61–0.75)
Murmur[7,12,51,54,55,58,62,65]	8	4,004	45.3 (43.8–46.8)	27.8 (25.8–29.9)	83.2 (81.6–84.8)	1.9 (0.9–3.9)	0.93 (0.79–1.08)
Rales[7,8,10,12,15,18–21,23,25,36,48,51,53–55,58–61,65]	22	8,775	48.2 (47.1–49.2)	62.3 (60.8–63.7)	68.1 (66.7–69.4)	1.8 (1.5–2.1)	0.60 (0.51–0.69)
Wheezing[7,8,12,15,20,23,36,48,53,55,58,59,65]	13	6,970	44.2 (43.0–45.3)	22.3 (20.9–23.8)	64.0 (62.5–65.4)	0.6 (0.5–0.8)	1.19 (1.10–1.30)
Absent fever[7,23,36,49,59,62,63]	7	3,197	43.6 (41.9–45.3)	92.4 (90.9–93.8)	20.6 (18.8–22.5)	1.14 (1.02–1.27)	0.4 (0.3–0.6)

- Martindale JL, Wakai A, Collins SP, Levy PD, Diercks D, Heistand BC, Fermann GJ, deSouza I, Sinert R. Diagnosing Acute heart Failure in the Emergency Department: A Systematic Review and Meta-analysis. Acad Emerg Med. 2016;23(3):223-242.

Fluid Resuscitation

Standard of Care

- Volume Responsiveness

Exam Finding	Sensitivity	Specificity	-LR	+LR
CVP	62%	76%	0.5	2.6
Passive Leg Raise (Pulse Pressure)	79 – 86%	80 – 90%	0.45	3.6
Passive Leg Raise (Cardiac Output)	88%	92%	0.13	11

- Simel DL, Goldberg K, Raja A. Make the Diagnosis: Hypovolemia, Adult. The Rational Clinical Exam.

POCUS-Guided Fluid Resuscitation

Introduction

- DO NOT IGNORE THE GUIDELINES.
- POCUS may be beneficial to help guide IVF after initial resuscitation per guidelines.
- IVF Resuscitation is not a benign treatment.

POCUS-Guided Fluid Resuscitation

Fluid Responsiveness

- Definition: An increase in Cardiac output ~10% following a 500 ml bolus.
- Clinical Question -> Can IVC size and degree of respiratory variation predict which hypotensive patients will improve with IV fluids and which will not?

POCUS-Guided Fluid Resuscitation

Fluid Responsiveness

DOES RESPIRATORY VARIATION IN INFERIOR VENA CAVA DIAMETER PREDICT FLUID RESPONSIVENESS: A SYSTEMATIC REVIEW AND META-ANALYSIS

- "A small IVC is moderately predictive of fluid responsiveness, however, a dilated IVC cannot rule out fluid responsiveness."

Long E, Oakly E, Duke T, Babl FE. Does Respiratory Variation in Inferior Vena Cava Diameter Predict Fluid Responsiveness: A Systematic Review and Meta-Analysis. SHOCK 2017; 47(5):550–559.

POCUS-Guided Fluid Resuscitation

Fluid Responsiveness

- Volume Responsiveness

Exam Finding	Sensitivity	Specificity	-LR	+LR
CVP	62%	76%	0.5	2.6
Passive Leg Raise (Pulse Pressure)	79 – 86%	80 – 90%	0.45	3.6
Passive Leg Raise (Cardiac Output)	88%	92%	0.13	11
Respiratory Variation of IVC	63 – 76%	73 – 86%	0.28 – 0.51	2.33 – 5.43

- Simel DL, Goldberg K, Raja A. Make the Diagnosis: Hypovolemia, Adult. The Rational Clinical Exam.
- Long E, Oakly E, Duke T, Babl FE. Does Respiratory Variation in Inferior Vena Cava Diameter Predict Fluid Responsiveness: A Systematic Review and Meta-Analysis. SHOCK 2017; 47(5):550–559.
- Zhang Z, Xu X, Ye S, Xu L. Ultrasonographic Measurement of the Respiratory Variation in the Inferior Vena Cava Diameter is Predictive of Fluid Responsiveness in Critically Ill Patients: Systematic Review and Meta-Analysis. Ultrasound in Med & Bio. 2014;40(5):845-853.

POCUS-Guided Fluid Resuscitation

Fluid Tolerance

- Definition: The ability to receive IV fluids without developing adverse affects; such as, pulmonary edema/hypoxia.
- Clinical Question -> Can POCUS help determine who will likely tolerate additional fluid administration?
  - Integrated POCUS exam of heart, IVC and lungs.
  - Based upon expert opinion; not supported by current evidence.

- Theerawit P, Tomuan N, Sutherasan Y, Kiatboonsri S. Critical Care 2012,16(Suppl 1): P248. doi: 10.1186/cc10855.
- Lictenstein D, Karakitsos D. Integrating lung ultrasound in the hemodynamic evaluation of acute circulatory failure (the fluid administration limited by lung sonography protocol). Journal of Critical Care (2012)27, 533.e11–533.e19.

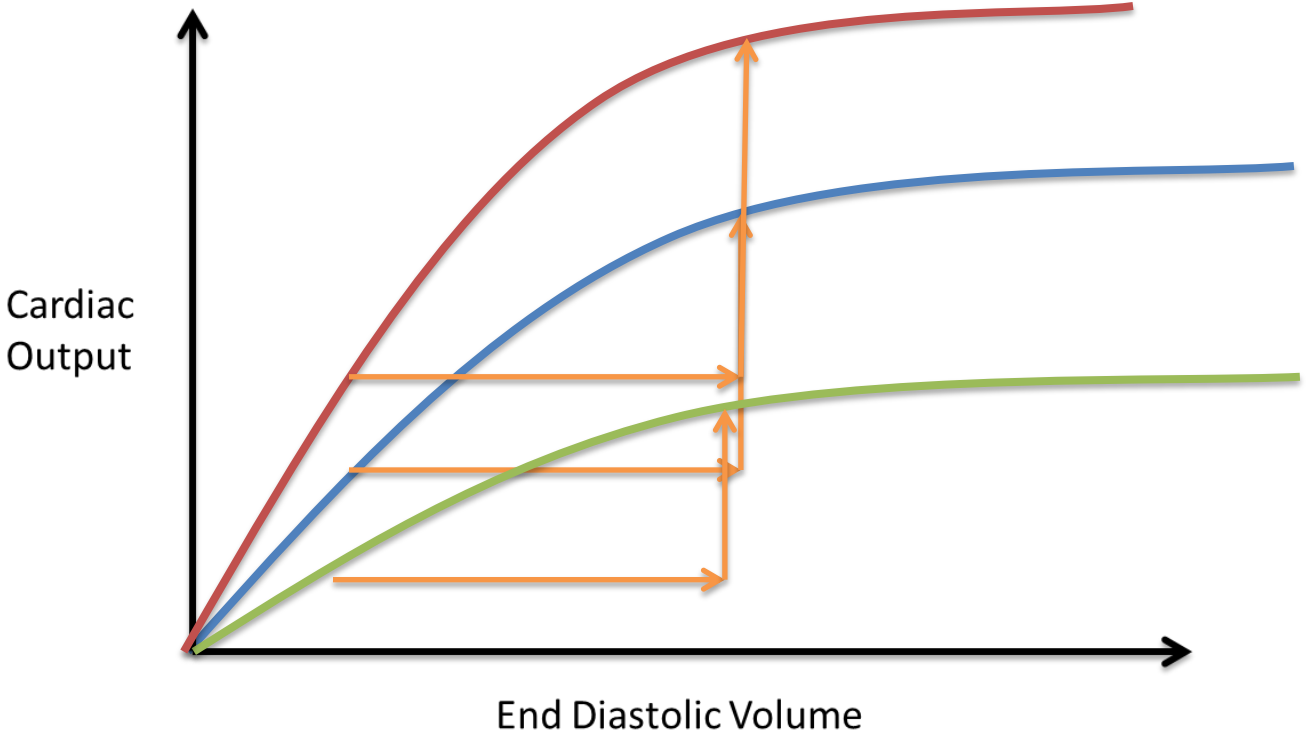
Lung Ultrasound

Introduction

- Scope:
  - Pulmonary edema
  - Consolidation/Pneumonia
  - Pleural effusions
  - Pneumothorax
  - PE, Asthma, COPD (in the absence of other findings)
- Indications:
  - Hypoxia / Dyspnea.
  - Cough
  - Assessing volume status / Fluid resuscitation.

POCUS-Guided Fluid Resuscitation

Fluid Tolerance



- Theerawit P, Tomuan N, Sutherasan Y, Kiatboonsri S. Critical Care 2012,16(Suppl 1): P248. doi: 10.1186/cc10855.
- Lictenstein D, Karakitsos D. Integrating lung ultrasound in the hemodynamic evaluation of acute circulatory failure (the fluid administration limited by lung sonography protocol). Journal of Critical Care (2012)27, 533.e11–533.e19.

POCUS-Guided Fluid Resuscitation

Fluid Tolerance

	Fluid Tolerance	Mixed Findings	Fluid Intolerance
Heart	Hyperdynamic LV Small RV / Normal RV Function	Reduced LV Function	Reduced LV Function Dilated RV / reduced RV Function
IVC	Small Collapsing	Small Collapsing	Large Reduced collapse
Lung	A-Lines	A-Lines	Diffuse B-Lines

Fluid Tolerant

POCUS-Guided Fluid Resuscitation

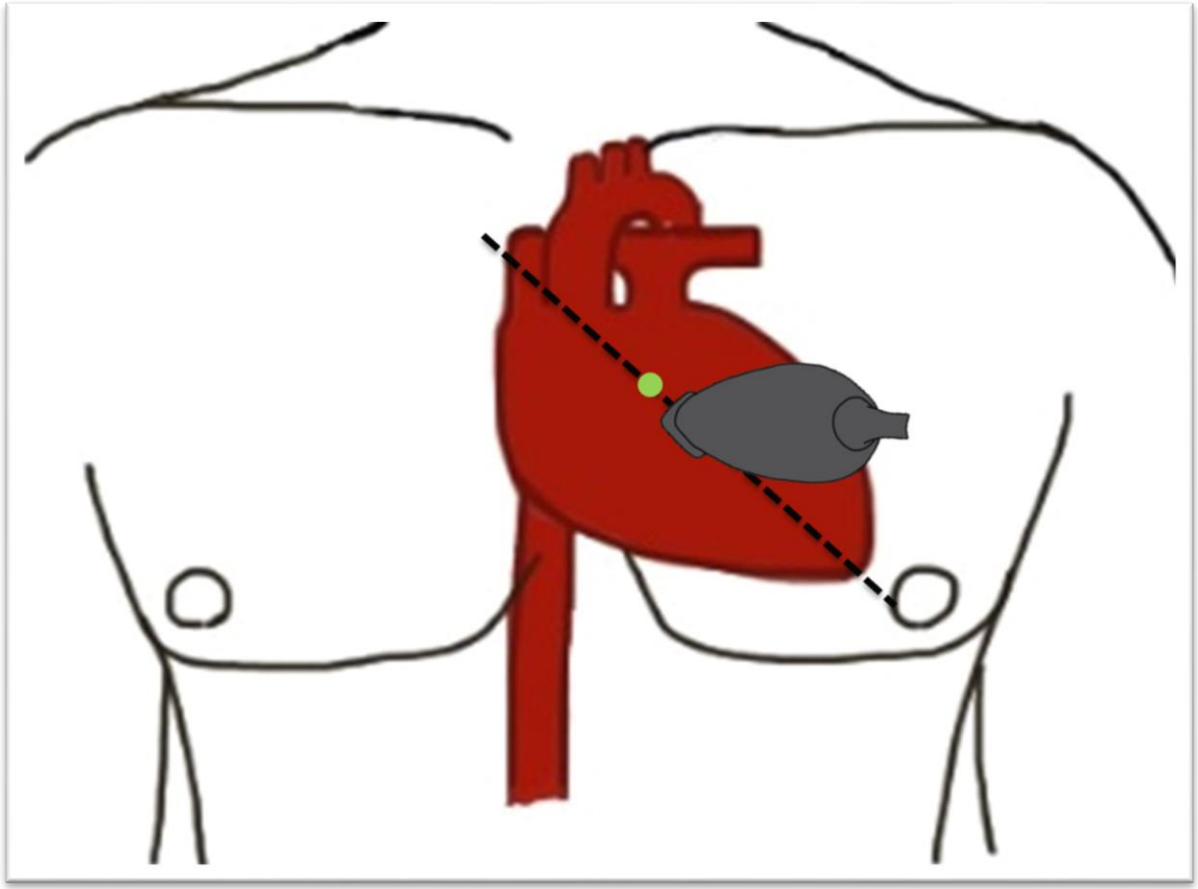
Fluid Tolerance

	Fluid Tolerance	Mixed Findings	Fluid Intolerance
Heart	Hyperdynamic LV Small RV / Normal RV Function	Normal Systolic Function	Reduced LV Function Dilated RV / reduced RV Function
IVC	Small Collapsing	Large Not collapsing	Large Reduced collapse
Lung	A-Lines	Diffuse B-Lines	Diffuse B-Lines

Fluid Intolerant

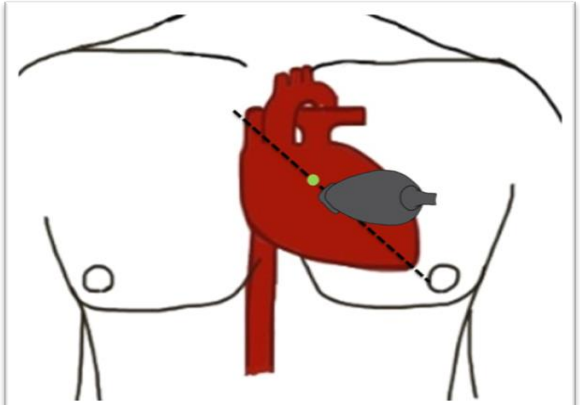
POCUS-Guided Fluid Resuscitation

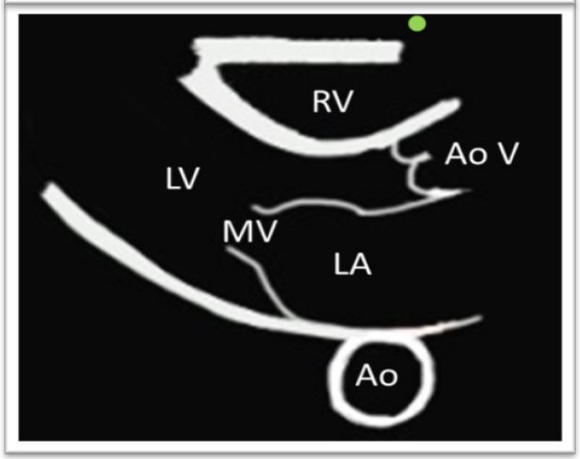
Parasternal Long Axis (PLAX)

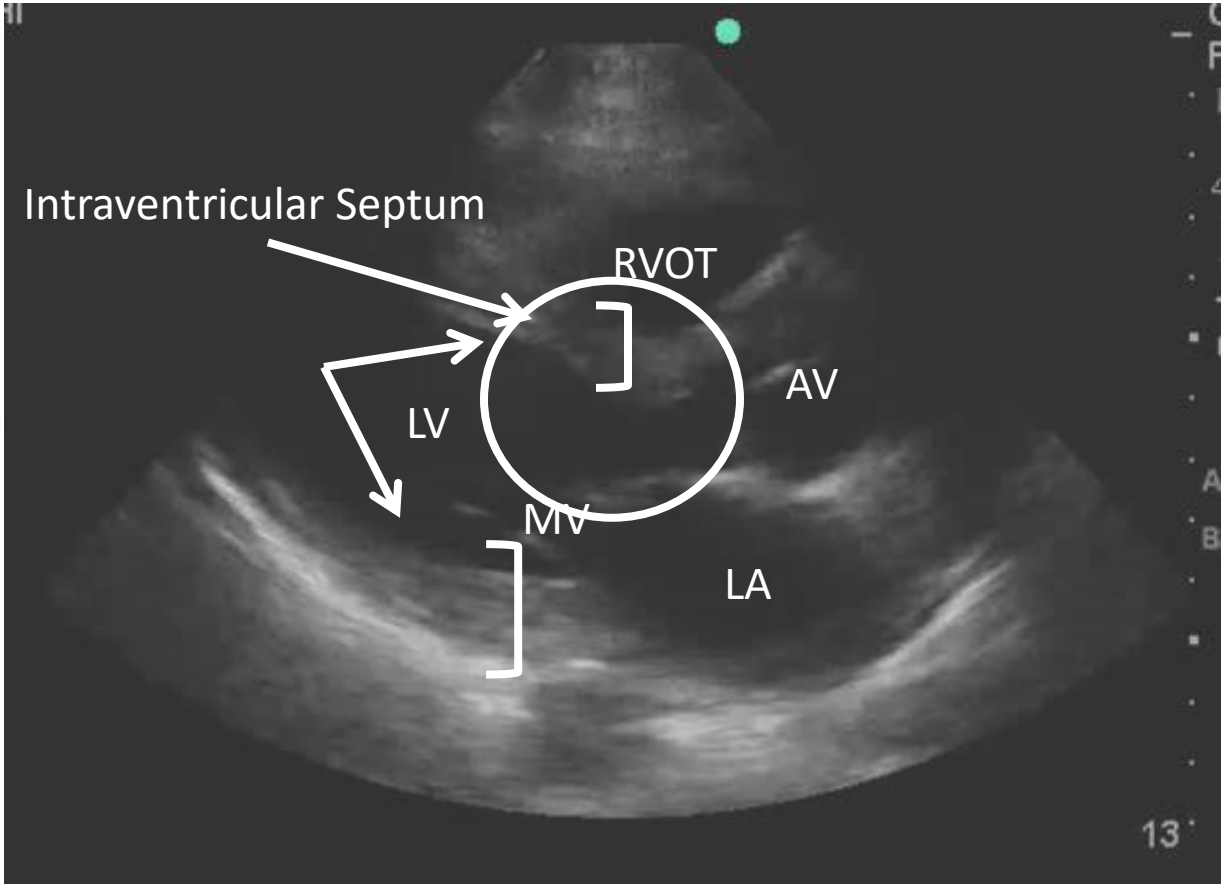


POCUS-Guided Fluid Resuscitation

Parasternal Long Axis (PLAX)

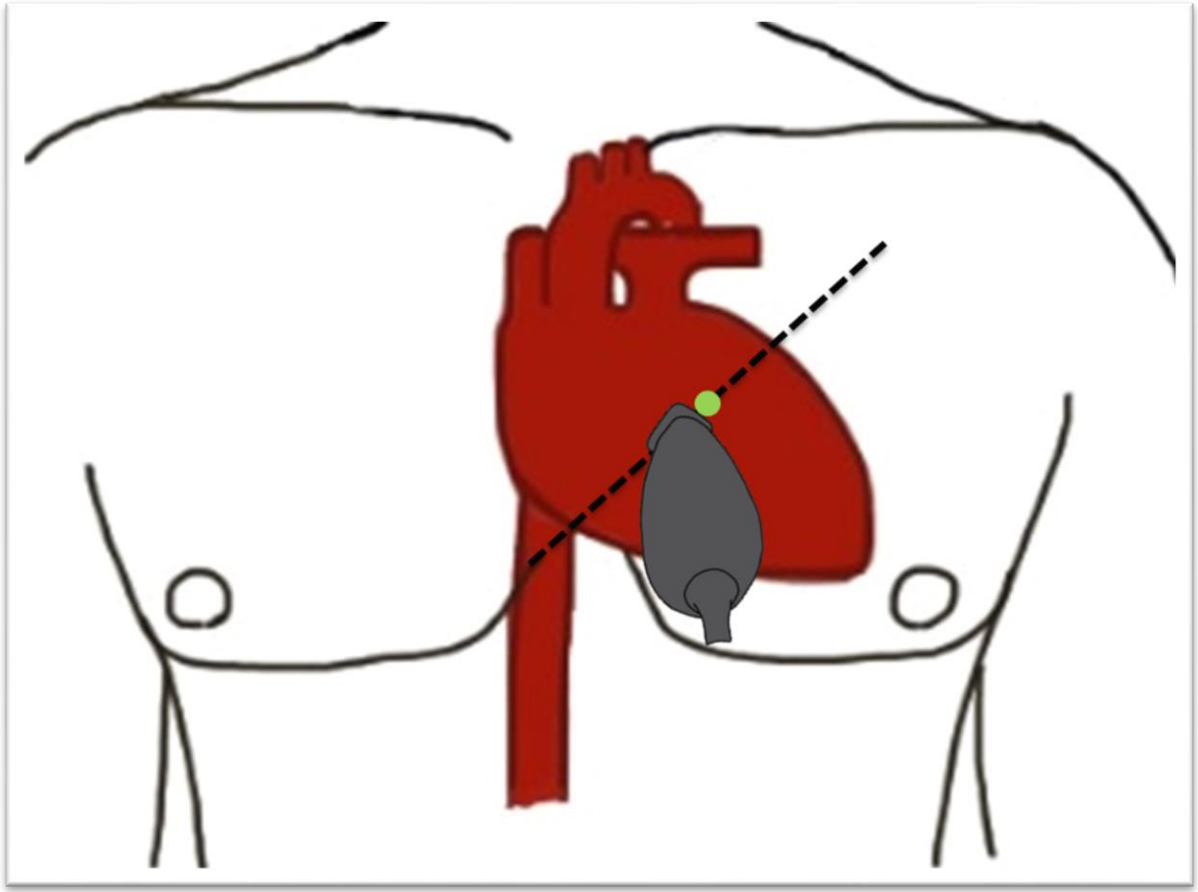






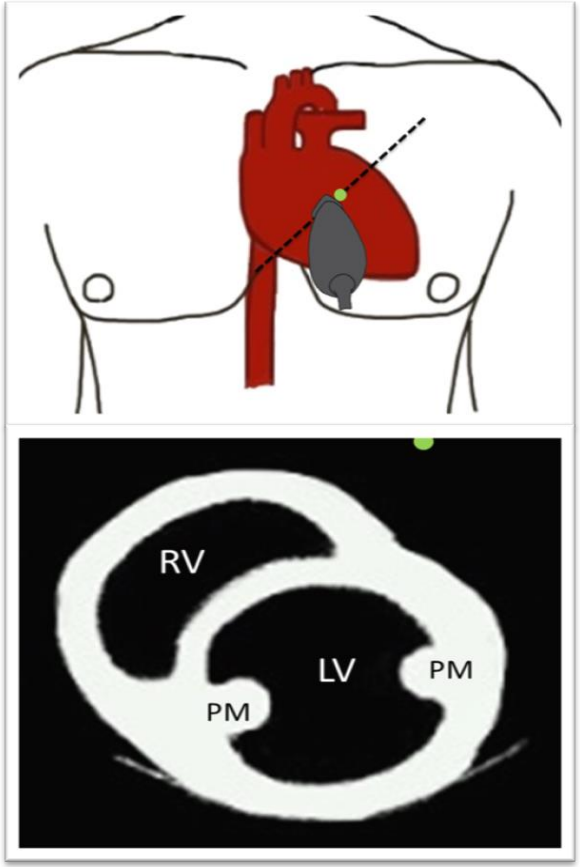
POCUS-Guided Fluid Resuscitation

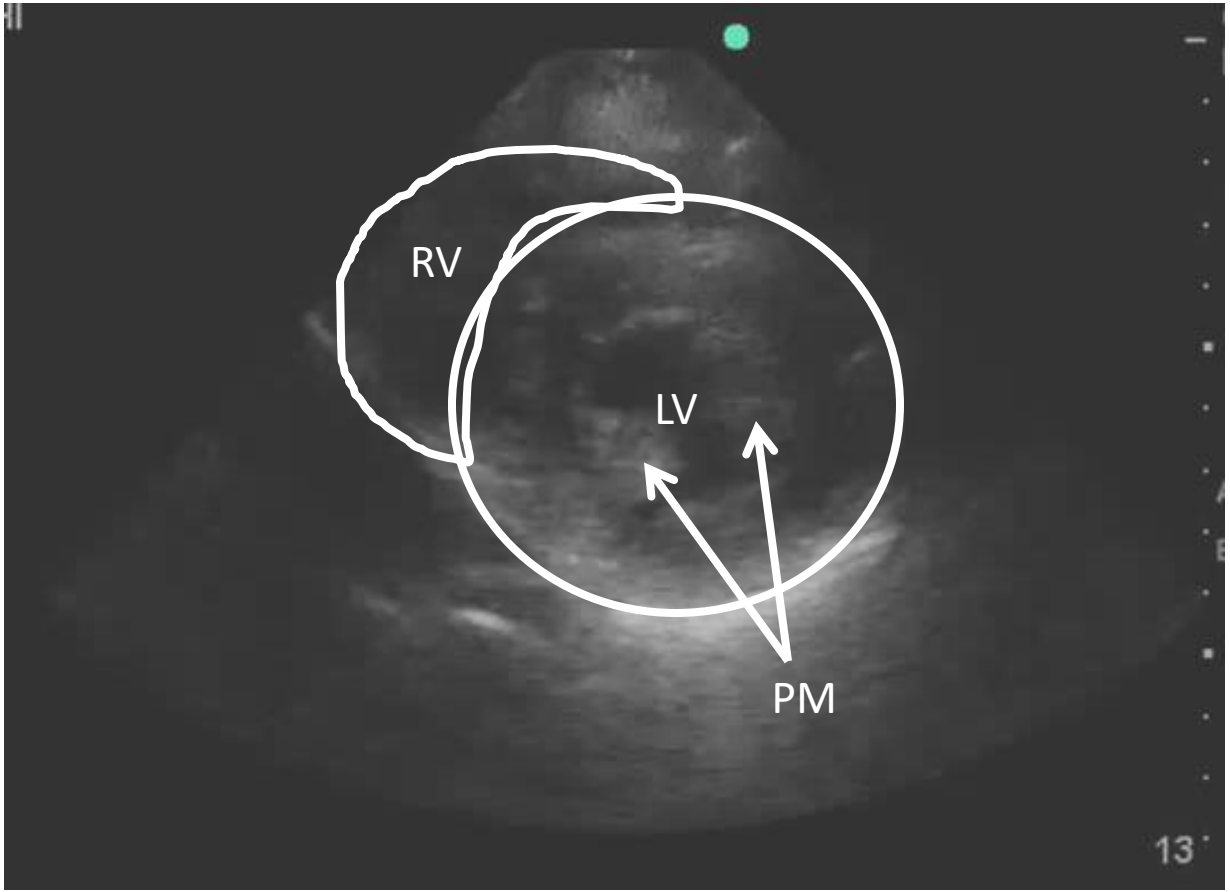
Parasternal Short Axis (PSAX)



POCUS-Guided Fluid Resuscitation

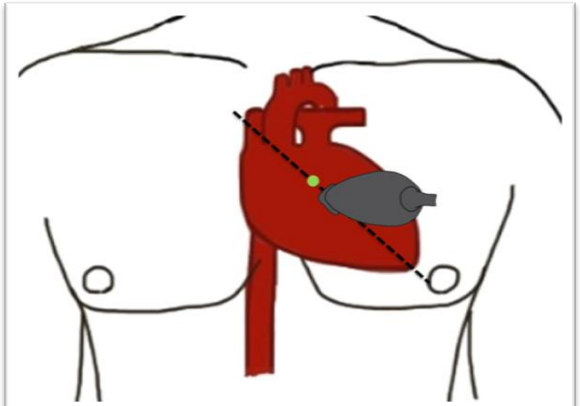
Parasternal Short Axis (PSAX)

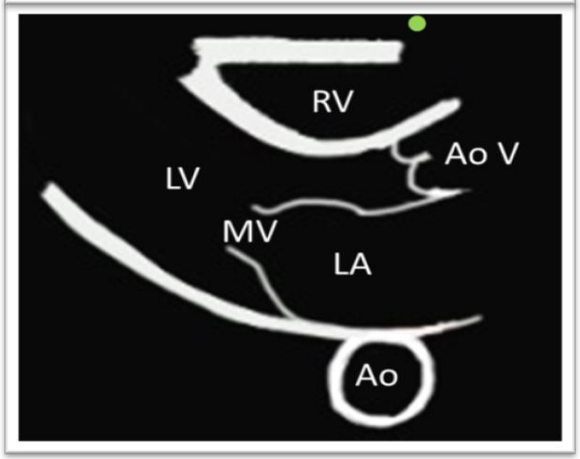


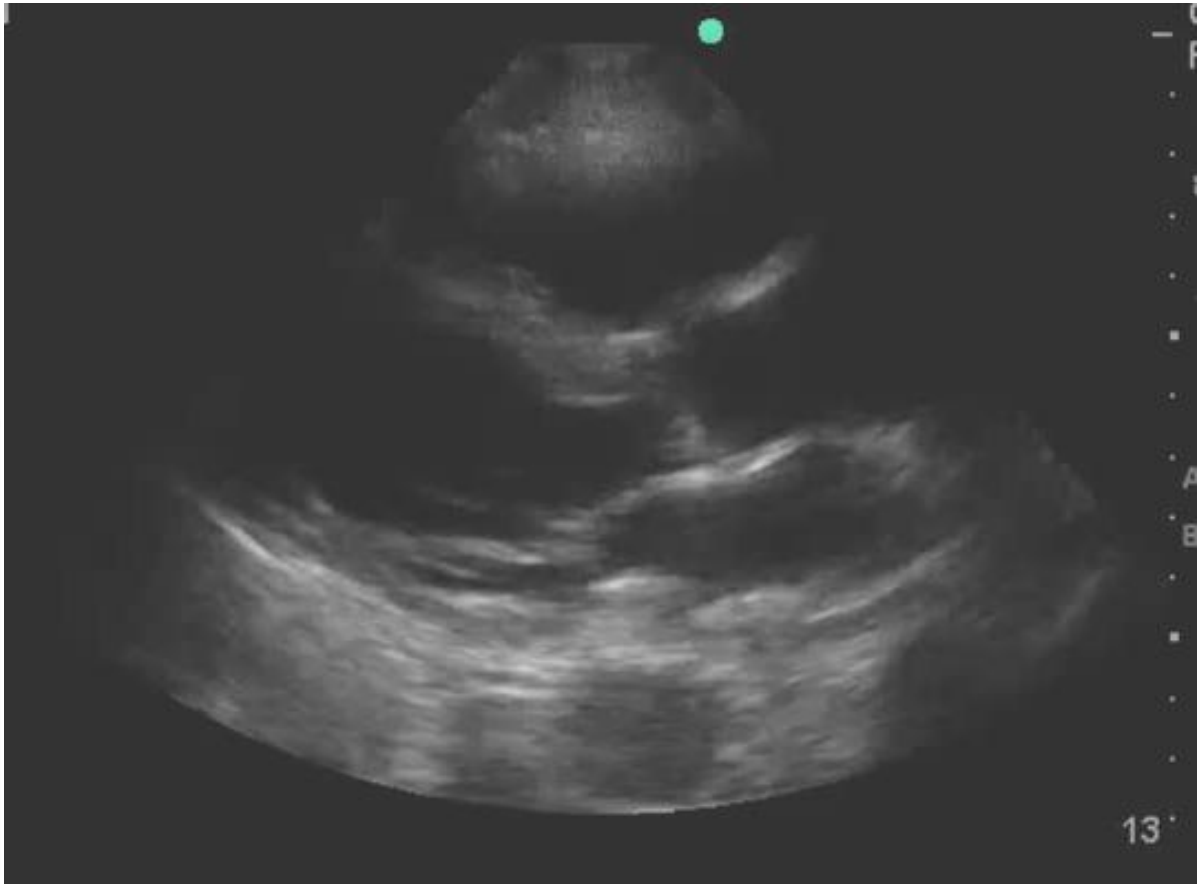


Case 2

Parasternal Long Axis (PLAX)

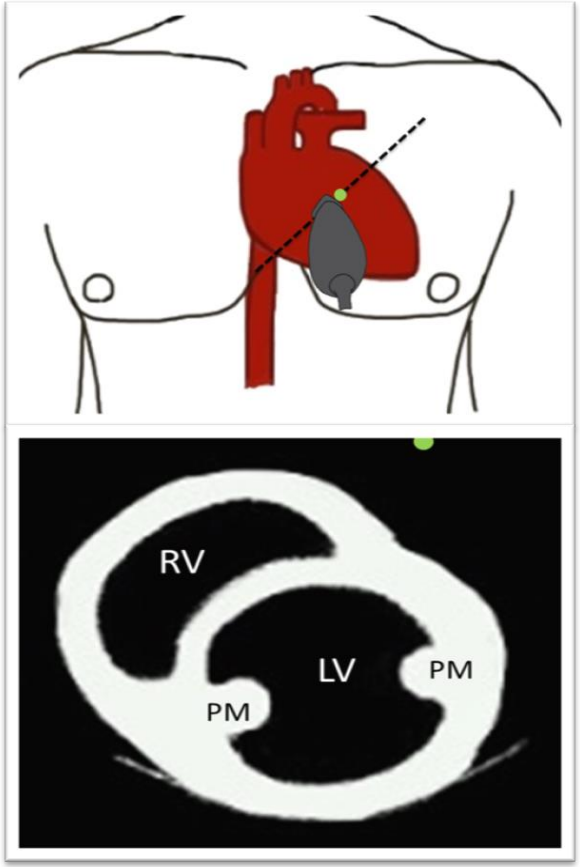






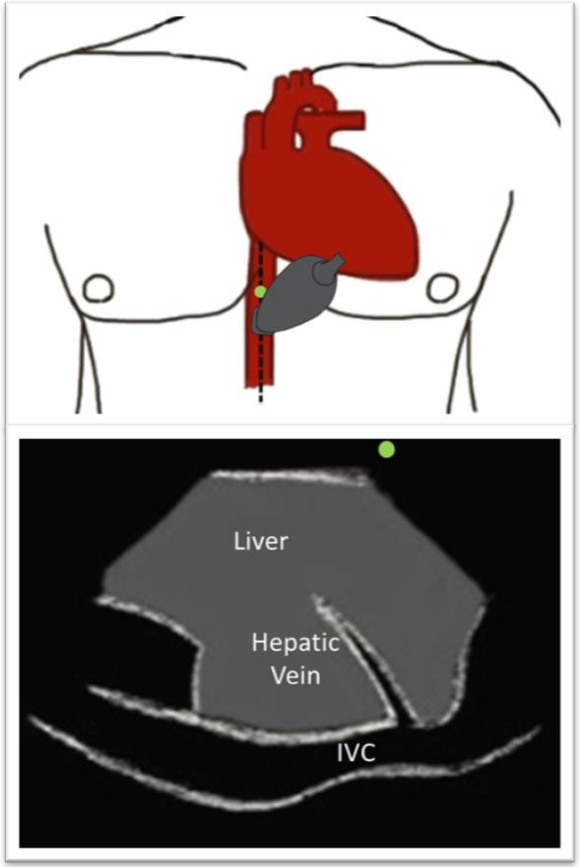
Case 2

Parasternal Short Axis (PSAX)



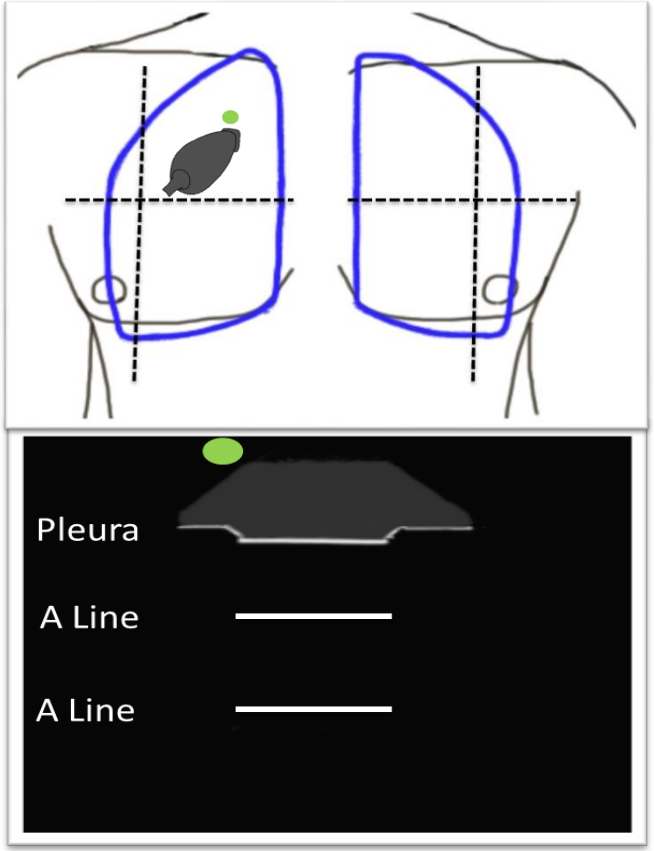
Case 2

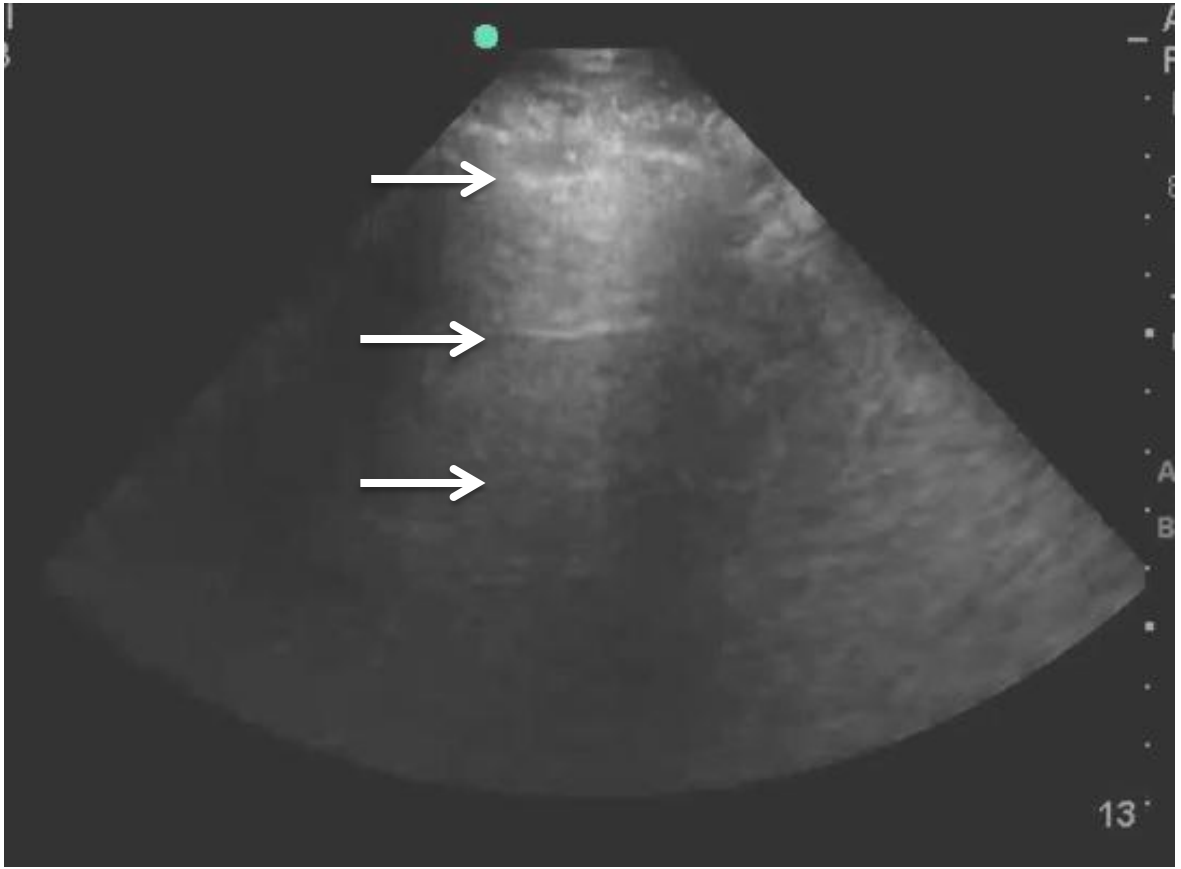
Inferior Vena Cava (IVC)



Case 2

A Lines + Lung Sliding





Case 2

Reflection Question

In the setting of ongoing sepsis, borderline hypotension, and known CHF (net fluid positive 2.5L) what would you do regarding her fluid administration?

a. Avoid further fluid administration.
b. Continue maintenance fluids, but avoid further aggressive fluid resuscitation.
c. Give a small bolus of 500 ml of isotonic saline.
d. Aggressively fluid resuscitate with isotonic saline (i.e. 2 L).

POCUS in Sepsis

Literature Review

- Accuracy of point of care ultrasound to identify the source of infection in septic patients: a prospective study

Standard of Care (History / Physical / Basic labs)

vs

Standard of Care + Targeted POCUS (Kidneys, soft tissues, lungs, gallbladder, etc.)

POCUS in Sepsis

Literature Review

- Accuracy of point of care ultrasound to identify the source of infection in septic patients: a prospective study

	Standard of Care	Standard of Care + POCUS
Sensitivity	48%	73%
Specificity	86%	95%
LR+	3.54	16.1
LR-	0.59	0.28
Diagnostic Accuracy	53%	75%

POCUS in Sepsis

Literature Review

- Accuracy of point of care ultrasound to identify the source of infection in septic patients: a prospective study
  - Antibiotic Regimen altered in 24% of cases
  - Diagnosis made substantially quicker

Focused Renal Ultrasound

Introduction

- Scope:
  - Nephrolithiasis
  - Hydronephrosis
- Indications:
  - AKI
  - UTI with Sepsis
  - Renal colic

Focused Renal Ultrasound
Literature Review

	Sensitivity	Specificity
Nephrolithiasis	19 – 62%	90 – 98%
Hydronephrosis	72 – 97%**	73 – 93%

**Sensitivity improved with IV fluid resuscitation.

- Yilmaz S, Sindel T, Arslan G, Ozkaynak C, Karaali K, et al. Renal colic: Comparison of spiral CT, US, and IVU in detection of ureteral calculi. Eur Radiol. 1998;8:212-217.
- Sheafor DH, Hertzber BS, Freed KS, Carroll BA, Keogan MT, Paulson EK, DeLong DM, Nelson RC. Nonenhanced Helical CT and US in the Emergency Evaluation of Patients with Renal Colic: Prospective Comparison. Radiology. 2000;217:792–797.
- Fowler KA, Locken JA, Duchesne JH, Williamson MR. US for Detecting Renal Calculi with Nonenhanced CT as a Reference Standard. Radiology. 2002; 222:109–113.
- Kanno T, Kubota M, Sakamoto H, Nishiyama R, Okada T, Higashi Y, Yamada H. Determining the Efficacy of Ultrasonography for the Detection of Ureteral Stone. Urology. 2014;84:533-537.

Focused Renal Ultrasound

Ultrasound First Approach

ORIGINAL ARTICLE

Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis

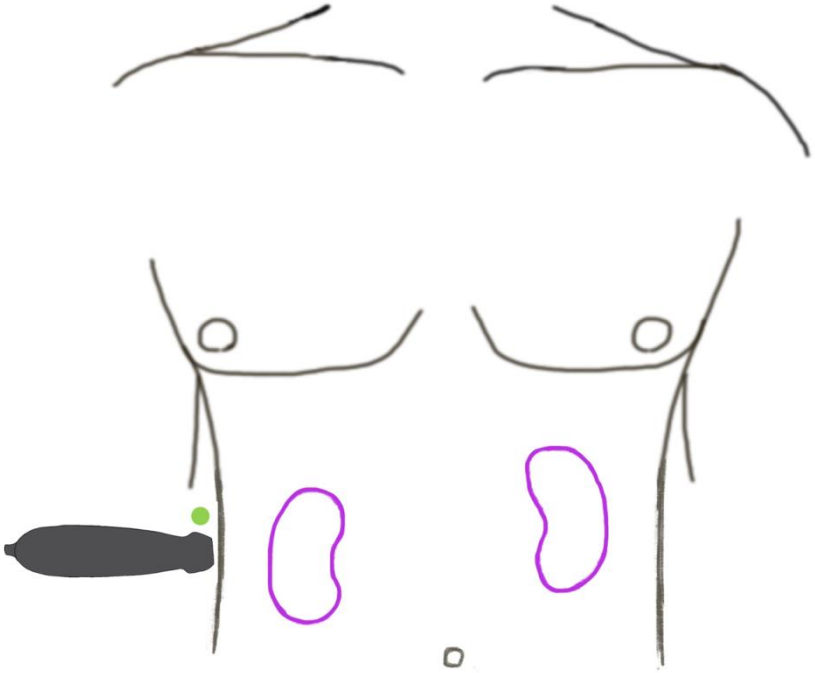
Rebecca Smith-Bindman, M.D., Chandra Aubin, M.D., R.D.M.S., John Bailitz, M.D., Rimon N. Bengiamin, M.D., R.D.M.S., Carlos A. Camargo, Jr., M.D., Dr.P.H., Jill Corbo, M.D., R.D.M.S., Anthony J. Dean, M.D., Ruth B. Goldstein, M.D., Richard T. Griffey, M.D., M.P.H., Gregory D. Jay, M.D., Ph.D., Tarina L. Kang, M.D., Dana R. Kriesel, M.P.H., M.S., et al.

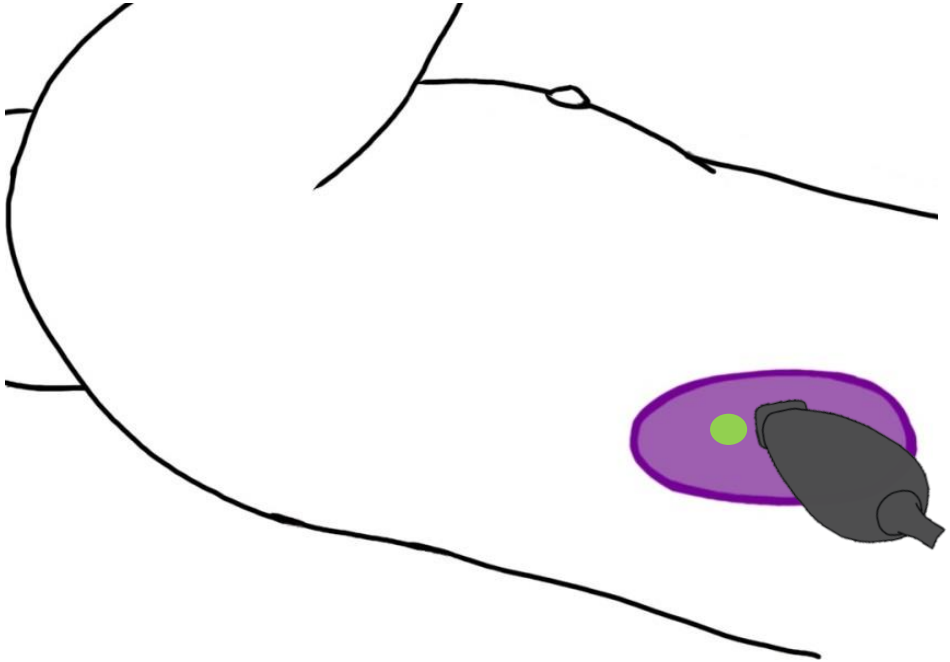
- POCUS vs Radiology Ultrasound vs CT for initial evaluation.
- No statistical difference in:
  - Serious adverse events
  - Average pain score (at day 7)
  - Return ED visits or Hospitalizations
  - Overall diagnostic accuracy.

Smith-Bindman R, Aubin C, Bailitz J, et al. Ultrasonographyversus computed tomography for suspected nephrolithiasis. NEngl J Med. 2014;371(12):1100-1110.

Focused Renal Ultrasound

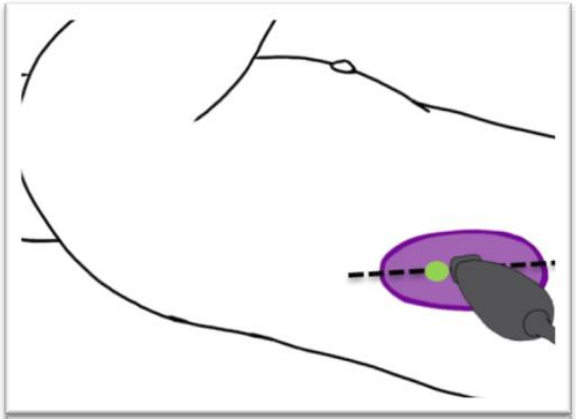
Longitudinal Axis

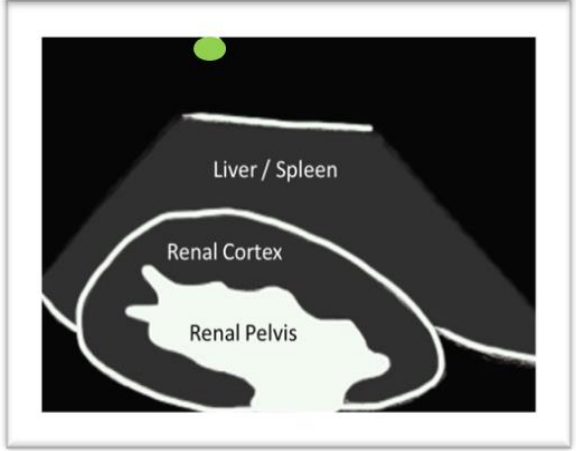


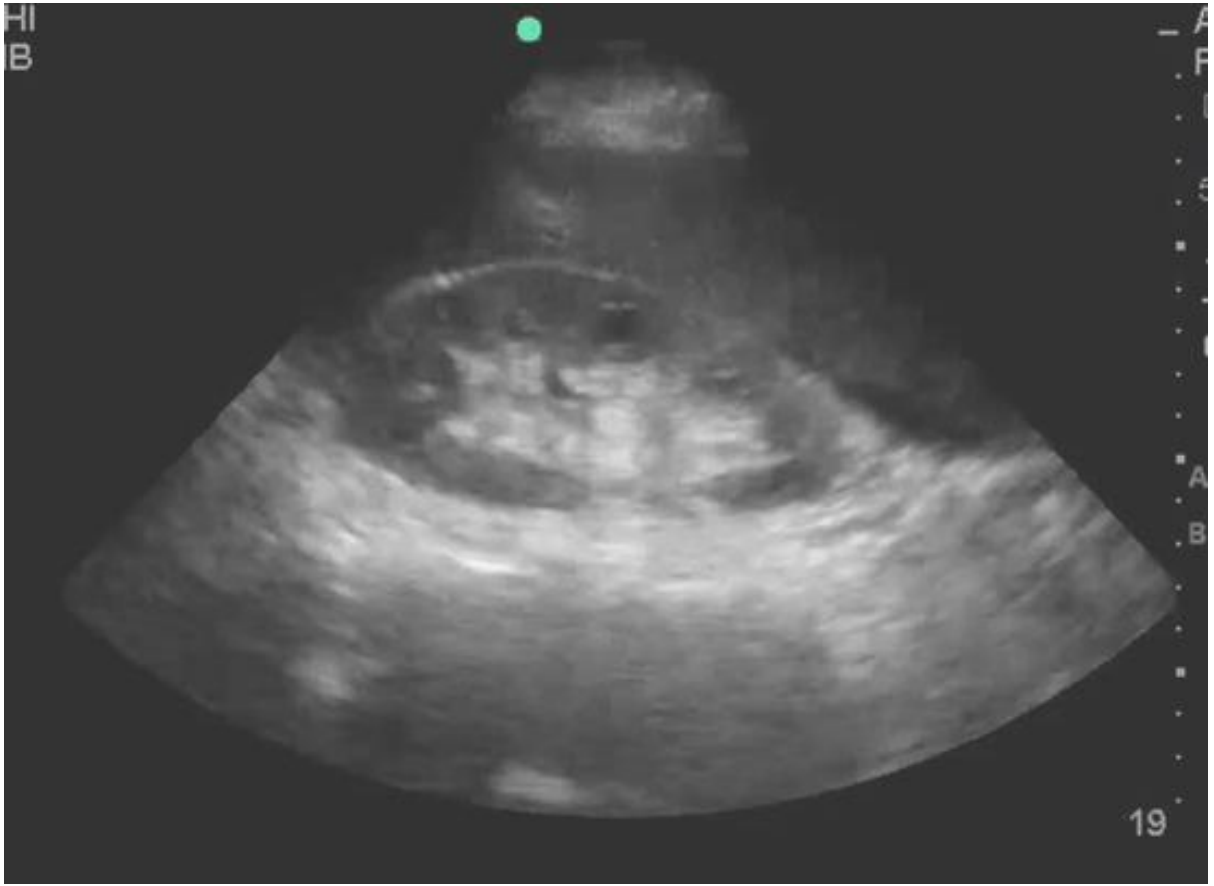


Focused Renal Ultrasound

Longitudinal Axis

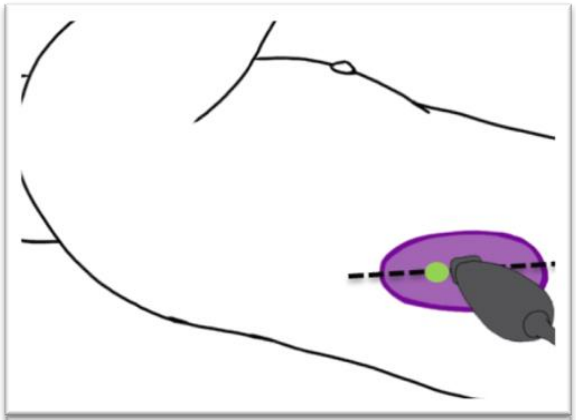


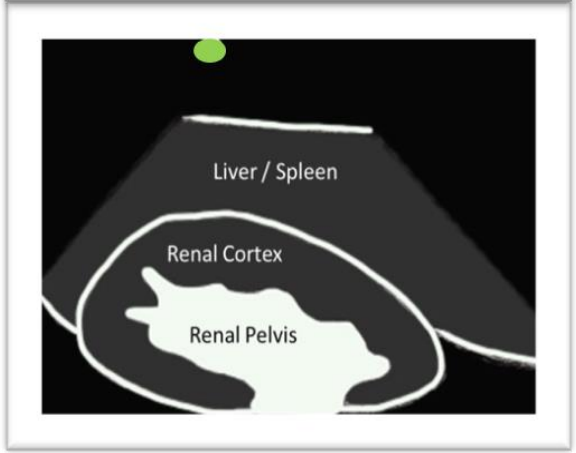


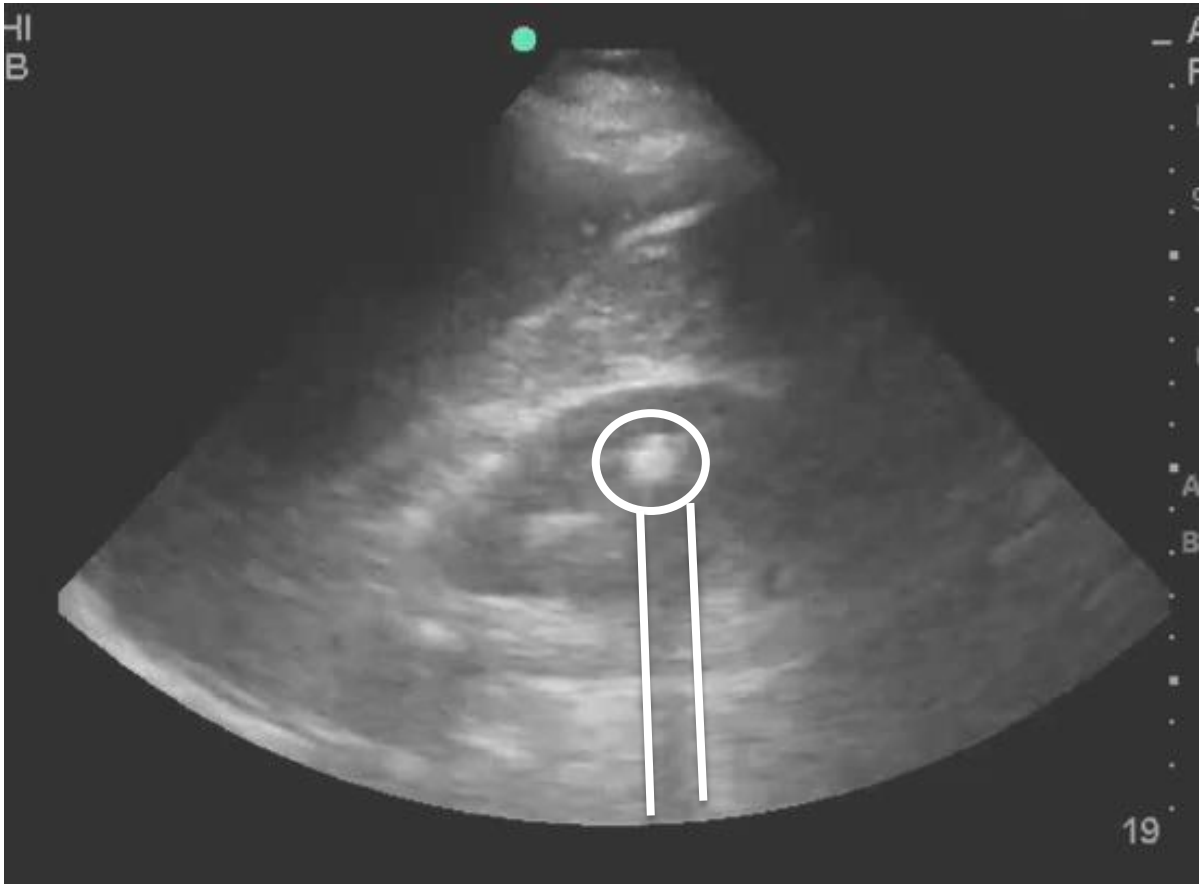


Focused Renal Ultrasound

Nephrolithiasis

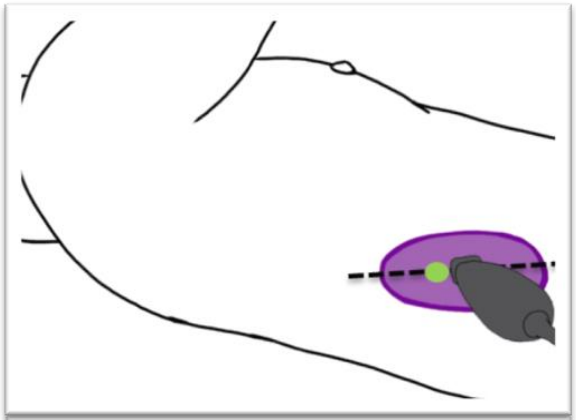


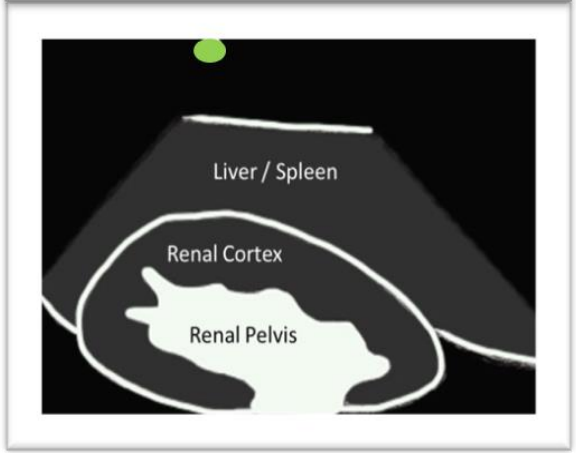


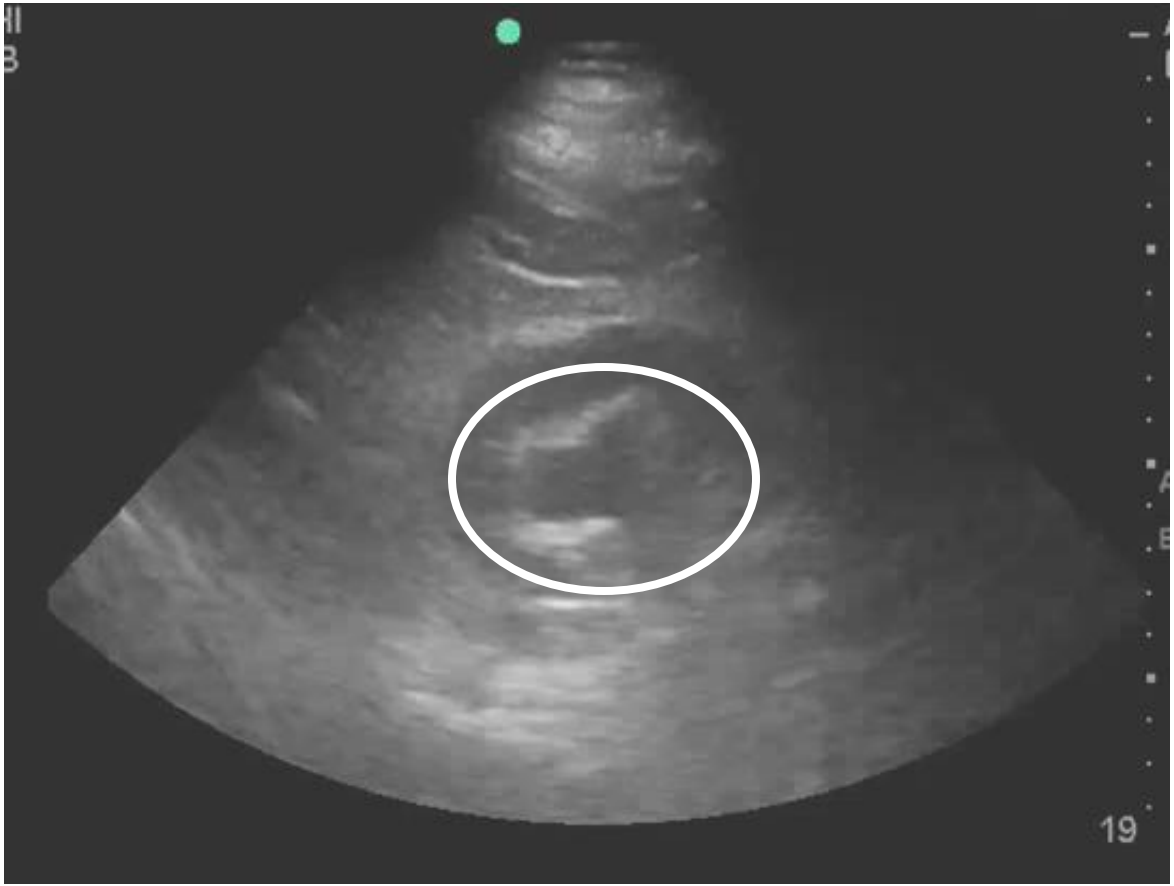


Focused Renal Ultrasound

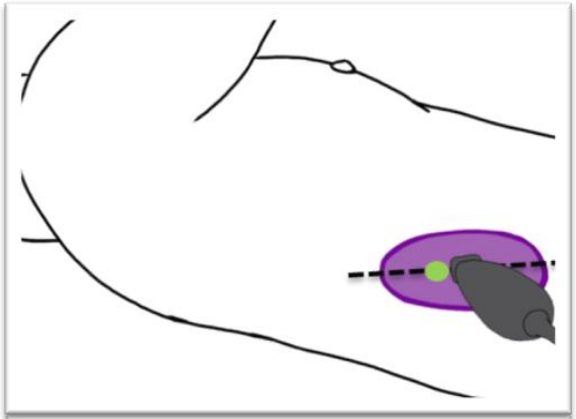
Hydronephrosis

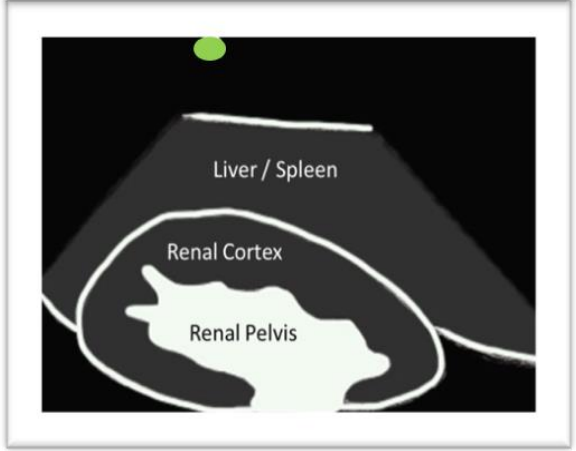






Case 2
Left Kidney





Case 2
Conclusion

- Found to be fluid tolerant, and aggressively fluid resuscitated.
- Focused Renal Ultrasound demonstrates unilateral hydronephrosis, concerning for distal obstruction.
  - CT abdomen/pelvis confirms obstructive stone.
  - Emergent urostomy tube placed.

Case 3

HPI

- A 70 year-old female hospitalized for COPD exacerbation.
- PMH:
  - COPD
  - Chronic hypoxic respiratory failure
  - Diastolic heart failure
  - Diabetes mellitus type II

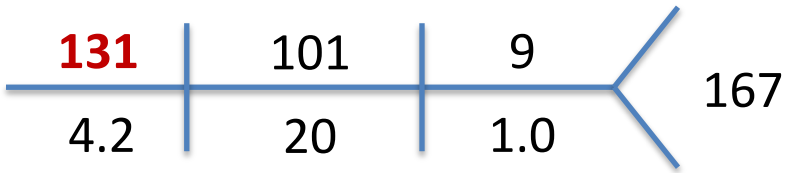
Case 3

HPI

- Vital signs
  - HR **103**
  - BP 123/58
  - RR **22**
  - Temp **37.8**
  - SpO2 91% on 5 L/min nasal cannula

Case 3

Labs



- Lactate **2.7**

Case 3

HPI

- HPI:
  - Erythema of the left thigh began overnight. No expansion noted.
  - Swelling and pain increased.
- Physical Exam:
  - Poorly demarcated area of erythema. Tender to palpation. Fluctuance noted on palpation.

Focused Soft Tissue Ultrasound

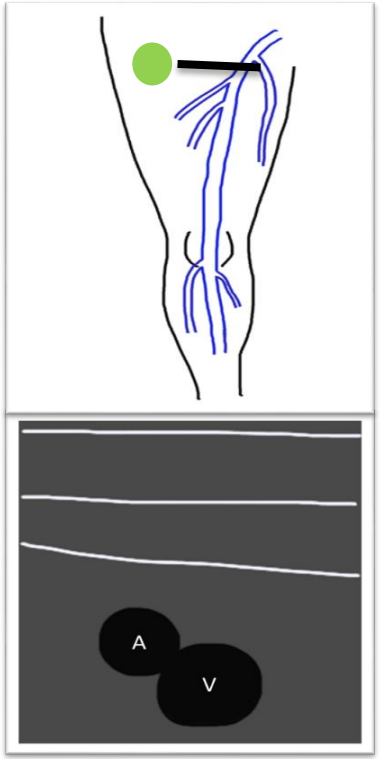
Introduction

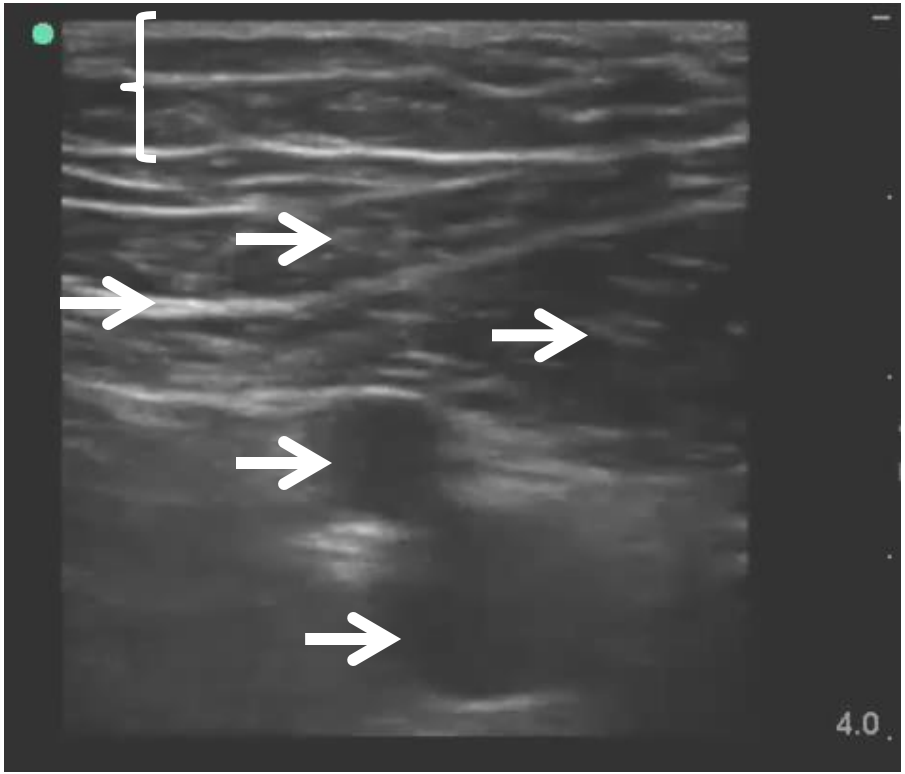
- Scope
  - Skin and Soft Tissue Infection (SSTI)
    - Differentiation of cellulitis and abscess
  - Foreign body identification

Focused Soft Tissue Ultrasound

Image Interpretation

- Normal

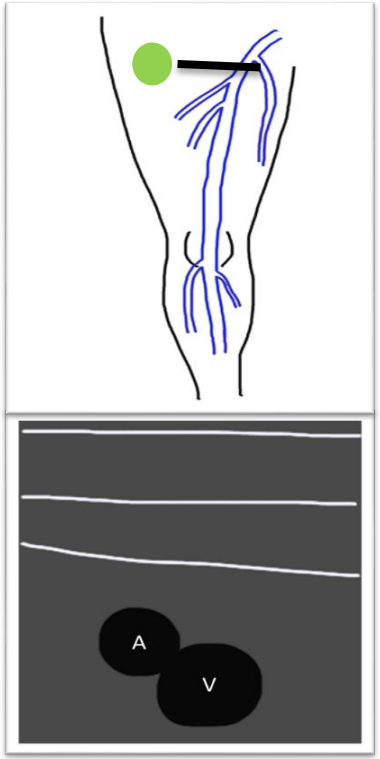


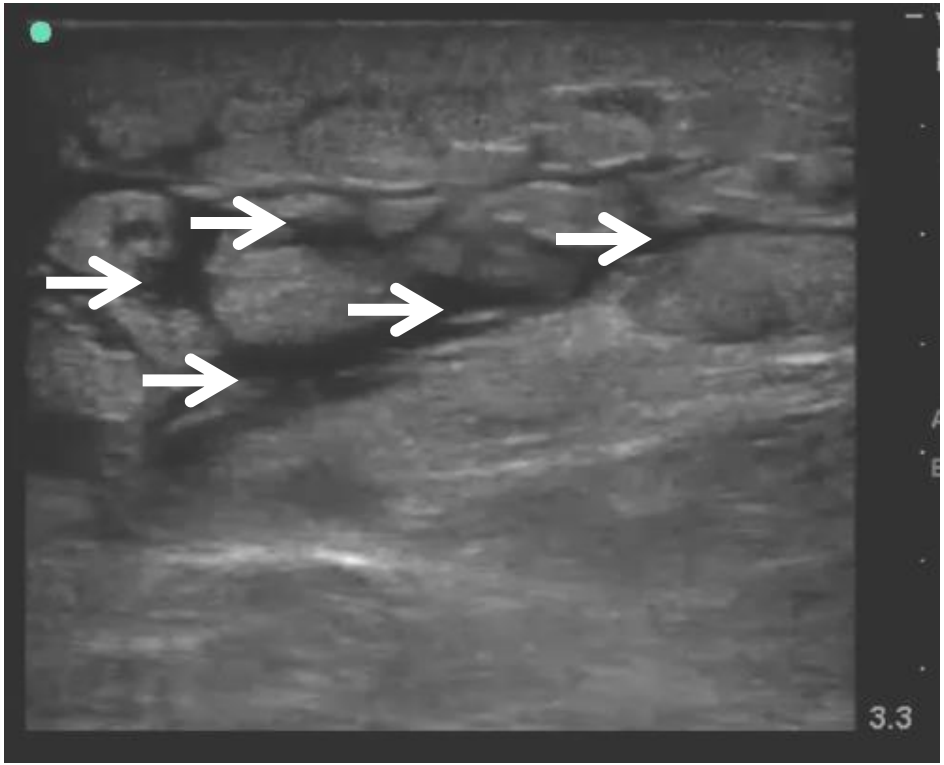


Focused Soft Tissue Ultrasound

Image Interpretation

- Cellulitis

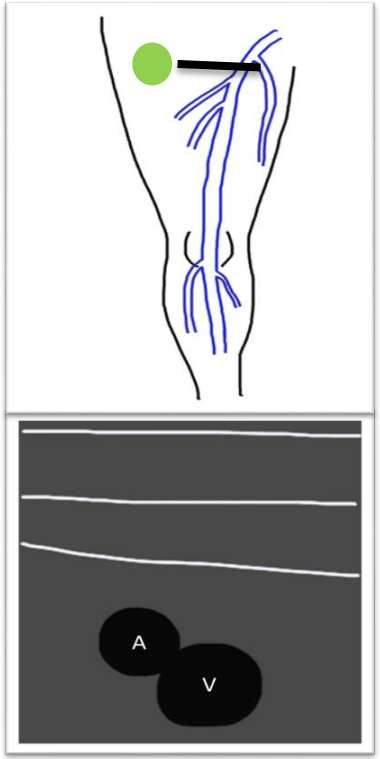


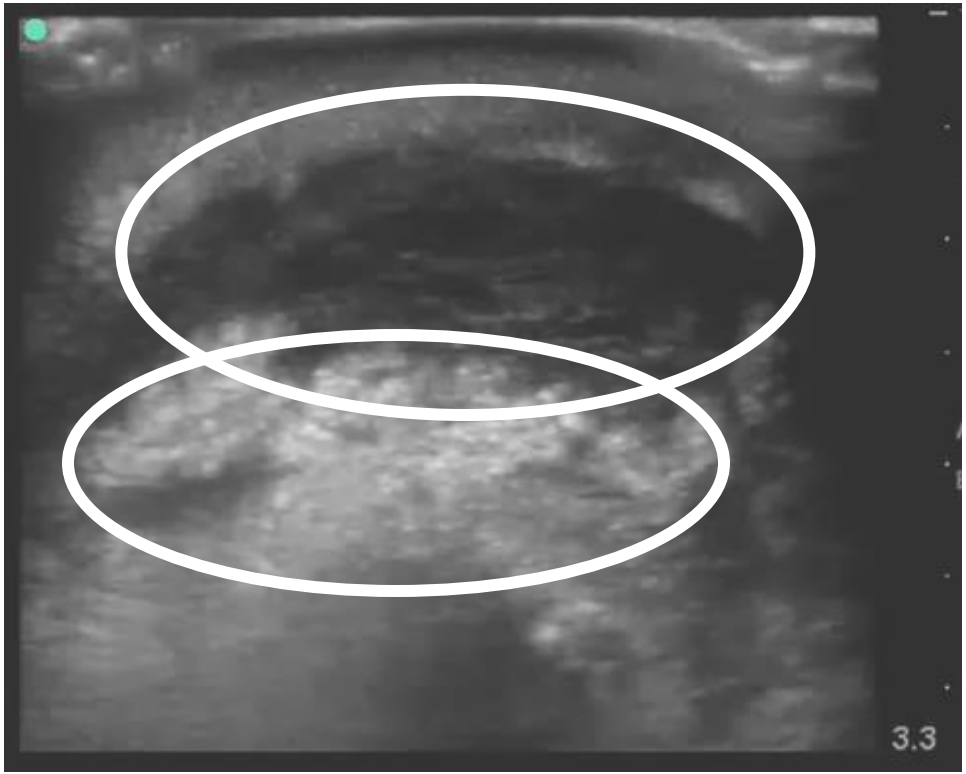


Focused Soft Tissue Ultrasound

Image Interpretation

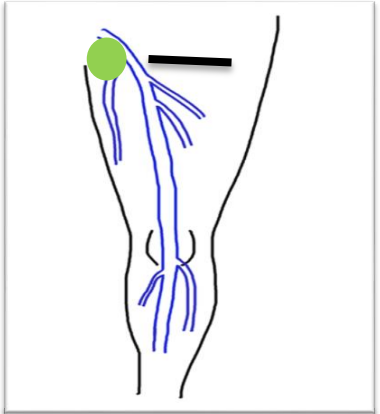
- Abscess

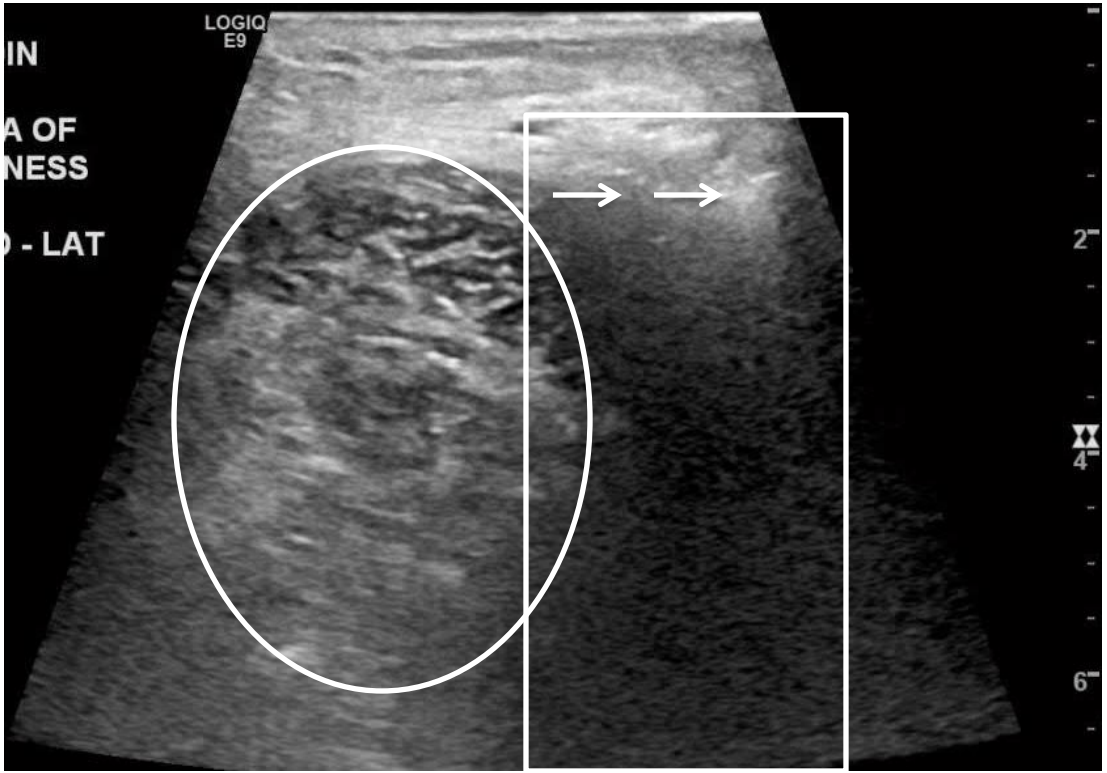




Case 3

Focused Soft Tissue Ultrasound





Case 3

Conclusion

- STAT CT pelvis and general surgery consult placed.
- STAT broad-spectrum antibiotics initiated.
- CT confirmed findings consistent with necrotizing soft tissue infection.
- Emergent surgical debridement pursued.

Case 3

CT

Focused Soft Tissue Ultrasound

Literature Review

- 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

Focused Soft Tissue Ultrasound

Literature Review

- Necrotizing Fasciitis
  - Test Characteristics:
    - Sensitivity 88.2%
    - Specificity 93.3%
    - 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.

Presentation Conclusion

By Case

- Case 1
  - POCUS aids in diagnostic evaluation of hypotensive patients.
  - Incorporation of POCUS has not been show to have a mortality benefit.
- Case 2
  - POCUS cannot rule in / out fluid responsiveness, however, can likely help guide fluid management.
  - POCUS aids in evaluating septic patients.
  - POCUS-first approach for suspected nephrolithiasis is safe and beneficial for identifying occult pathology.
- Case 3
  - POCUS improves evaluation and treatment of SSTIs.

Questions?

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