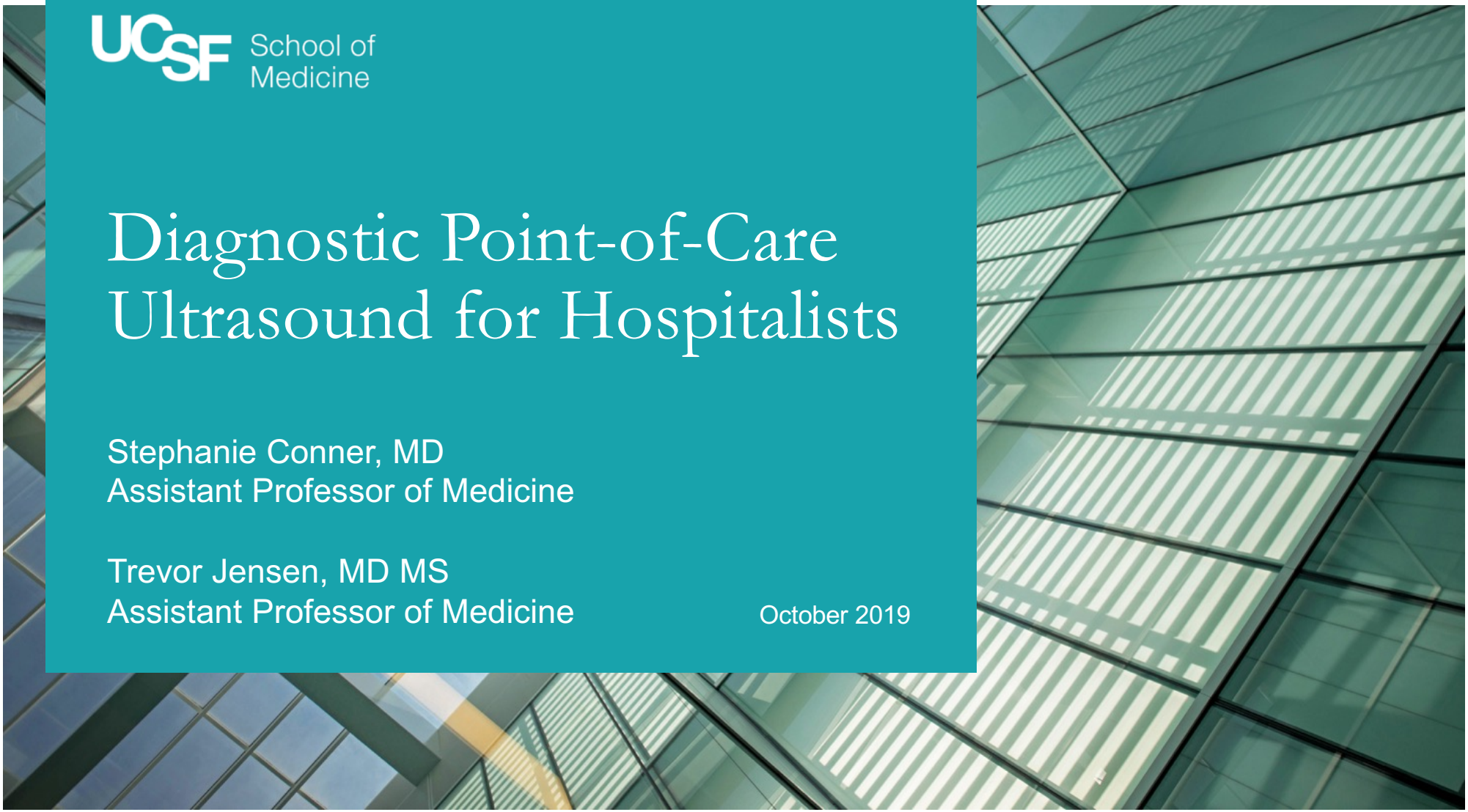

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Diagnostic Point-of-Care Ultrasound for Hospitalists

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October 2019

Disclosures

- Stephanie Conner: none
- Trevor Jensen: none

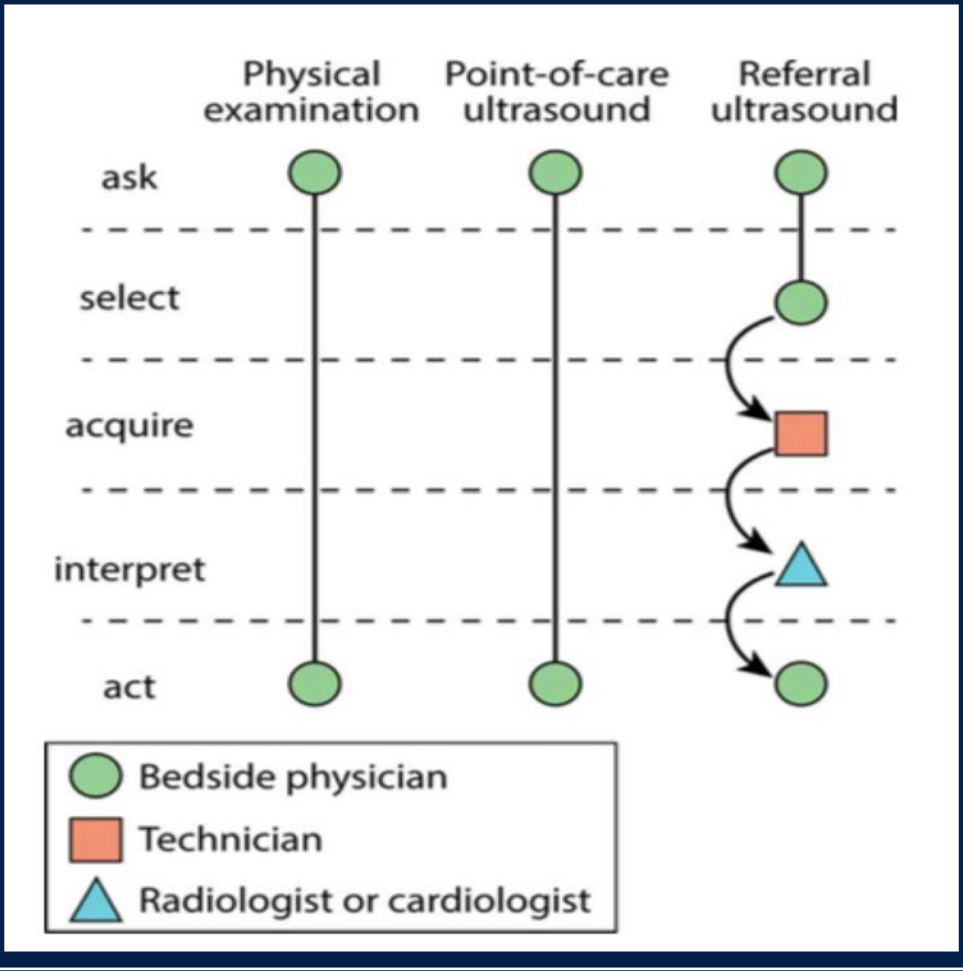
Session Outline

Point-of-Care Ultrasound (POCUS) is the future of the physical exam.

- How POCUS is currently used in hospitalized patients
- Common clinical scenarios for POCUS use
- How to get started with POCUS (for yourself & your institution)

What is POCUS?

- Performed *and interpreted* by primary provider…
- …at the bedside…
- …focused…
- …to help answer a clinical question…
- …quickly.



Soni, Diagnostic POCUS for Hospitalists. JHM, 2015

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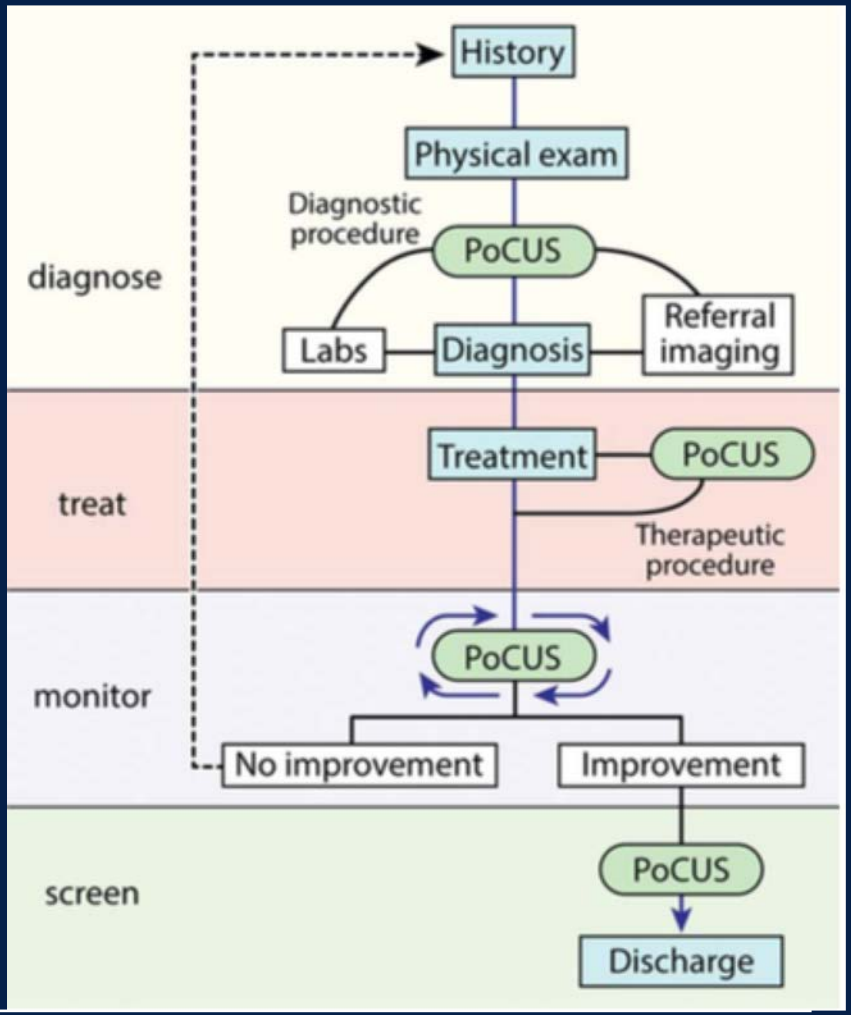
How can we use POCUS?

- Diagnostic
- Therapeutic (procedural guidance)
- Treatment monitoring
- Disease screening



Soni, Diagnostic POCUS for Hospitalists. JHM, 2015

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Why POCUS?

- Decreases procedural complications
  - now standard of care for many procedures
- Increases efficiency and accuracy of diagnosis
  - Great data: hypoxia/dyspnea algorithms, inpatient heart failure management, fluid responsiveness, etc.
- Increases patient satisfaction
- Use supported by professional societies

Why else POCUS?

- **It's really cool!**
- 2017 UCSF Three-Site Survey of Hospitalists:
  - 93% believe POCUS is important for diagnostics
  - 88% believe POCUS should be part of residency training
  - 93% believe faculty would benefit from education
- Residents are learning (and using) it

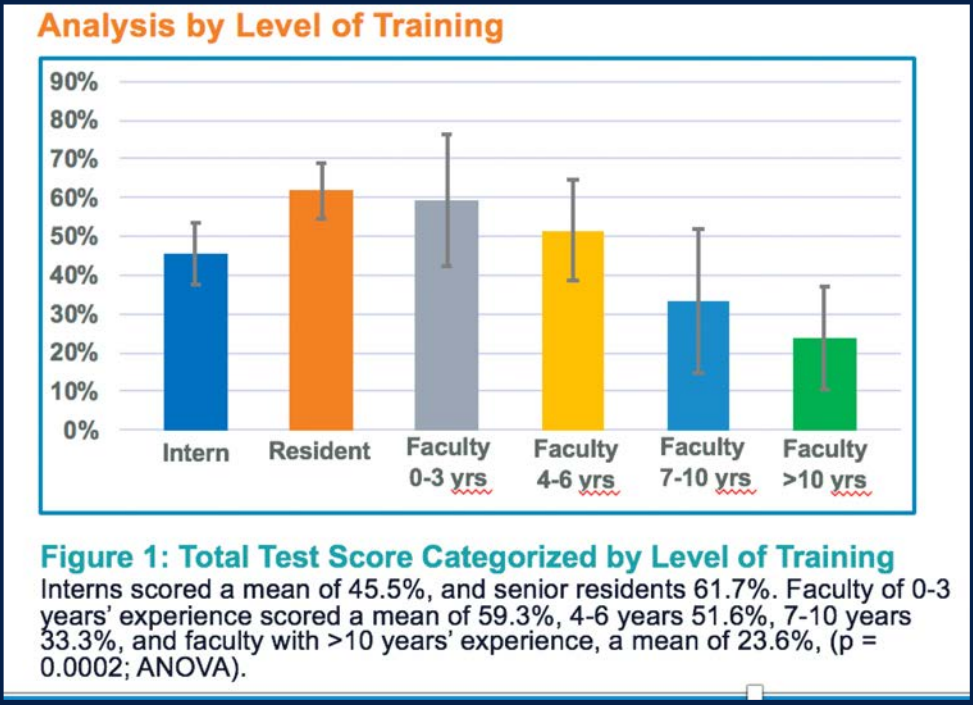

Figure 1: Total Test Score Categorized by Level of Training
Interns scored a mean of 45.5%, and senior residents 61.7%. Faculty of 0-3 years' experience scored a mean of 59.3%, 4-6 years 51.6%, 7-10 years 33.3%, and faculty with >10 years' experience, a mean of 23.6%, (p = 0.0002; ANOVA).

Anstey et al, SHM abstract, 2018

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What is the scope of POCUS in HM?

TABLE 1. **Common POCUS applications for hospitalists**

Cardiac	Pulmonary	Abdominal	Vascular	MSK	Procedural
LV assessment	Pleural effusion	Free fluid	DVT	Cellulitis	Paracentesis
RV assessment	Interstitial syndromes	Kidney size	AAA	Abscess	Thoracentesis
Atrial size	Alveolar syndromes	Hydronephrosis		Joint effusions	CVC placement
Right atrial pressure (IVC/IJ)	Pneumothorax	Bladder volume		Fractures	PIV placement
Pericardial effusion		Gallbladder			Arterial line placement
Chamber hypertrophy		Spleen size			Arthrocentesis
Gross valvular abnormalities		Liver size			Abscess drainage
					Lumbar puncture

Multisystem

Hypotension and shock: cardiac, RAP, pulmonary, DVT, abdominal free fluid

Resuscitation: cardiac, RAP, pulmonary

Dyspnea: pulmonary, Cardiac, RAP, DVT

Acute renal failure: renal, bladder, IVC, pulmonary

LV, left ventricle; RV, right ventricle; IVC, inferior vena cava; IJ, internal jugular vein; DVT, deep venous thrombosis; AAA, abdominal aortic aneurysm; CVC, central venous catheter; PIV, peripheral intravenous catheter; RAP, right atrial pressure.

Soni et al, "Point-of-Care Ultrasound for Hospitalists: A Position Statement of the Society of Hospital Medicine." JHM 2019

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Cases: Inpatient Care as a POCUS Hospitalist

- 4 common inpatient scenarios
  - Brief HPI and exam
  - Demo image acquisition and review normal
  - Review abnormal images
  - Discuss how POCUS impacted care delivery

Case 1: Mr. Seth is short of breath

- **HPI**: 61 yo M with history of obesity, CAD s/p CABG (2016), HFrEF (EF 45%), COPD is admitted to medicine for COPD exacerbation 2/2 CAP. He has been treated with nebulizers, prednisone, and antibiotics (ceftriaxone/doxycycline). On HD #3, a Rapid Response is called for increasing respiratory distress and anxiety. You go to bedside with the Rapid Response team.

- **Vitals:** T98.5, HR 117, BP 192/97, RR 26, O2 sat 82% on RA → 93% on 6L NC
- **Exam:**
  - General: In moderate distress.
  - CV: Tachycardic, Irregular, no MRG. Unable to assess JVP. 1+ pitting edema of the lower extremities bilaterally.
  - Lung: tachypneic, increased WOB, scattered wheeze with bilateral lower lobe rales.

- **Labs:** Most recent normal CBC and BMP, BNP 421 (unknown baseline), troponin pending, EKG non-ischemic in Afib. CXR ordered.

Case 1: Mr. Seth is short of breath **+ POCUS!**

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On admission, >3 b-lines in R anterior lung, otherwise normal. IVC 1.8cm and collapsible

- **Vitals:** T98.5, HR 117, BP 192/97, RR 26, O2 sat 82% on RA → 93% on 6L NC
- **Exam:**
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  - Lung: tachypneic, increased WOB, scattered wheeze with bilateral lower lobe rales.

Now, diffuse b-lines in bilateral lung fields, bilateral pleural effusions. IVC 2.4cm and minimally collapsible.

- **Labs:** Most recent normal CBC and BMP, BNP 421 (unknown baseline), troponin pending, EKG non-ischemic in Afib. CXR ordered.

(You were done with your POCUS assessment by the time the CXR was ordered ☺)

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Demo: Lung Ultrasound (LZ 1-3)

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Demo: Lung Ultrasound (LZ 4)

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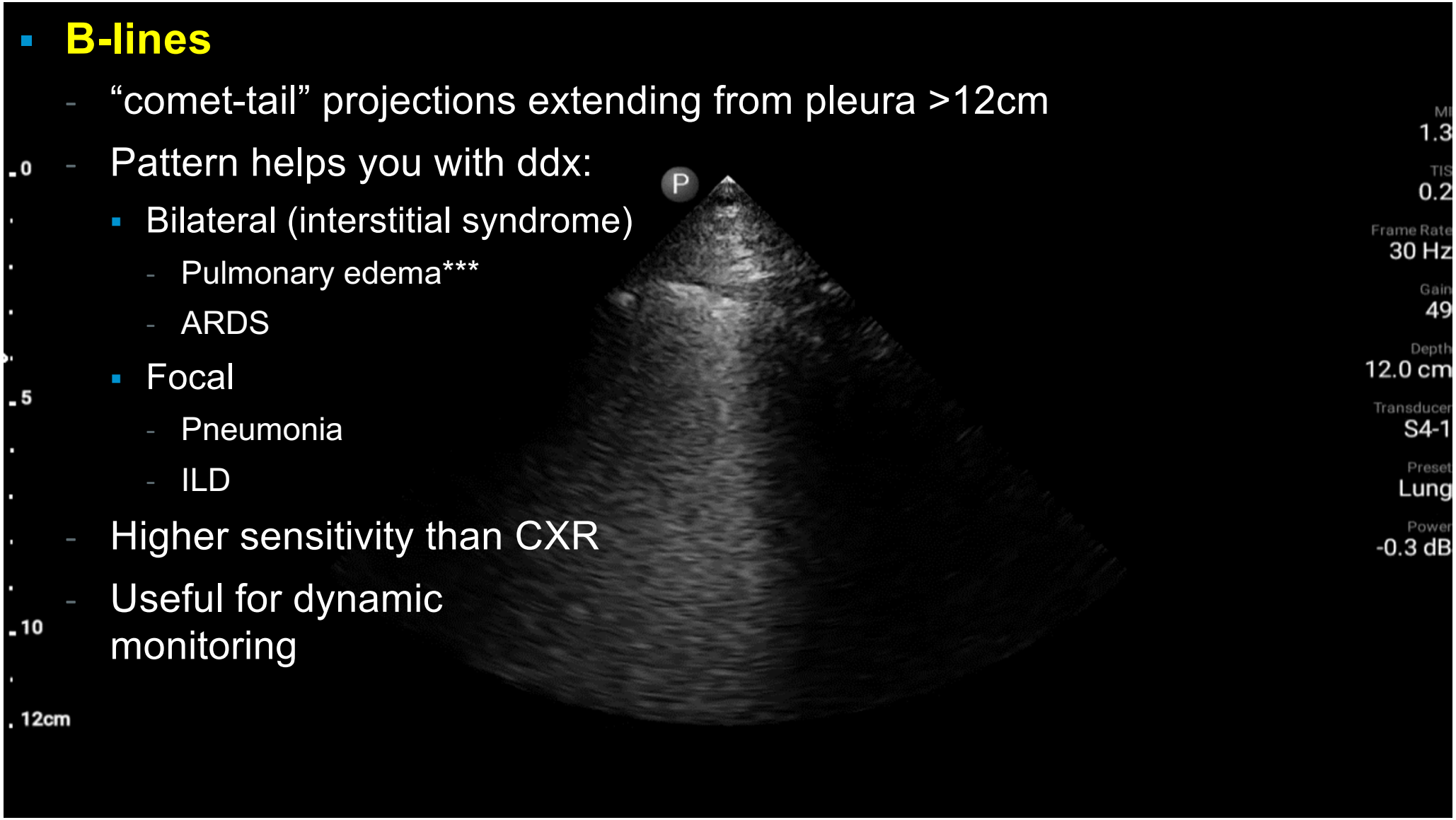
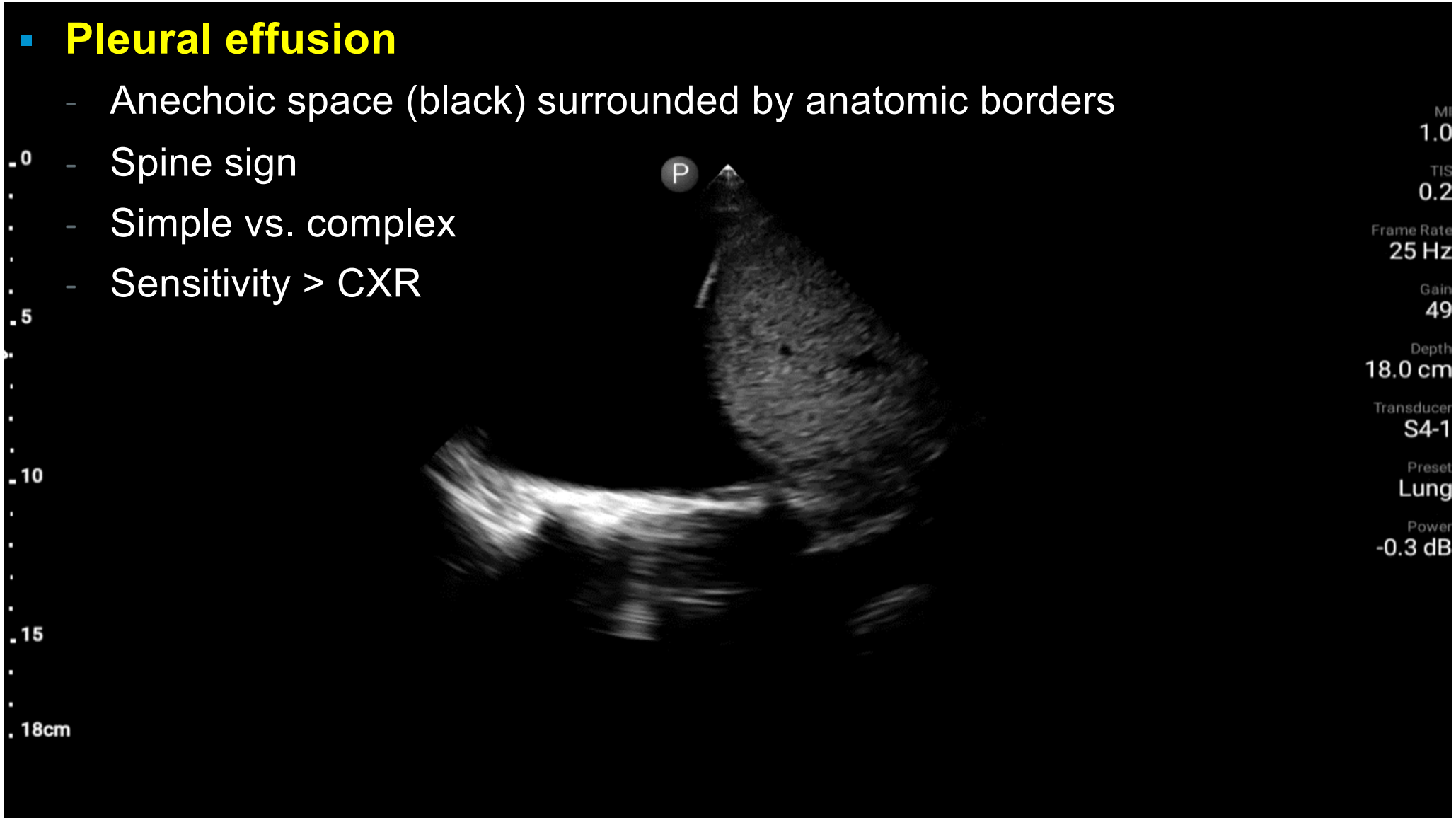
Demo: IVC Ultrasound

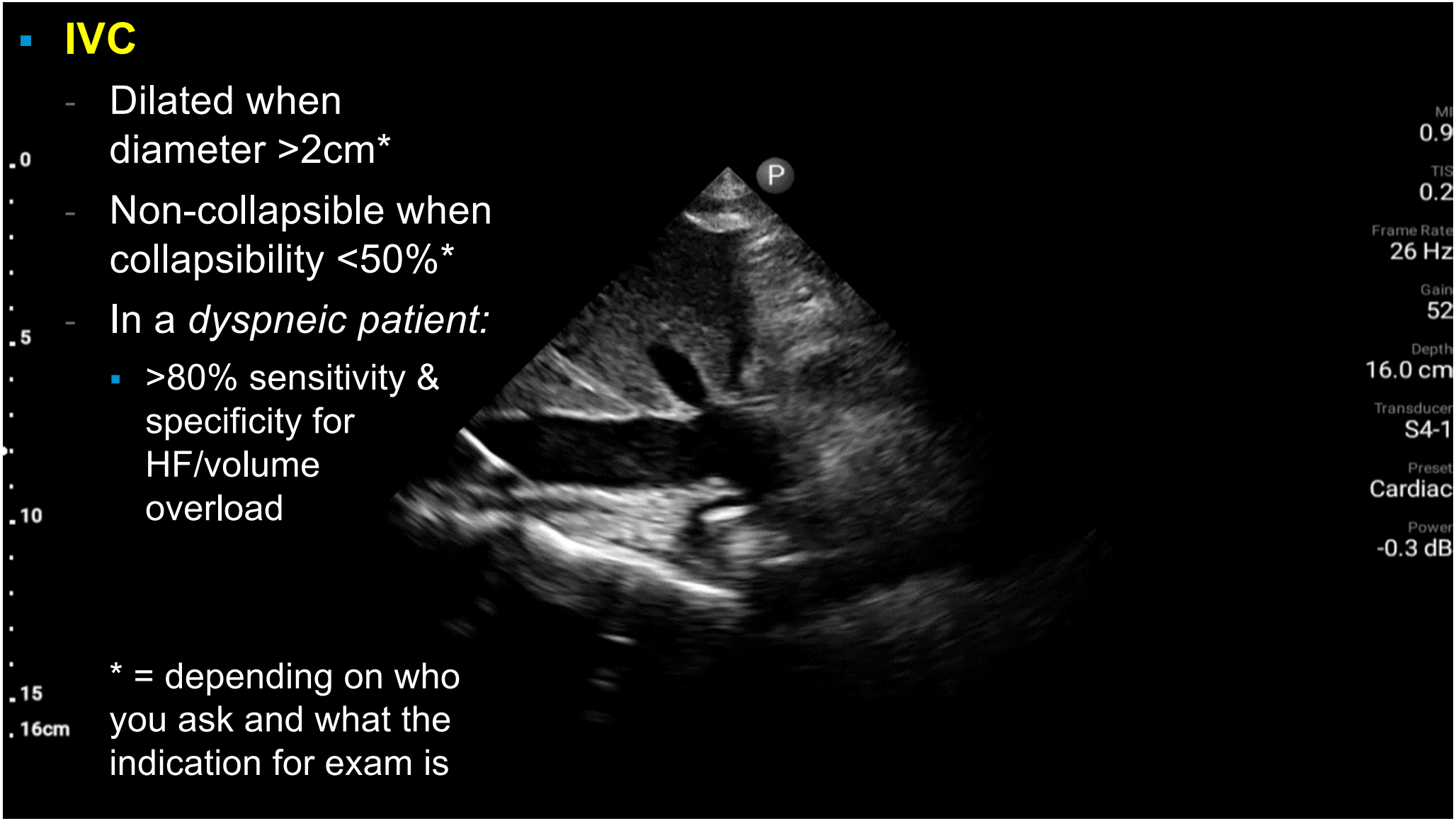
- **B-lines**
  - “comet-tail” projections extending from pleura >12cm
  - Pattern helps you with ddx:
    - Bilateral (interstitial syndrome)
      - Pulmonary edema***
      - ARDS
    - Focal
      - Pneumonia
      - ILD
  - Higher sensitivity than CXR
  - Useful for dynamic monitoring



- **Pleural effusion**
  - Anechoic space (black) surrounded by anatomic borders
  - Spine sign
  - Simple vs. complex
  - Sensitivity > CXR



- **IVC**
  - Dilated when diameter >2cm*
  - Non-collapsible when collapsibility <50%*
  - In a *dyspneic patient:*
    - >80% sensitivity & specificity for HF/volume overload



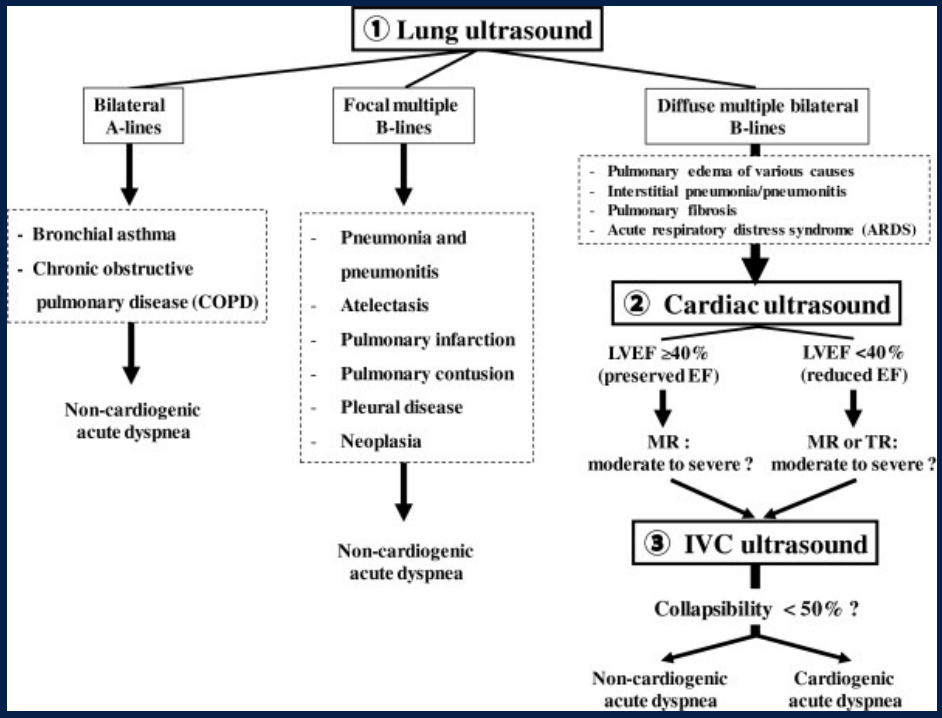
* = depending on who you ask and what the indication for exam is

Case 1 Resolution

- You diagnose interstitial syndrome and pleural effusions on lung POCUS; volume overload on IVC US
- Given his hypertension you consider flash pulmonary edema vs decompensated HF as etiology for his dyspnea and hypoxia. You give him IV Lasix and treat his blood pressure
- 2 hours later, BP normalized and hypoxia improving
- You make a mental note to check his lung and IVC US again tomorrow to decide about thoracentesis and further need for diuretics

Case 1 Take Home Points

- POCUS improved the quality of your admission exam, and helped you *quickly* identify why his condition acutely changed



- When possible:
  - Have an algorithmic approach
  - Use in combination
    - Combined lung-cardiac-IVC US has >90% accuracy in diagnosing heart failure in dyspneic patients

Kajimoto et al, Cardiovascular Ultrasound, 2012.

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Case 2: Mrs. Essig is hypotensive

- **HPI**: 52yo F with history of metastatic breast cancer c/b R malignant pleural effusion on chemotherapy presents with generalized weakness, dyspnea, and lethargy. Her ROS is otherwise negative. In triage, her HR 123 and BP 82/40, so she was given 2L IVF with improvement. You are called for admission for failure to thrive and infectious workup.

- **Vitals:** T97.5, HR 112, BP 90/47, RR 16, O2 sat 96% on RA
- **Exam:**
  - General: arousable but somnolent, appears comfortable
  - CV: Tachycardic, regular, no MRG. JVP to 6cm. Chronic lymphedema of the lower extremities bilaterally (baseline per patient's husband).
  - Lung: breathing comfortably on RA, diminished breath sounds RLB but otherwise CTA bilaterally

- **Labs:** CBC and BMP normal. Tbili 1.6, normal AST/ALT. BNP 235 (unknown baseline). TnI negative.

Case 2: Mrs. Essig is hypotensive **+ POCUS!**

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- **Labs:** CBC and CMP normal. BNP 235 (unknown baseline). TnI negative. CXR with stable L pleural effusion from prior.

Lungs with a-lines throughout all lung fields, moderate L pleural effusion

IVC 1.8cm with ~50% collapse with inspiration

Cardiac US with mildly reduced LVEF, pericardial effusion

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Demo: Cardiac US (Parasternal Long Axis)

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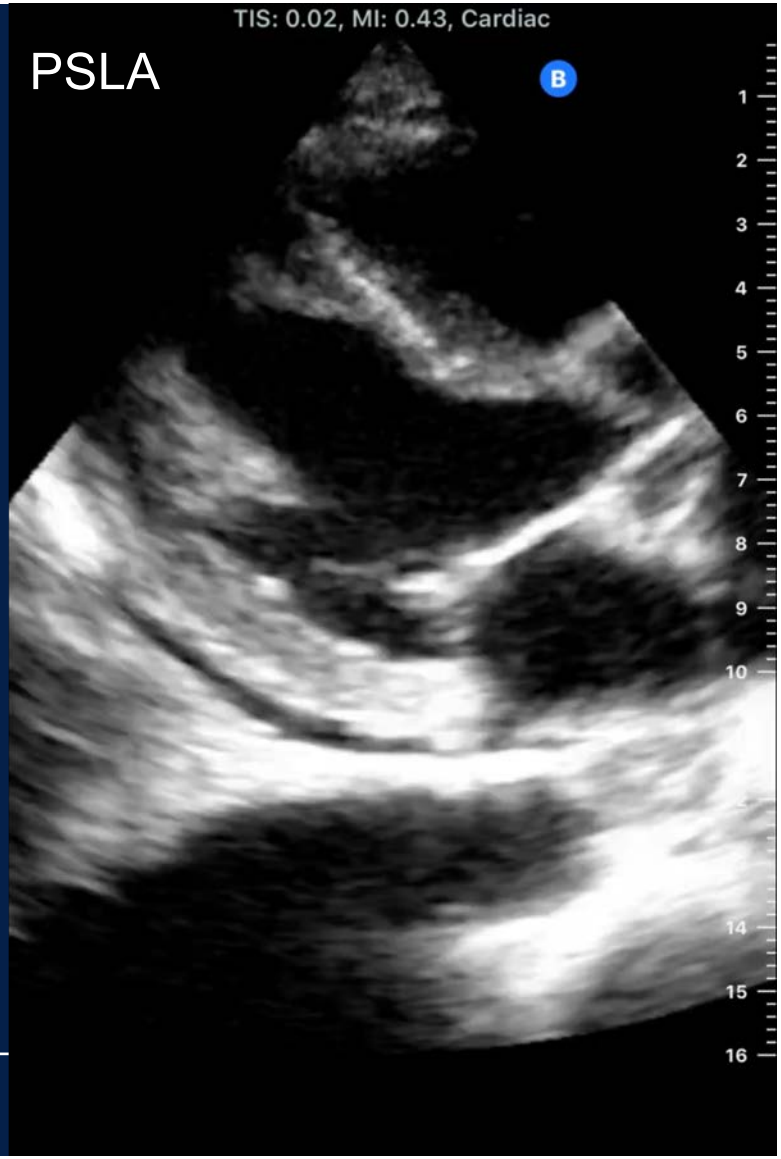
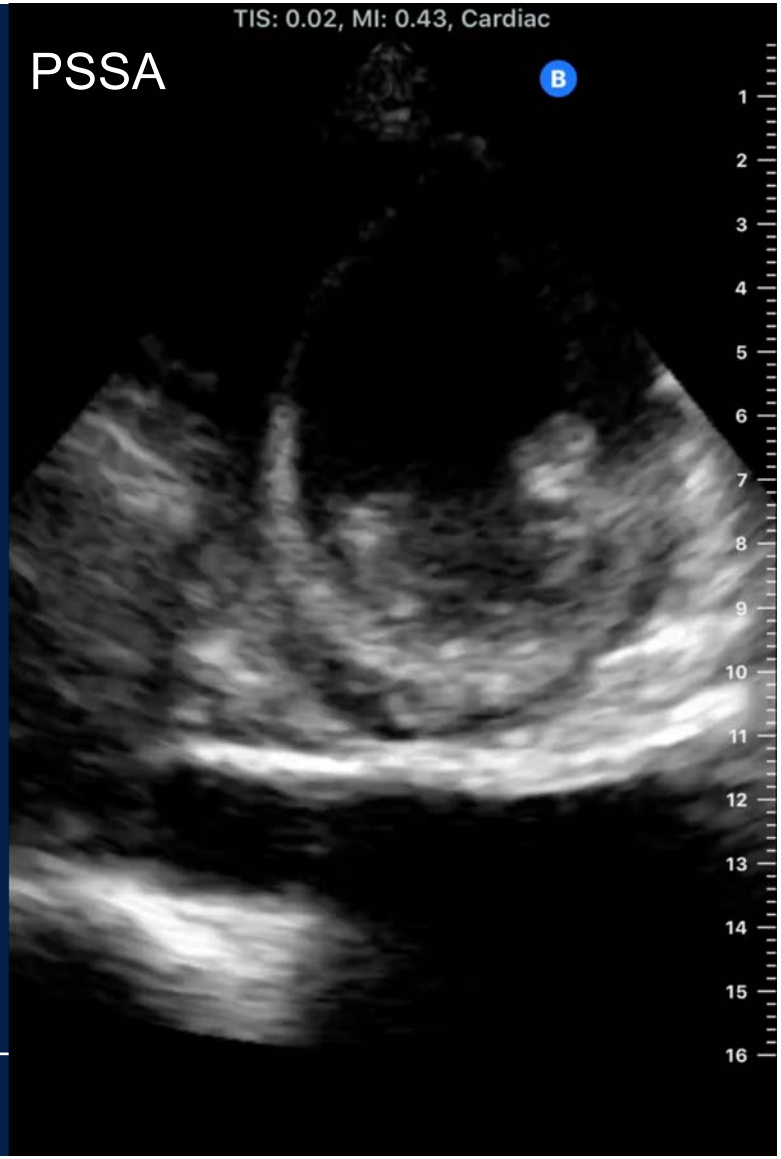
Demo: Cardiac US (Parasternal Short Axis)

- **LV Ejection Fraction**
  - Evaluation
    - End-point Septal Separation (EPSS)
    - Fractional Shortening
    - Myocardial Thickening
  - Qualitative assessment:
    - Hyperdynamic
    - Normal
    - Mild-moderately reduced
    - Severely reduced
  - Hospitalist assessment of LV dysfunction = 91% sensitivity; 88% specificity

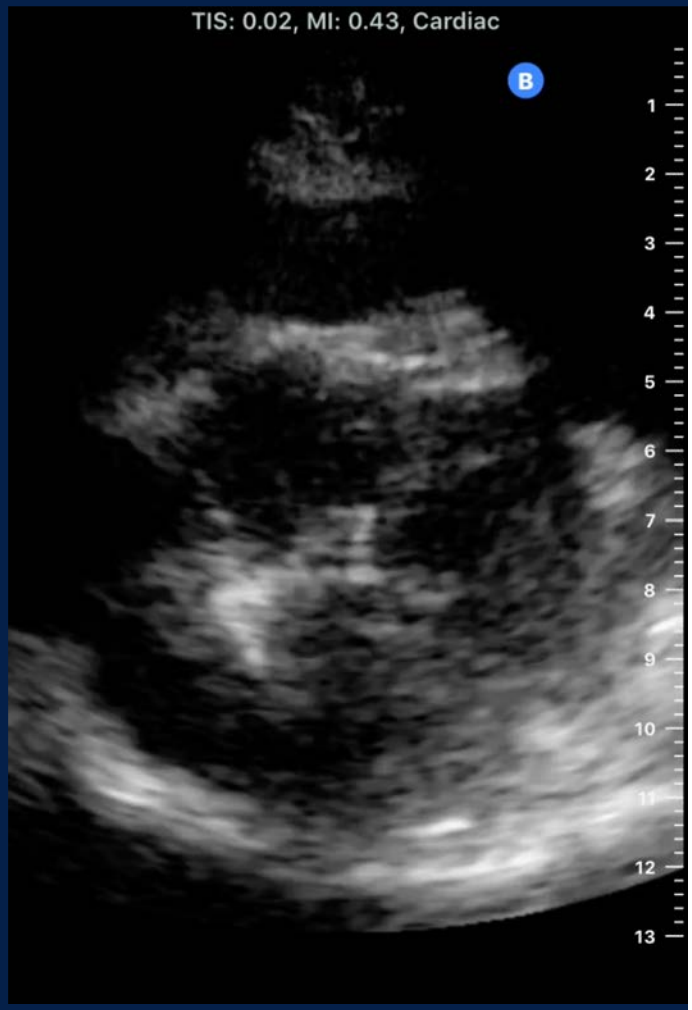


- **Pericardial Effusion**
  - Anechoic (black) space between the pericardium and heart
  - Qualitative assessment:
    - Small = <1cm, non-circumferential
    - Moderate = 1-2cm, +/- circumferential
    - Large = >2cm, circumferential
  - Hospitalist assessment of moderate-large pericardial effusion = 100% sensitivity; 87% specificity
  - Apical 4 chamber, sub-xiphoid best for evaluating signs of chamber collapse (tamponade)



Case 2 Resolution

- You diagnose new mild-moderate LVEF reduction (likely 2/2 chemotherapy) and new small pericardial effusion (likely malignant); she last had a normal TTE one year ago.
- Repeat TTE on HD#1 confirms new EF 40%, pericardial effusion enlarges from small to moderate in 1st 24 hours
- HD#3 she develops tamponade physiology, undergoes pericardial drain placement. Patient and family opt for hospice referral.



Case 2 Take Home Points

- POCUS on admission led you to a faster, new diagnosis of HFrEF. This ultimately affected:
  - Clinical management: more cautious with IVF
  - Further diagnostic testing: ordered TTE from admission
  - Monitoring evolution of pericardial effusion

Table 4 Diagnostic Test Characteristics of Hand-Carried Echocardiography Using Standard Echocardiography as the Reference Standard in 210 Participants*

Cardiac Abnormality	Prevalence n/total n	Sensitivity* % (95% CI)	Specificity* % (95% CI)	$LR_{positive}$* (95% CI)	$LR_{negative}$* (95% CI)
LV systolic dysfunction	67/210	84 (73-92)	85 (78-90)	5.4 (3.7-8.1)	0.2 (0.1-0.3)
Pericardial effusion, moderate or large	3/210	100 (29-100)	87 (82-91)	7.7 (2.6-10.1)	0 (0-0.6)

Adapted from Lucas et al, Am J Med 2011

Case 3: Dr. Nye has an AKI

- **HPI**: 84yo M with history of BPH, HTN, DM2 presents to the hospital with AMS, lower abdominal pain and decreased urination. In the ED, he is noted to have K 6.4 on iSTAT. The ED physician tells you that he had hydronephrosis and a distended bladder on POCUS, so a foley was placed with 400cc urine output. He also received treatment for hyperkalemia. Because of the patient's ongoing abdominal pain, the ED physician orders a CT abd/pelvis.

- **Vitals:** all within normal limits
- **Exam:**
  - General: mildly agitated but redirectable, no distress
  - Abd: soft, +suprapubic tenderness, no CVA tenderness, no distension, NABS
  - GU: foley in place draining cloudy yellow urine

- **Labs:** WBC 11.7, BUN 48, Cr 2.6, K 6.1. CBC, CMP, coags otherwise normal. UA +WBC, +nitrite, +LE, +blood. Urine culture pending. CTAP ordered, not yet done.

Case 3: Dr. Nye has an AKI

+ POCUS!

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Renal US: Bilateral hydronephrosis

Bladder still distended with foley balloon visible

FAST negative for free fluid

IVC 1.4cm, collapsible with inspiration

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Demo: Renal Ultrasound (RUQ)

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Demo: Renal Ultrasound (LUQ)

10/2/19

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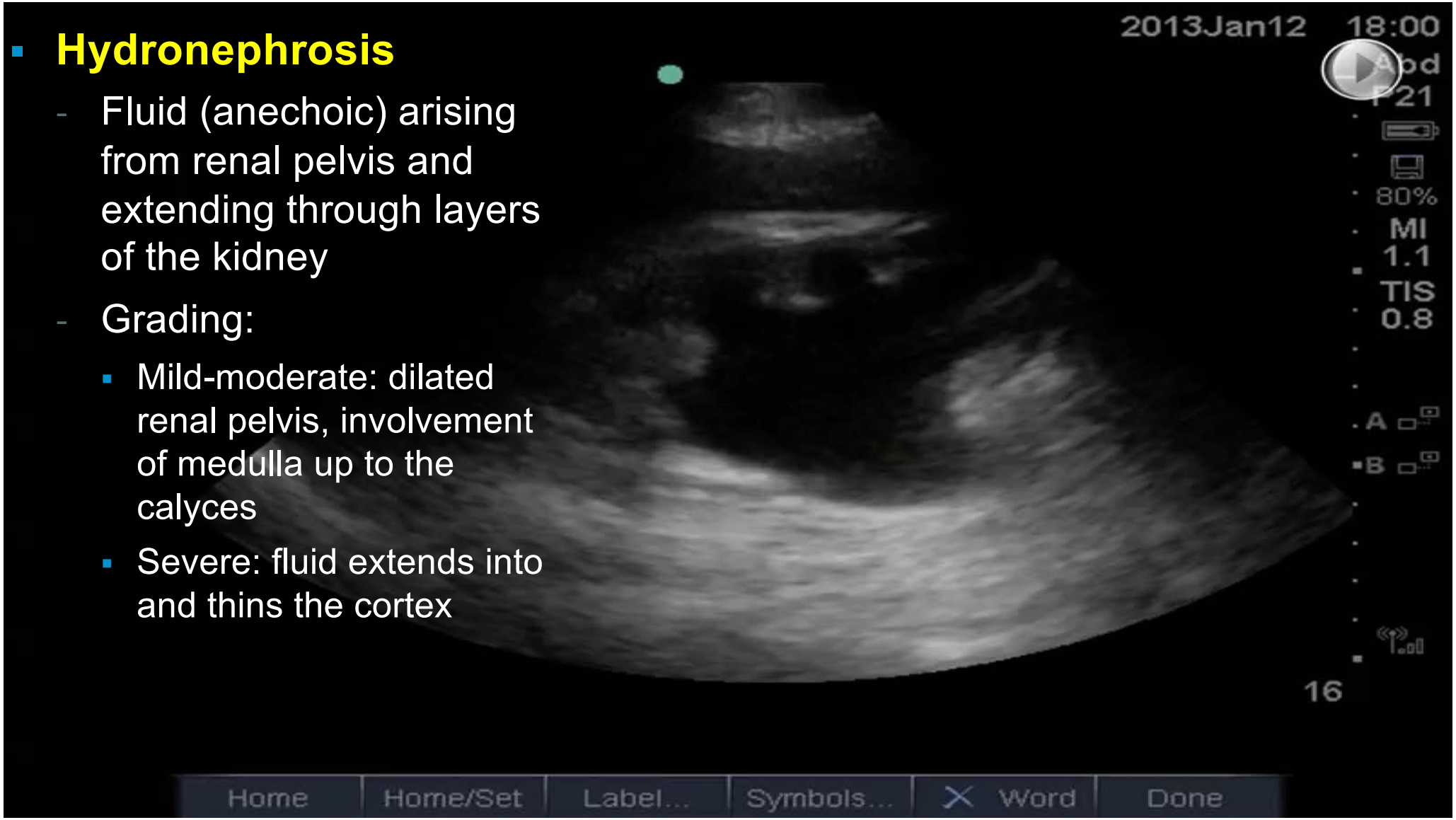
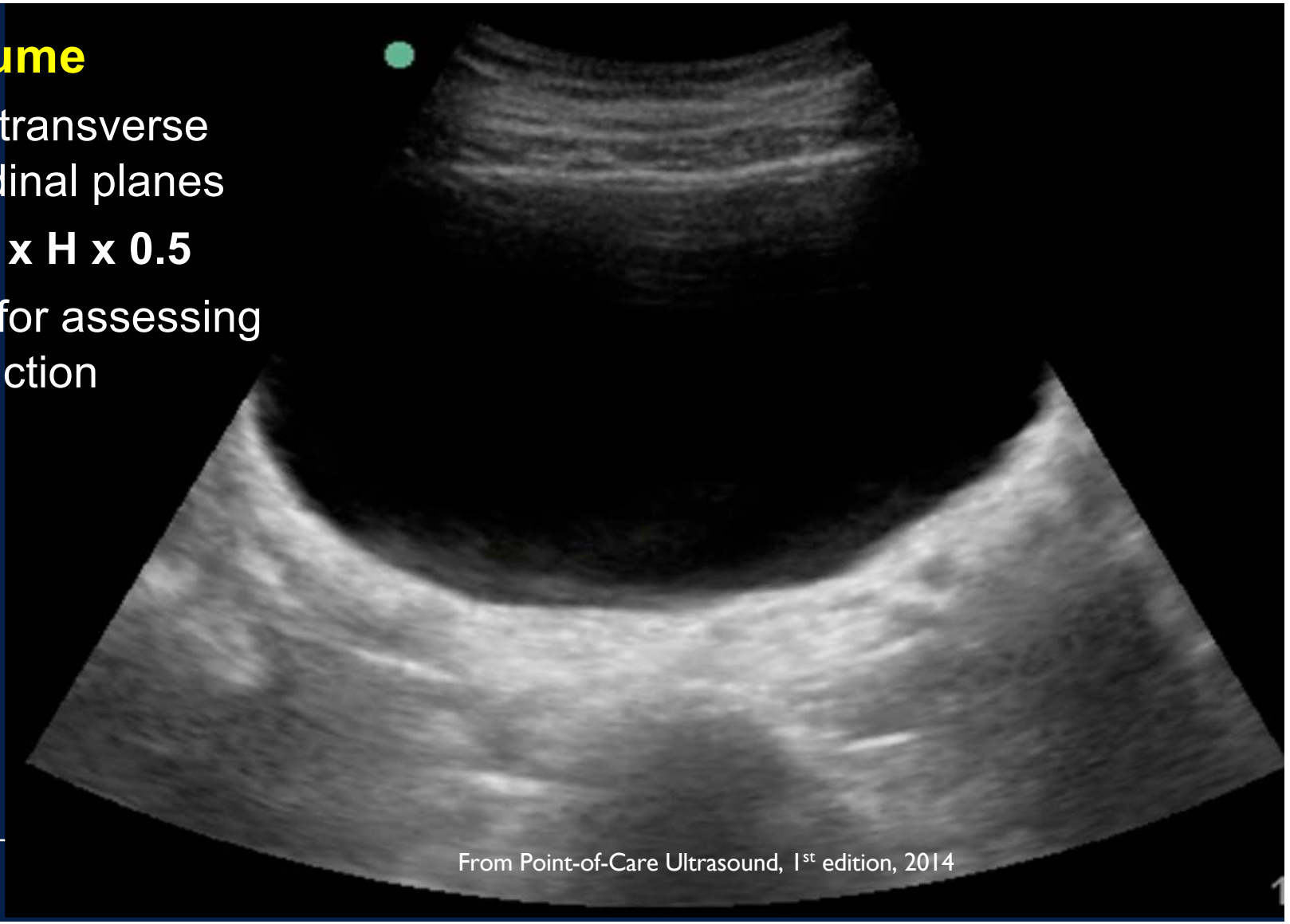
Demo: Bladder Ultrasound

- **Hydronephrosis**
  - Fluid (anechoic) arising from renal pelvis and extending through layers of the kidney
  - Grading:
    - Mild-moderate: dilated renal pelvis, involvement of medulla up to the calyces
    - Severe: fluid extends into and thins the cortex



- **Bladder Volume**
  - Measure in transverse and longitudinal planes
  - **BV = L x W x H x 0.5**
  - Also useful for assessing foley dysfunction



From Point-of-Care Ultrasound, 1st edition, 2014

Case 3 Resolution

- The foley was flushed and repositioned with return of an additional 800cc. He is started empirically on ceftriaxone for UTI and Tamsulosin for BPH. His abdominal pain resolves and you cancel the CT scan ordered in the ED.
- On the following day, the urine culture results positive for pan-sensitive E Coli, and he is narrowed to cephalexin for a planned 7 day course. His creatinine is improved and his K is normalized. The foley is removed and he passes a trial of void prior to discharge.

Case 3 Take Home Points

- POCUS helped you quickly identify a complication in your treatment plan, which helped you avoid a potential bad outcome as well as unnecessary CT scan.
- Accuracy of bladder volume by POCUS > bladder scan
- Detecting hydronephrosis is a readily attainable skill
  - IM residents x5 hrs of renal US practice = 94% sensitivity; 93% specificity for moderate-severe hydronephrosis

Case 4: Ms. Nidus has cellulitis

- **HPI**: 36yo F with history of IVDU, DVT no longer on anticoagulation presents to the ED on a Saturday night with a red, swollen, and painful RLE. She reports sometimes injecting into her R leg and does not always sterilize the needle beforehand. She has not had any fevers or chills. The leg is painful and a little swollen; she says it is similar to her prior episode of DVT. She denies any chest pain, palpitations, or dyspnea. The ED starts her on IVF, empiric antibiotics for cellulitis and orders a RLE Doppler, which is yet to be done.

- **Vitals:** Afebrile, HR 98, BP 108/55, RR 16, O2 sat 98% RA
- **Exam:**
  - General: awake, alert, cooperative. In mild distress 2/2 pain.
  - CV: RRR, no MRG.
  - MSK: RLE tender, erythematous, warm to touch on the anterior and lateral aspect of the distal RLE, extending from R ankle to just below the knee. No fluctuance or purulence. She is diffusely TTP overlying the area. Mild pitting edema of R>LLE. Intact femoral, popliteal, and DP pulses.

- **Labs:** WBC 12.3, Hgb 13.9, Plt 335. CMP normal. D-dimer 785. PT, INR, PTT within normal limits. Doppler RLE is ordered, but won't be performed until the techs arrive on Monday morning.

How many people would anticoagulate her?

Case 4: Ms. Nidus has cellulitis

+ POCUS!

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IVC 0.9cm diameter with almost 100% collapsibility with inspiration

Normal LVEF

Soft tissue US +cobblestoning, no deep fluid pockets

DVT US non-collapsible at level of common femoral vein

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Demo: Soft Tissue Ultrasound

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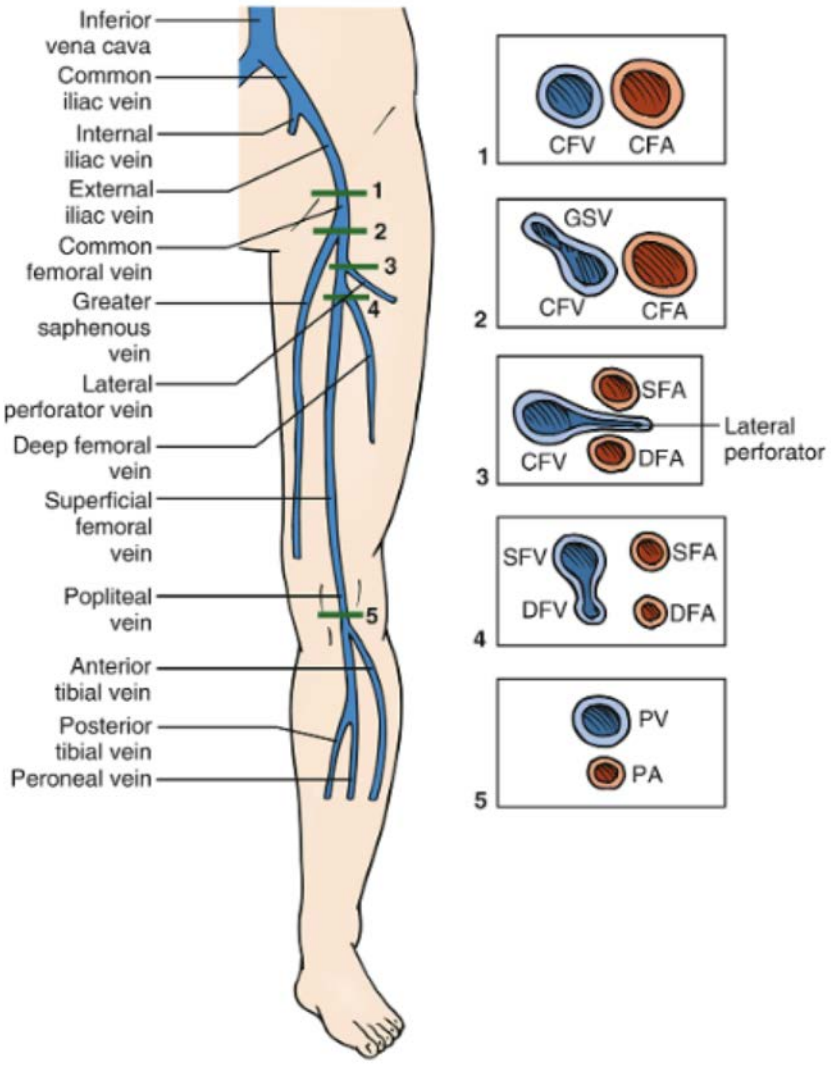
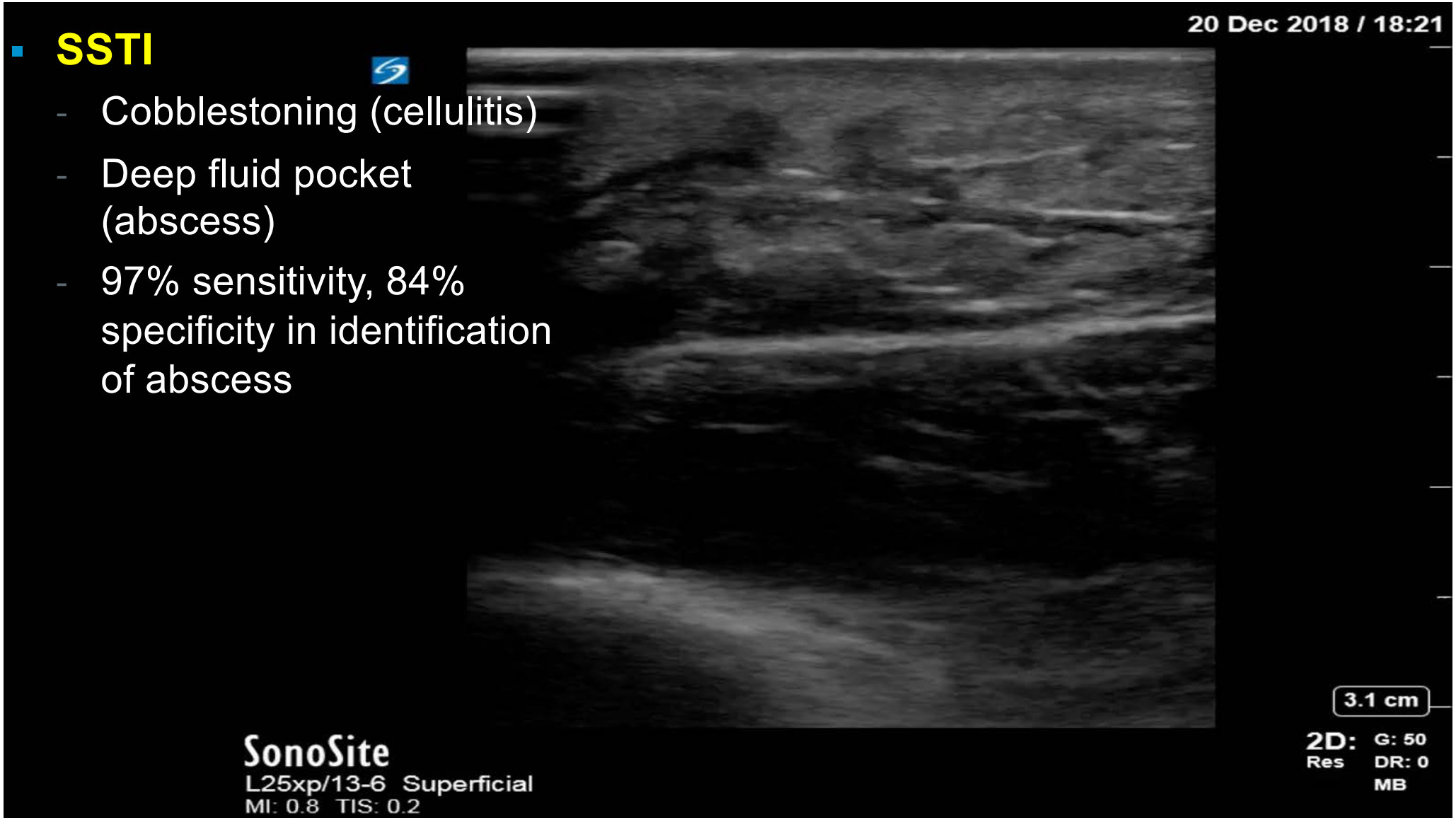
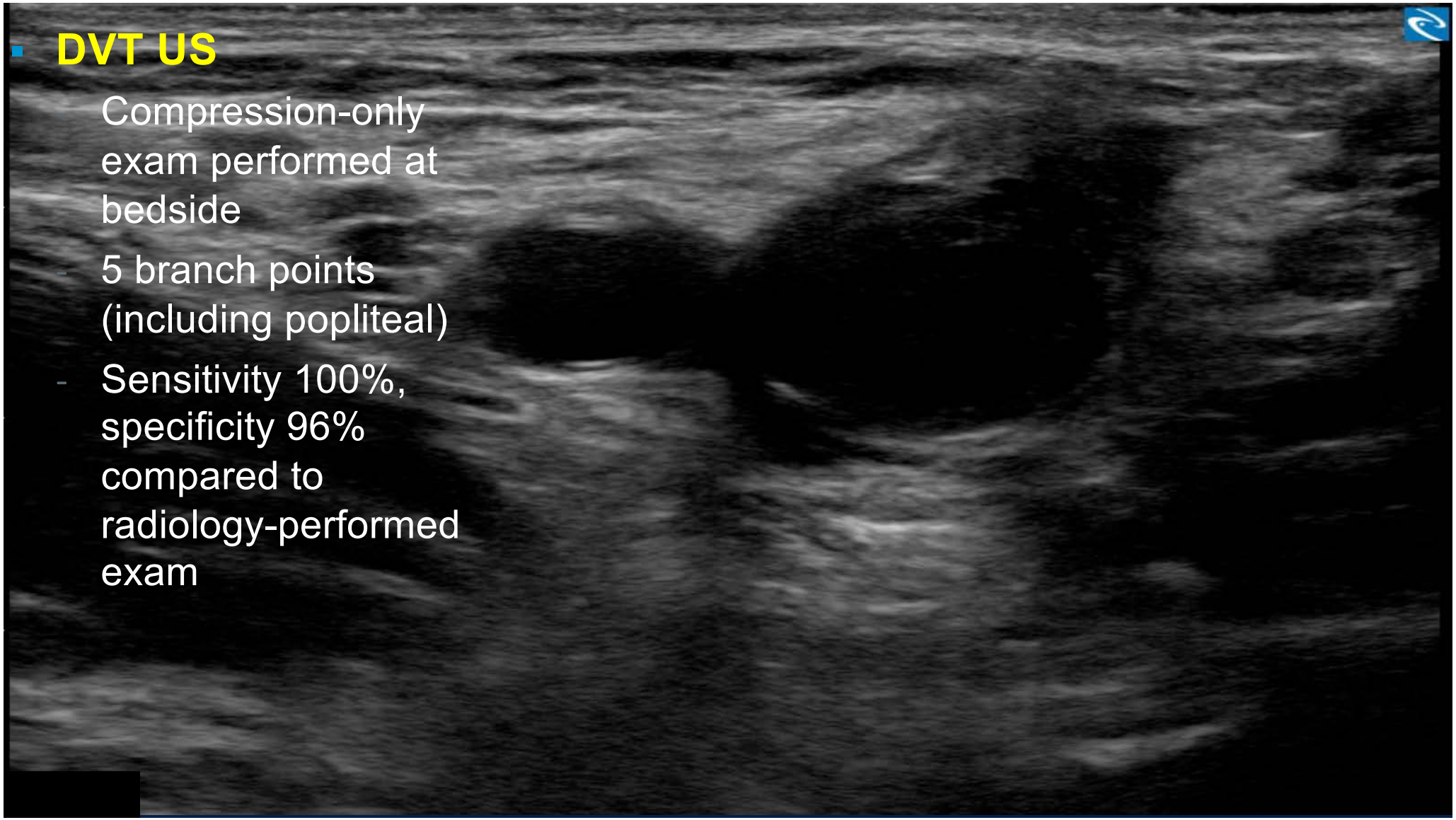
Demo: DVT US



Soni et al. Point of Care Ultrasound. Elsevier. 2015

- **SSTI**
  - Cobblestoning (cellulitis)
  - Deep fluid pocket (abscess)
  - 97% sensitivity, 84% specificity in identification of abscess




DVT US
Compression-only exam performed at bedside
5 branch points (including popliteal)
Sensitivity 100%, specificity 96% compared to radiology-performed exam

Case 4 Resolution

- She was given an additional 1L IVF with normalization of her lactate and improvement in hemodynamics.
- She was started on therapeutic lovenox for DVT seen on POCUS exam; confirmed by radiology DVT study 36 hours later.
- She tolerated oral antibiotics well with improvement in cellulitis. Her leg pain and swelling improved over the next 2 days. Prior to discharge, she was transitioned to oral rivaroxaban with plans to follow up with a community PCP

Case 4 Take Home Points

- In a resource-limited environment (overnights, weekends) POCUS can lead to a measurable difference in time to initiation of appropriate therapy.
- POCUS can help guide fluid resuscitation in the setting of hypotension or tachycardia.
- Just because you POCUS, doesn't mean you can't order the formal study!

So why do we POCUS?

- Facilitates earlier diagnosis and treatment
- Avoids additional tests and reduces radiation exposure
- Facilitates safe treatment monitoring, prognostication
- Skills are attainable and lead to better quality care delivery than exam alone

POCUS doesn't replace the physical exam; it enhances the physical exam.

Data for the POCUS we covered

Exam	Statistical Performance
IVC	Correlation coefficient 0.7-0.9
LVEF	LR +5.4; LR -0.2
Pericardial Effusion	LR +7.7; LR -0.0
Pulmonary Edema	Sensitivity 94%; Specificity 92%
Pleural Effusion	Sensitivity 93%; Specificity 96%
Hydronephrosis	Sensitivity 94%; Specificity 93%
DVT	Sensitivity 100%; Specificity 96%
Abscess	Sensitivity 97%; Specificity 84%

Data for POCUS Algorithms

- Rapid Ultrasound in Shock and Hypotension (RUSH)

	Shock Type Based on Final Diagnosis				
	Hypovolemic (n = 16)	Cardiogenic (n = 20)	Obstructive (n = 11)	Distributive (n = 11)	Mixed (n = 11)
Sensitivity	100%	90%	90.9%	72.7%	63.6%
Specificity	96.2%	98%	98.2%	100%%	98.2%
PPV [c]	88.9%	94.7%	90.9%	100%	87.5%
NPV	100%	97%	98.3%	95.1%	93.3%
Kappa (P Value)	0.92 (0.000)	0.89 (0.000)	0.89 (0.000)	0.81 (0.000)	0.70 (0.000)

- BLUE protocol for dyspnea/hypoxia

Findings	Diagnosis	Sensitivity (%)	Specificity (%)
A lines (normal)	Asthma/COPD	89	97
Diffuse B lines (>2 lung zones)	Pulmonary edema	97	95
Loss of pleural line, consolidation, patchy B lines	Pneumonia	89	94
A lines without pleural sliding, lung point	Pneumothorax	81	100

How can you integrate POCUS into your practice?

- Depends on:
  - Context: what is available where you're practicing
  - Frequency: how often will you do an exam
  - Difficulty: how hard the exam is to learn and perform
  - Patient-related factors: habitus, imaging windows
  - Data: how helpful your exam is in answering your question (LR)

Addressing Barriers

- Hardware
- Training
- Time and money constraints
- Credentialing and privileging

https://www.krestonreeves.com/news-and-events/12/07/2019/address-business-growth-barriers

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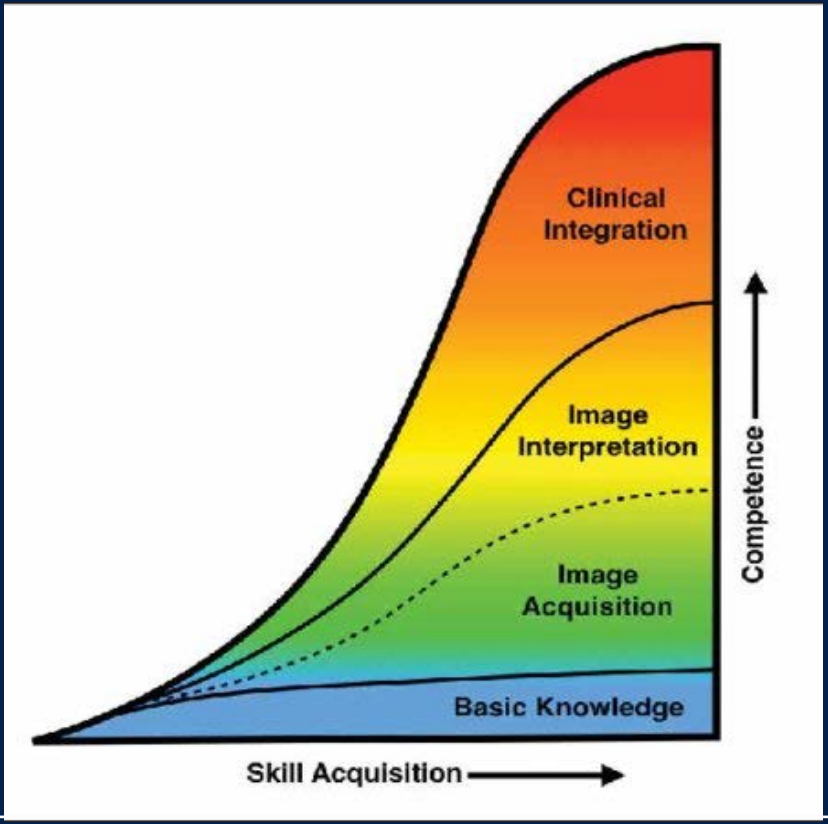
POCUS Learning Pathways



- Self-learning, ad hoc skill acquisition (FOAMed)
- Learn from local experts (EM, critical care colleagues)
- Attend workshops (SHM, ACP, AIUM, UCSF)
- Undertake a certificate program (ACCP, SHM)

Soni et al. Cert of POCUS. JHM 2017

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Our institution's experience

Getting started…

- Champion(s)
- Leadership buy-in
  - Education
  - Research
  - Procedures
  - Clinical outcomes




"The larger issue now is to decide whether we believe that – in this case hospitalists – building competency in ultrasound among generalist physicians will enhance patient safety, quality, and value. **Personally, I do."**

- Bob Wachter, 2012

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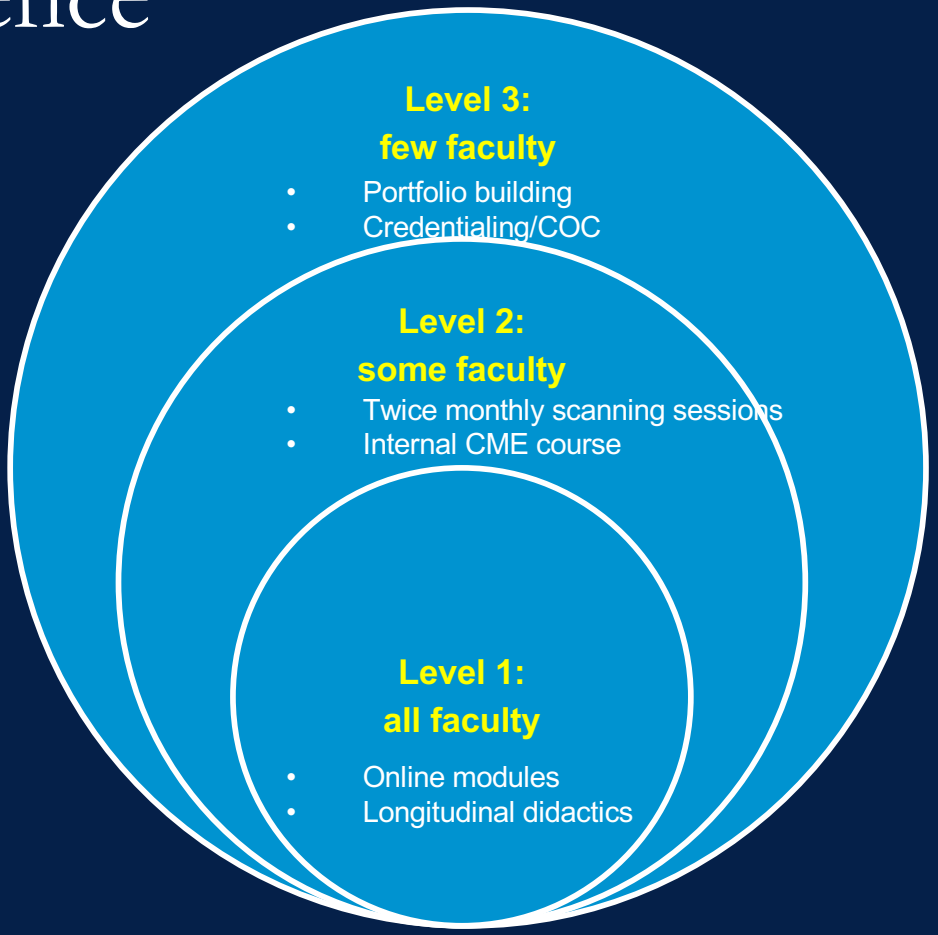
Our institution's experience

Building momentum…

- Training program development
- Equipment investment



Conner et al, POCUS Journal, in press.

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Our institution's experience

Making it official…

- Quality assurance
- Privileging and credentialing
- Integration into EMR and billing (*work in progress*)

Review of Session Goals

- How POCUS is currently used in hospitalized patients
- Common clinical scenarios for POCUS use
- How to get started with POCUS (for yourself & your institution)

POCUS is the future of the physical exam.

Questions?

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Credit: University of South Carolina Point of Care US