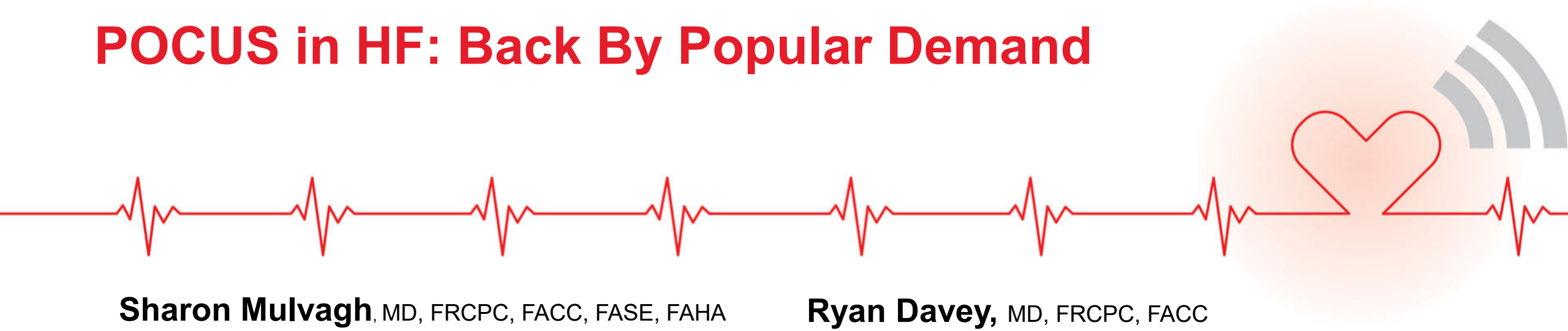
POCUS in HF: Back By Popular Demand



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Conflict of Interest Disclosures:

- None that are relevant to this presentation
- I will not discuss off-label uses

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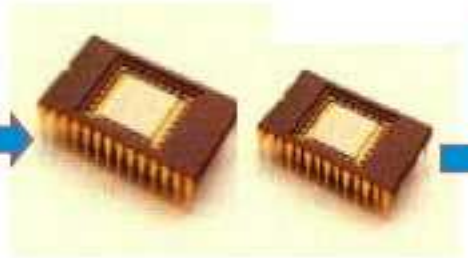
OBJECTIVES

1) Understand the purpose and basic components of point of care ultrasound (POCUS)
2) Describe typical POCUS findings associated with heart failure
3) Understand the pitfalls of POCUS technology and interpretation

POLL: My exposure to POCUS would be best characterized by which of the following statements:

1) I regularly use POCUS in clinical assessments with confidence
2) I am occasionally using POCUS, and feel confident in my skills
3) I am occasionally using POCUS, but do not feel confident in my skills
4) I have limited prior echo experience and am contemplating getting a POCUS device
5) I have access to a POCUS device, but have no idea how to use it
6) I don't have access to a POCUS device, but wish I did, and want to learn how to use it
7) POCUS? It's just HOCUS-POCUS. Why do we need it?

Portability and Miniaturization of Ultrasound Systems



THEN

NOW

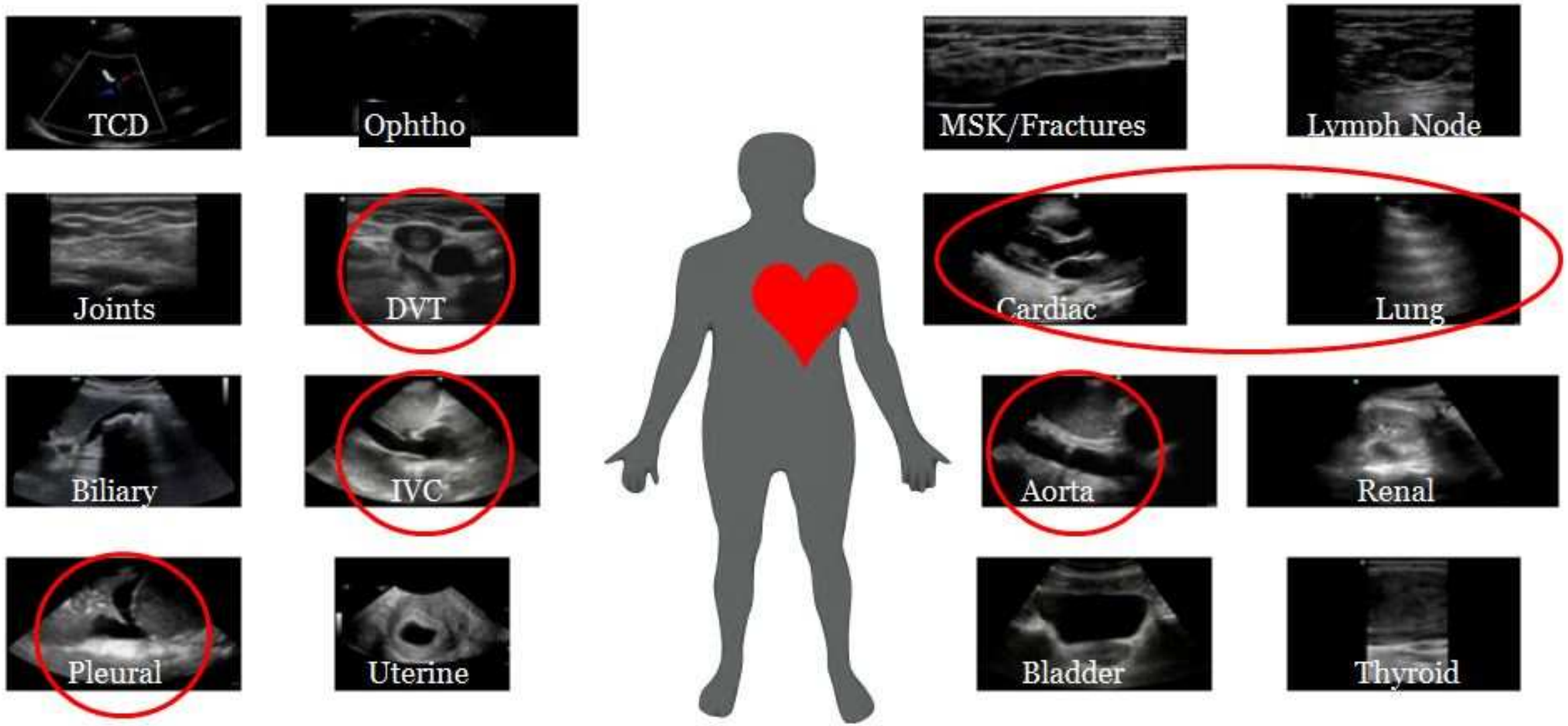

DISRUPTION

What is Point-of-Care Ultrasound?

- **Ultrasonography performed and interpreted by the clinician at the bedside and integrated in to patient care in real time**

-bedside, rapid, small
-goal directed workflow
-diverse specialties
-multi-system interrogation
-24/7 availability
-repeatable
-live streaming/AI guidance

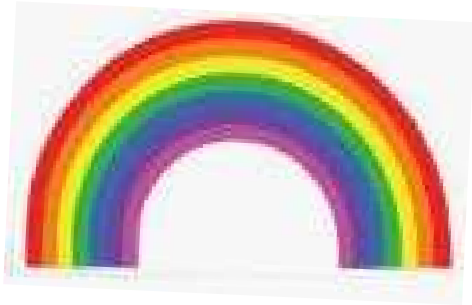
POCUS Scope


TCD
Ophtho
MSK/Fractures
Lymph Node
Joints
DVT
Cardiac
Lung
Biliary
IVC
Aorta
Renal
Pleural
Uterine
Bladder
Thyroid

POCUS is a spectrum

Focused Cardiopulmonary Ultrasound

- **FOCUS**
- Umbrella term
- Real-time, bedside
- Targeted clinical question
- Heart Lung Vessels
- Can include Limited TTE, CCE, POCUS, UAPE



Limited Transthoracic Echocardiogram

- **Limited TTE**
- Can be real-time, bedside
- Targeted clinical question
- Heart (vessels)
- Sonographer or echocardiographer
- Can be converted to comprehensive TTE (3D, UEA, strain etc.)
- Rigorous archiving

Critical Care Echocardiogram

- **CCE**
- Real-time, bedside
- Targeted clinical question
- Heart Lung Vessels
- Critical Care provider and setting
- Results reported, Archived

Cardiopulmonary Point-of-care Ultrasound

- Cardiopulmonary **POCUS**
- Real-time, bedside
- Targeted clinical question
- Heart Lung Vessels
- Multiple providers and settings
- Results archived, reported (ideally)

Cardiopulmonary Ultrasound AssistedPhysical Examination

- Cardiopulmonary **UAPE**
- Real-time, bedside
- Targeted or routine especially if auscultation is challenging (noise, PPE interference)
- Heart Lung Vessels
- Multiple providers and settings
- Results integrated into chart; no report

Cardiac POCUS: Training and Goals

CARDIAC POCUS

- Medical Student/Novice Curriculum
- ≥1-2 weeks training
- Cardiac POCUS Portfolio
  - 30-50 proctored cardiac POCUS scans with image review and interpretation in comparison with full feature echo
- Cardiac POCUS Refresher
  - 10 proctored scans

GUIDELINES AND STANDARDS

Recommendations for Echocardiography Laboratories Participating in Cardiac Point of Care Cardiac Ultrasound (POCUS) and Critical Care Echocardiography Training: Report from the American Society of Echocardiography

James N. Kirkpatrick, MD, FASE, Richard Grimm, DO, FASE, Amer M. Johri, MD, FASE, Bruce J. Kimura, MD, Smadar Kort, MD, FASE, Arthur J. Labovitz, MD, FASE, Michael Lanspa, MD, FASE, Sue Phillip, RCS, FASE, Samreen Raza, MD, Kelly Thorson, MSRS, ACS, RDCS, RCCS, FASE, and Joel Turner, MD, FRCP, *Seattle, Washington; Cleveland, Ohio; Kingston, Ontario and Montreal, Quebec, Canada; San Diego and Palo Alto, California; Stony Brook, New York, Tampa and Naples, Florida; Salt Lake City, Utah; Baltimore, Maryland; Plano, Texas*

Keywords: Cardiac POCUS, Critical care echocardiography, Training, Echocardiography laboratory

Kirkpatrick JN et al. J Am Soc Echocardiogr. 2020; 33:409-22

Table 2 Sample objectives for cardiac POCUS

1) List the views that should be acquired as part of the cardiac POCUS examination.
2) Obtain all of the views that should be acquired as part of the cardiac POCUS examination.
3) Perform an interpretation of a cardiac POCUS examination to include interpretation of left and right ventricular function, left ventricular wall thickness, left atrial size, presence of pleural and/or pericardial effusion, IVC size and collapsibility.
4) Describe tamponade physiology findings as they will appear on cardiac POCUS.
5) Describe cardiac POCUS examination findings associated with pulmonary embolism.
6) Describe cardiac POCUS examination findings associated with heart failure with reduced ejection fraction.
7) Describe cardiac POCUS examination findings associated with heart failure with preserved ejection fraction.

IVC, inferior vena cava; *POCUS*, point of care ultrasound.

Basic Point of Care Echocardiography for Heart Failure

LV size/function

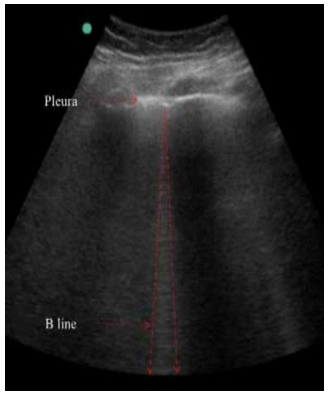
RV size/function

Pericardial Effusion

IVC - Volume Status

Significant Valvulopathy

A-lines



B-lines

Lung Exam

The Basics: Acquisition

- **Which probe?**
  - Phased array
  - Curvilinear
  - Linear
- **Which setting?**
  - Cardiac
  - Lung windows
- **Which buttons to push/slide?**
  - depth
  - gain

- **What is meaning of**
  - black/white?
  - Red/blue?
- **What windows/views?**
  - How to get them

Basic Ultrasound controls ("Knobology")

- Probe selection

  -**low** frequency: (2-5 MHz): **deep** structures: cardiac, abdomen

  -**high** frequency: (8-10 MHz): **shallow** structures: vascular, lung

US penetration is inversely proportional to the frequency

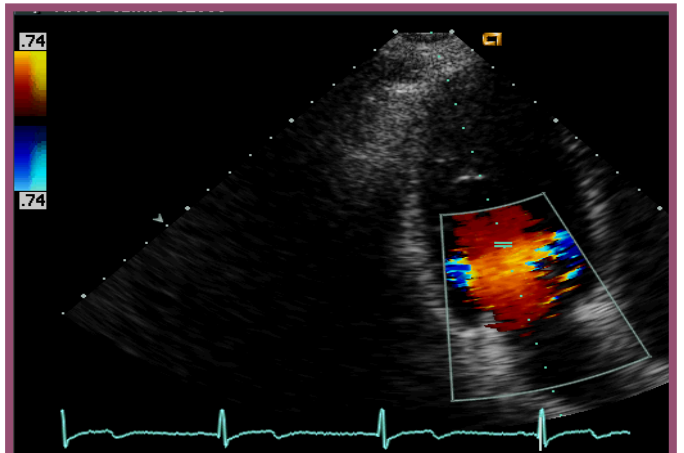
- 2-D controls

  - depth
  - overall gain (brightness)

- Color Flow Doppler

  -red: towards

  - blue: away



Basics: Ultrasound Tissue Characteristics

- *Echogenic structures are white*
  - Bone
  - Tissue
  - Air

Ultrasound reflection

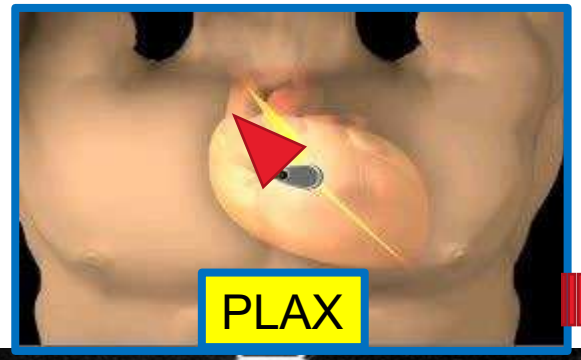
- ***Echolucent fluid is black***
  - **blood**
  - **effusions**

Ultrasound transmission

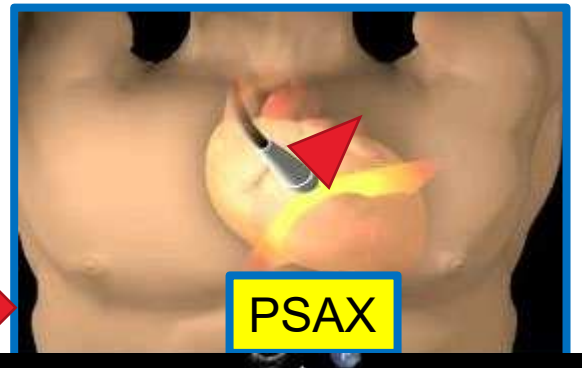
Basic Exam: Cardiac: Parasternal

- ***Parasternal Window:***
  - ***Long Axis (PLAX)***
  - **Short Axis (PSAX)**

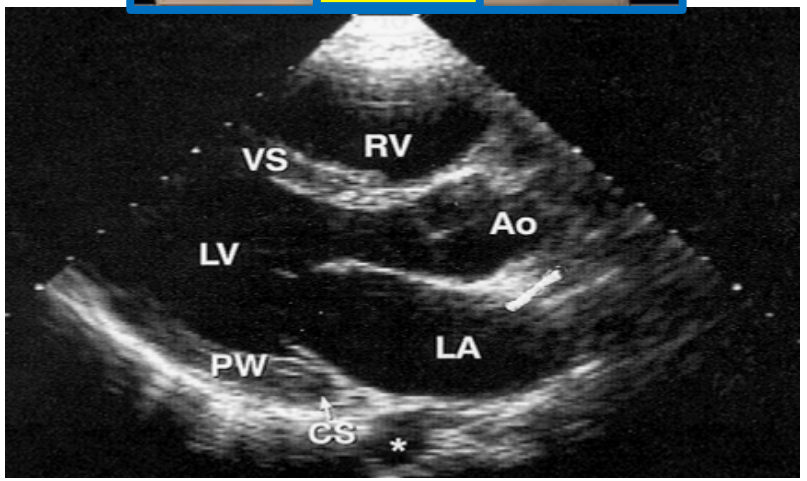
Probe Indicator Pointing to Patient's right shoulder

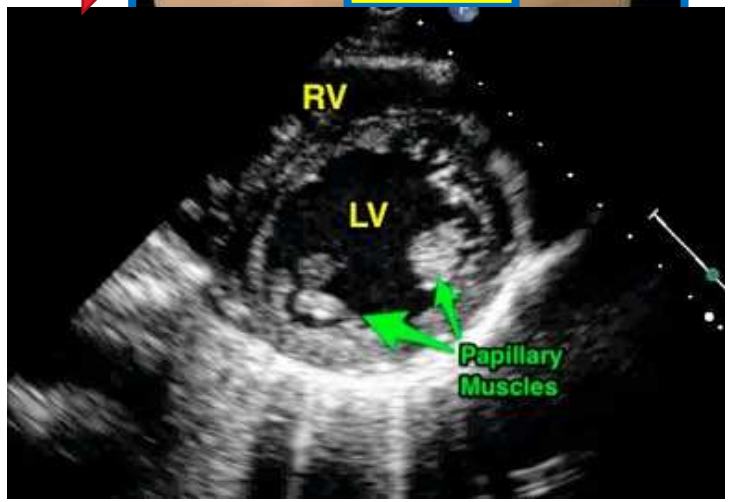


90° Clockwise rotation

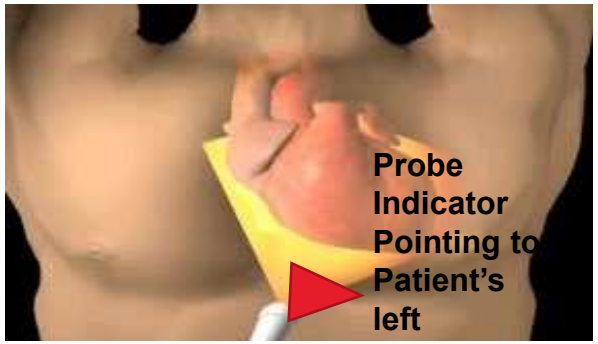


- LV/RV size
- Aorta/ LA size
- LV/RV function
- MV, AV
- Pericardial fluid?



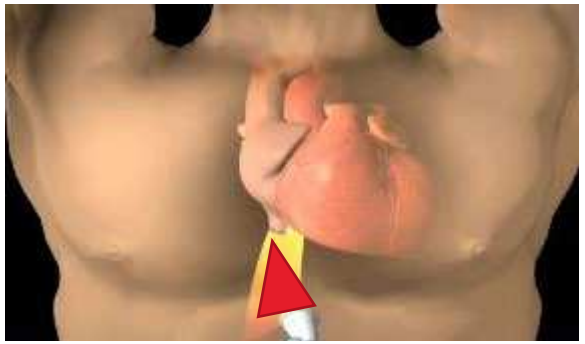


Basic Exam: Cardiac: Subcostal – 4C and IVC

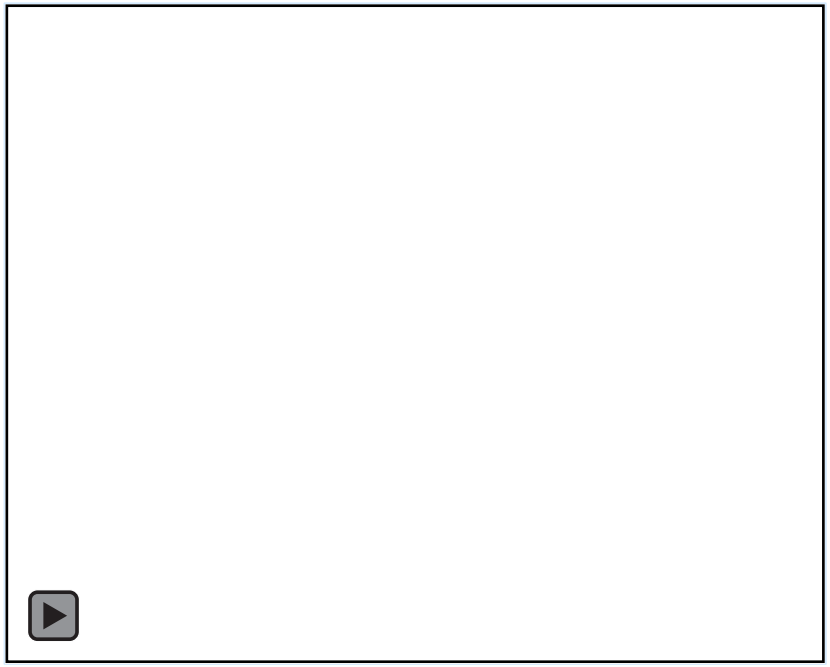


90° COUNTER Clockwise rotation

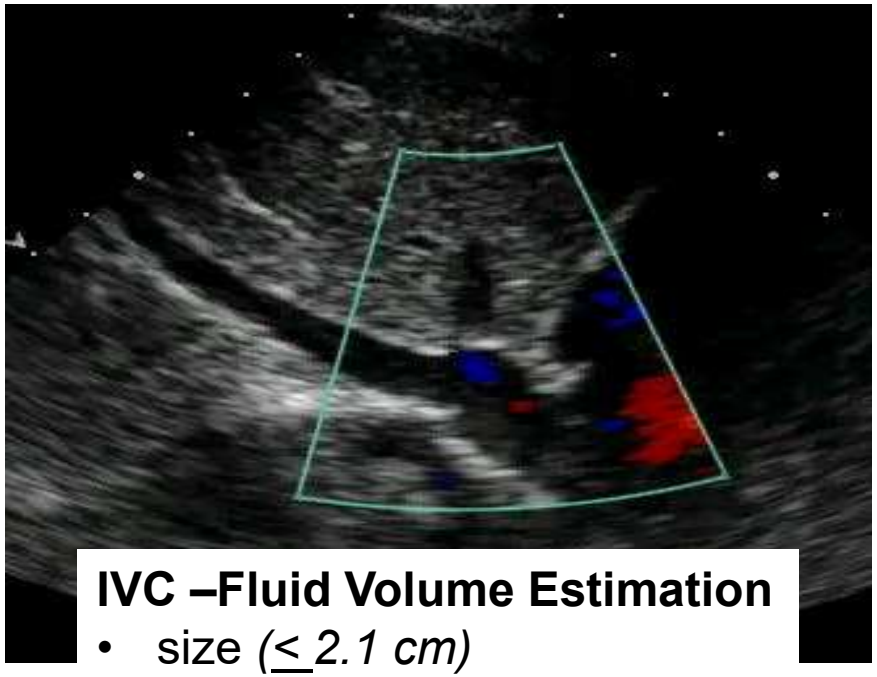
Angle to Patient's right



Assess IVC 1-2 cm from insertion at RA

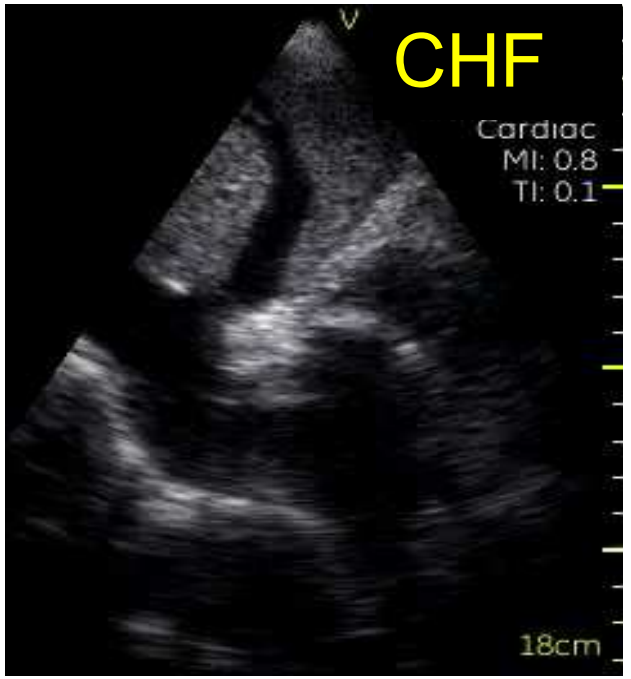


4-chamber view
-assess pericardial effusion



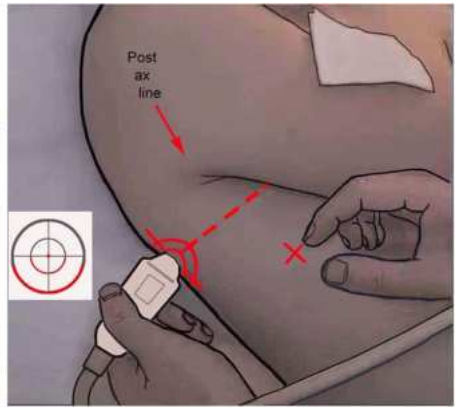
IVC –Fluid Volume Estimation
- size *(≤ 2.1 cm)*
- respiratory variation:

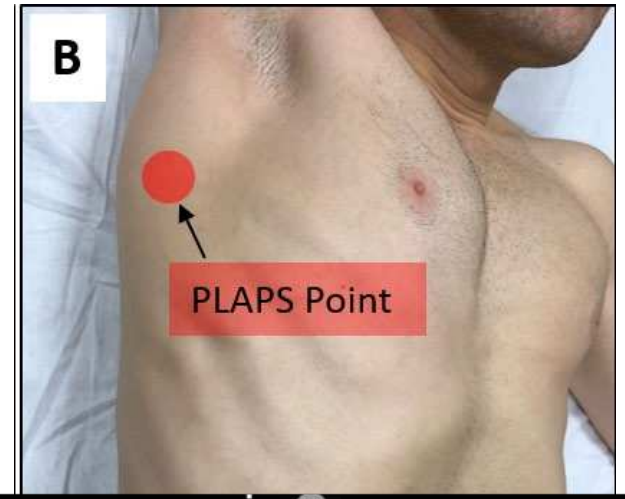
decreases > 50% with sniff

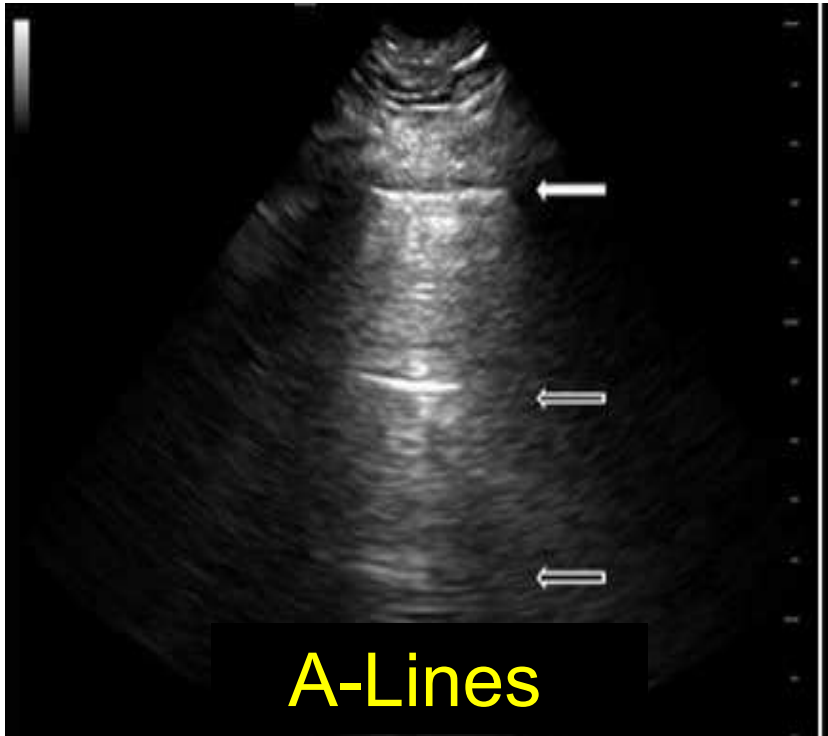


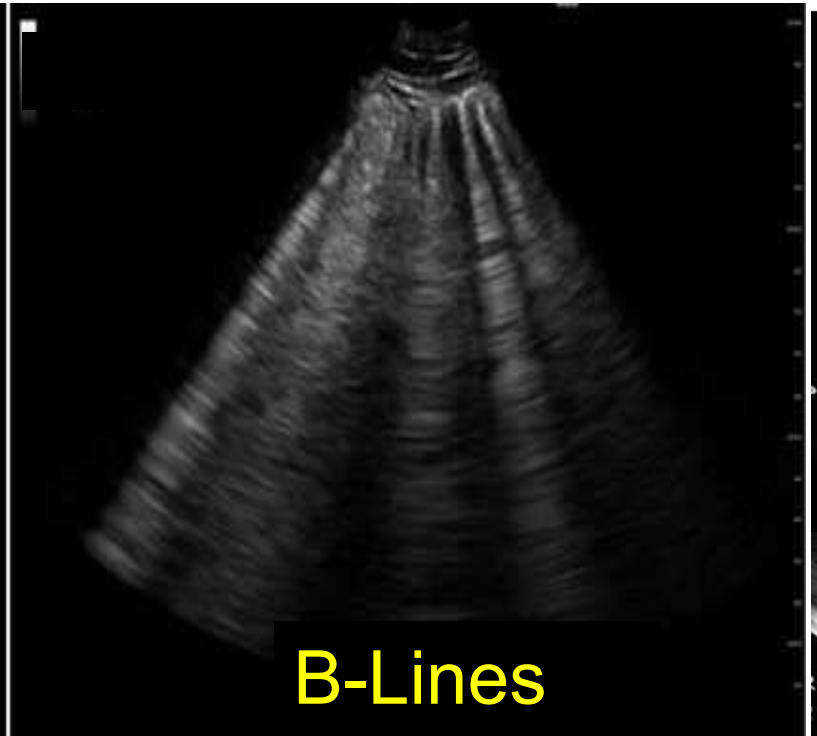
Basic Exam: Lung

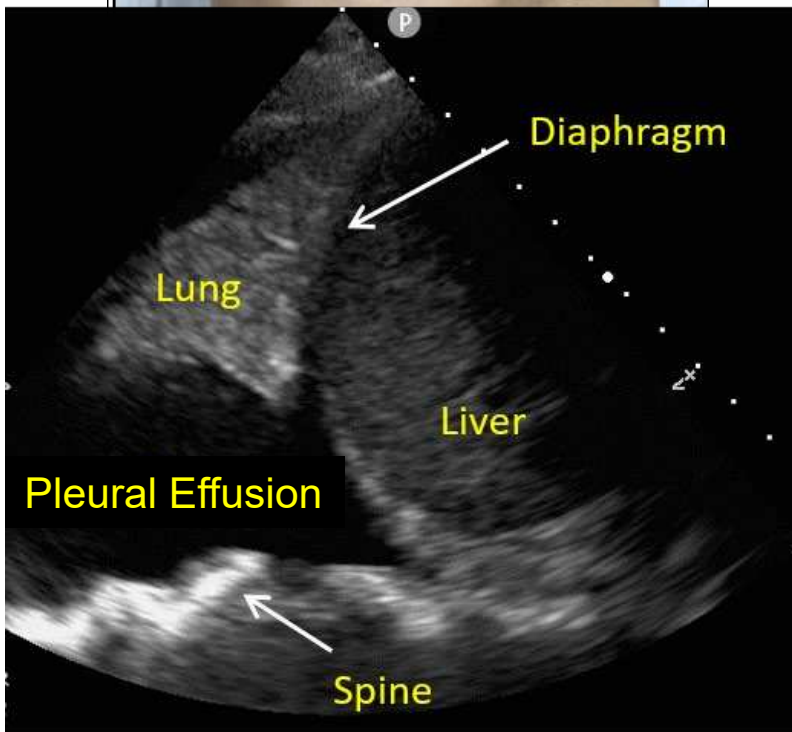
Lungs just don't get in the way!
Valuable info in the *artifacts* observed



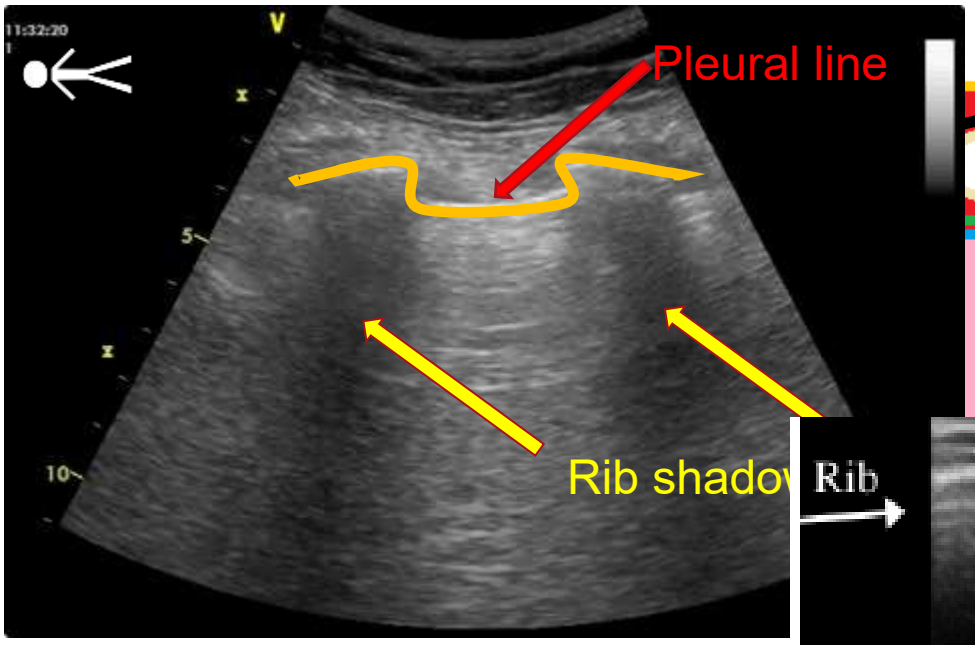


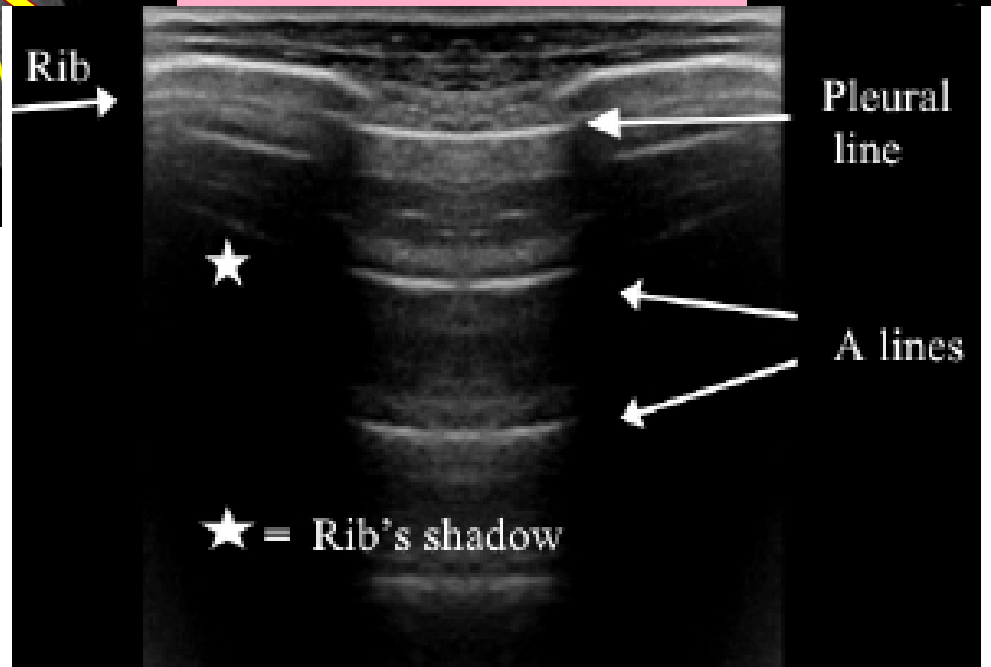


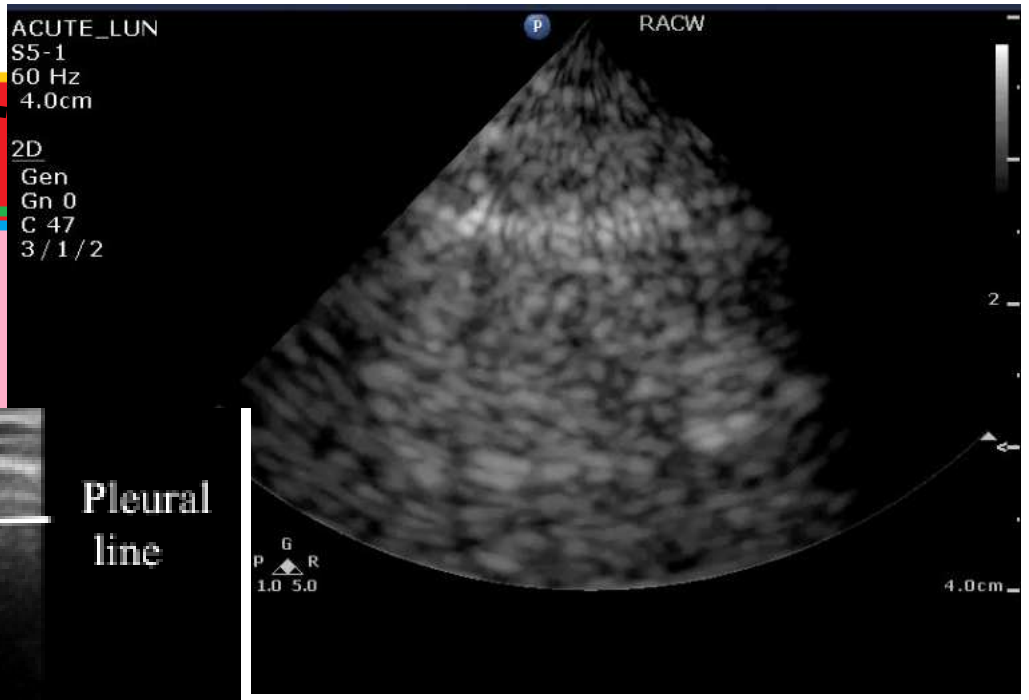




Lung US:
Bat sign, pleural line (sliding), A-lines (artifact)







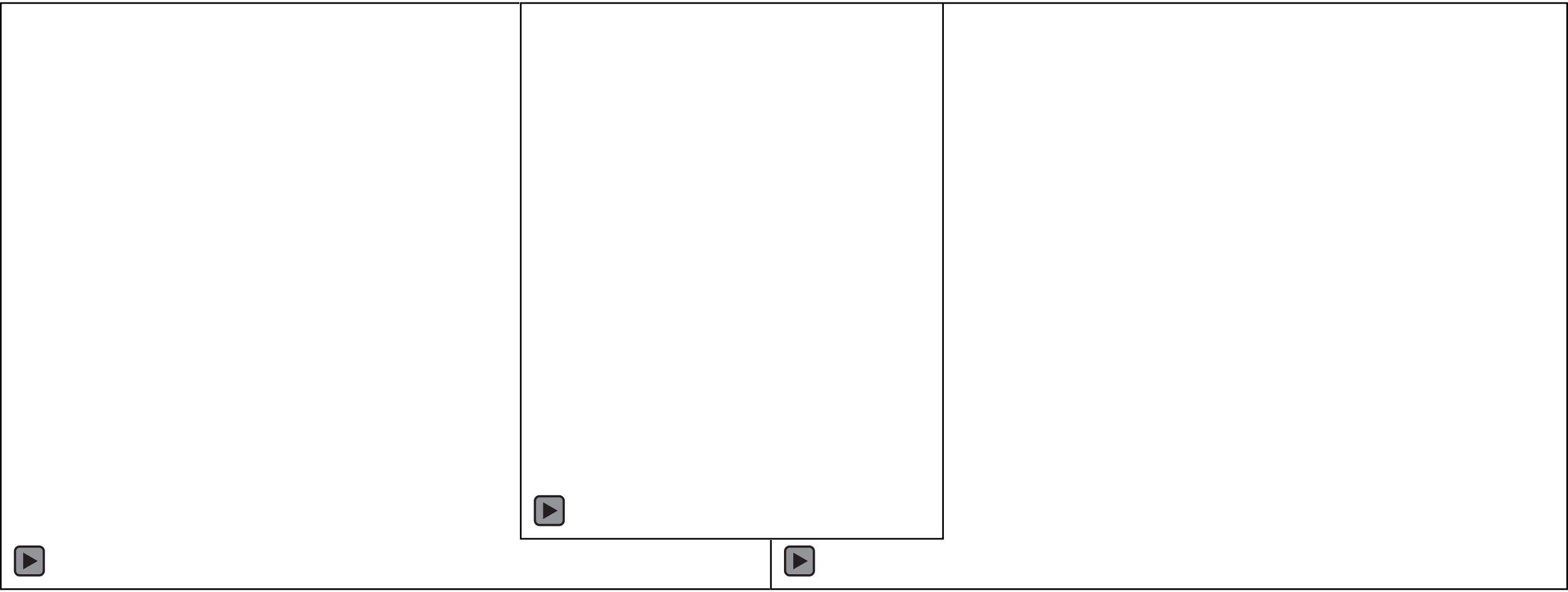
Lung sliding

A-lines

Normal Lung

Lung US: Pneumothorax

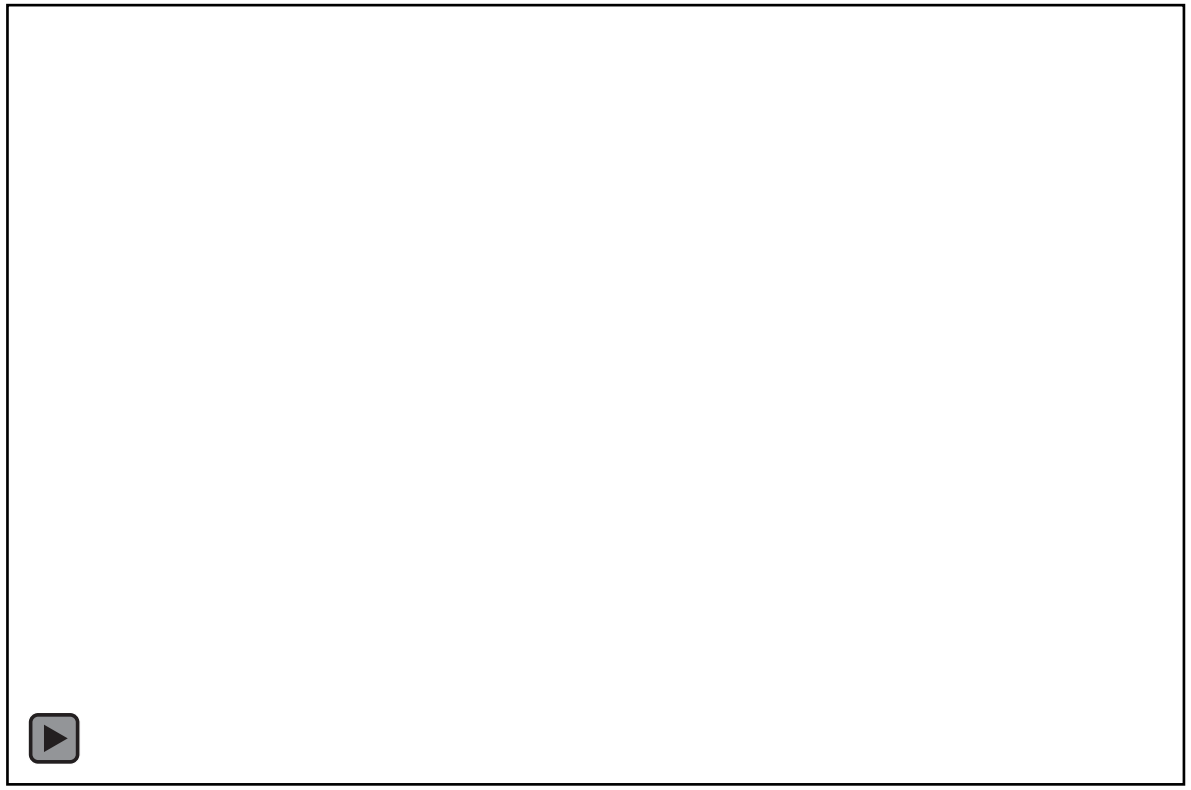
– no pleural sliding VS. Normal - pleural sliding present



Sartori. *Accuracy of Transthoracic Sonography in Detection of Pneumothorax After Sonographically Guided Lung Biopsy: Prospective Comparison with Chest Radiography.* Am J Roentgenography, 2007

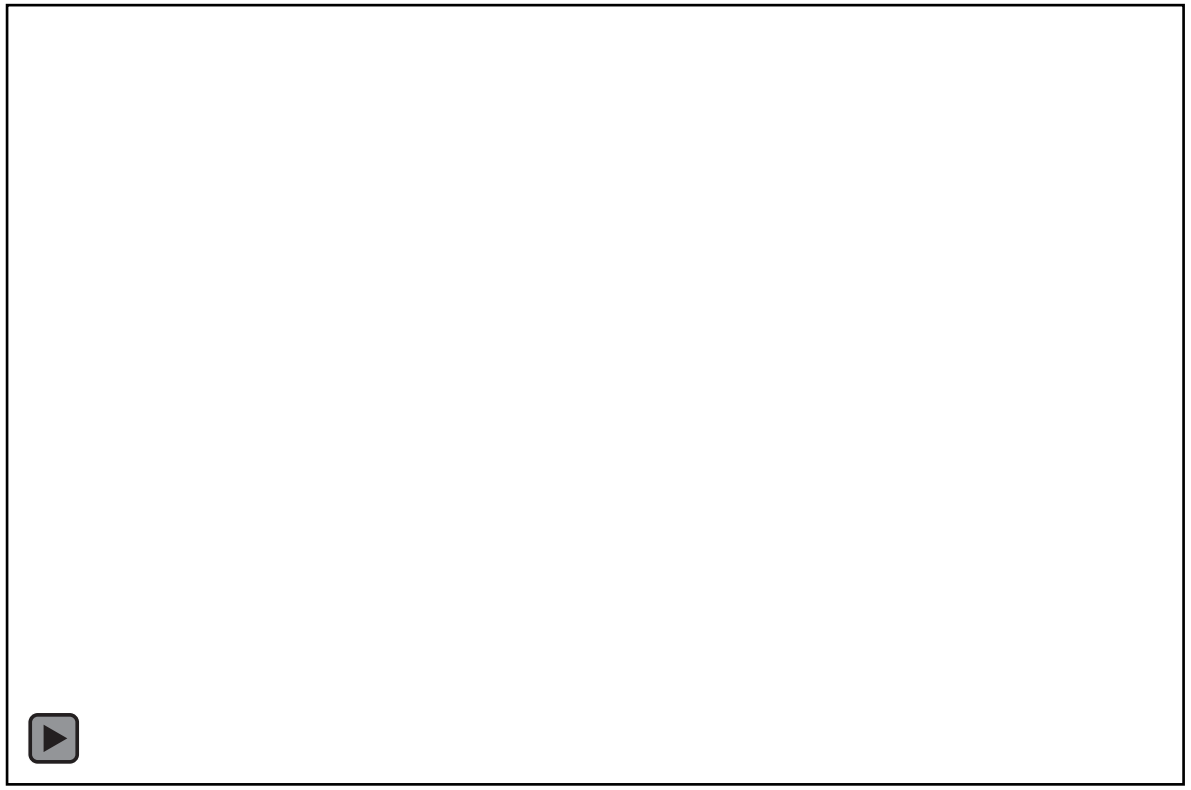
Lung US:

Consolidation



- Air bronchograms
- Spine Sign

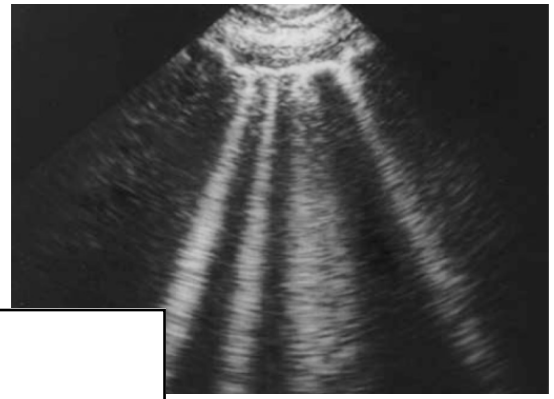
…and Pleural Effusion



- Air bronchograms
- Pleural fluid

Lung US: B lines

≥ 3 abnormal, consistent w/ INTERSTITIAL SYNDROME



- Discrete laser-like vertical hyperechoic reverberation artifacts
- Arise from the pleural line, extend to the bottom of screen
- move synchronously with lung sliding

(Volpicelli et al, 2012)

B-lines: Helpful in [illegible]ents: pulmonary edema vs. COPD

(Lichtenstein & Mezière, Intensive Care Med, 1998)

Cases

Case #1: 68M, progressive dyspnea, edema, h/o HFpEF

- Presents to ED
- Has not seen family doctor in person in 6 months due to COVID restrictions
- PMHx: mild CAD on cor angio last year, type II DM, HTN and morbid obesity (BMI = 44)
- Physical exam: 2+ woody edema to the mid shin, JVP is not well visualized, breath sounds are clear, BP 135/85, HR 95, T 37.2, Sat 96%
- Labs: WBC 6.5, Hgb 130, Cr 135, Na 133, hsTnT 40 (N < 15), BNP pending
- Cardiomegaly on CXR with clear lung fields
- POCUS to “determine volume status”

Case #1: 68 yo male, progressive dyspnea, edema, h/o HFpEF

Case #1

Based on the clinical information, what do you think this patient's most likely diagnosis is and what is the best management?

1. COVID-19, swab, steroids, discharge with close follow-up
2. Heart failure exacerbation, IV Lasix with virtual GP follow-up
3. Heart failure exacerbation, IV Lasix with Rapid HFC follow-up
4. Heart failure exacerbation, refer for admission

See: https://ehmrg.ices.on.ca/#/

Pitfalls of IVC assessment

- Since IVC size and collapsibility are used as the surrogates for RA pressure, anything that can affect this interaction may yield an erroneous interpretation.

Conditions that may cause UNDERestimation of RAP by IVC POCUS	Conditions that may cause OVERestimation of RAP by IVC POCUS
Obesity	Tamponade
High Positive Pressure Ventilation	Severe tricuspid regurgitation
COPD/Asthma exacerbation	Pericardial constriction

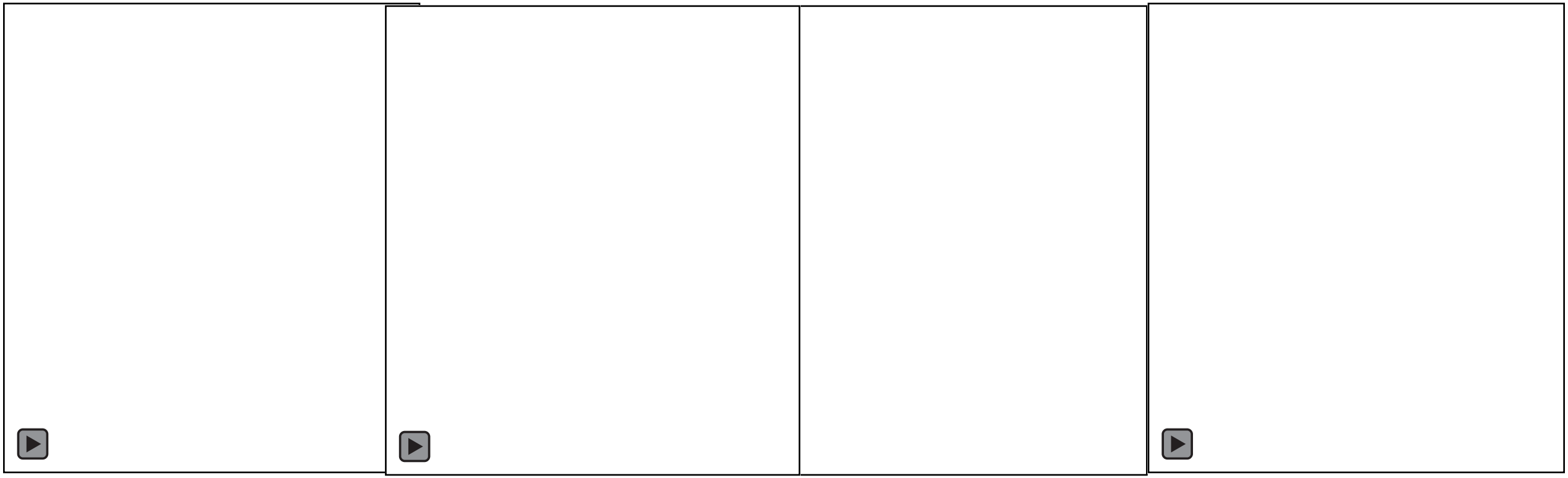
Blanco and Volpicelli *Crit Ultrasound J (2016) 8:15*

Case #2: 79M progressive SOBOE, 3-4 pillow orthopnea, PND

.

- Seen in HFC
- Known ischemic cardiomyopathy (prior CABG) with initial EF 30%
- on optimal medical therapy
- Last echo (3 months ago):
  - EF 50%, mild inferior hypokinesis, mild MR, normal RV size and function
- ECG: Atrial fibrillation (average rates 70-80), IVCD QRS 130ms
- PMHx: CKD with BL Cr 250, mod-severe PAD
- Physical exam:
- 3+ systolic murmur, JVP 6-8cm, few inspiratory crackles
- Labs: WBC 5.6, Hgb 123, Cr 43, Na 130, hsTnT 50 (N < 15), BNP pending

Case #2



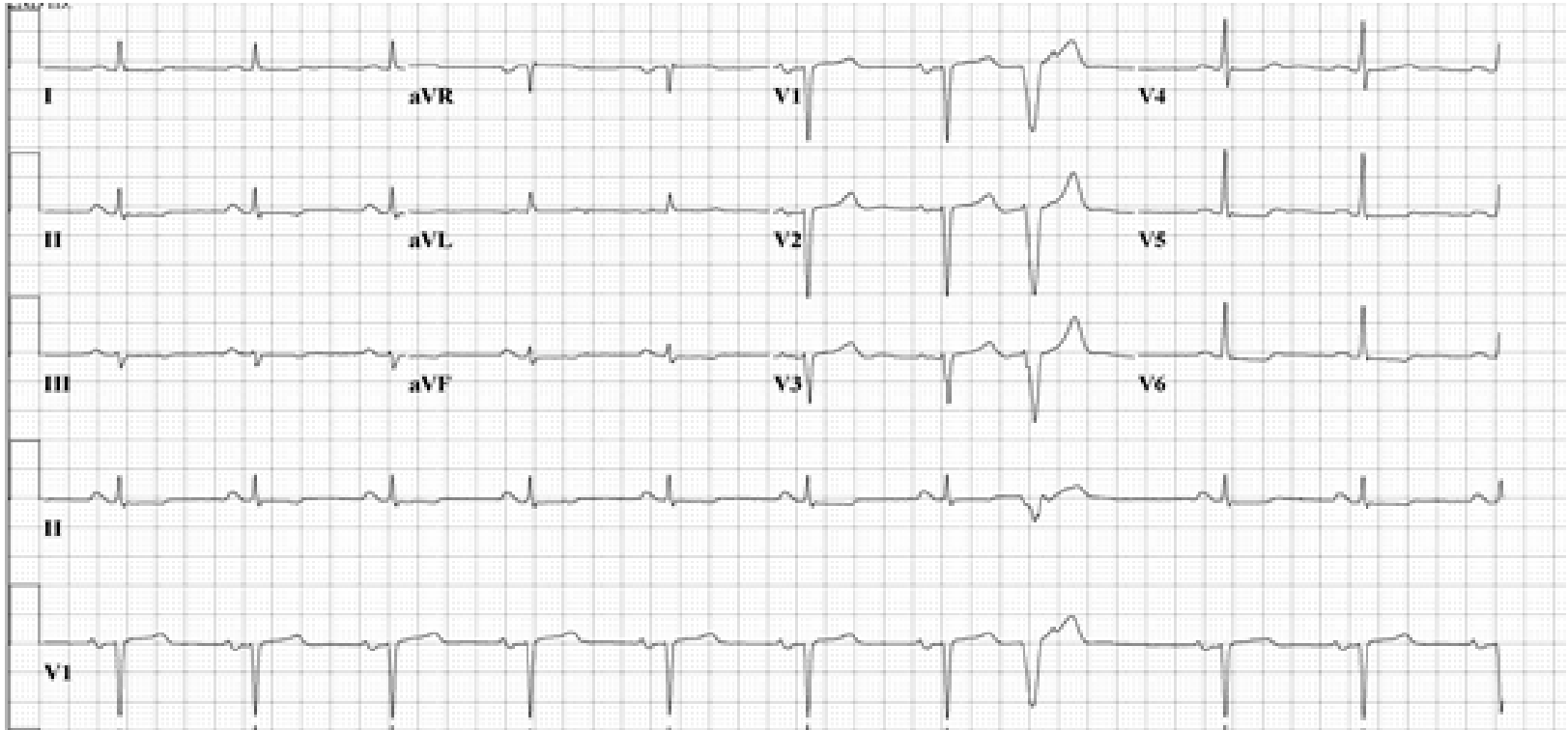
Case #2:

Based on the clinical and POCUS features, which of the following would you recommend?

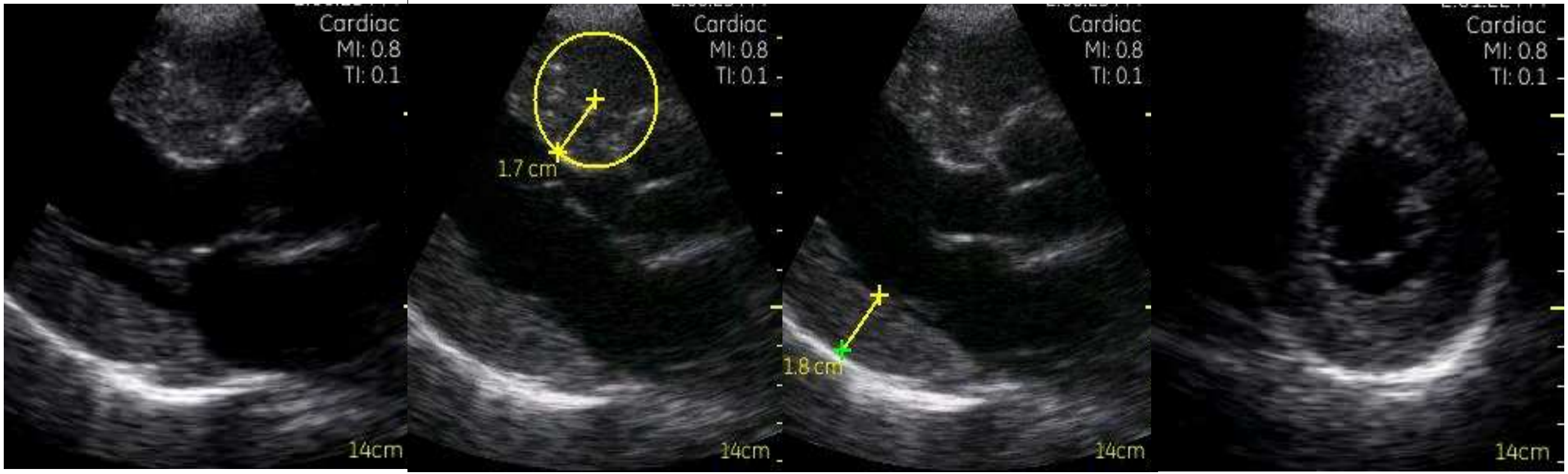
1. Urgent redo sternotomy and MV replacement
2. Consideration for MitraClip
3. Obtain comprehensive (full) TTE
4. Coronary angiography

Case #3: 62M mild SOBOE and mild peripheral edema

- Referred to cardiology clinic
- PMHx: spinal stenosis, carpal tunnel syndrome
- Physical examination:
  - JVP 8-10cm ASA, 1+ pitting edema to the shins bilaterally
- Investigations: nt-proBNP 1200 pg/mL
  - ECG:



Case #3: 62M mild SOBOE and mild peripheral edema



Case #3

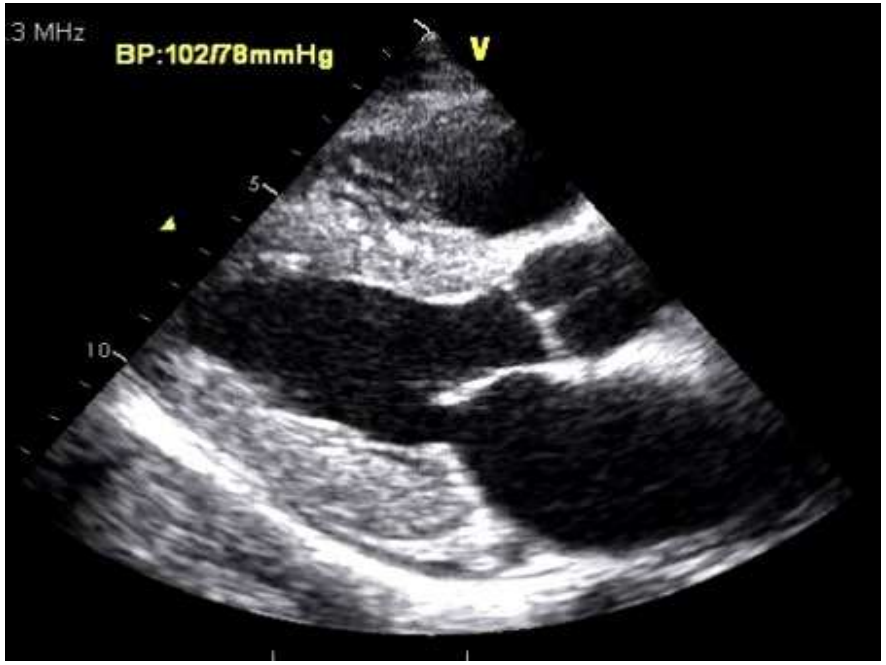
What medication is most likely to have a mortality benefit in this patient:

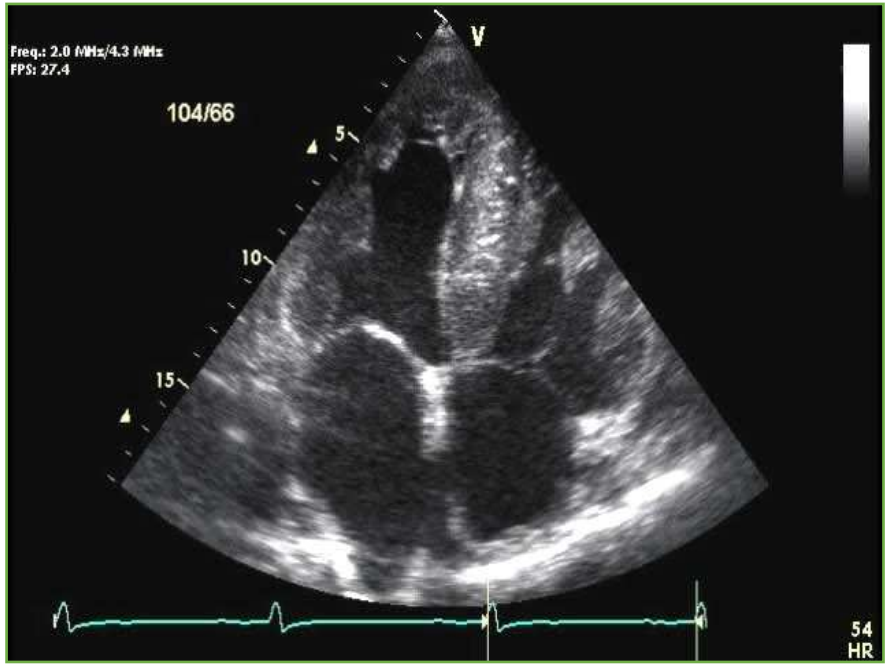
1. Loop diuretic
2. Tafamidis
3. Dexamethasone
4. Doxycycline

Screening evaluation for cardiac amyloid

- symmetrical thickening of myocardium (often biventricular) which has a bright echogenic appearance
- differentiate from other causes of LVH (e.g. HCM) by reviewing ECG
  - amyloid more likely if low (or normal) ECG voltages in presence of concentric wall thickening
- Other clues: bi-atrial enlargement (in the absence of atrial fibrillation), thickened valves, small pericardial effusion
- LVEF normal or reduced; apical sparing

Adapted from: Fine, NM, et al. CJC. 2020

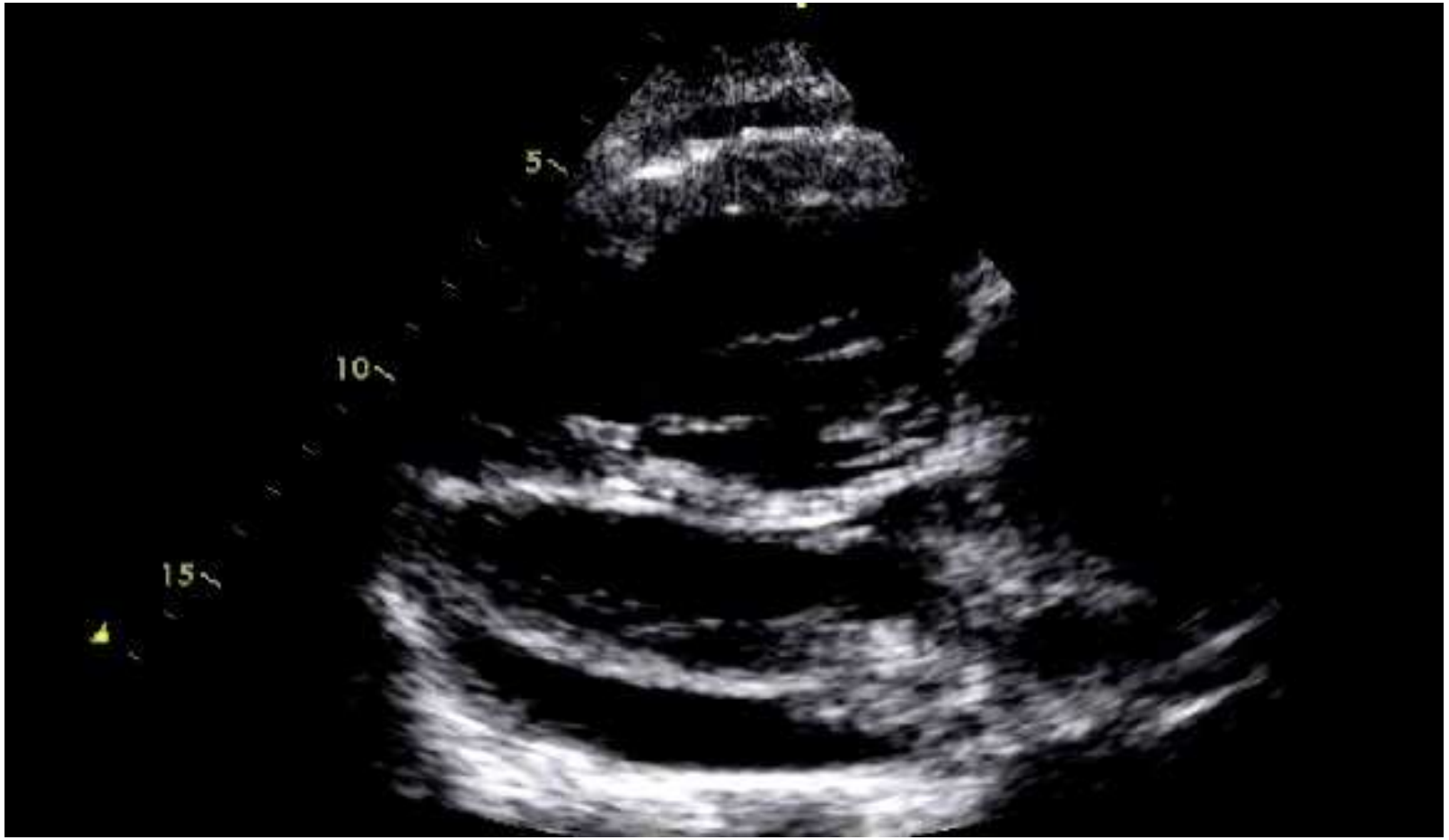




Case #4: 33F with worsening SOB and exertional syncope

- presents to internist's office
- no significant past medical history
- other symptoms include: early satiety and bloating, intermittent mild peripheral edema, occasional exertional chest discomfort
- Physical exam:
  - reveals mildly elevated JVP but otherwise no other obvious findings
- Investigations: Normal CBC, lytes, BUN 10, Cr 135
- ECG: RBBB with anterior ST depressions
- In office POCUS

Case #4: 33F with worsening SOB and exertional syncope



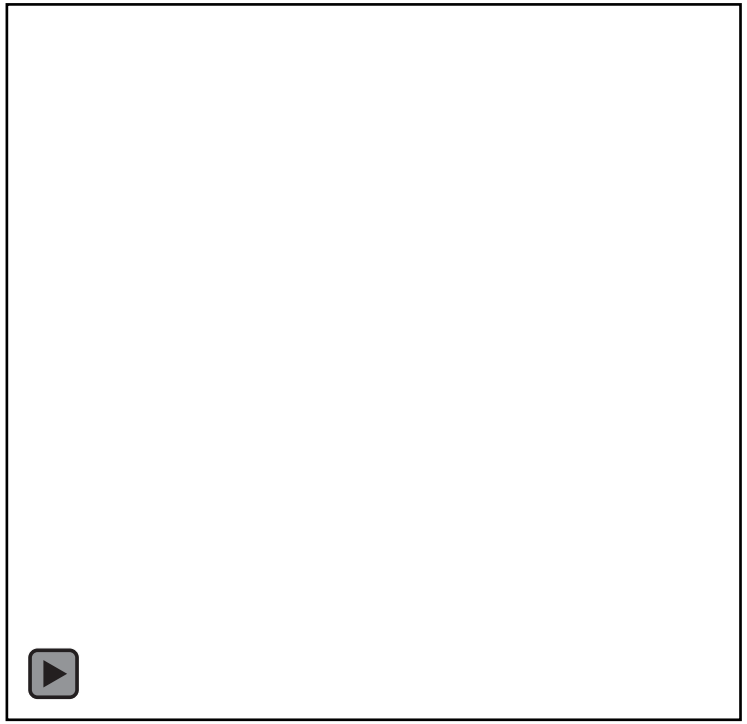
Case #4

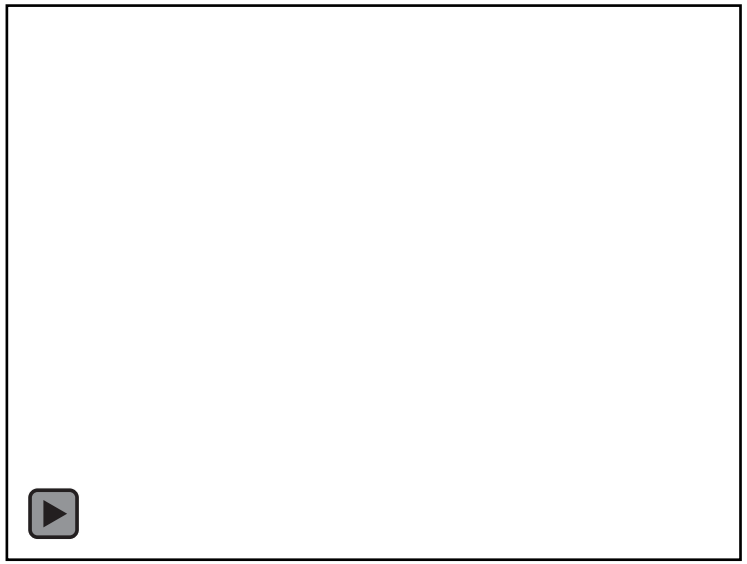
After ordering a comprehensive (full) TTE to confirm your clinical suspicions, what investigation would be most likely to provide a definitive diagnosis and guide management?

1. Right heart catheterization
2. Nt-pro-BNP assessment
3. 6MWT
4. Chest x-ray

Pulmonary hypertension findings on POCUS

- CW Doppler of tricuspid regurgitant jet is required to estimate RVSP
- It does not exit on handheld POCUS devices
- Qualitative 2-D measures include:
  - RV size assessment
    - Is RV > LV in PLAX or 4C views?
    - Does RV overtake the apex? (McConnell's sign)
  - RV structural assessment
    - Is RV D-shaped or show septal flattening in PSAX view?
  - RA size assessment
    - Is RA > LA in 4C view?
  - Is RV free wall thickened (subcostal or PLAX views)?





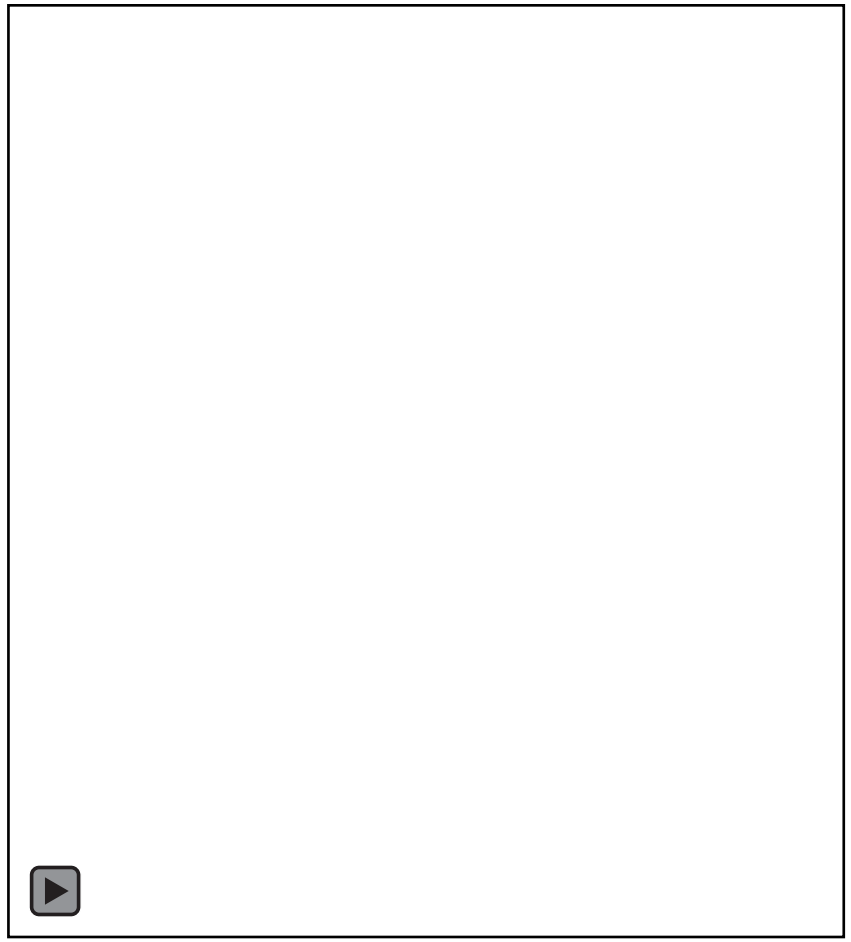
Adapted from: Rudski et al, JASE 2010

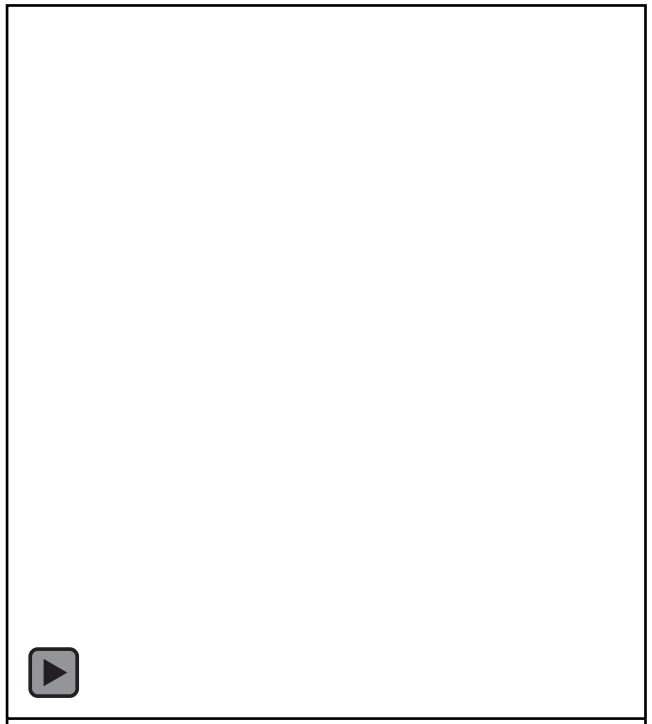
:

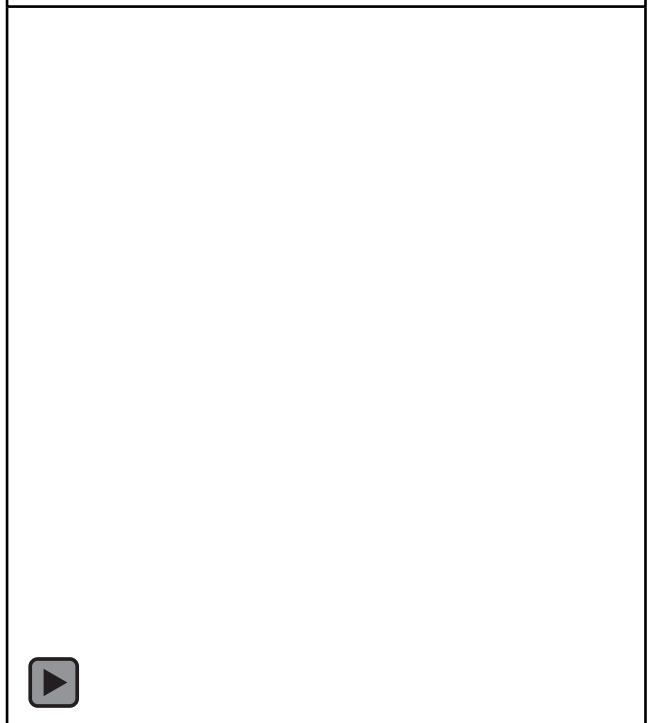
Case #5: 32F worsening SOB post-COVID

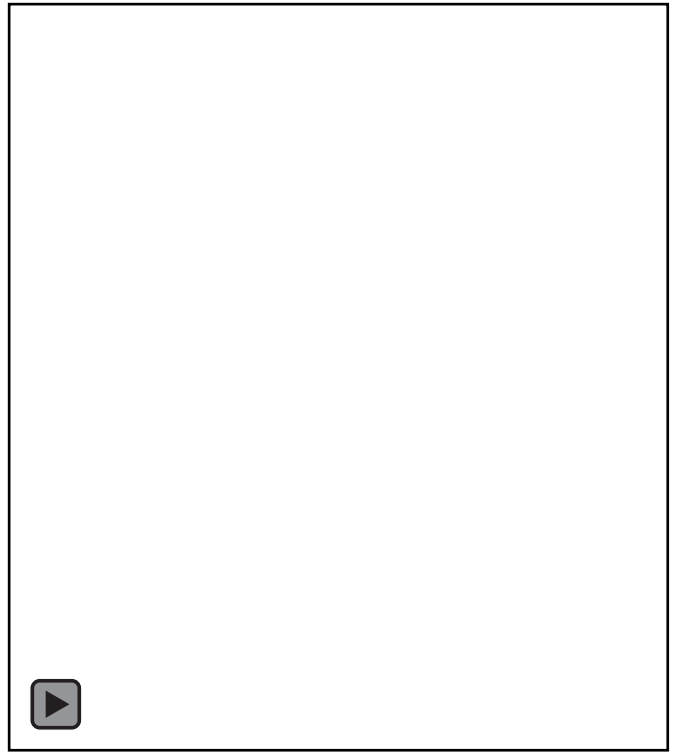
- presents to ED with acute dyspnea
- she had been diagnosed with a mild case of COVID-19 approximately 3 weeks earlier
- Physical exam:
  - BP 90/50, HR 120, RR 20, T 36.8, JVP 10-12cm, O2 sat 92% on 6L;
  - Chest: diffuse crackles; Cardiac: Gr2/6 holosystolic murmur
  - Extremities: cool
- Investigations:
  - Lactate 3.5, WBC 7.2, ABG: pH 7.35, PaO_2 85
  - ECG: sinus tachycardia
  - Chest x -ray shows diffuse interstitial pattern

Case #5

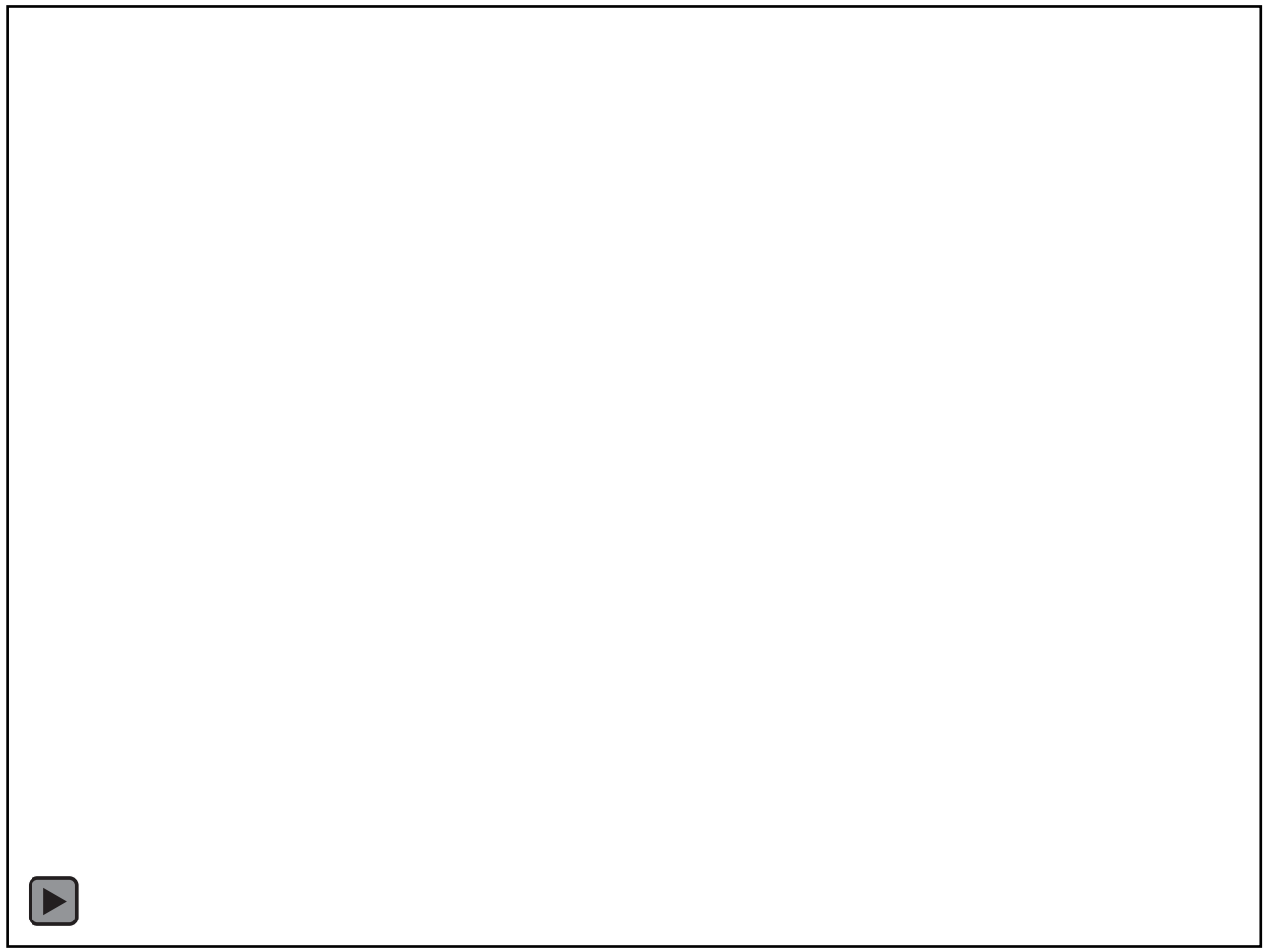








Lung US for Pulmonary Edema



88% sensitivity
90% specificity

Outperforms CXR

Lichtenstein AJRCCM 1997; Agricola Chest 2005;Lichtenstein Chest 2015; Enghard Crit Care 2015;

Wooten *J Ultrasound Med 2019; 38:967–973*. Garibyan *J UltrasoundMed 2018; 37:1641–1648*

Case #5 -

Patient suddenly develops high grade AV block necessitating temporary pacing and evidence of cardiogenic shock despite empiric corticosteroids. An endomyocardial biopsy shows fulminant myocarditis. Which of the following treatments would you consider next?

1. Urgent Cardiac transplant listing
2. Intra-aortic balloon pump
3. Mechanical circulatory support (VAD ± ECMO)
4. Repeat Endomyocardial biopsy

POCUS and COVID19

ASE AMERICAN SOCIETY OF ECHOCARDIOGRAPHY

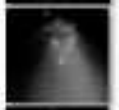
Sound Saves Lives

ASE Statement on Point-of-Care Ultrasound (POCUS) During the 2019 Novel Coronavirus Pandemic

Amer M. Johri, MD, MSc, FRCPC, FASE (Chair), Benjamin Galen, MD, FACP, James I Kirkpatrick, MD, FASE, Michael Lanspa, MD, FASE, FCCM, Sharon Mulvagh, MD, FASE, FRCPC, Ritu Thamman, MD, FASE, *Kingston, Ontario, Canada; Bronx, New York; Seattle, Washington; Salt Lake City, Utah; Halifax, Nova Scotia, Canada; Pittsburgh, Pennsylvania*

J Am Soc Echocardiogr. 2020:33(6):670-673

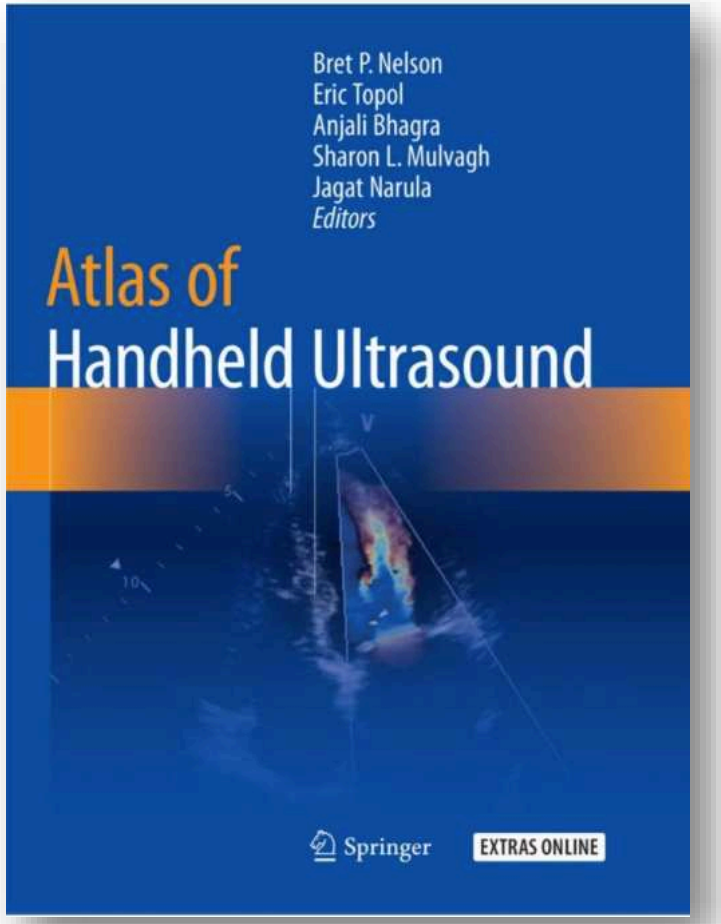
Table 1. ASE POCUS Protocol in Suspected or Confirmed COVID-19 Infection. A modified POCUS protocol to assist in the assessment of COVID-19 patients includes heart, chest and vessel views.

COVID19 POCUS Protocol	Structure Imaged	Assessment	Disease Associations
Cardiac 	**Left Ventricle**	Size, Global and Regional Function	Myocarditis ACS Cardiomyopathy Shock
	**Right Ventricle**	Size and Function; TR for PASP if available	PE Cardiomyopathy
	**Pericardium**	Effusion	Tamponade
	**Valves**	Gross Regurgitation or stenosis	Pre-existing CV disease
Lung 	**8 or 12 point exam**	B Lines (A lines, pleural sliding are normal)	Edema or Pneumonia
		Sub-pleural Consolidation Thickened Pleura	Pneumonia ARDS
		Lobar consolidation with air Bronchograms	Pneumonia ARDS
		Effusion	CHF
Vascular 	**JVP or Subcostal IVC**	Fluid Status	CHF, hypovolemia
	***+/- Leg Veins****	*2 point compression**	DVT

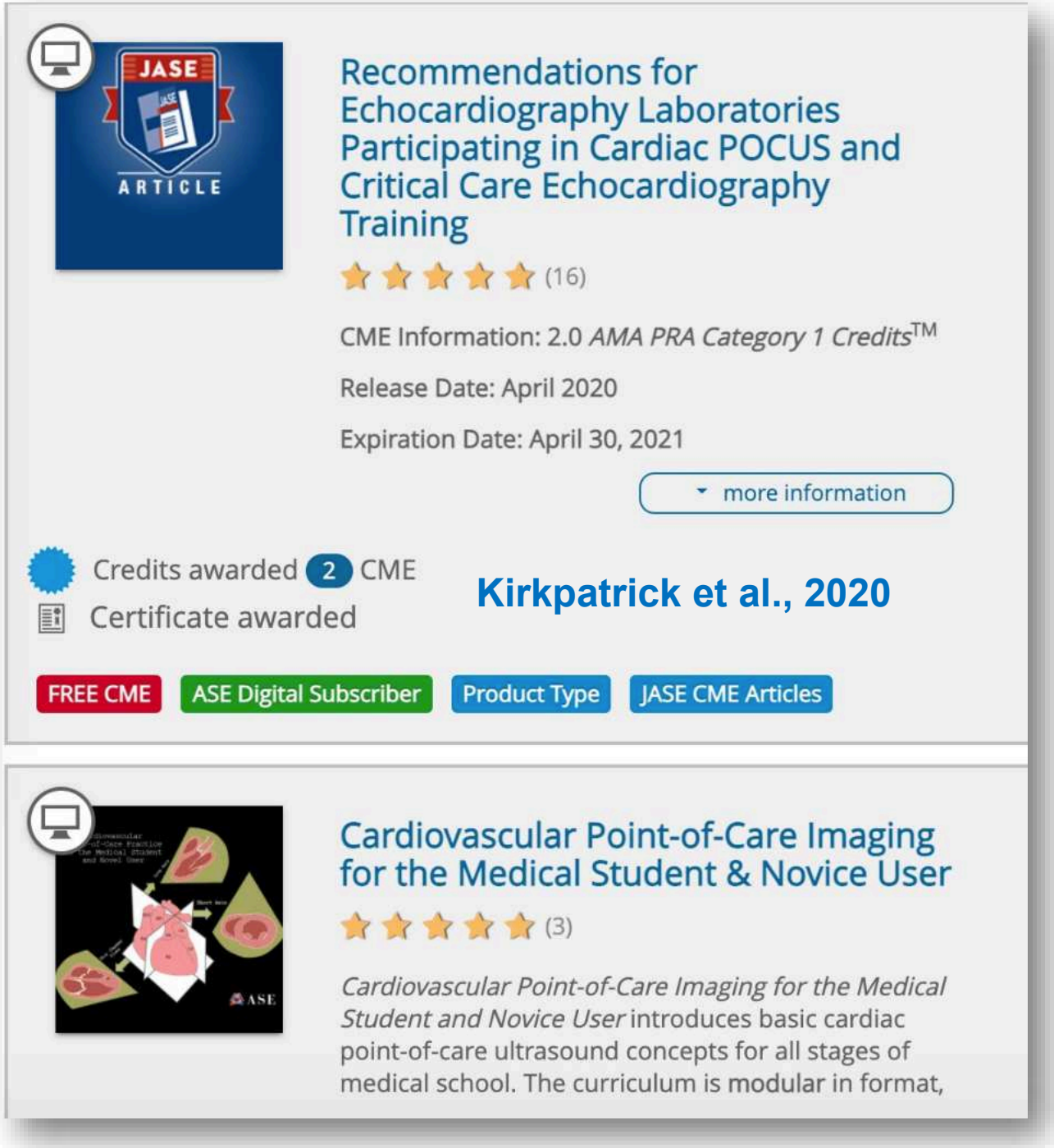
How to POCUS?

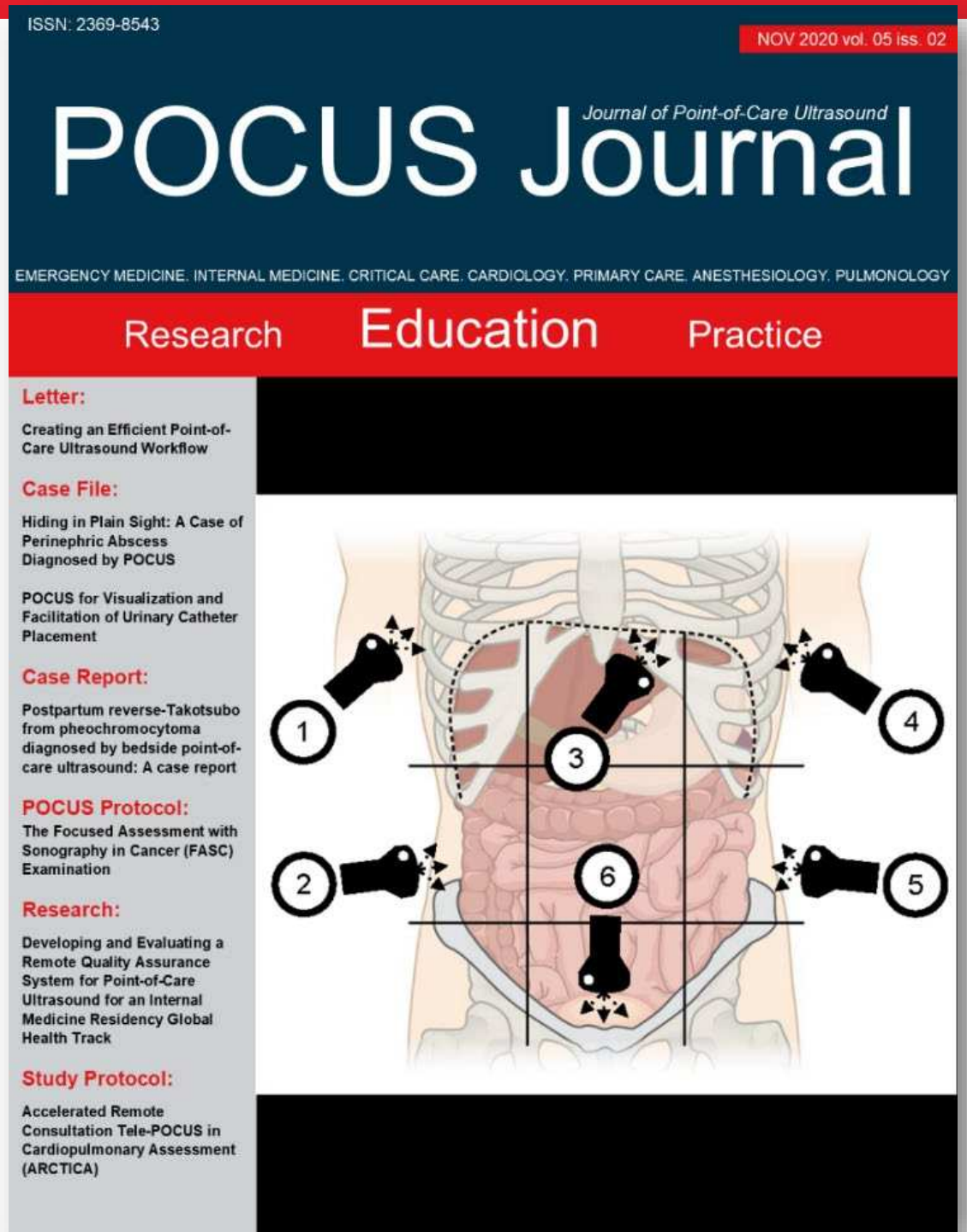
- Critical Care & EM: Defined training pathways
- GIM & others: emerging
- Medical School: emerging

- What about new users in practice?
- *On-line resources:*
  - *Cases, Modules, Videos, textbooks*
  - *Social Media – Twitter #POCUS*



- **Google:**
  - **ASE Learning Hub: FREE!**
- **In catalogue search bar type: POCUS**
- **Collaboration endorsed by ASE, CSE, AIUM, Winfocus**





- **POCUSJOURNAL.COM**
  - **Peer-reviewed**
  - **Tutorials, resources, image library**
  - **Cases, trials, and original research**

- **Heart & Lung**
- **GI/GU**
- **Pediatrics/NICU**
- **Global Health, Workflow and Policy**

POCUS:
CLOUD-BASED LEARNING, AI & Augmented Reality

- **Lumify: REACTS-** integrated “tele-ultrasound”
- **Butterfly: Augmented Reality Telemedicine Technology** “Tele-Guidance technology”

https://www.usa.philips.com

https://www.youtube.com/watch?v=GpJYzfn1J5Y

www.butterflynetwork.com

https://www.youtube.com/watch?v=dIIOTFyKMVU

Hub and Spoke Model

- **Accelerated Remote Cardiopulmonary Tele-Pocus In COVID-19 Assessment (ARCTICA)**

- Geographically remote regions virtually connected to experts
- Live-streamed images
- Digital rapport creation

PI- A. Johri, Queen's University

Critical Care Echocardiography Examination (CCEeXAM)

Content Outline

- **Functional Anatomy**
- **Clinical Diagnosis and Management**
- **Technical Skills & Equipment Optimization**
- **Integrated ultrasound imaging**

Certification

www.echoboards.org

Annually since Jan 2019

Panebianco N et al. Soc Crit Care Med 2021 epub ahead of print

POCUS - Advantages

- Real time imaging
- Portable
- Noninvasive
- Widely available
- No ionizing radiation
- Inexpensive
- ***Extension of physical exam***

POCUS - Pitfalls

- Misdiagnosis, missed diagnosis; lack of training
- *Archivability*

ACP American College of Physicians®
Leading Internal Medicine, Improving Lives

CLINICAL GUIDELINE

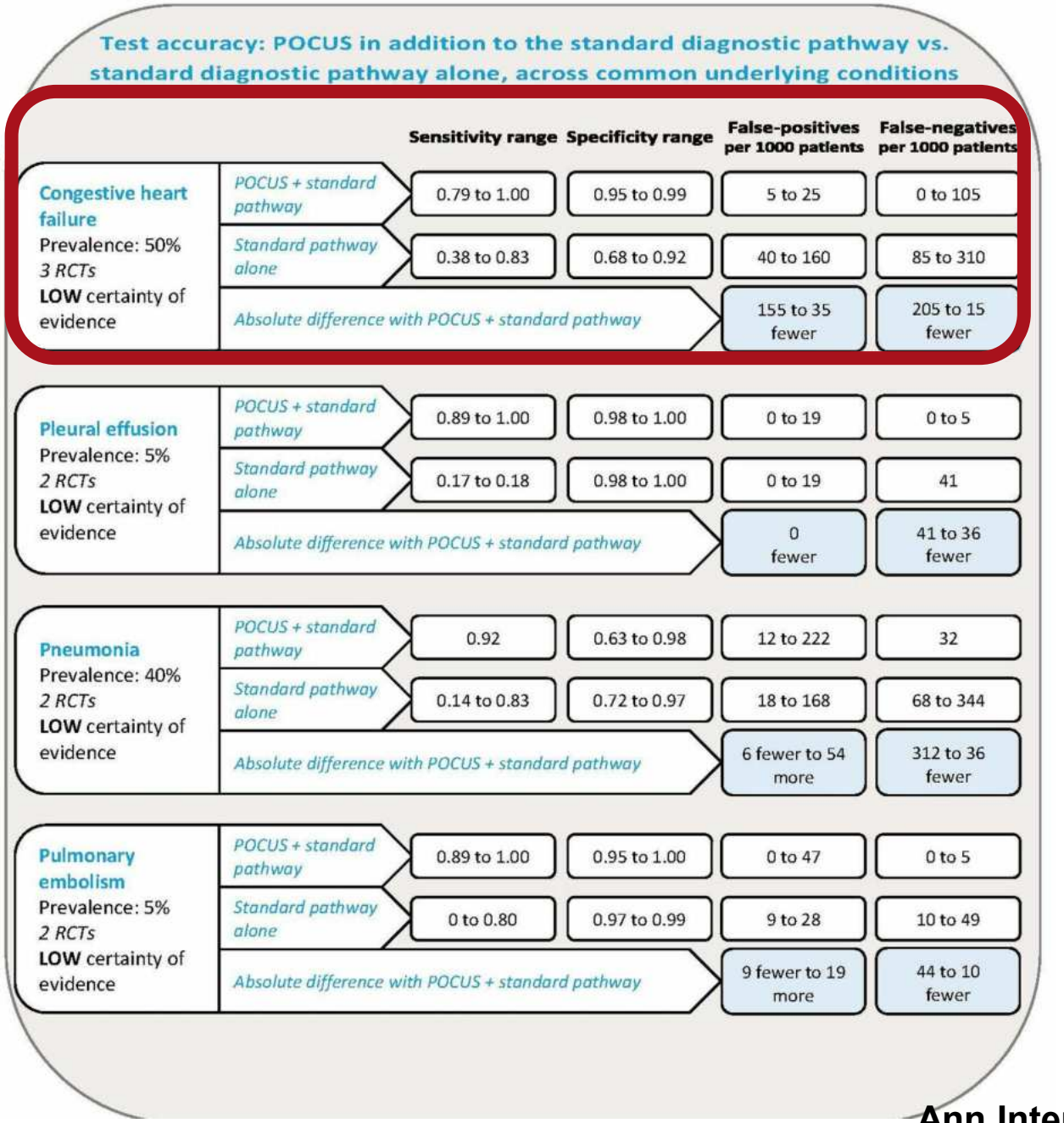
Appropriate Use of Point-of-Care Ultrasonography in Patients With Acute Dyspnea in Emergency Department or Inpatient Settings: A Clinical Guideline From the American College of Physicians

Amir Qaseem, MD, PhD, MHA; Itziar Etxeandia-Ikobaltzeta, PharmD, PhD; Reem A. Mustafa, MD, MPH, PhD; Devan Kansagara, MD, MCR; Nick Fitterman, MD; and Timothy J. Wilt, MD, MPH; for the Clinical Guidelines Committee of the American College of Physicians*

Recommendation:

ACP suggests that clinicians may use point-of-care ultrasonography in addition to the standard diagnostic pathway when there is ***diagnostic uncertainty in patients with acute dyspnea in emergency department or inpatient settings*** *(conditional recommendation; low-certainty evidence).*

https://doi.org/10.7326/M20-7844 Annals of Int Med April 27, 2021



In ED patients with dyspnea, POCUS is most robust for CHF diagnosis!

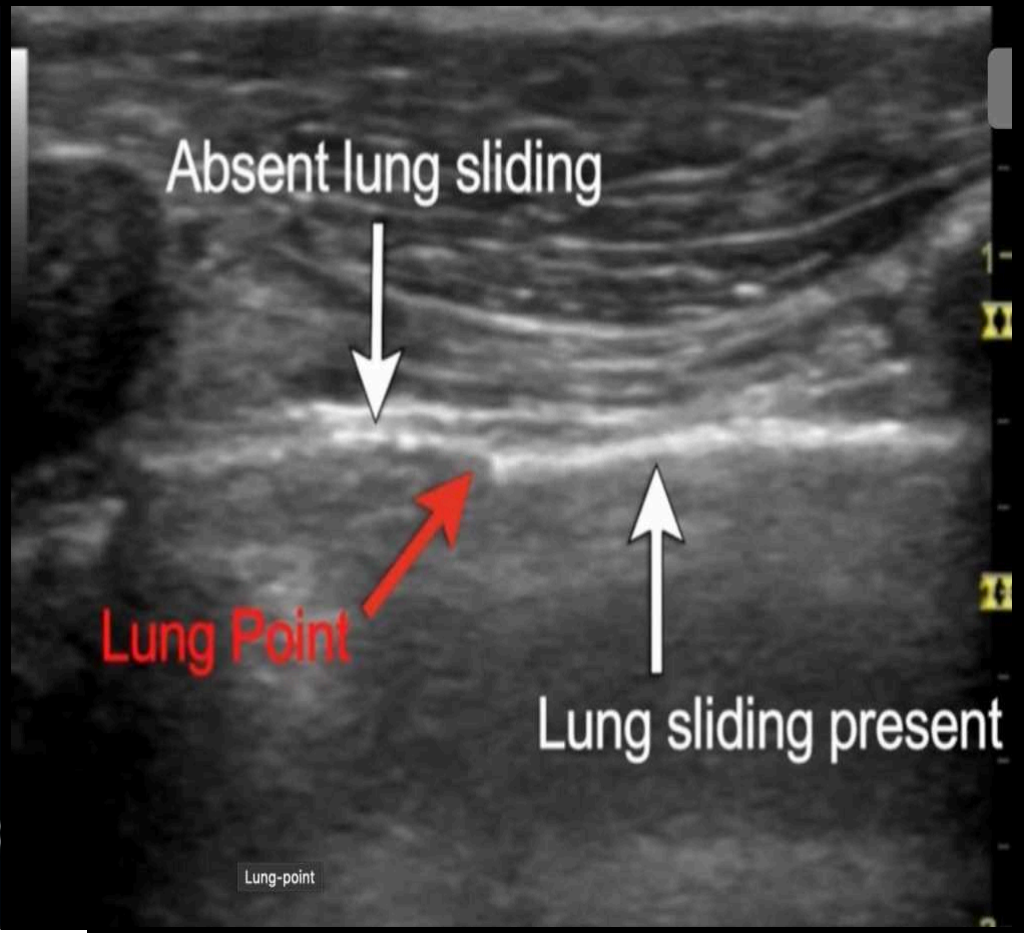
- ACP systematic database review
  - diagnostic accuracy studies
- POCUS increased correct diagnosis
  - *-by 32% overall*
  - -best for *CHF and pleural effusion*
  - -less so for pneumonia/PE
- unlikely associated with serious harms
- focus POCUS on anatomical sites
  - diagnostic
  - treatment uncertainties
- knowledge gaps/future research:
  - clinical outcomes (QOL, ICU admission),
  - MD training (type, amount),
  - devices

Ann Intern Med. Published online: 27 April 2021 doi:10.7326/M20-7844

Take Home Points: POCUS in HF

- POCUS is a disruptive innovation that is here to stay
  - Challenges our conventional CV approaches
- Newer devices, less cost, potential for interactive guidance
- Added value of POCUS: immediacy of results, integrated into patient care in real-time, increases diagnostic accuracy
- Basic assessment: cardiac, lung, vascular (IVC)
  - rapid, repeatable
- HF practice: a new bedside tool to assist with:
  - differential diagnosis of dyspneic patients
  - serial monitoring, dismissal timing
  - follow-up, Rx guidance
- *Requires appropriate training*

Thank You! Q & A

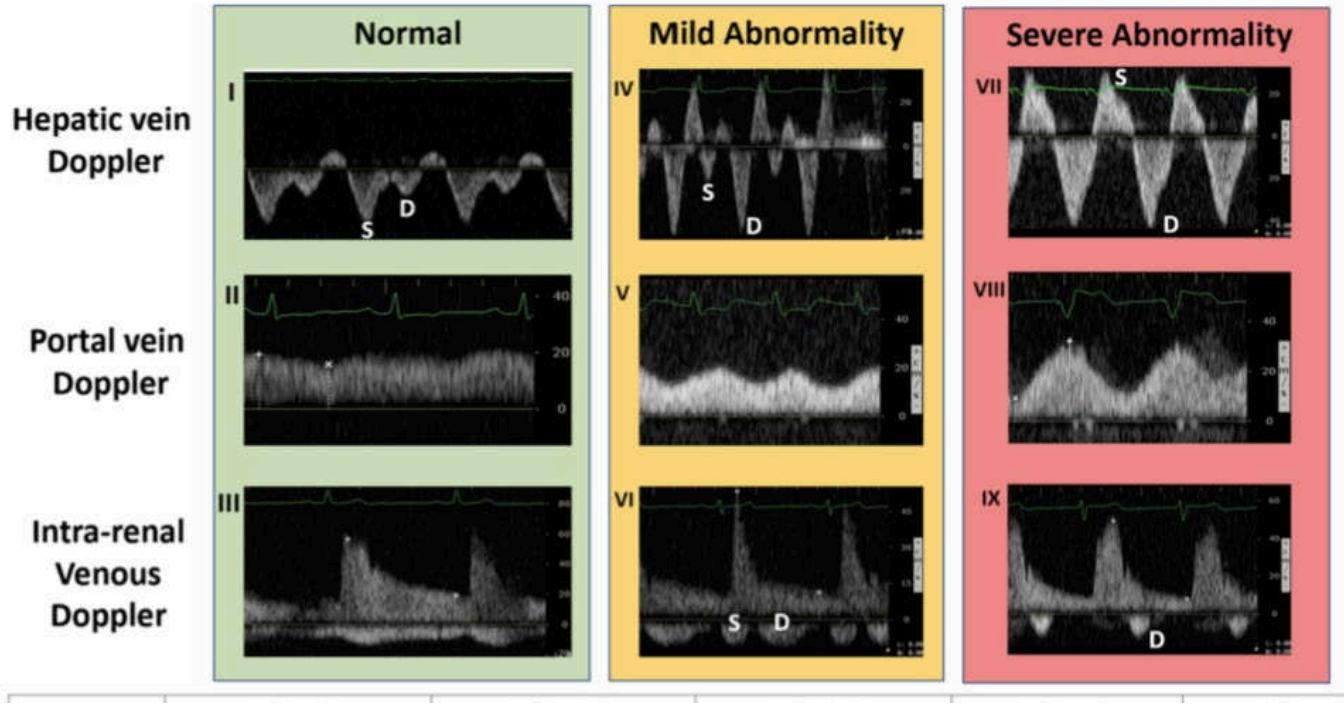


CHEST / 134 / 1 / JULY, 2008

ORIGINAL ARTICLE Open Access

Quantifying systemic congestion with Point-Of-Care ultrasound: development of the venous excess ultrasound grading system

William Beaubien-Souligny[1,2*], Philippe Rola[3], Korbin Haycock[4], Josée Bouchard[5], Yoan Lamarche[6], Rory Spiegel[7] and André Y. Denault[1,8]



VExUS C

IVC < 2 cm

IVC ≥ 2 cm
Normal patterns **or**
mild abnormalitie(s)
(Any combination of : I, II, III, IV, V, VI)

IVC > 2 cm
Severe abnormalities
in **at least one** pattern
(At least one of : VII, VIII, IX)

IVC > 2 cm
Severe abnormalities
in multiple patterns
(At least two of : VII, VIII, IX)

LR 6.37
AKI

Tele-POCUS Mentorship

- Learners call expert trainers by tele streaming software
- Experts view the physical probe orientation and POCUS scans
- Provide live guidance and mentorship