Ultrasound in the Medical ICU

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Acknowledgement and appreciation: Josh Miller MD

Conflicts of Interest

- None

Objectives

- Discuss common uses and scenarios for ultrasound in the medical ICU
- Discuss the decision-making process when using ultrasound in the medical ICU
- Discuss the future of ultrasound

40-year-old female with septic shock

She has group A strep bacteremia is on 3 pressors. She recently had a central line placed. Chest Xray read as line in place with no pneumothorax. Unfortunately, the patient becomes hypoxic, hypotensive and bradycardic.

What would you do?

What is the next best step in this patient's clinical care?

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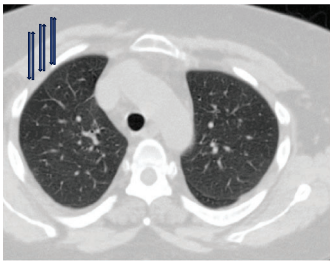
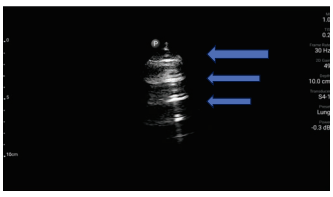
A. Add angiotensin II
B. Give TPA
C. Perform pericardiocentesis
D. Place a small-bore chest tube

A Lines

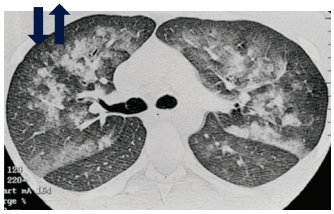
- Normal thoracic artifact
- Ultrasound beam will not go through air

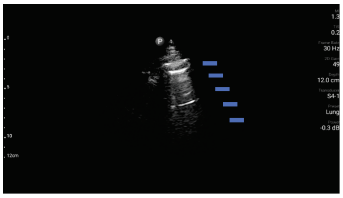
A Lines – Reverberation Artifact



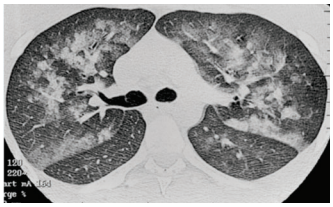


Abnormal Findings





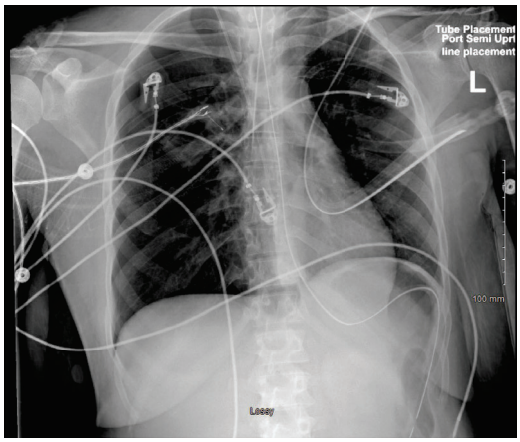
Abnormal – B lines



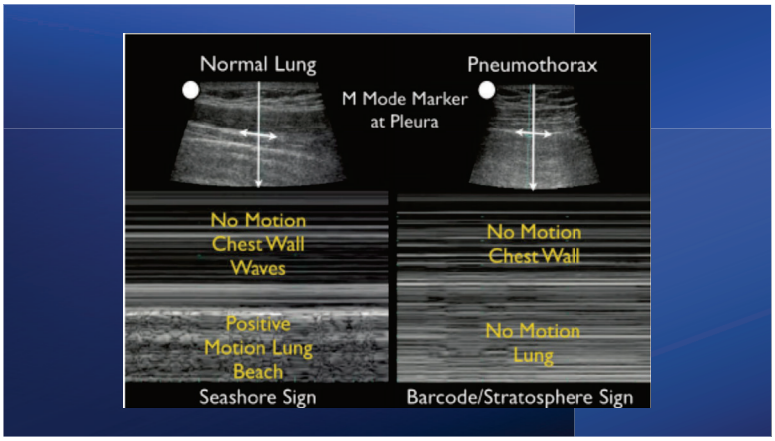
Abnormal – Consolidated lung

Lets revisit our case…

40-year-old female with septic shock, on 3 pressors who becomes acutely hypotensive, hypoxic(on the ventilator) and bradycardic

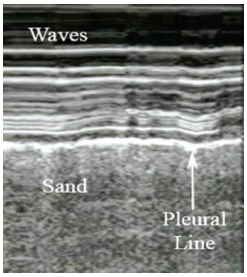


Pneumothorax



M Mode

Seashore - Normal



Bar Code - Abnormal

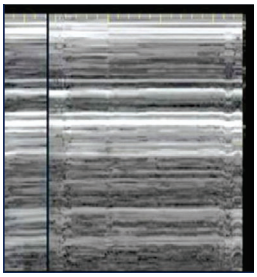


Table 1

A comparison of other ultrasonographic signs associated with the true lung point sign in pneumothorax with the *signs related to the imitations of the lung point sign.*

Ultrasound phenomenon	Interface of pleural sliding and absence of sliding	Barcode sign	A lines	Vertcal pheromena	Lung pulse	Other specific findings
True lung point sign	+	+	+	–	–	–
Physiological lung point sign	+	–	–	–	+	Z-shape formed by the pleural line and pericardium; pulsating myocardial wall present
Pseudo-lung point sign	+	–	–	+	+	–
Bleb point sign	+	+	+	–	–	–
Pleurofascial point sign	+	–	–	–	–	Diaphragm and pareschymal organs below may be displayed

Skulec R. Emer Med Int 2021;2021:6897946

What is the next best step in this patient's clinical care?

A. Add angiotensin II
B. Give TPA
C. Perform pericardiocentesis
D. Place a small-bore chest tube

43-year-old Women with Dyspnea

She is seen in the ER, PMH of COPD related to her asthma. She was having difficulty breathing and had substernal chest pain. She had recently lost her mother. Pulse oximetry saturation on room air was 87%. ECG showed nonspecific T wave changes and a CXR showed bilateral pulmonary edema. She was placed on high-flow nasal oxygen and transferred to your ICU.

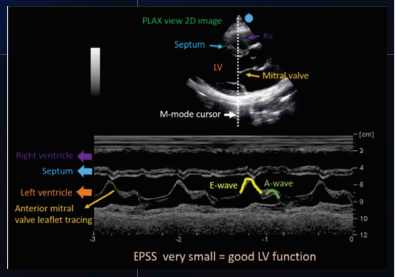
What do you do?

Which of the following diagnoses best explains this patient's presentation?

Which of the following diagnoses best explains this patient's presentation?

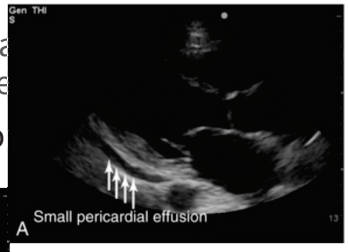
A. Acute coronary syndrome
B. Cardiac Tamponade
C. COPD Exacerbation
D. Pulmonary Embolus
E. Stress cardiomyopathy

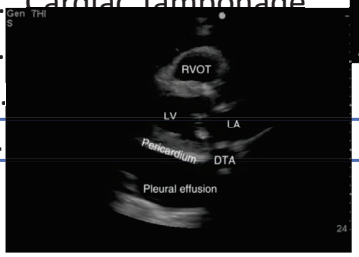
E Point Septal Separation



Which of the following dia
explains this patient's pre

A. Acute coronary syndro
B. Cardiac Tamponade
C.
D.
E.





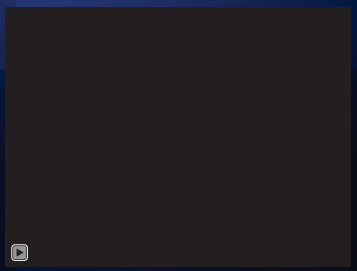
What is causing this patient's Hypotension

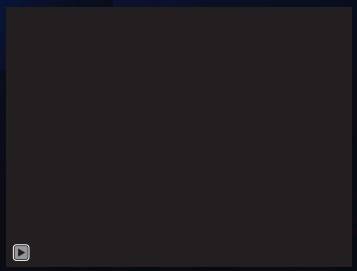
Tamponade

- Collapse of a right-sided chamber during diastole
  - Right ventricle collapses during diastole(when it should be filling)
- Collapse of right atrium during ventricular systole(when it should be filling)

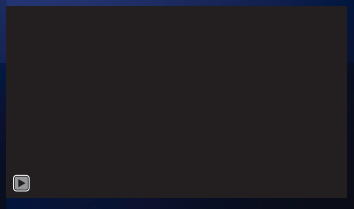
What is causing this patient's dyspnea

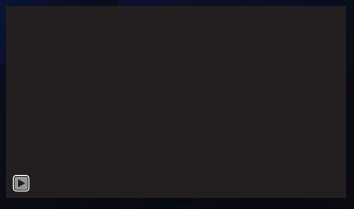
Pulmonary Embolus





IVC





Indications for Inferior Vena Cava Ultrasound

Indication	Notes
Central venous pressure	Approximation in spontaneously breathing patients
Pericardial effusion	Nondilated IVC can rule out tamponade physiology
Right heart failure	Dilated IVC seen in cor pulmonale and severe tricuspid regurgitation Cannot use IVC to infer CVP or volume responsiveness
Device placement confirmation	Identify correct placement of venous devices, including extracorporeal membrane oxygenation (ECMO) catheters and femoral transvenous pacemakers
Volume responsiveness	Limited utility

CVP, Central venous pressure; *IVC*, inferior vena cava.

When is Visualizing the IVC helpful

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Inferior Vena Cava Diameter and Collapsibility and Central Venous Pressure

IVC Diameter and Collapse (%)	Central Venous Pressure (Mean) (mm Hg)
Normal: ≤2.1 and >50%	0–5 (mean 3)
Intermediate: ≤2.1 cm and <50% collapse or >2.1 cm and >50% collapse	5–10 (mean 8)
High: >2.1 and <50%	10–20 (mean 15)

IVC, Inferior vena cava.

Estimate of CVP

****It is important to note these measurements have been validated in awake and spontaneously breathing patients and not in ventilated patients

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Fluid Responsiveness

- Spontaneous
  - Limited
  - In shock states, near-total collapsibility or small IVC size (<1 cm) suggest preload sensitivity but should be integrated with other clinical data and ultrasound findings of the heart and lungs”
- Ventilated
  - IVC distensibility index (IVCmax diameter – IVCmin diameter / IVCmax diameter) of greater than 12% to 18%, some literature up to 33%.
  - These patients also had to meet strict enrollment criteria, including ventilating **tidal volume of ≥8 cc/kg** and a **regular cardiac rhythm**.

Soni. Point of care Ultrasound. 2nd Edition.

Preau S, Bortolotti P, Colling D, et al. Diagnostic accuracy of the inferior vena cava collapsibility to predict fluid responsiveness in spontaneously breathing patients with sepsis and acute circulatory failure. Crit Care Med. 2017;45(3):e290–e297. PMID: 27749318

Tricuspid Regurge

Ultrasound and RVSP

- Ultrasound can be used to estimate pulmonary pressures
- Right ventricular (RV) systolic pressure (RVSP) = 4(tricuspid regurgitant jet velocity [TRV])^2 + right atrial pressure (RAP)
- Assumption in calculating the pulmonary artery systolic pressure (PASP) is that in the absence of RV outflow tract obstruction, **RVSP is equal to PASP**
- **Estimation of the right atrial pressure (RAP) is calculated by interrogating the inferior vena cava (IVC; both diameter and collapse with sniffing)**.

Ex) Estimated RAP is up to 5 mm Hg, when the IVC is <2.1 cm and collapses at least 50% in inspiration. IVC is measured at >2.1cm and does not collapse, so lets sayt the **RAP was estimated at 15 mm Hg. We can measure the TR jet.**

RVSP = 4(TRV)^2 + RAP
RVSP = 4(3.1 m/s)^2 + 15 mm Hg. RVSP = 53.4 mm Hg

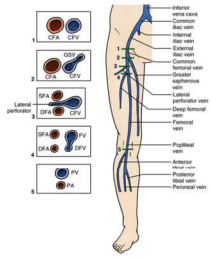
Diastolic Dysfunction

- TDI
- E and A waves in continuous tissue doppler
  - First peak occurs early (E wave), is passive, related to mitral valve opening, and generally is the larger of the two peaks
  - Second peak is the atrial systole (A wave) and is generally the smaller of the two
  - The relationship between early- and late-diastolic filling conveys information about diastolic function.

What is causing this Patient's Shock?

DVT

- Easy to do
- Can learn in 15 minutes



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Right Common Femoral

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ECMO Identification of positioning Avalon Catheter

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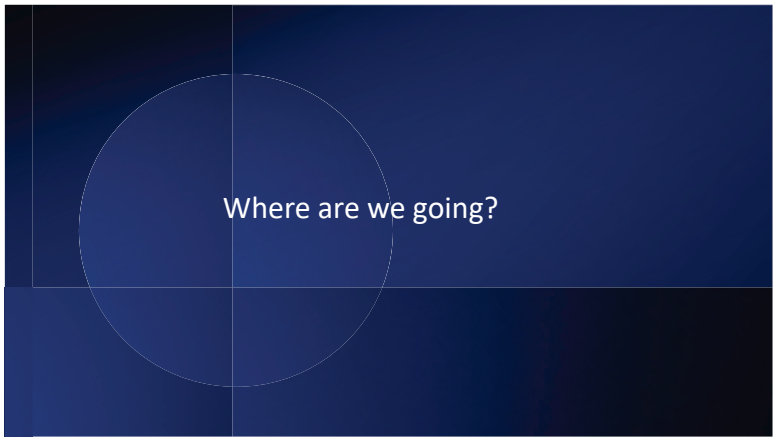
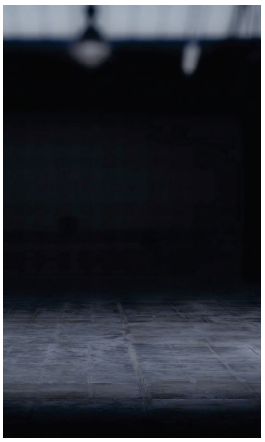
Procedures

- Ultrasound is always helpful



Influence of AI in ultrasound

- Auto capture of LV outflow tract VTI
- Inferior vena cava distensibility
- Pulmonary B lines
- Pitfalls
  - You can't have AI unless you can get the images



Summary Points

- Knowing some simple things such as, what an A line, B lines, pleural effusion and consolidated lung look like when using ultrasound can help a clinician make decisions
- You don't need advance ultrasound or cardiac knowledge to make critical and important treatment decisions
- Ultrasound can be an integral component of an ICU clinician's armamentarium helping identifying disease and improving diagnostic accuracy and timely delivery of care
- Encouragement - Just pick up the probe, ask questions and enjoy!

Thank you for this opportunity!

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