Point-of-Care Ultrasound and Physical Examination for the Hospitalist

Discussants:

Ian Ross, M.D., FACP

Assistant Professor of Medicine
Washington University School of Medicine
John Cochran VA, Medicine Service

Richard Shellenberger, D.O., FACP

Associate Program Director
Internal Medicine Residency, Trinity Health Ann Arbor Hospital , Ann Arbor, Michigan

Moderator:

Woo Moon, D.O., FACP

Associate Professor of Medicine
Mercy Hospitalists & Mercy St. Louis IM Residency

Disclosures

- None

Learning Objectives

- Recognize diagnostic strengths and limitations of physical examination and POCUS
- Compare and contrast physical exam, POCUS and standard studies for diagnoses commonly encountered by the hospitalist
- Develop a diagnostic approach integrating both modalities

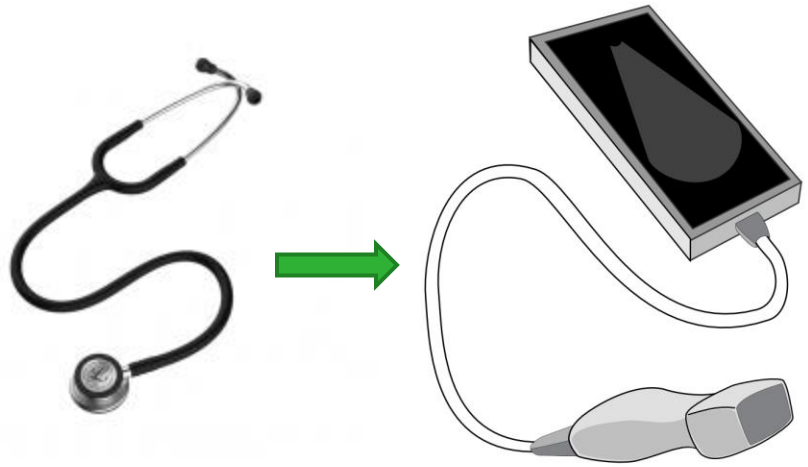
Dr. Shellenberger and the physical exam-based approach

- Background
  - MSUCOM medical school – Good education in PE
  - SJMHAA – now Trinity Health for Residency and now Faculty/APD
- What I like most about Physical Exam
  - It is what makes us “Physicians” and clinicians
- How I use Physical Exam in my practice
  - Rely on the PE for all clinical decisions
- 1 common myth about Physical Exam (dispelled)
  - That it is not accurate, reliable or cool!

Dr. Ross and the POCUS-based approach

POCUS = point-of-care ultrasound

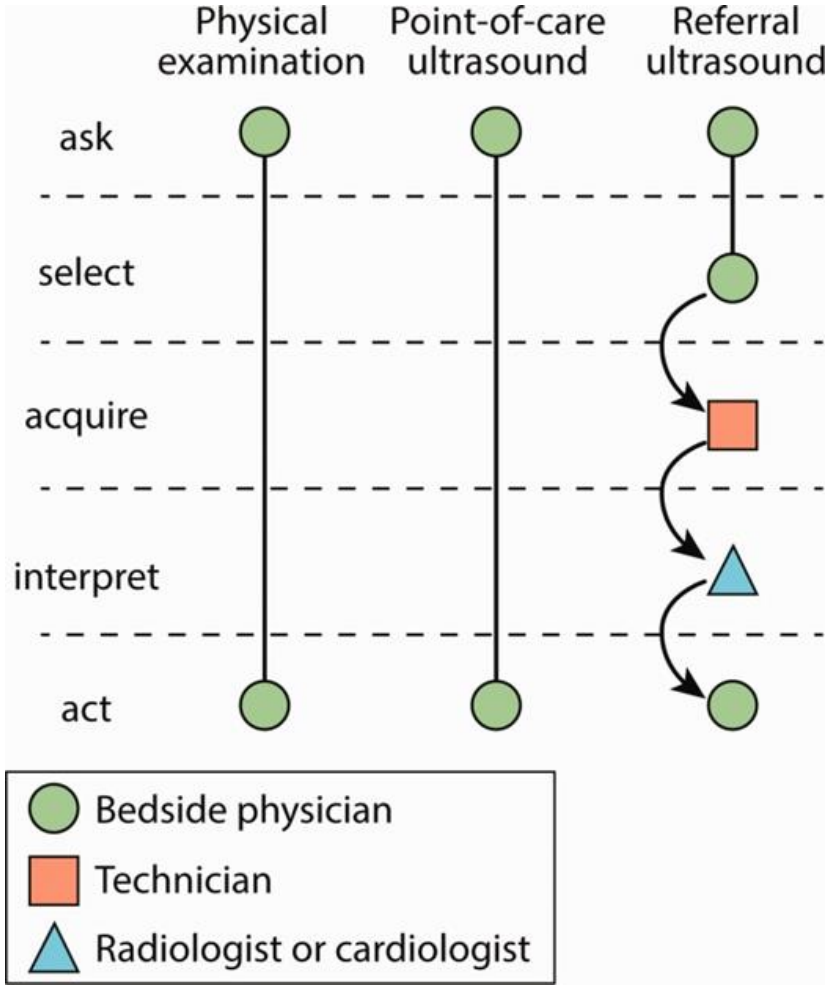
DOES	DOES NOT
Answer a focused clinical question with multisystem exam	Replace comprehensive/consultative diagnostic radiology studies
Allow for serial exams	Replace standard diagnostic pathways

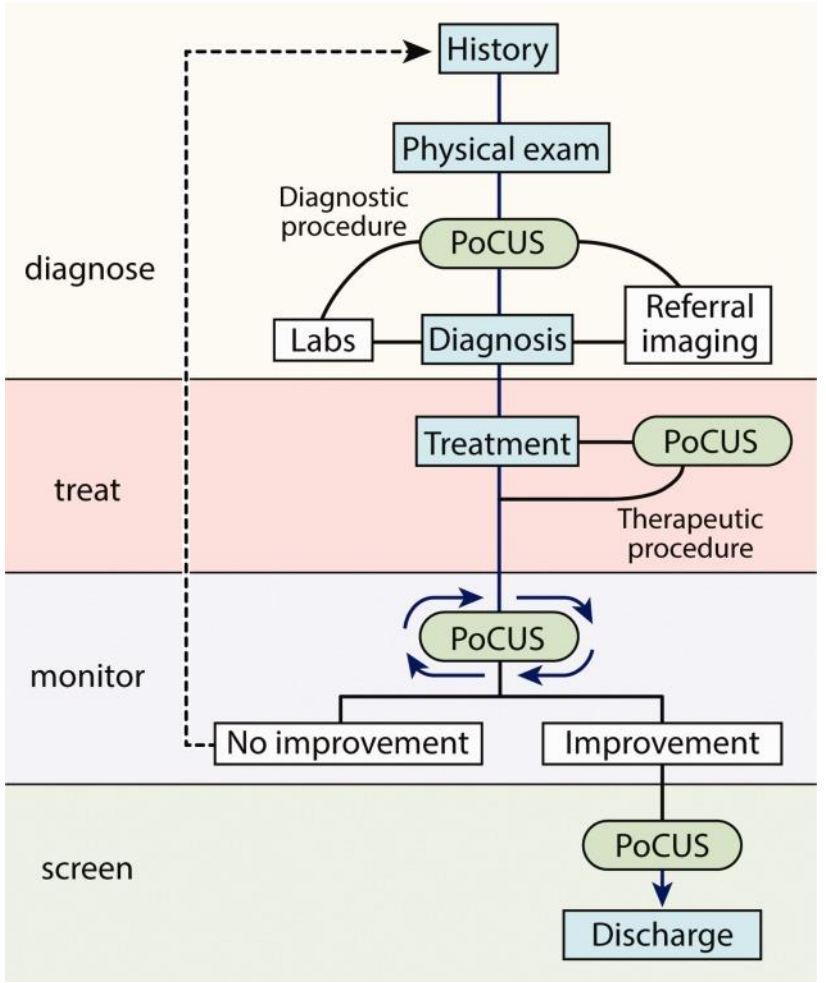


Skill development requires practice in:

- Indication
- Acquisition
- Interpretation
- Medical decision-making (clinical integration)

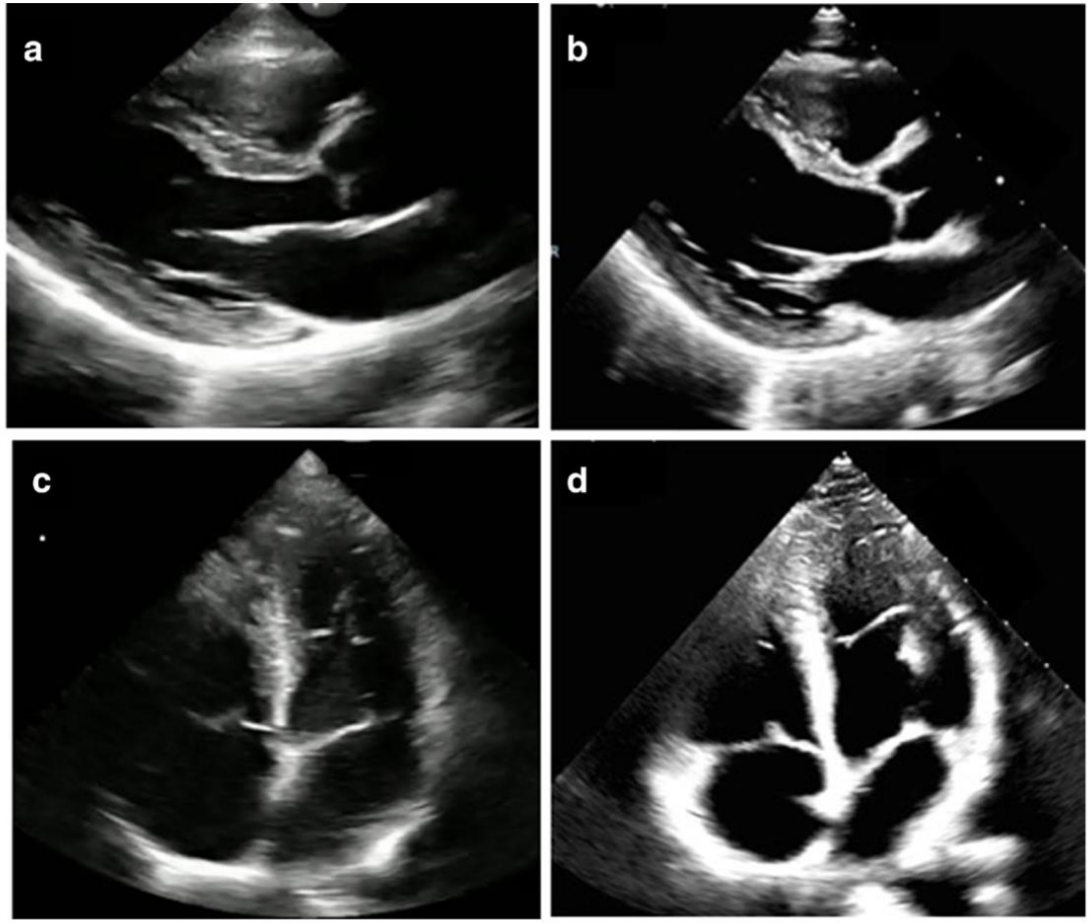
Dr. Ross and the POCUS-based approach



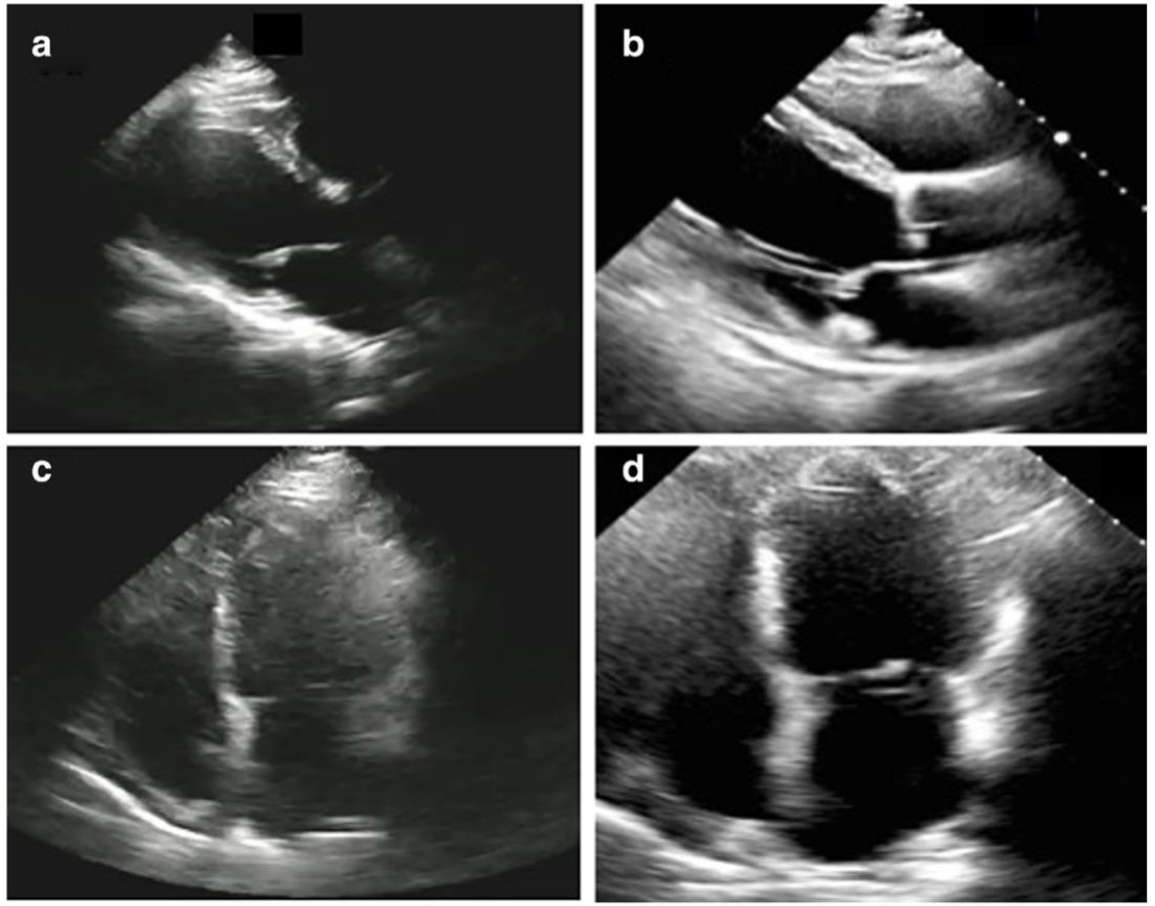


A myth about POCUS: overcomes obesity difficulties

Patient 1: Normal BMI



Patient 2: High BMI



Lee, L et al. *Current Cardiology Reports*. 2020

Clinical case

- CC: “I feel lightheaded”
- 62 yo M with ESRD, CAD s/p PCI (2010), HTN, COPD who presents with hypotension during dialysis. BP was recorded at 70/40 and patient felt lightheaded. A nurse noted he was confused, and dialysis was stopped. A 1L normal saline fluid bolus was administered and he was sent to the ED. He now feels improved.
- ROS: intermittent chest discomfort, dyspnea on exertion, and cough over last week.
- ED Vitals: Temp 36.8 C HR 110 BP 105/85 RR 16 (94% RA)

Ross- DDx and Approach

- New congestive heart failure
- Pericardial effusion
- Severe aortic stenosis
- Right heart failure
- Occult infection
- Dehydration/poor intake

Goals of initial assessment:

1. Cardiovascular & pulmonary focused exams (physical *and* POCUS)
2. Volume status (!)
3. Rule out serious/life-threatening etiologies

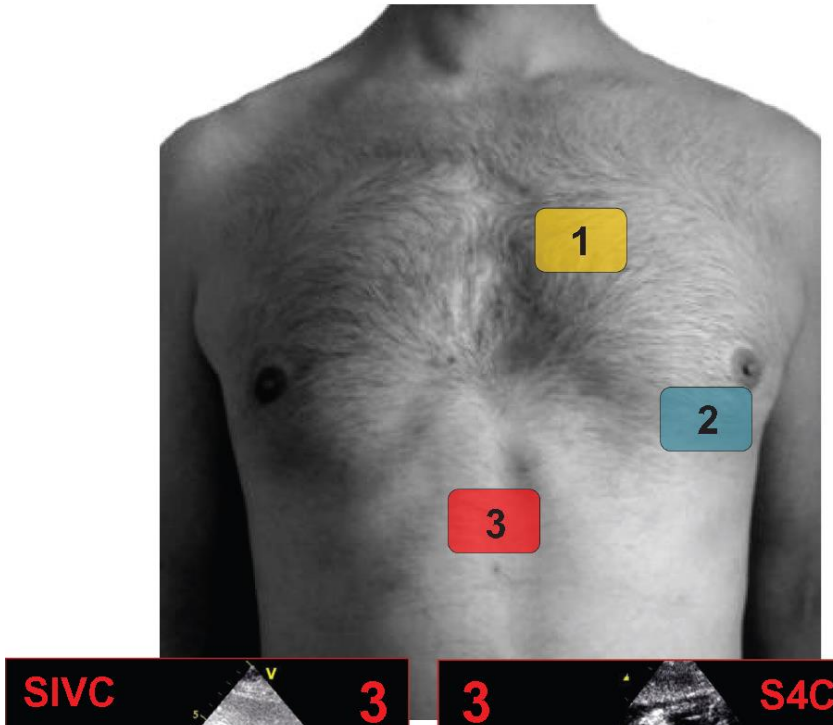
Shellenberger- DDx and Approach

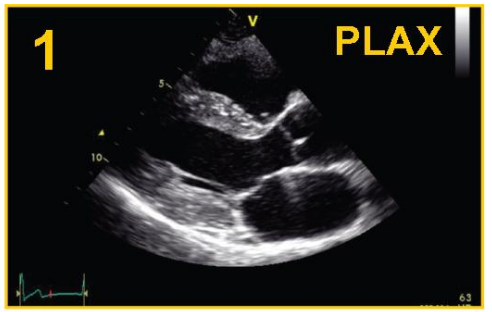
- Additions to Dr. Ross's list
  - Volume depletion
  - Sepsis
  - MI
  - Adrenal insufficiency
  - Aortic aneurysm rupture
- Initial assessment
  - ABCs and orthostatic vital signs
  - Head to toe examination (fast but thorough)
  - Always think of what is the most serious or life-threatening possibilities and try to assess for these first!

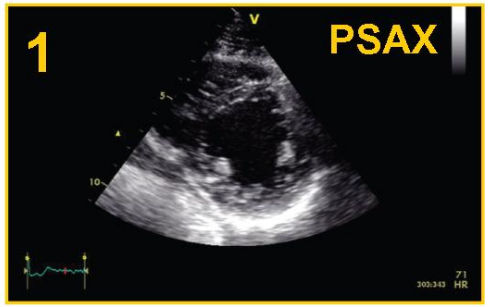
Cardiac Ultrasound Exam

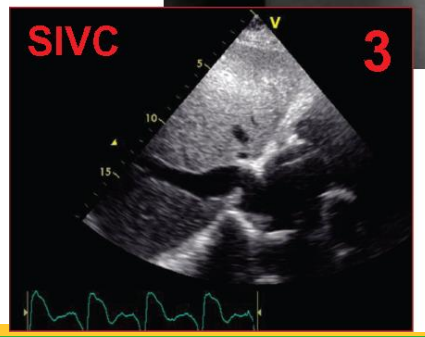
5 Classic Views

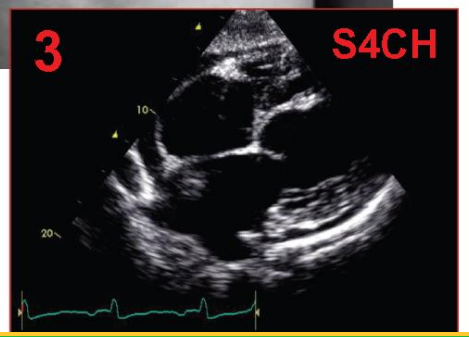
- Parasternal long axis
- Parasternal short axis
- Apical four chamber
- Subxiphoid four chamber
- Inferior vena cava

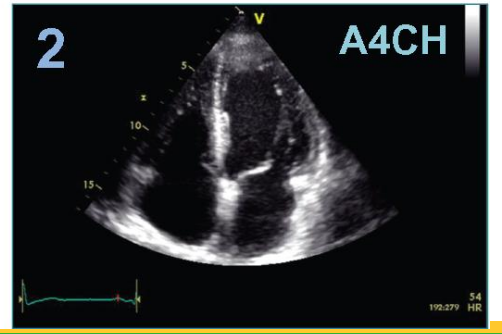












Focused Interpretation

- LV systolic function
- RV enlargement
- Pericardial effusion
- IVC size/collapsibility

Neskovik AN et al. *European Heart Journal – Cardiovascular Imaging* 2018

Left Ventricular Systolic Function

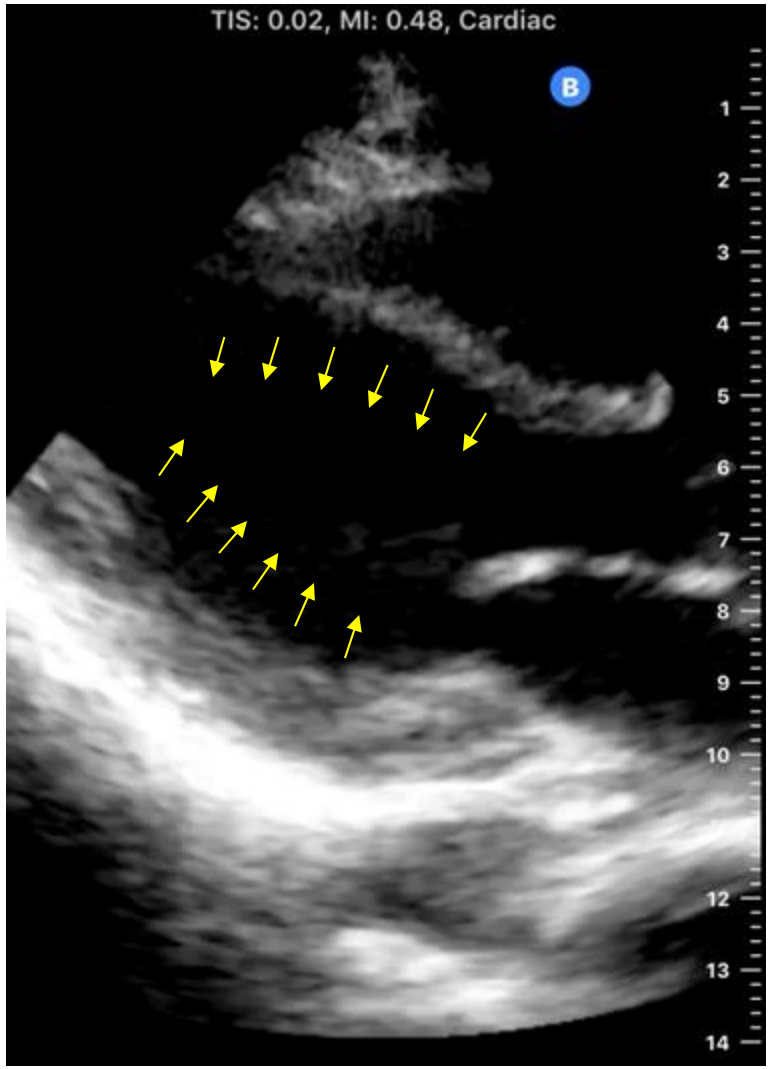
- Mostly a *qualitative* assessment

- Categorized as hyperdynamic, normal, reduced or severely reduced

1. Endocardial excursion
2. Myocardial thickening and
3. Septal motion of the anterior mitral valve leaflet (EPSS)
    - Only utilized in PSLA

LV Systolic Function- Parasternal Long Axis

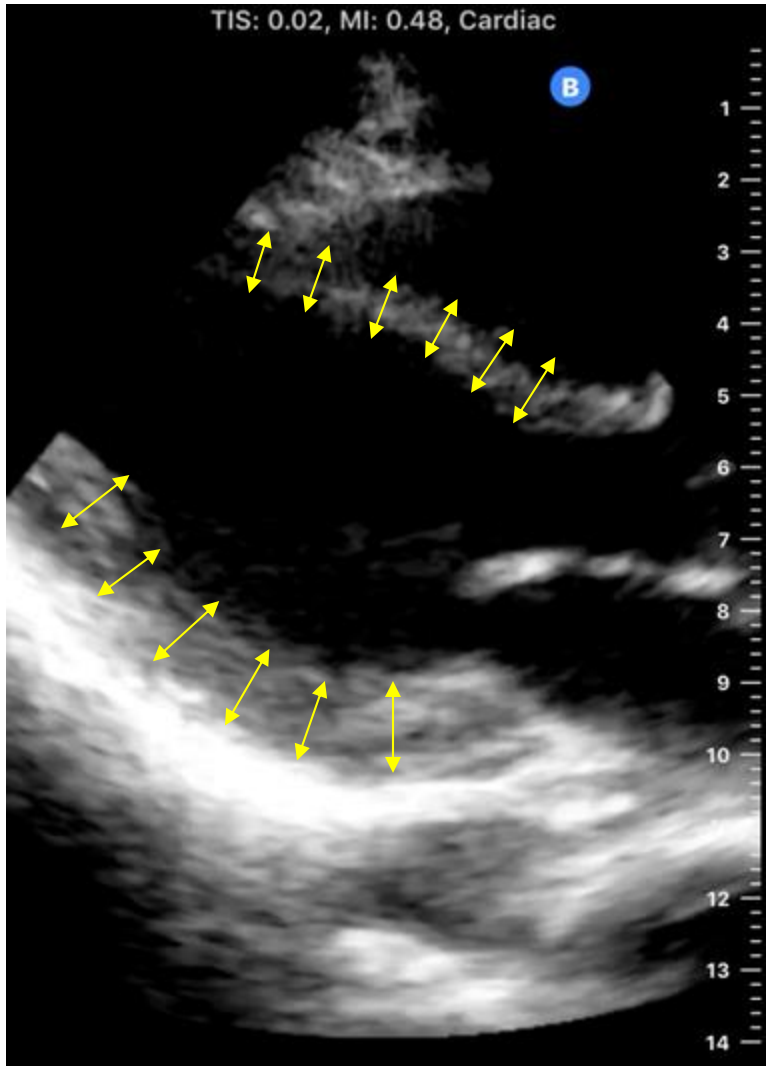
1) ***Endocardial excursion***:



LV Systolic Function- Parasternal Long Axis

1) *Endocardial excursion:*

2) ***Myocardial thickening:***

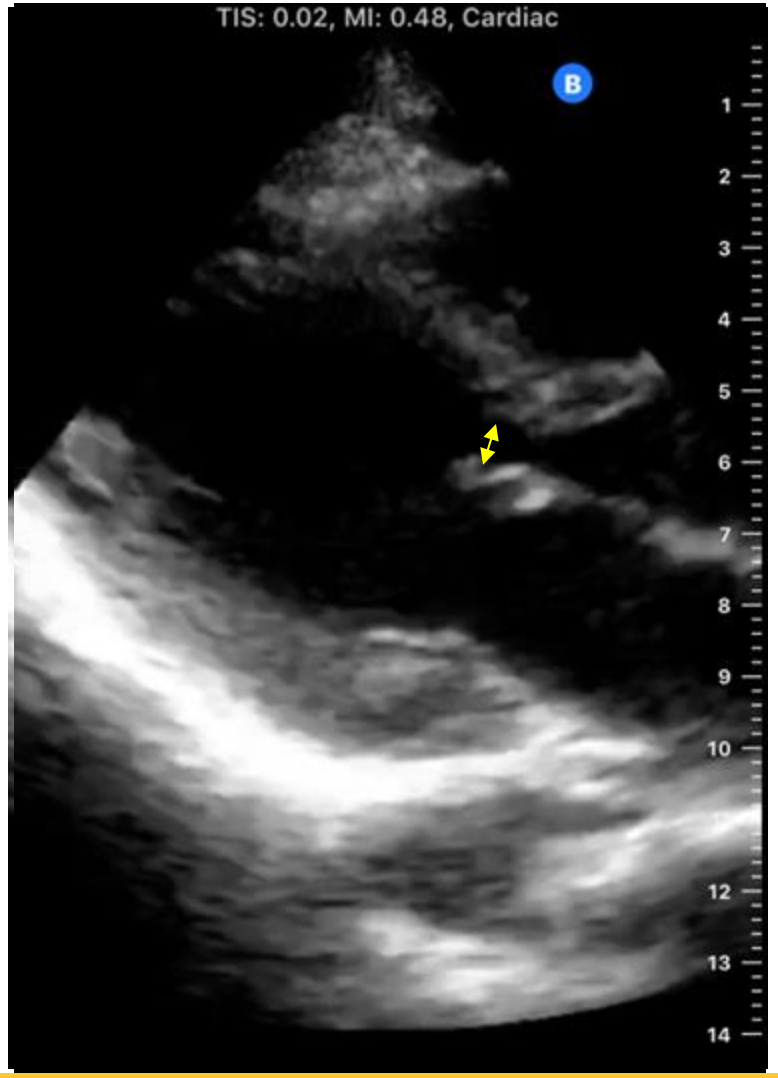


LV Systolic Function- Parasternal Long Axis

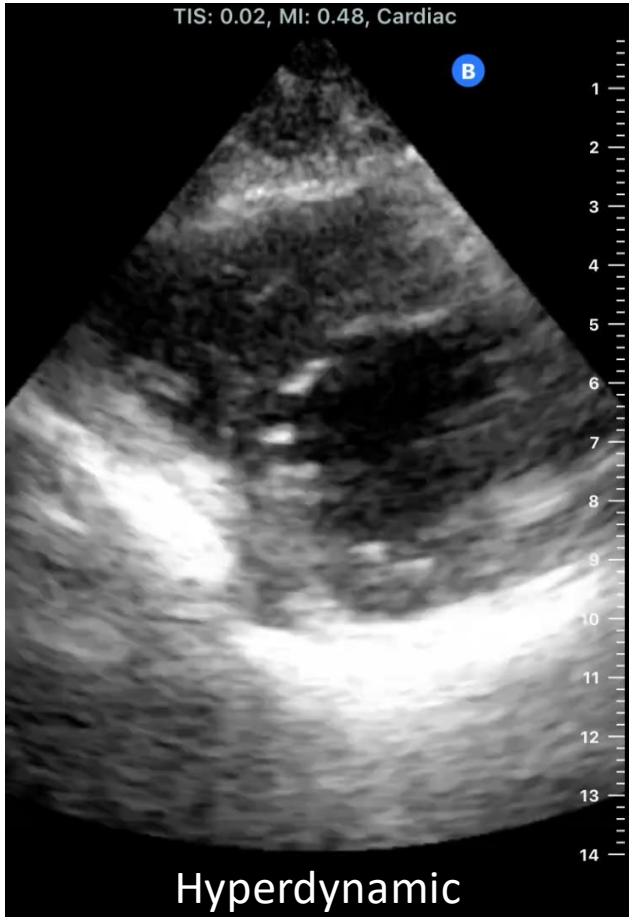
1) *Endocardial excursion:*

2) *Myocardial thickening:*

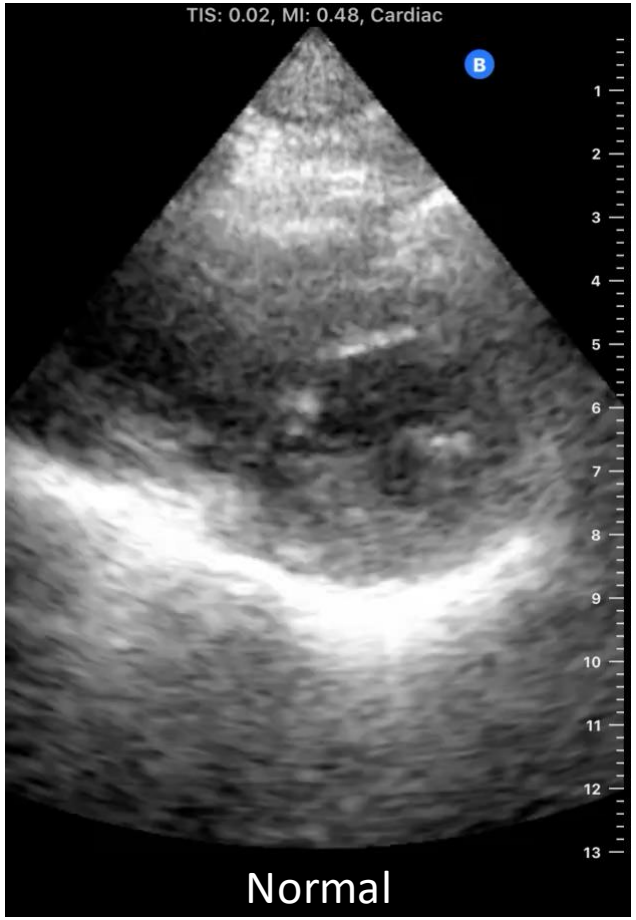
3) ***Anterior mitral valve leaflet motion:***



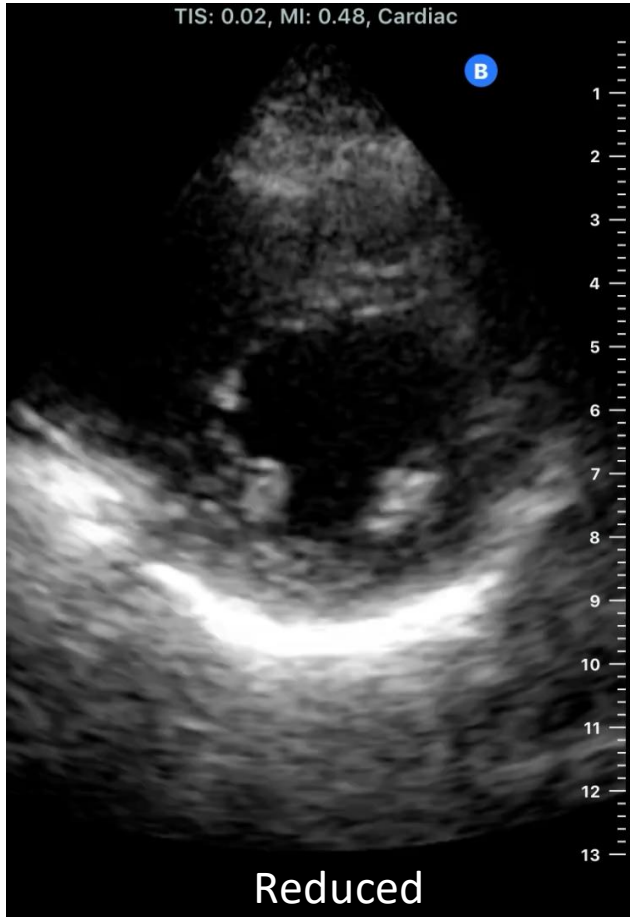
LV Systolic Function- Parasternal Short Axis



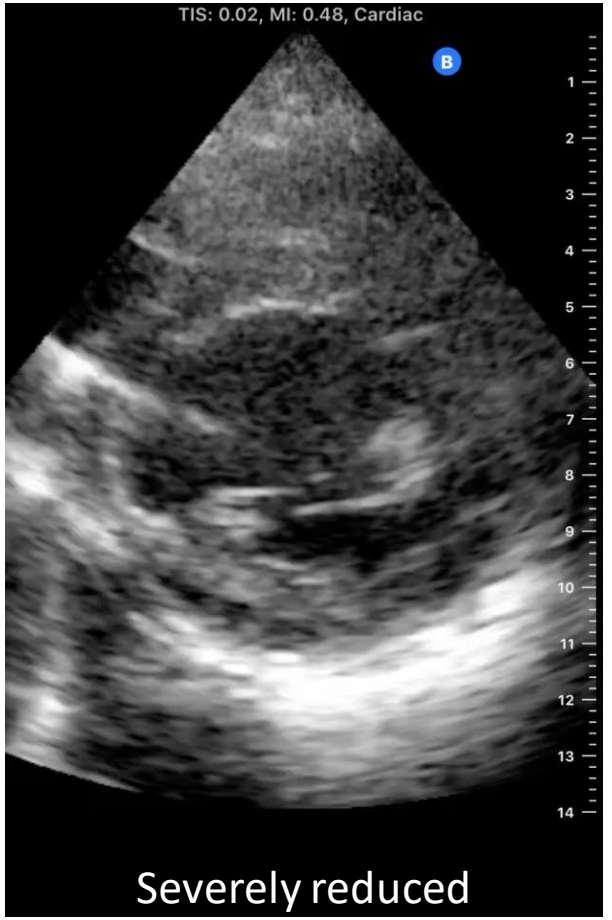
Hyperdynamic



Normal



Reduced



Severely reduced

POCUS & LV Systolic Function

Visual estimate of *any* EF abnormality (handhelds vs TTE)

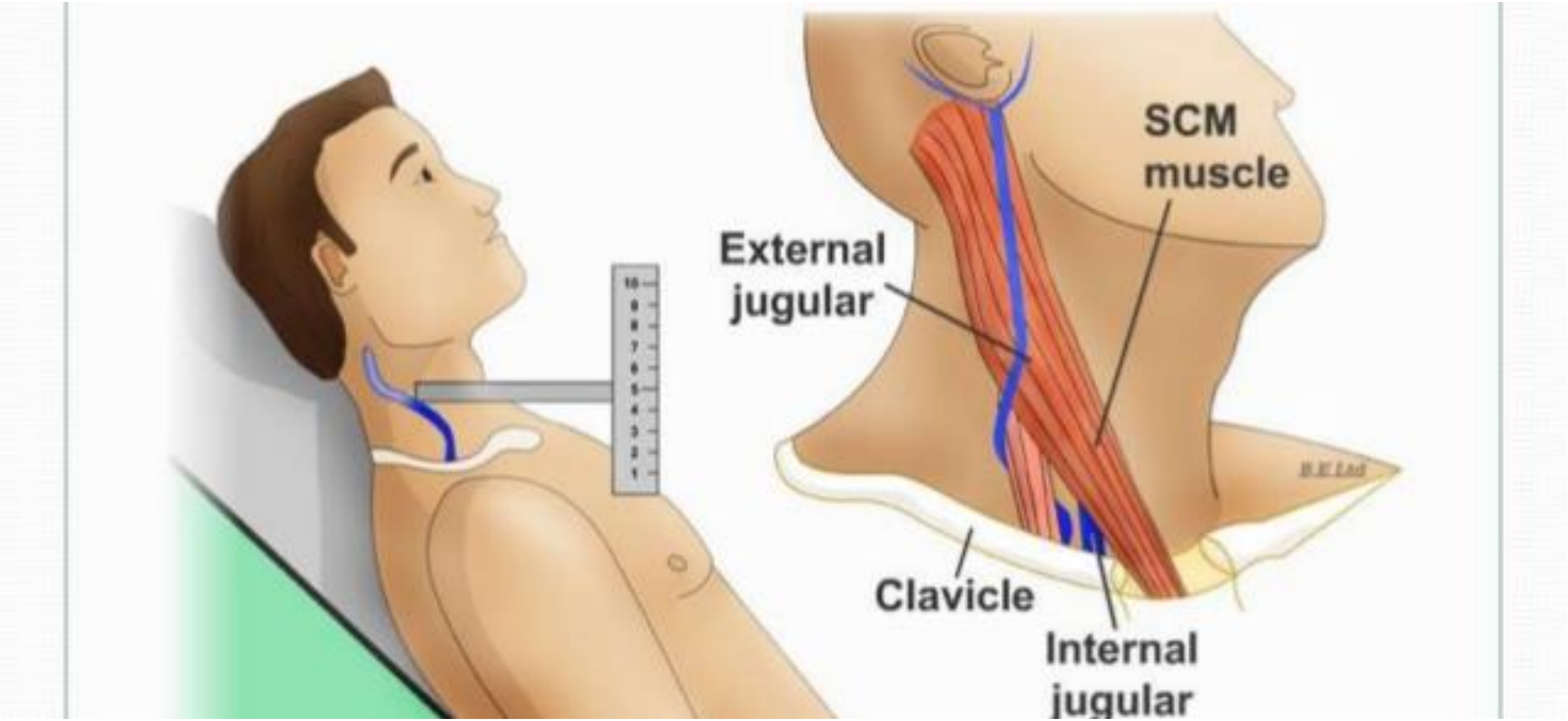
- Experienced user:
  - Any EF: 88% sens, 96% spec
  - **Mod-severe EF:** 93% sens, 96% spec
  - **Diagnostic OR 276**
- Inexperienced user:
  - Any EF: 83% sens, 89% spec
  - **Mod-severe EF**: 84% sens, 91% spec
  - **Diagnostic OR 41**

Jenkins S *et al*. *Heart* 2021

CHF – Neck Veins

- Jugular venous pressure
  - Reference is sternal angle = 5 cm
  - Measure vertical height
  - EJ or IJ?
  - Right or left?
    - L compressed by aorta in mediastinum

Jugular Venous Pressure



Hepato-jugular reflux

1. Apply pressure to the liver *(RUQ)*
2. Observe for a rise in JVP

Positive result

=

Sustained rise ≥ 4cm

Data on PE for CHF

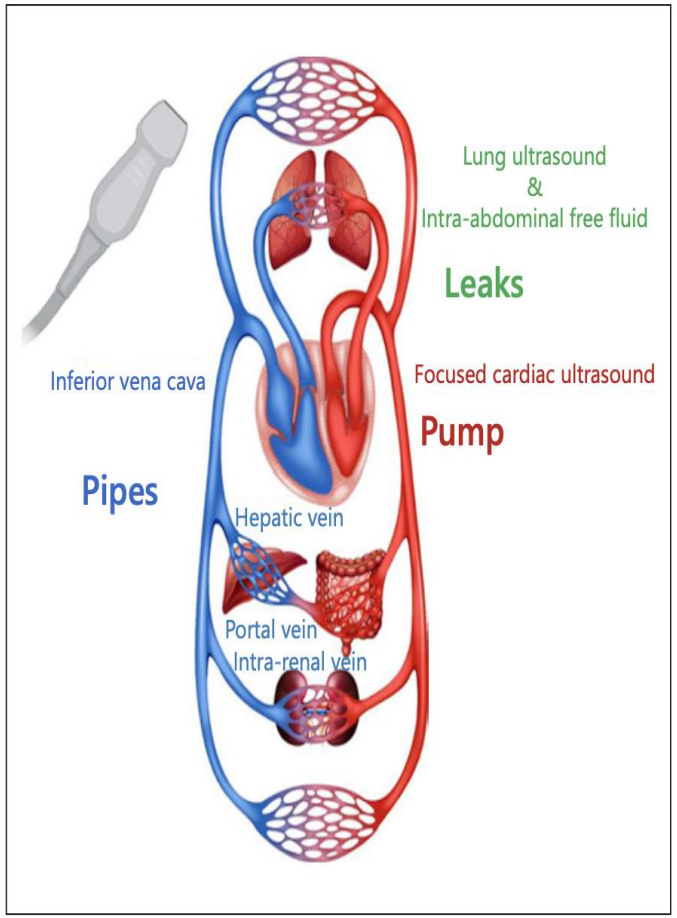
- Estimating bedside CVP vs right heart catheterization
  - JVP 8 cm (+) LR = 9.7 (-) LR = 0.3
  - JVP 12 cm + LR = 10.4 (-) LR = 0.1
    - IOR for JVP varies from 0.1 to 0.8
- **Abdominojugular test** for elevated LVEDP
  - (+) LR = 8.0 (-) LR = 0.3
    - IOR = 0.92
    - IOR for radiologist for CHF only 0.83!
- PMI Lateral to MCL gives + LR of **10.1** for detecting EF < 50%

Shellenberger RA, Balakrishnan B, Avula S, Ebel A, Shaik S. Diagnostic value of the physical examination in patients with **dyspnea**. Cleve Clin J Med. 2017 Dec;84(12):943-950.

POCUS and Volume Status

- One of the most useful modalities of combined cardiac/lung/vascular
- Augmentation of exam

Finding	Physical Exam	POCUS
LV systolic dysfunction	S3, displaced PMI	EPSS, visual EF estimate
Pulmonary edema	Crackles	B-lines, bilateral
Effusion	Decreased sounds	Visualized effusion
RV enlargement	L parasternal heave	RV:LV size ratio
Elevated CVP/RAP	JVP	IVC assessment/sono JVP



Ultrasound JVP

1. Hospital bed at 30-45º incline

2. Relaxed neck, slight left head turn

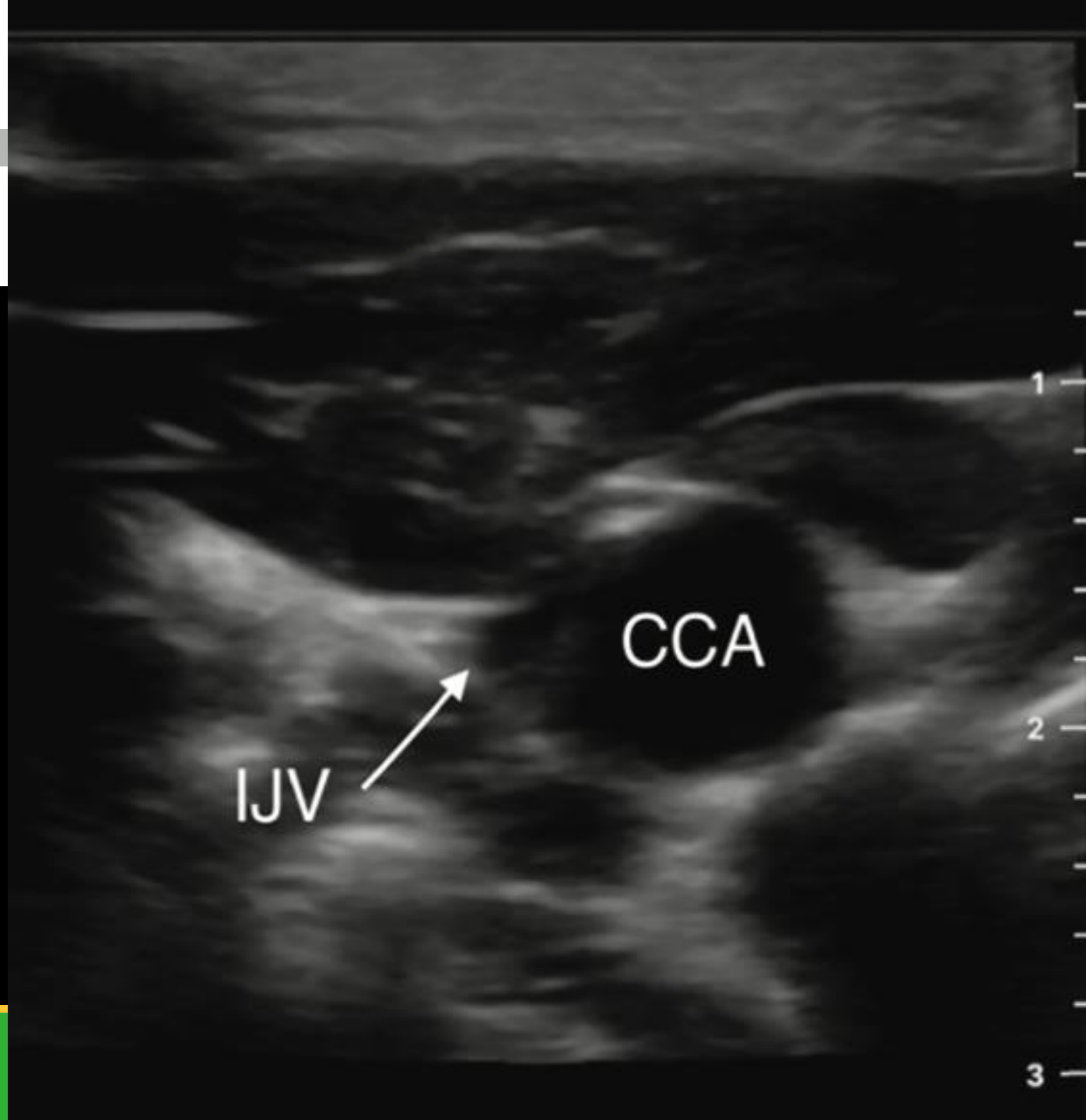
3. Probe transverse position, parallel to floor

   Start just above clavicle

   Track up (cranially)

4. Note point where IJ < CCA throughout resp cycle

   Est height above sternal angle



Wang L et al. *Annals of IM*. 2022.

Ultrasound JVP

Technique	Strengths	Limitations	Sens	Spec	+LR	-LR	Take-aways
Visual JVP	- No resources req'd - Extensively studied - Prognostic	- Not visible in some - Wide variation in accuracy depending on experience	47-92	83-96	8.9	0.3	Your go-to, tried and true technique…but takes practice!
US JVP	- Obtainable in all pts - Fairly easy to learn	- Must have ultrasound - Variable techniques	73-78	77-95	3.4	0.3	Performs similarly to vJVP but attainable in 100%
IVC	- Pairs well with other POCUS modalities	- Must have ultrasound - Technical factors limit - Training required to avoid mistakes - Requires respiratory effort from pt	73-87	82-85	4.9	0.16-0.32	Effective but due to necessary training, can be highly user-dependent

**All numbers are in reference to detection of an elevated CVP, which can be defined as >8 cm H2O or >5 mm Hg.*

Bhagra A et al. *Mayo Clinic Proceedings.* 2016
McGee S. Evidence-Based Physical Diagnosis. Chapter 36, 295-307
Rizkallah J. et al. *PLOS ONE.* 2014
Wang L. et al. *Annals of IM.* 2022

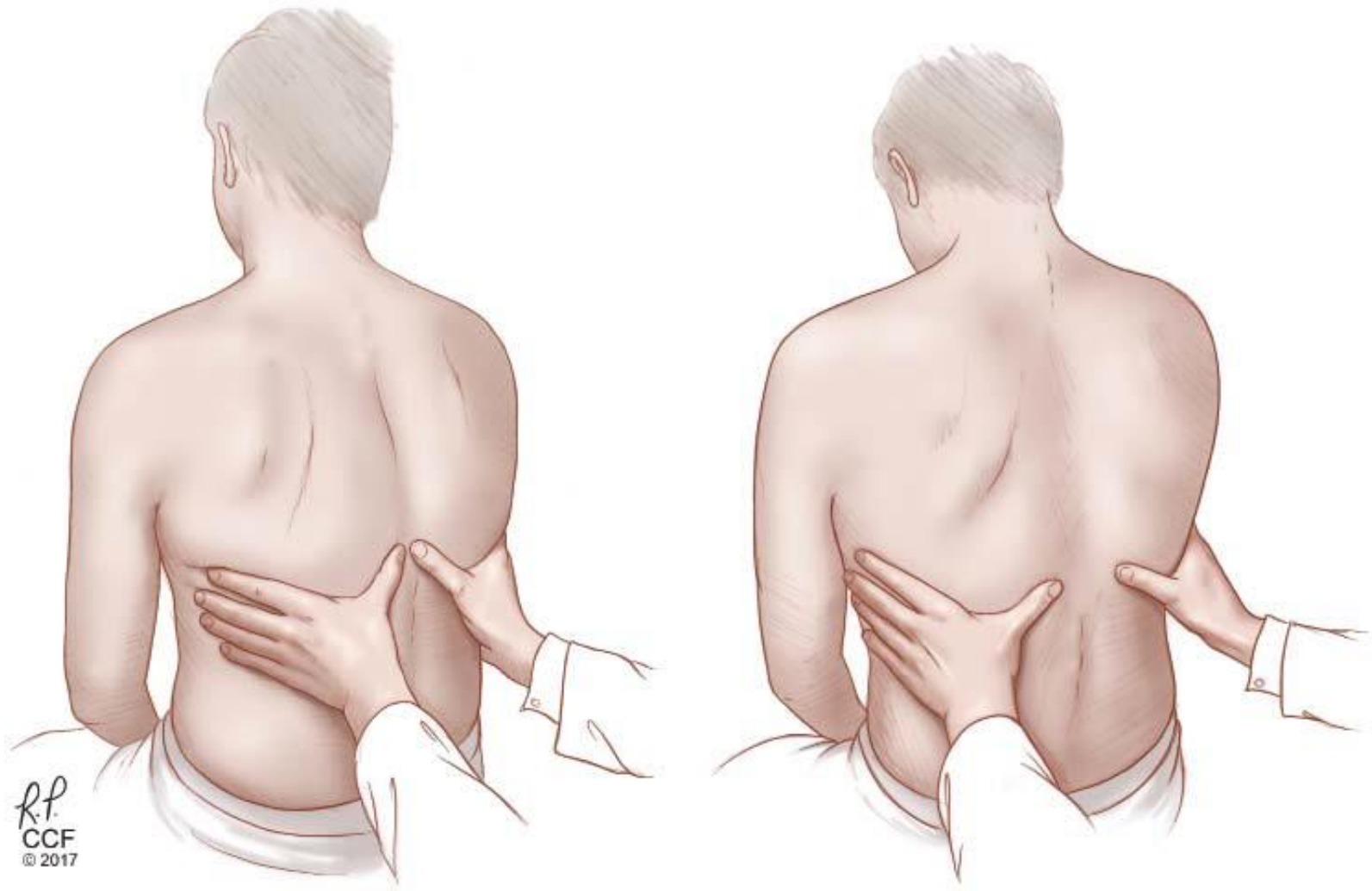
Physical examination for pneumonia

TABLE 3

Signs of pneumonia

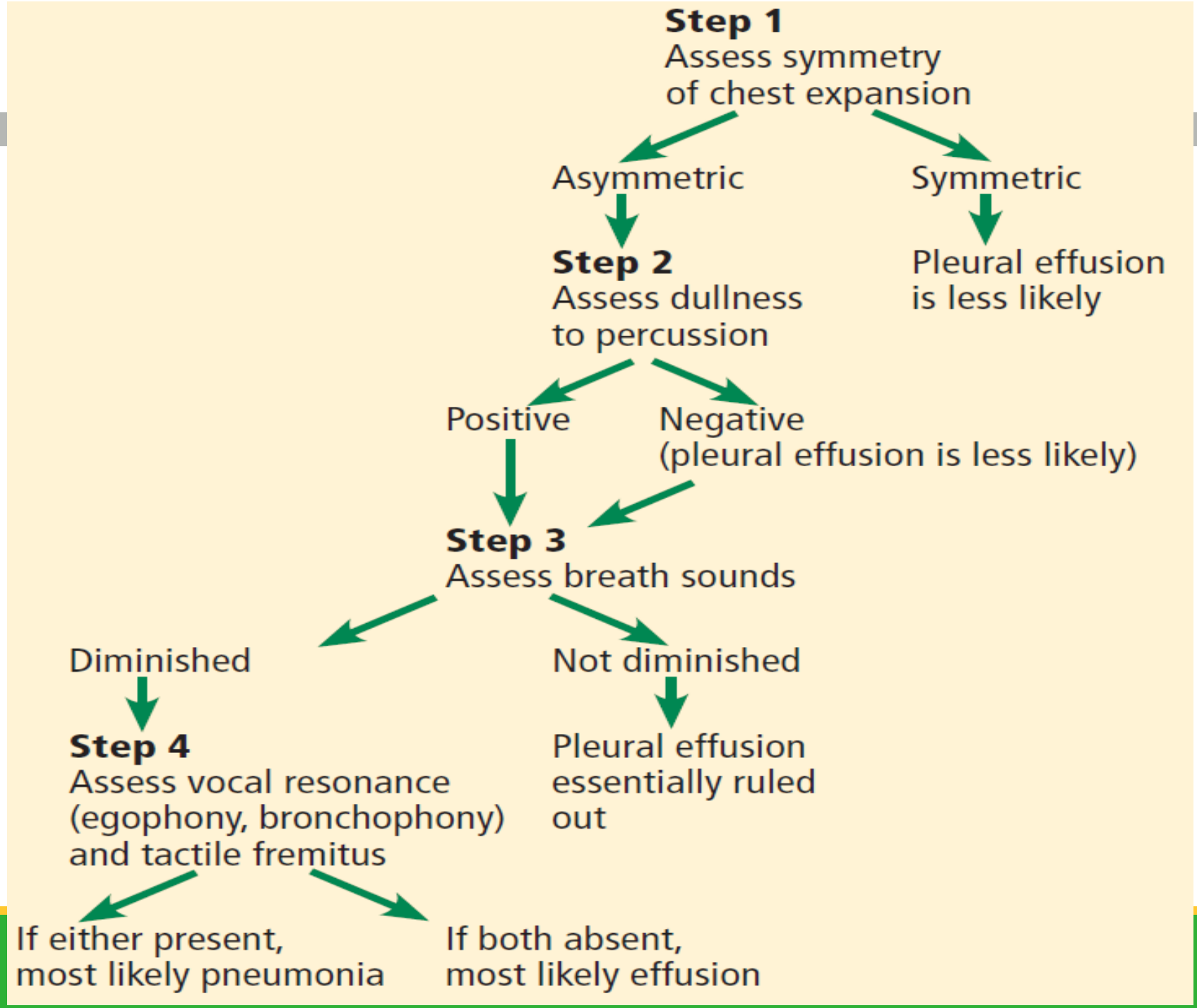
Signs	Positive likelihood ratio	Negative likelihood ratio
Asymmetric chest expansion[6]	44.1	1.0
Egophony[6,10,11]	6.8	0.9
Dullness to percussion[6,10–12]	5.7	0.9
Bronchophony[10]	3.3	0.9
Crackles[6,10–12]	3.2	0.7
Diminished breath sounds[10–12]	2.5	0.7

Remember this



Pleural Effusions

Findings	Likelihood ratios	
Percussion dullness	**(+) 8.7**	(-) 0.3
Chest expansion	**(+) 8.1**	(-) 0.3
Diminished tactile fremitus	(+) 5.7	**(-) 0.1**
Diminished breath sounds	(+) 5.2	**(-) 0.1**
Diminished vocal resonance	(+) 6.5	(-) 0.3


Step 1
Assess symmetry of chest expansion
Asymmetric
Symmetric
Step 2
Assess dullness to percussion
Pleural effusion is less likely
Positive
Negative (pleural effusion is less likely)
Step 3
Assess breath sounds
Diminished
Not diminished
Step 4
Assess vocal resonance (egophony, bronchophony) and tactile fremitus
Pleural effusion essentially ruled out
If either present, most likely pneumonia
If both absent, most likely effusion

Lung examination

- Crackles (never rales!)
  - Early inspiratory
    - Detecting COPD – LR =14.6
- Paninspiratory Crackles
  - CHF or PNA
- Late inspiratory fine crackles
  - Fibrosis


Krankies

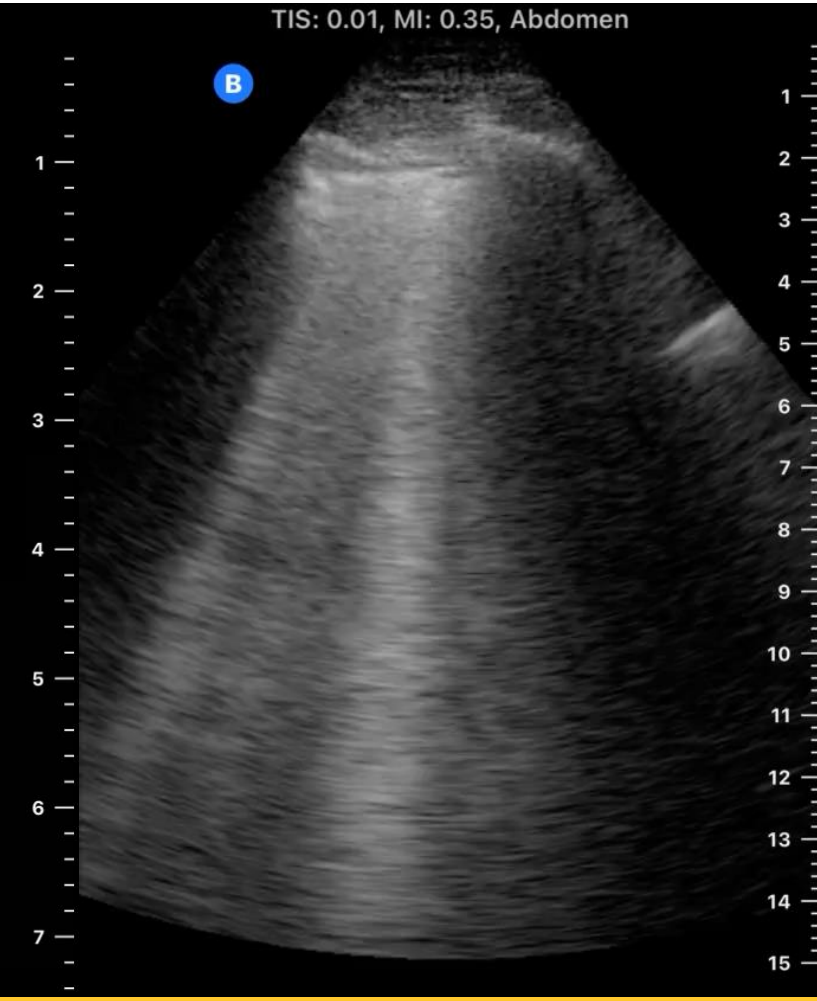
Lung/Pleura Ultrasound

Pulmonary Edema

- A negative chest x-ray in ED will miss 1/5 diagnoses of acute heart failure[1]
- Lung US vs CXR[2,3]
  - Sensitivity 15% higher (as high as 92%)
  - Specificity: 92 vs 87%

Normal lung (A-line pattern)

Diffuse B-lines

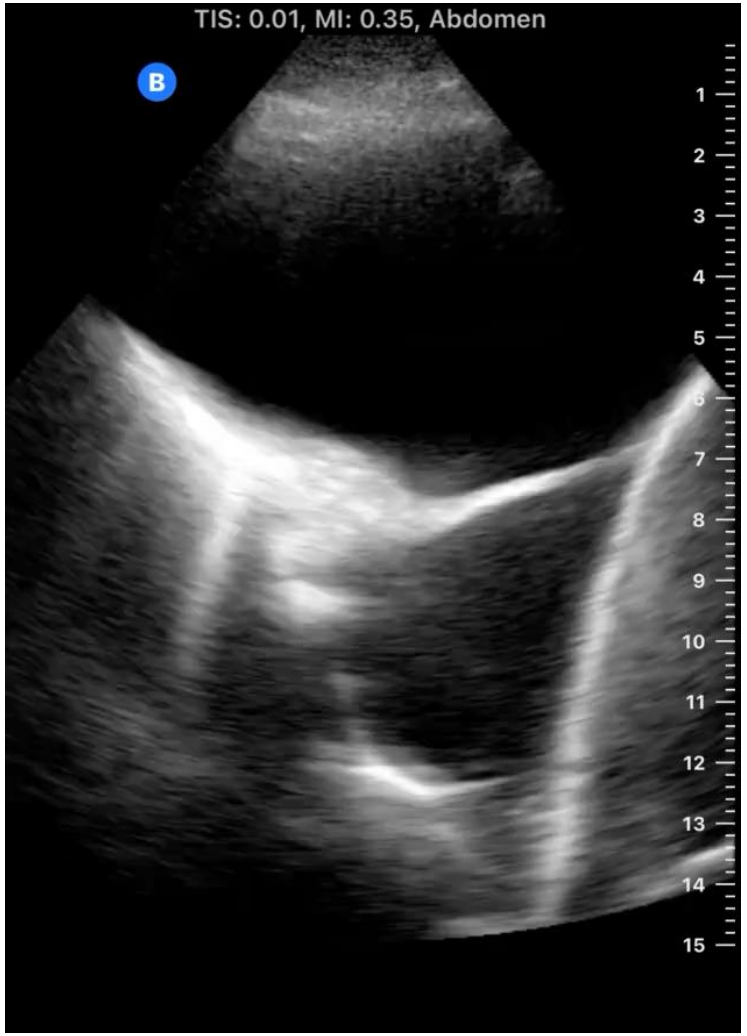


1. Collins SP et al. *Annals of Emerg Med* 2006 2. Chiu L et al. *Am J Cardiol* 2022 3. Maw AM et al. *JAMA Network Open* 2019

Lung/Pleura Ultrasound

Pleural Effusion[1]

- LUS is extraordinarily sensitive
- Can detect 5-20 mL
- Upright CXR can't detect <150 mL
- Superior fluid characterization vs other imaging modalities



Ibitoye BO, et al. *Ultrasonography*. 2018

Lung/Pleura Ultrasound

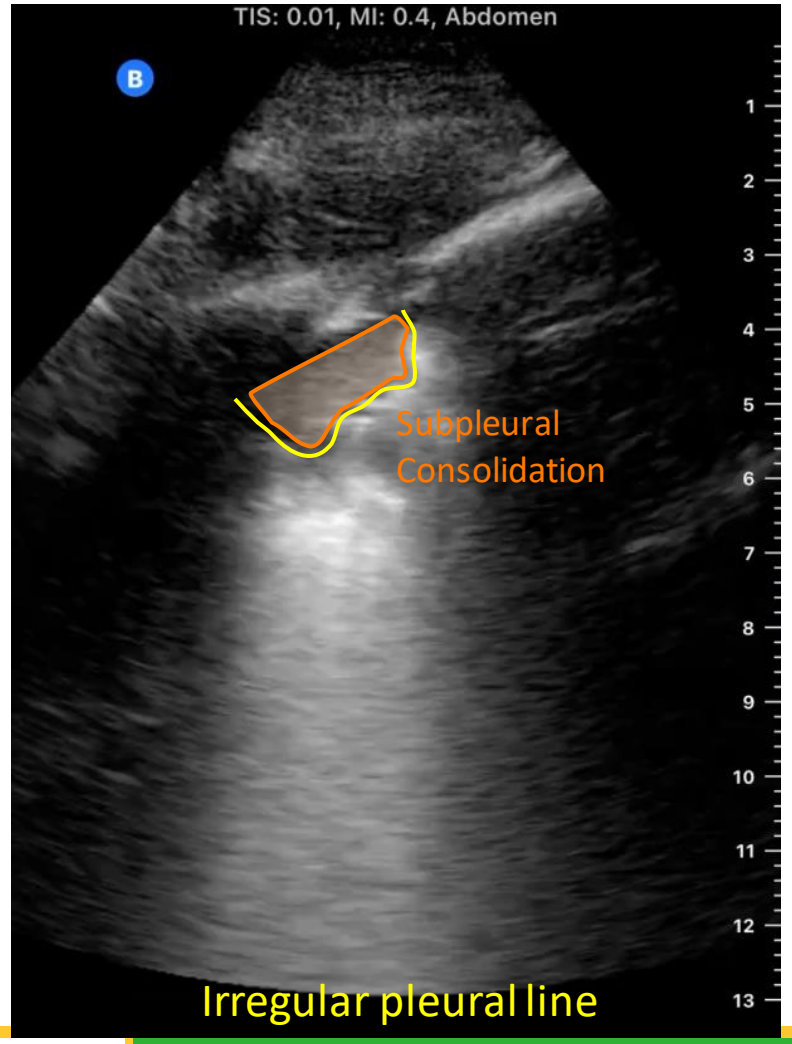
Pneumonia

- CT (+ clinical correlation) is still imaging gold standard
- LUS: 90-97% sens, 94-99% spec[1]
- Outperforms CXR: 75% sens/spec[2]
- Many patterns described

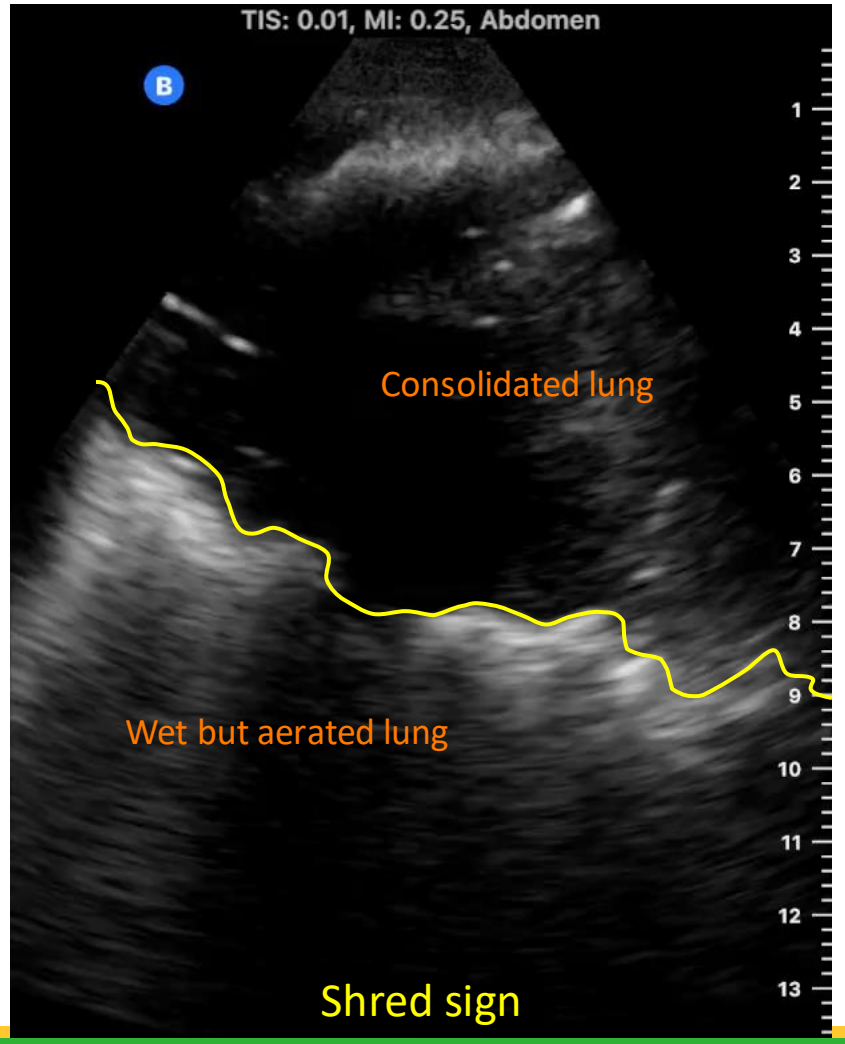
1. Hendin A et al. *CHEST* 2020

2. Gentilotti E et al. *Clin Microbiol Infect* 2022

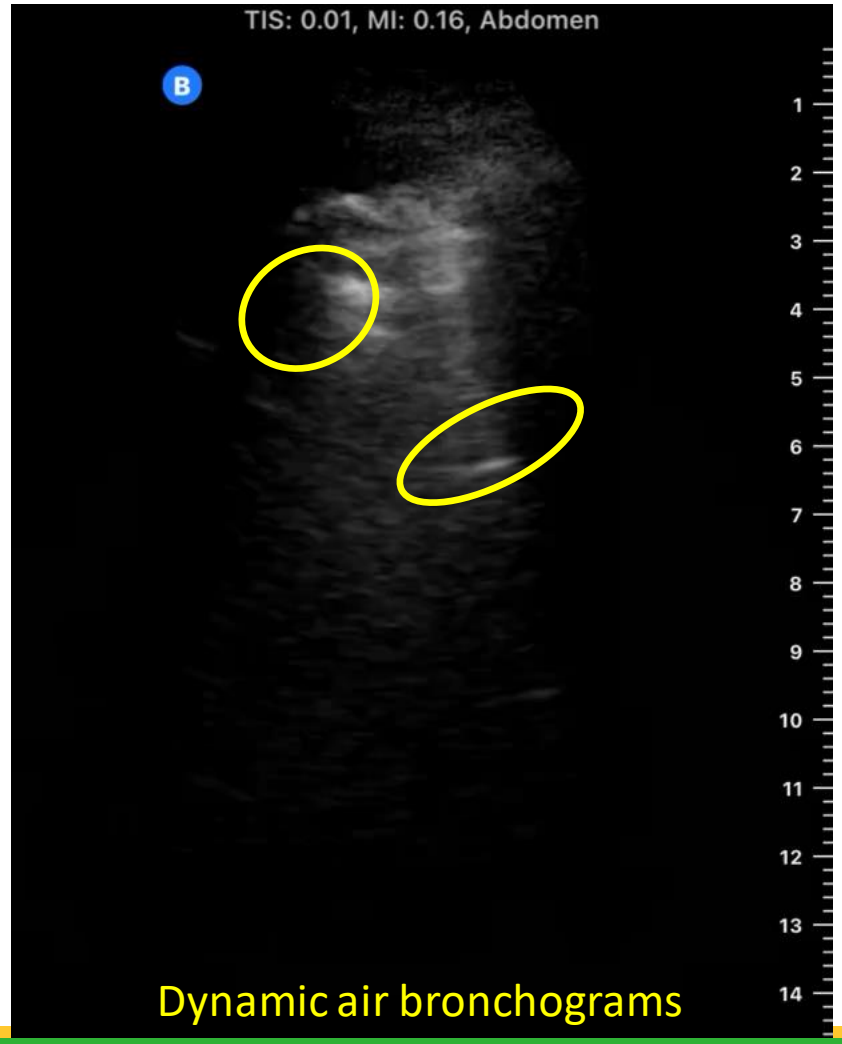
Pneumonia



Irregular pleural line



Shred sign



Dynamic air bronchograms

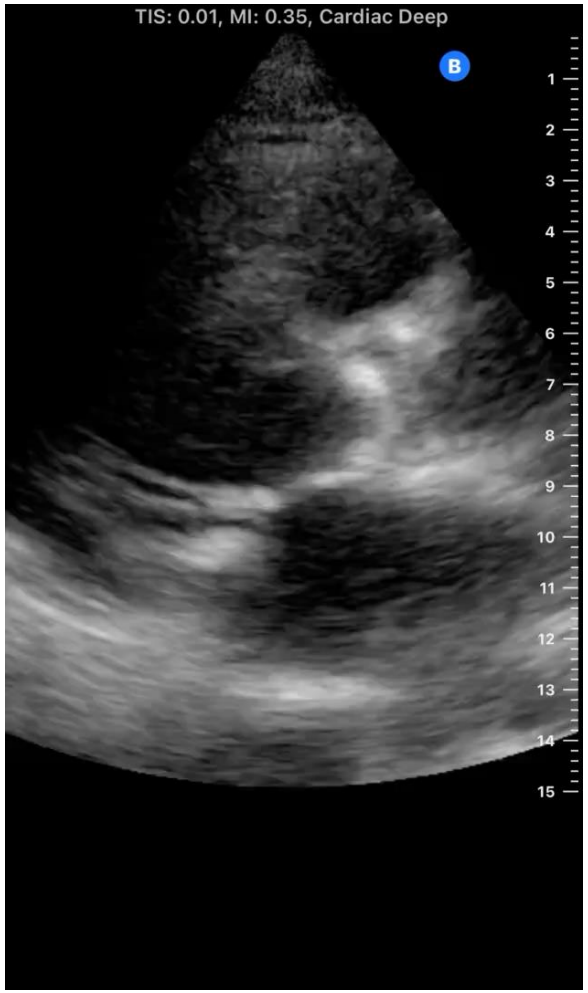
Hot off the press! Aortic Stenosis (moderate-severe)

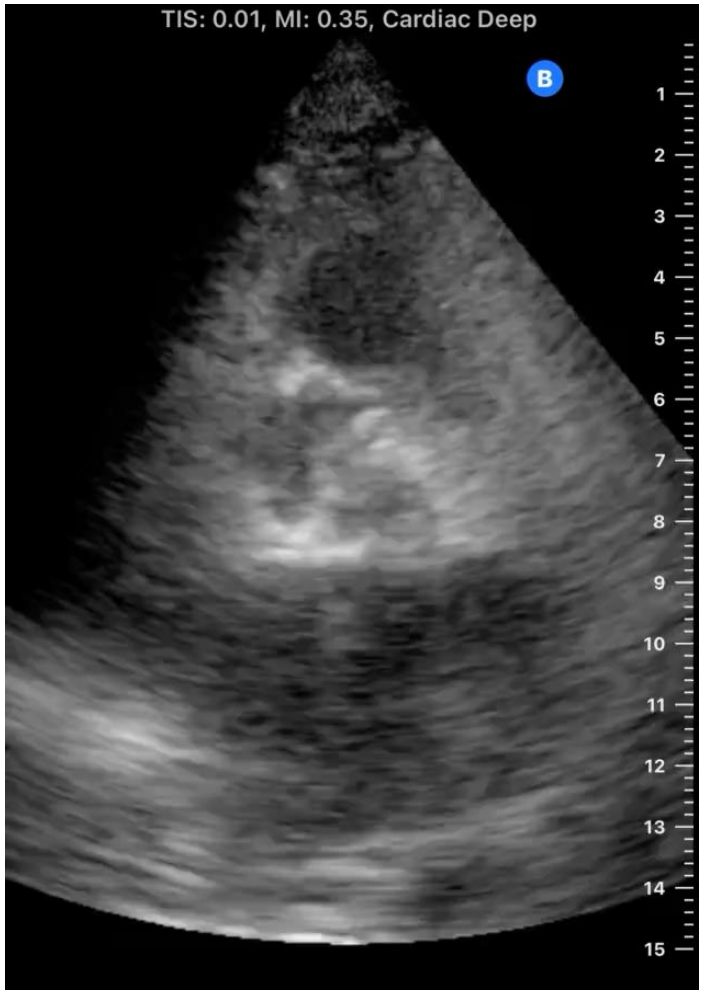
Physical exam finding	Sensitivity	Specificity	(+) LR	(-) LR
Diminished S2	59%	95%	10.9	0.4
Delayed carotid upstroke	57%	94%	9.0	0.5
Murmur radiating to the carotid	93%	66%	2.7	0.1

Shellenberger RA, Crass S, Jevicks J, Badhwar A, Albright J, Kumar A. Bedside Physical Examination for the Diagnosis of Aortic Stenosis: A Systematic Review and Meta-analysis. CJC Open. 2023 Feb 27;5(5):373-379. doi: 10.1016/j.cjco.2023.02.007. PMID: 37377515; PMCID: PMC10290951.

POCUS & Aortic Stenosis

- Stenosis → diminished mobility, thickening, calcification
- Normal appearance essentially rules out severe AS
- Need comprehensive echo but POCUS used for screening[1,2,3]

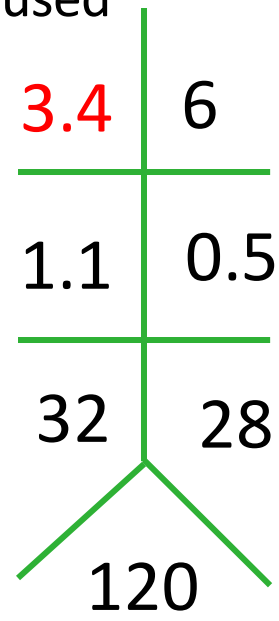


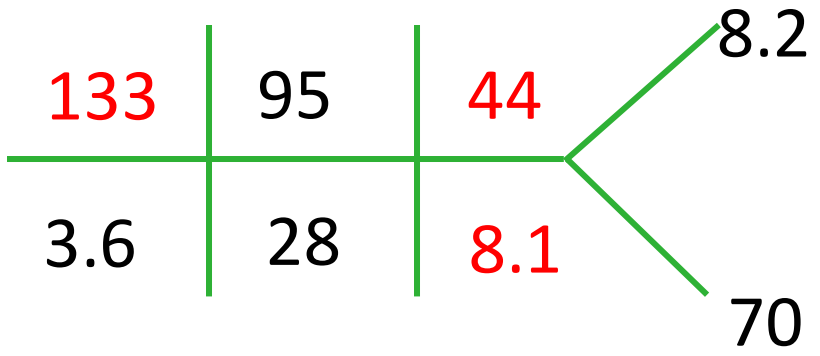


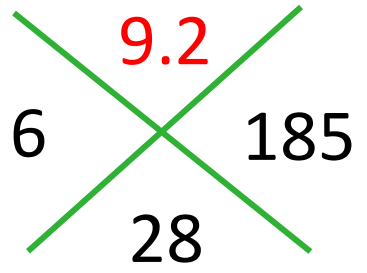
1. Gulič TG et al. Wiener klinische Wochenschrift. 2016
2. Cowie B et al. Anaesthesia 2011 et al.
3. Frederiksen CA et al. Scandinavian J of Trauma, Resuscitation, and EM. 2013

Back to case

- Physical exam:
  - CV: RRR, normal S1/S2. No murmurs. Distant heart sounds. JVP 14 cm
  - Lungs: CTAB, no crackles. Symmetric chest expansion. Normal percussion
  - Ext: 1+ edema to shins b/l. Warm and perfused
- ECG: sinus tachy, low voltage
- AP CXR: no acute process







Cardiac Tamponade

Physical Finding	Frequency (%)
Elevated Neck Veins (JVP)	100
Tachycardia	81-100
Pulsus paradoxus	
>10	98
>20	78
>30	49
Diminished Heart Tones	36-84
Pericardial rub	27

Pulsus Paradoxus – 2 methods

- #1 is old school and harder
  - Slowly deflate BP cuff (not the automatic)
  - Difference between:
    - SBP of the 1St Korotkoff sound that disappears with inspiration
    - SBP when the Korotkoff sound no longer disappears with inspiration
- #2 not as time honored but easier!
  - Difference in SBP in expiration and inspiration
  - Not as many studies

POCUS and Cardiac Tamponade

Broad DDx of Pulsus Paradoxus[1]

- Asthma exacerbation
- COPD exacerbation
- Hypovolemia
- Large compressive pleural effusion
- Hemodynamically significant pulmonary embolus

Pericardial effusion

- Recognition included in most protocols
- Non-cardiologists can reliably diagnose with >95% accuracy vs TTE[2,3]
- Focus on size & hemodynamics

1. Hamzaoui O et al. Euro Resp Journal 2013 2. Mandavia D et al. Ann Emerg Med 2001 3. Vignon P et al. Crit Care 2003

Cardiac Tamponade

Echo diagnostic criteria:

1. IVC Plethora (>2.1 cm, <50% inspiratory collapse)
2. Cardiac chamber collapse

POCUS

+

Comprehensive Echo

3. Exaggerated respiratory variation of transvalvular velocities
4. Expiratory hepatic vein diastolic flow reversals

Comprehensive Echo

Oh JK, The Echo Manual, Fourth Edition. 2019

Klein et al. J Am Soc Echocardiogr 2013

POCUS Findings in Cardiac Tamponade

IVC Plethora:

>2.1 cm in diameter with < 50% inspiratory diameter decrease

97% sensitive but 40% specific

(helpful NPV)

Cardiac chamber collapse

(≥ 1/3 of the cardiac cycle)

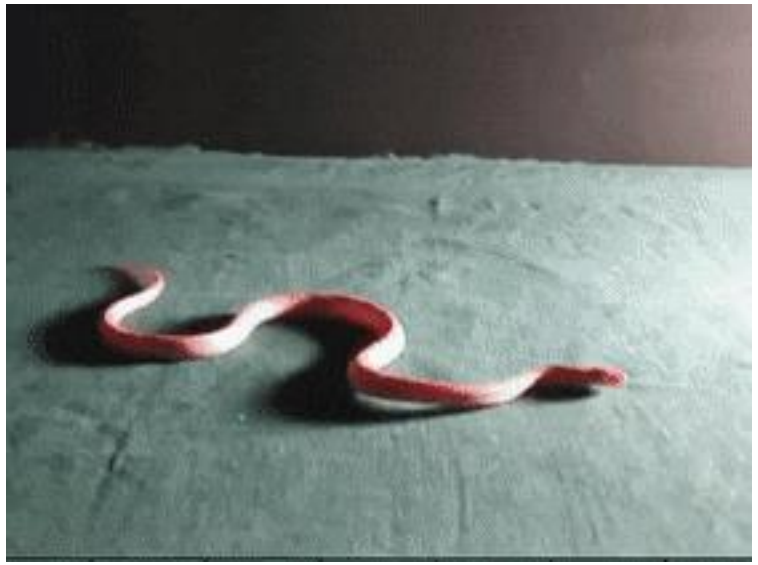
RV: early diastole

60-90% sens; 85-100% spec

RA: late diastole/early systole

94% sens; 100% spec

Cardiac Tamponade



Final Diagnosis

- **Dialysis-related pericardial effusion with cardiac tamponade**
- Thought to be related to pericarditis, inadequate volume removal or dialysis alone[1]
- Hypotension during dialysis can commonly be the presenting symptom[2]
- Patient underwent urgent pericardiocentesis with >1000 mL of serosanguinous fluid drained
- Workup for infection and malignancy was negative
- The patient continued dialysis without recurrence

1. Rehman KA et al. *Clin Cardiol* 2017

2. Comty CM et al. *Ann Intern Med*. 1971

Conclusions

- Physical examination is still relevant
- PE is fast and accurate
- PE is what makes us “physicians”
- You are never too experienced to learn new PE skills
- IM POCUS is an extension of physical examination
- Accuracy can meet or exceed other imaging modalities
- Responsible use requires training
- POCUS is not infallible and does not replace a quality examination

Q&A

Special thanks to: Woo Moon, D.O, FACP