Prehospital Point-of-Care-Ultrasound

Children's Hospital Colorado EMS Conference

January 27th, 2022

Julia Aogaichi Brant, MD

Children's Hospital Colorado

University of Colorado

Boulder | Colorado Springs | Denver | Anschutz Medical Campus

Objectives

1. Review what point of care ultrasound is, how it works, and its uses and limitations.
2. Identify how to detect the presence or absence of lung slide, cardiac activity, and how to distinguish a vein from an artery on ultrasound.

Disclosures

- I have nothing to disclose
- …except that I love ultrasound

What is POCUS?

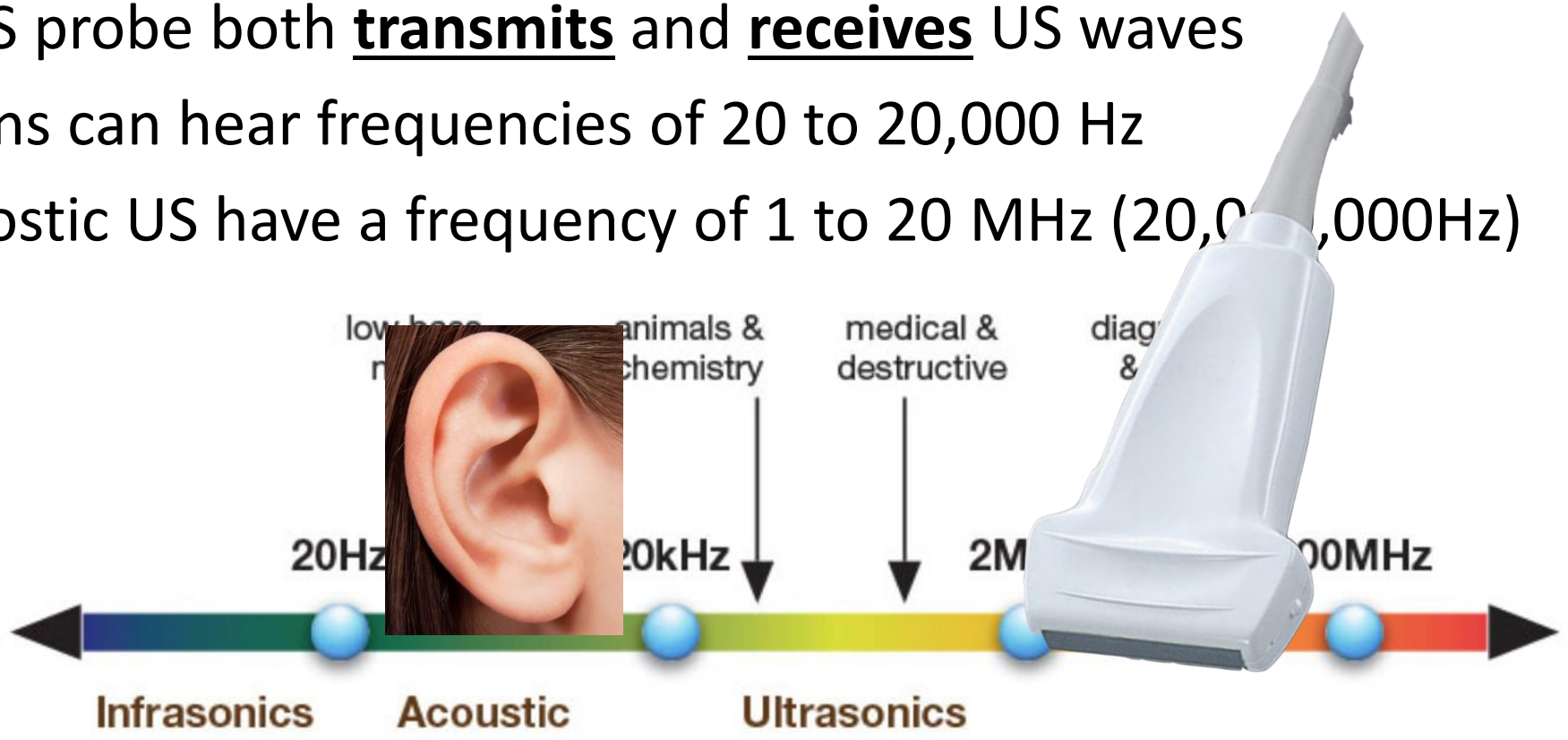
- POCUS stands for Point of Care Ultrasound
- “Real time”
- Portable
- Affordable
- Operator provides the read for the image

What can we use it for?

- Can actively alter decision making
  - Is there heart motion present? Yes or No?
  - Is there a pneumothorax? Yes or No?
- Augment the physical exam

Ultrasound basics

- **“<u>Ultra-sound</u>”** = sound waves transmitted at a frequency higher than human hearing
- The US probe both **<u>transmits</u>** and **<u>receives</u>** US waves
- Humans can hear frequencies of 20 to 20,000 Hz
- Diagnostic US have a frequency of 1 to 20 MHz (20,0 ,000Hz)



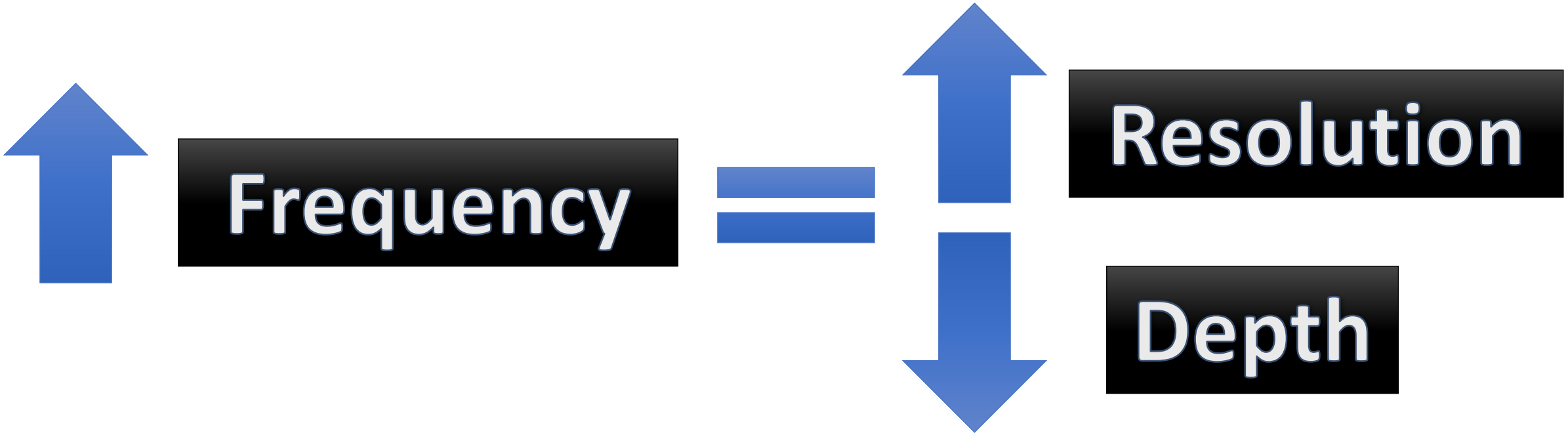
More US basics

- The image created depends on the characteristics of the both the **probe** and the **tissue** that the US wave is transmitted through

- All **probes** generate US waves of different **frequency** which impacts the resolution and depth of the image generate

- Different body **tissues** have different amounts of **impedance** (resistance to propagation of sound)

Probes: Frequency, Resolution and Depth



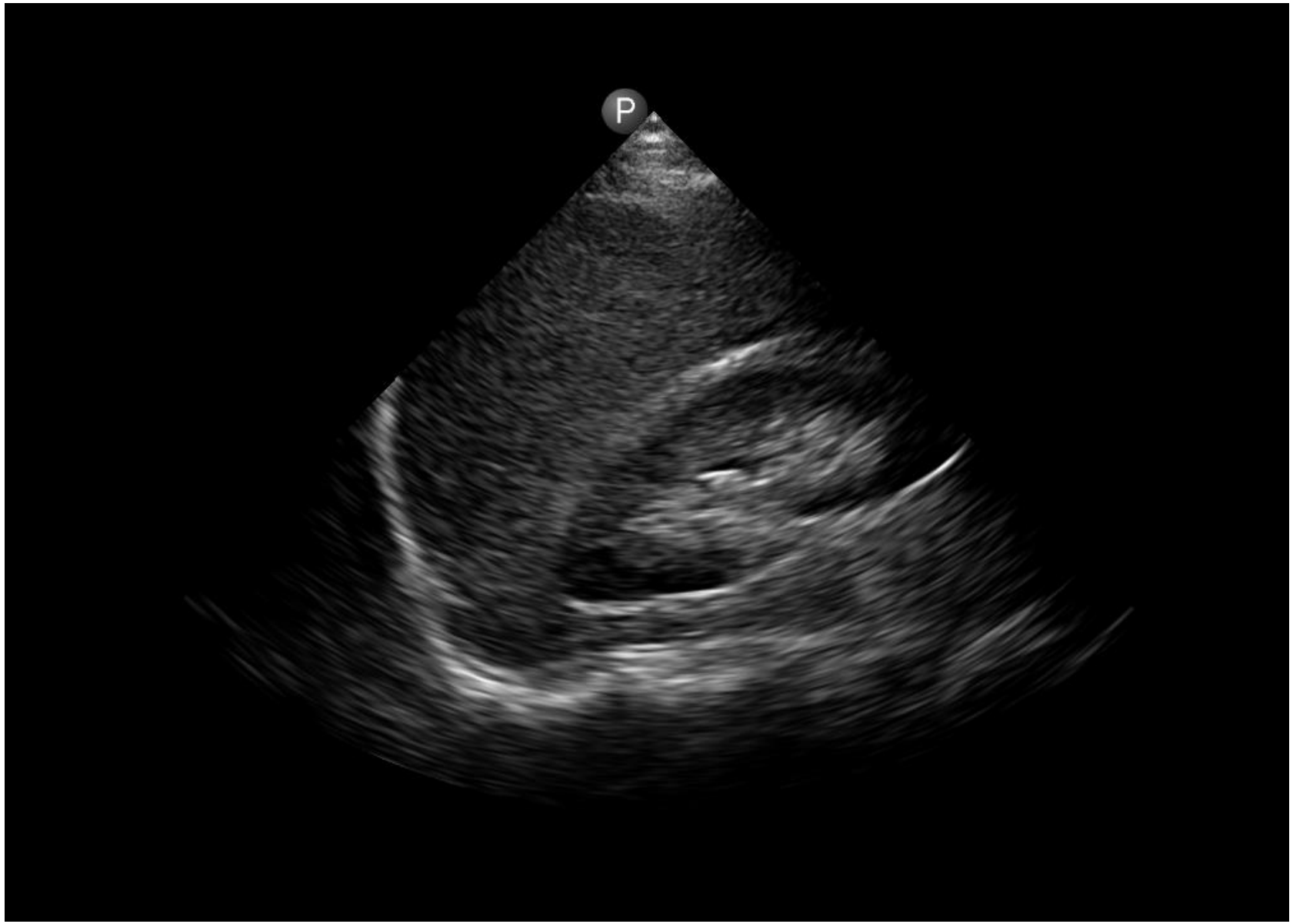
As frequency goes up, you will get a clearer picture (increased resolution) but you will not be able to see as deep into body (decreased depth)

Welcome to your crash course in reading US

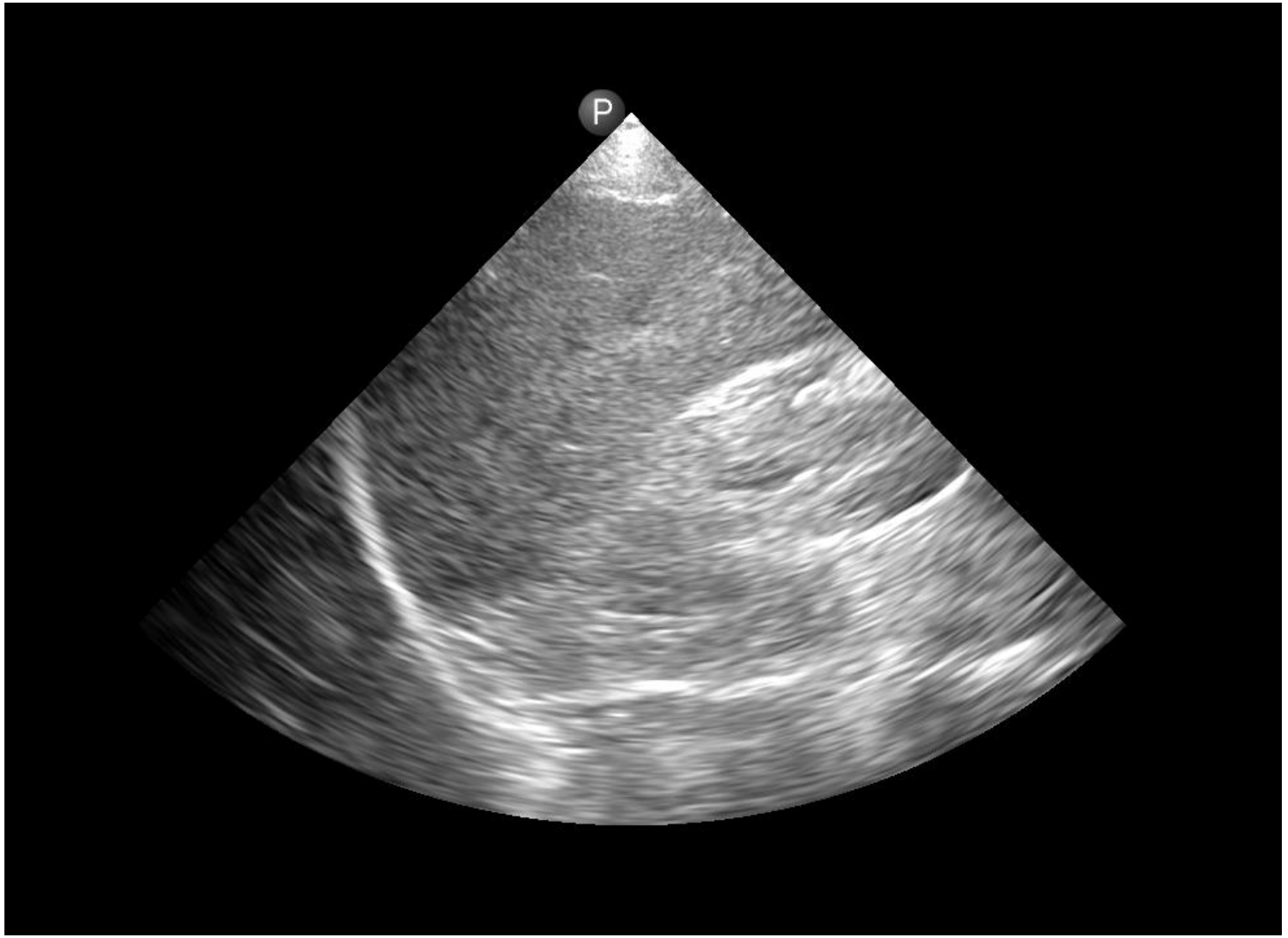
Black or hypo-echoic  Fluid

Gray or iso-echoic  Partial impedance (organs)

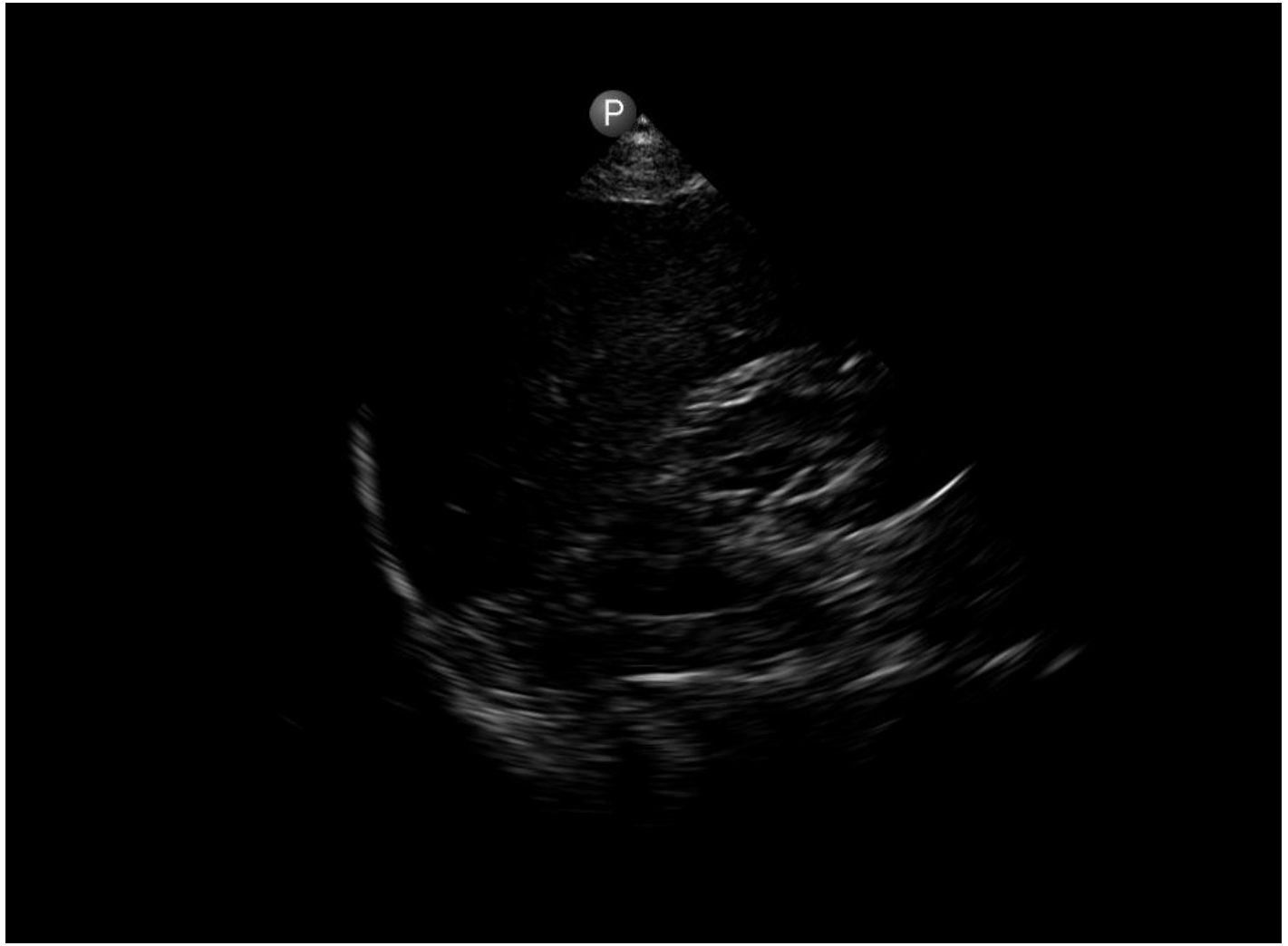
White or hyper-echoic  Bone or Air


P

What’s wrong with this image?



What’s wrong with this image?



3 kinds of probes

Linear probe

- High frequency
- Limited depth
- Great for skin findings, lungs, ET tube placement, arteries and veins (line placement

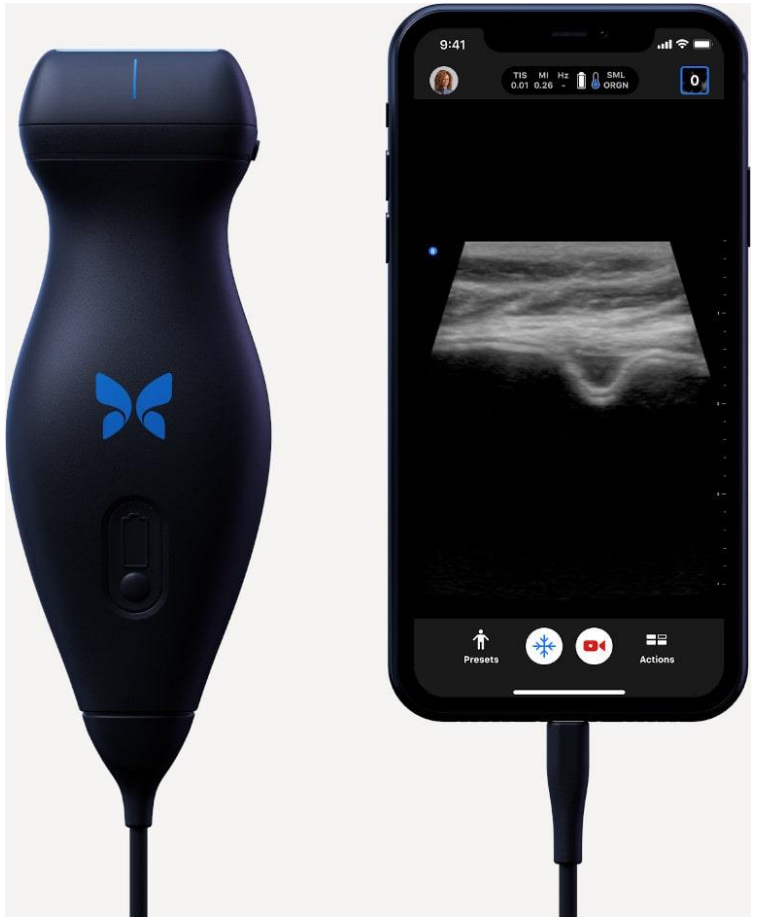
Cardiac probe

- Good for deeper structures
- Use for focused assessment with sonography for trauma (FAST) in big kids/adults
- Great for cardiac views

Curvilinear probe

- Lower frequency—better for deeper structures of the abdomen (FAST)
- Not super useful applications in EMS

Or just one



Prehospital POCUS (P-POCUS)

- Relatively new application
- Many studies have shown feasibility of P-POCUS
- Few to no studies on actual use or change in practice

Prehospital Applications

- Out of hospital arrest
- Pulseless Electrical Activity
- Pericardial effusion
- Pneumothorax
- Abdominal aortic aneurysm

Prehospital Procedures

- Difficult IV placement
- Needle decompression for pneumothorax
- Nerve blocks for analgesia
- Endotracheal tube placement confirmation
- Thoracotomies

In the news…

Bøtker *et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* (2018) 26:51
https://doi.org/10.1186/s13049-018-0518-x

Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

REVIEW Open Access

The role of point of care ultrasound in prehospital critical care: a systematic review

Morten Thingemann Bøtker[1,2*], Lars Jacobsen[3,4], Søren Steemann Rudolph[5,6] and Lars Knudsen[2]

In the news…

Review Paper

SAGE Open Medicine

Prehospital point-of-care ultrasound: A transformative technology

SAGE Open Medicine
Volume 8: 1–6
© The Author(s) 2020
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/2050312120932706
journals.sagepub.com/home/smo
SAGE

Colton B Amaral, Daniel C Ralston and Torben K Becker

In the news…

Printable 2020 Calendars
https://www.printable2020calendars.com

Original Article

Pre-hospital assessment with ultrasound in emergencies: implementation in the field

Kevin P. Rooney[1], Sari Lahham[2], Shadi Lahham[2], Craig L. Anderson[2], Bryan Bledsoe[3], Bryan Sloane[2], Linda Joseph[2], Megan B. Osborn[2], John C. Fox[2]

[1] *Department of Emergency Medicine, Henry Ford Hospital, Detroit, Michigan 48202, USA*
[2] *Emergency Medicine, University of California, Irvine, Orange, California 92868, USA*
[3] *Emergency Medicine, University of Nevada School of Medicine, Las Vegas, Nevada 89102, USA*

In the news…

ORIGINAL RESEARCH

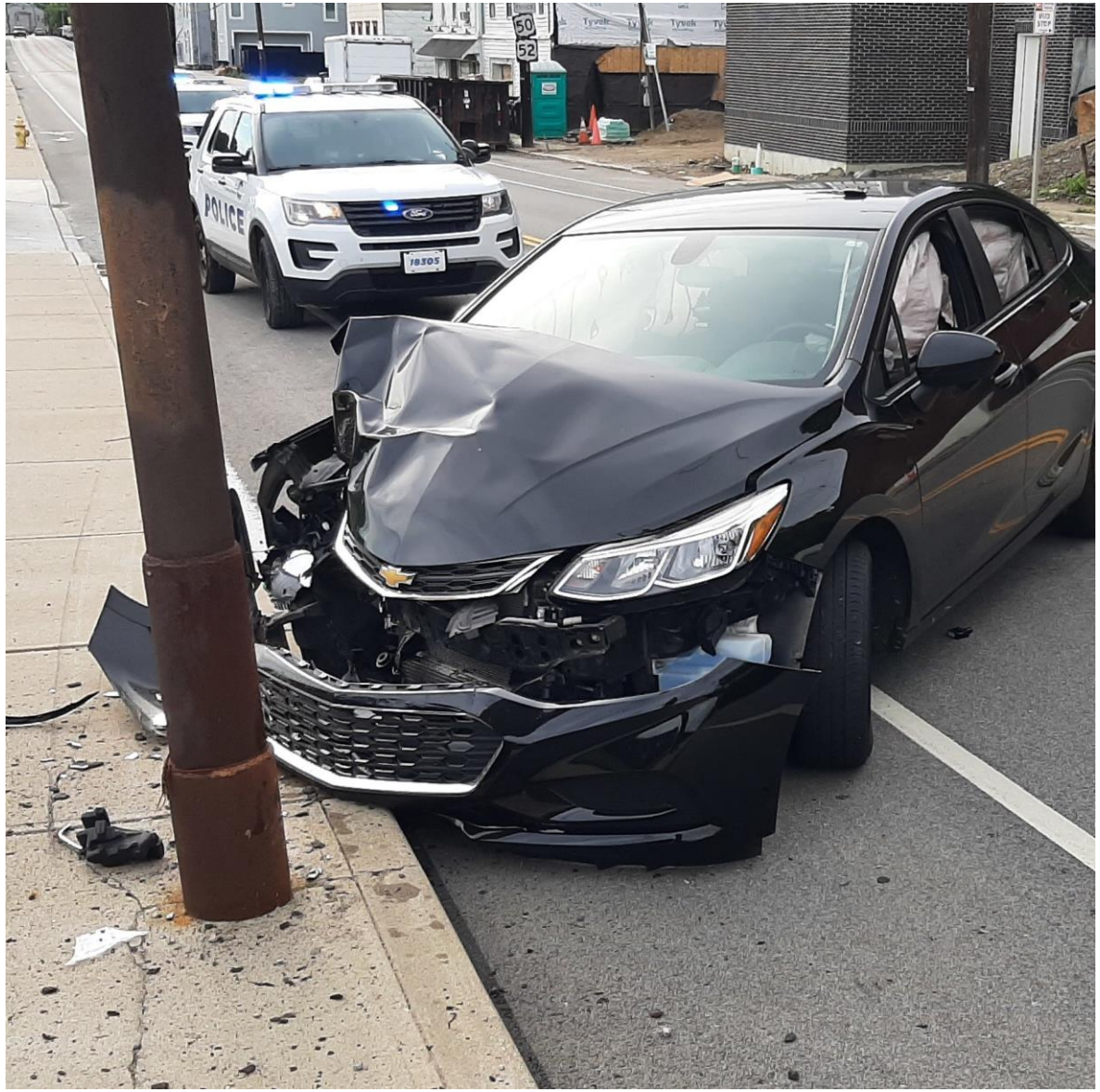
Paramedic-performed Prehospital Point-of-care Ultrasound for Patients with Undifferentiated Dyspnea: A Pilot Study

Jacob H. Schoeneck, MD*†
Ryan F. Coughlin, MD*
Cristiana Baloescu, MD*
David C. Cone, MD*
Rachel B. Liu, MD*
Sharmin Kalam, MD*
Amanda K. Medoro, MD*
Ian Medoro, MD*
Daniel Joseph, MD*
Kevin Burns, EMT-P, PA-C*
Jesse I. Bohrer-Clancy, MD*
Christopher L. Moore, MD*

*Yale University School of Medicine, Department of Emergency Medicine, New Haven, Connecticut
†Wake Forest University School of Medicine, Department of Emergency Medicine, Winston-Salem, North Carolina

Case 1

- You arrive to the scene of an MVA
- 16 year old unrestrained driver
  - Alert and oriented
  - Short of breath and complaining of right sided chest pain



Vitals and exam

- Clutching chest, tachypneic on exam
- Awake but anxious
- Remembers entire event, has difficulty speaking
- Heart rate:140s
- BP 80/54
- RR 30s
- Bilateral breath sounds

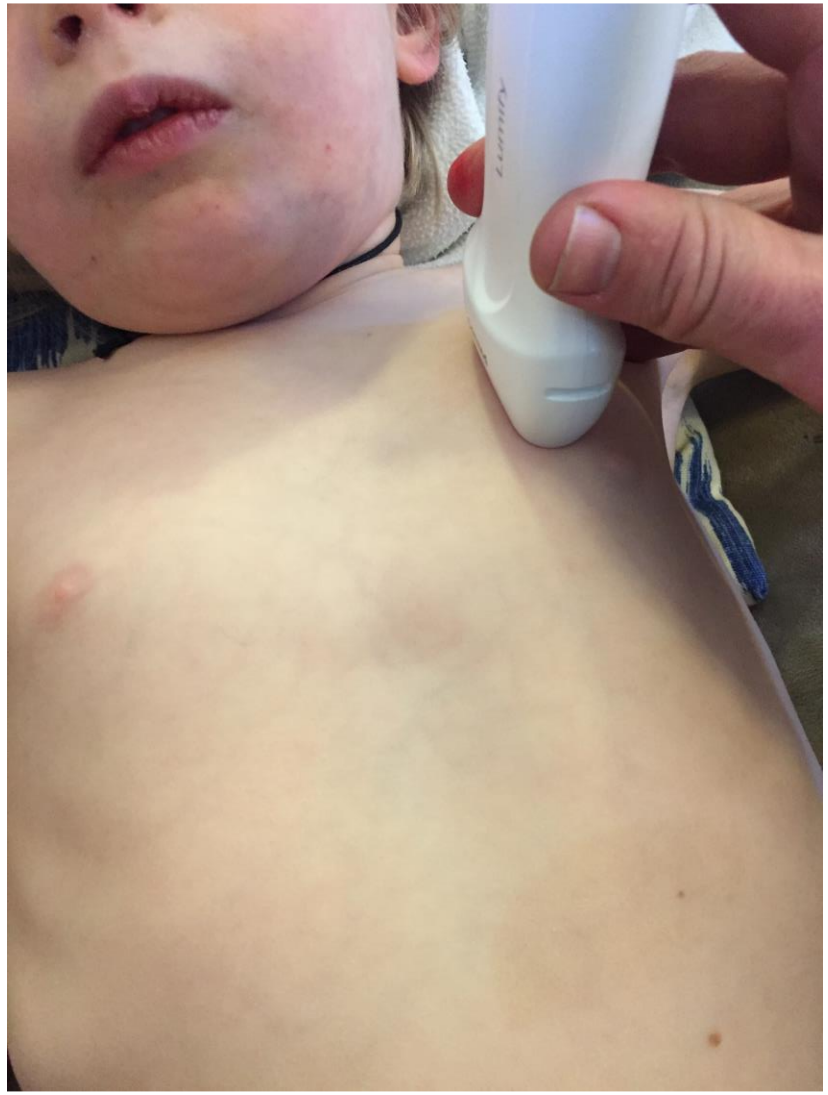
Diagnosis?

What do you do next?

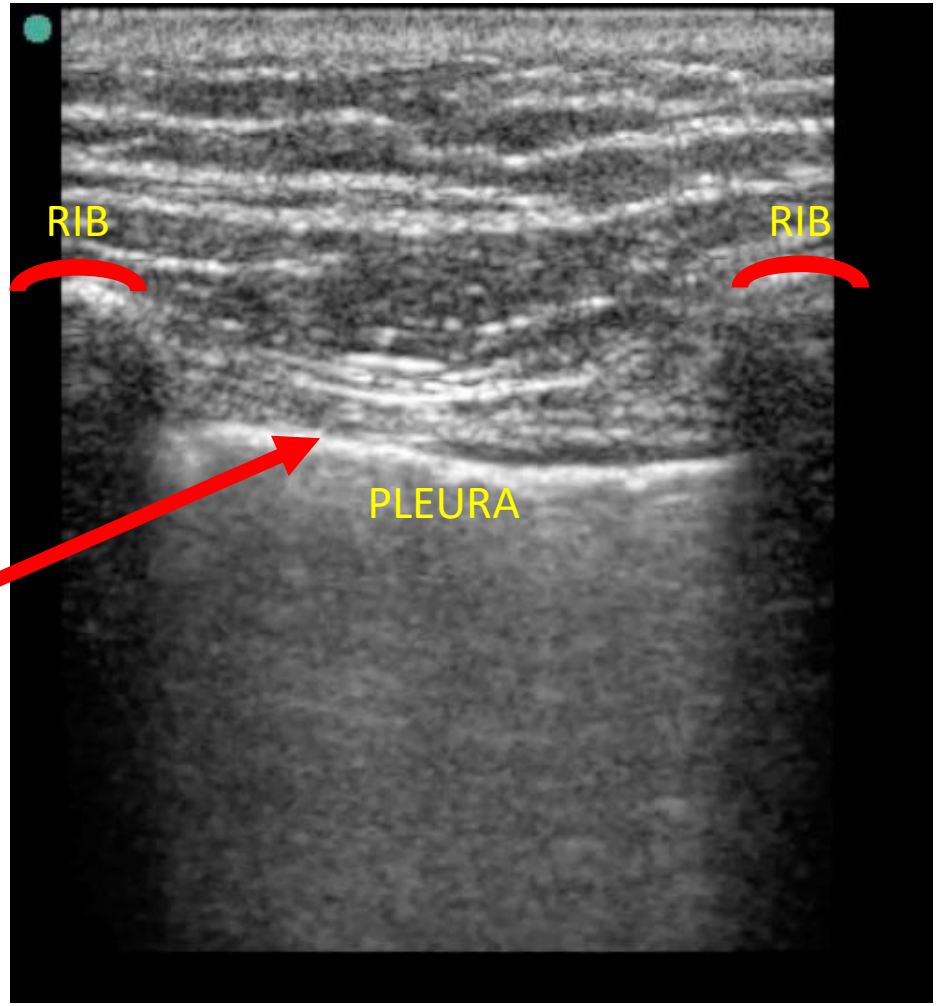
Introduction to lung ultrasound!

- Lungs are close to the surface→use the linear probe!
- Ultrasound hates air. Air (including air in the lungs) scatteres the ultrasound beam, making it impossible to “see” structures deep to the air interface
- Then why do we use ultrasound for lungs?
  - We are bad at auscultating lungs
  - Lung auscultation has a low sensitivity in different clinical situations
  - CXR is not much better
  - Ultrasound is a better option with better sensitivity (and it’s portable!)

Probe Position

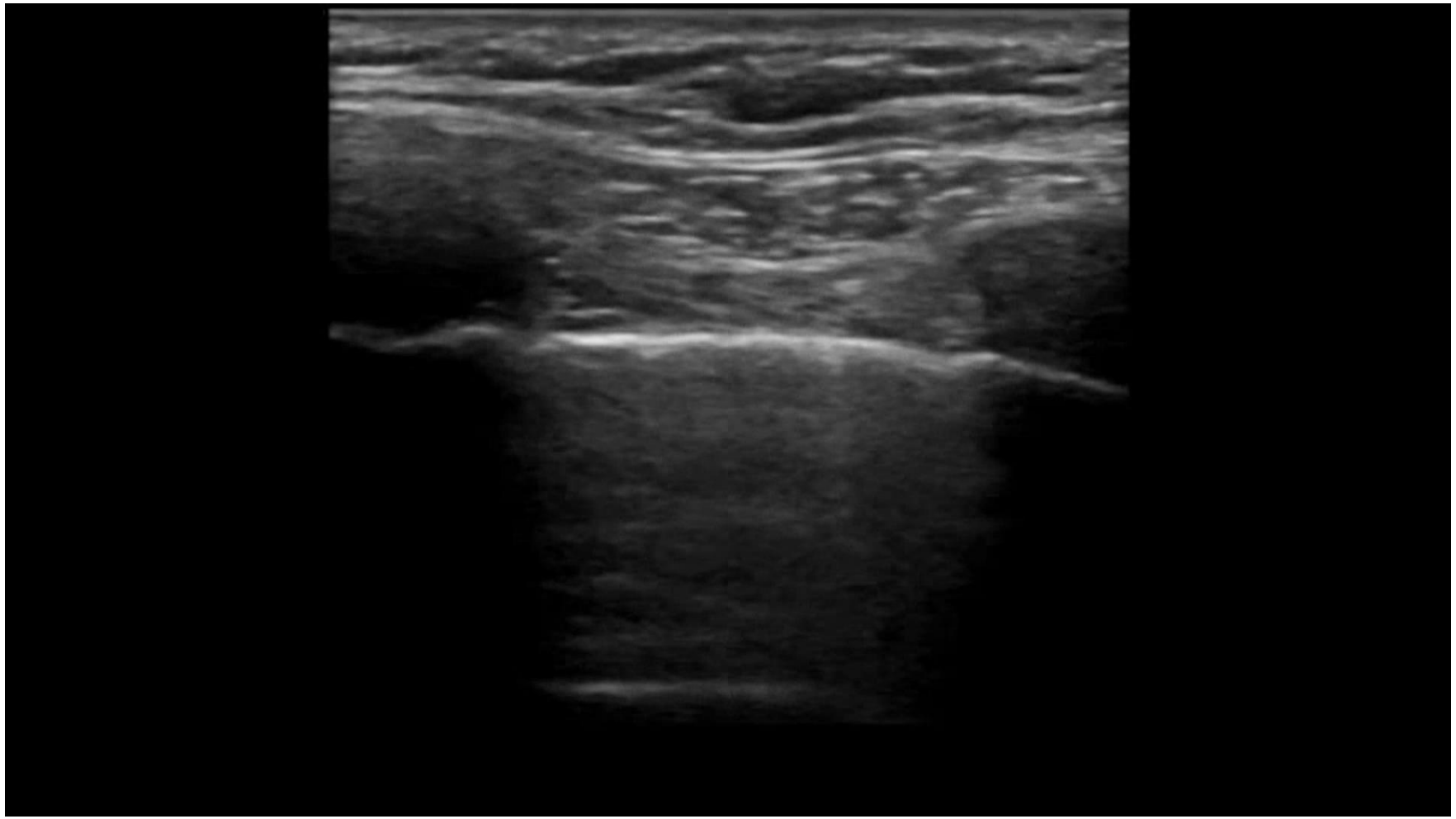


Basic lung image acquisition



Area of interest is the Pleural Line, where there should be Sliding if there is no pneumothorax

Normal lung



Abnormal lung

Compare sides…where is the pneumothorax?

Exceptions to the rule

- If you see B line which appears like a **Thick White Flashlight Beam (aka B-lines)**, there is NO pneumothorax
- There are other (much less common) things that cause no lung sliding.
  - Single lung intubation, pulmonary fibrosis, cardiopulmonary arrest, lung adhesions, lung scarring

Take home points for pneumothorax

1. The presence of lung sliding OR B-Lines definitively RULES OUT Pneumothorax AT THAT LUNG SPACE you are scanning
2. The absence of lung sliding is consistent with Pneumothorax-
   - If your clinical suspicion is high and patient it unstable, TREAT with needle decompression
   - If your clinical suspicion is high and patient is stable, put on oxygen and transfer ideally by ground to a center with surgery for chest tub placement
   - If your clinical suspicion is low, treat as you would pre-POCUS

Case 2

- You arrive to a home responding to a call about a 6mo F who has been vomiting for several hours
- She is currently sleeping
- Also has had 3 days of diarrhea with no urine output today

Vitals and exam

- Infant is sleepy and barely arousal
- Has a sunken fontanelle, dry mucus membranes
- HR 180s
- BP 75/palp
- BGL 70

Diagnosis?

What do you do next?

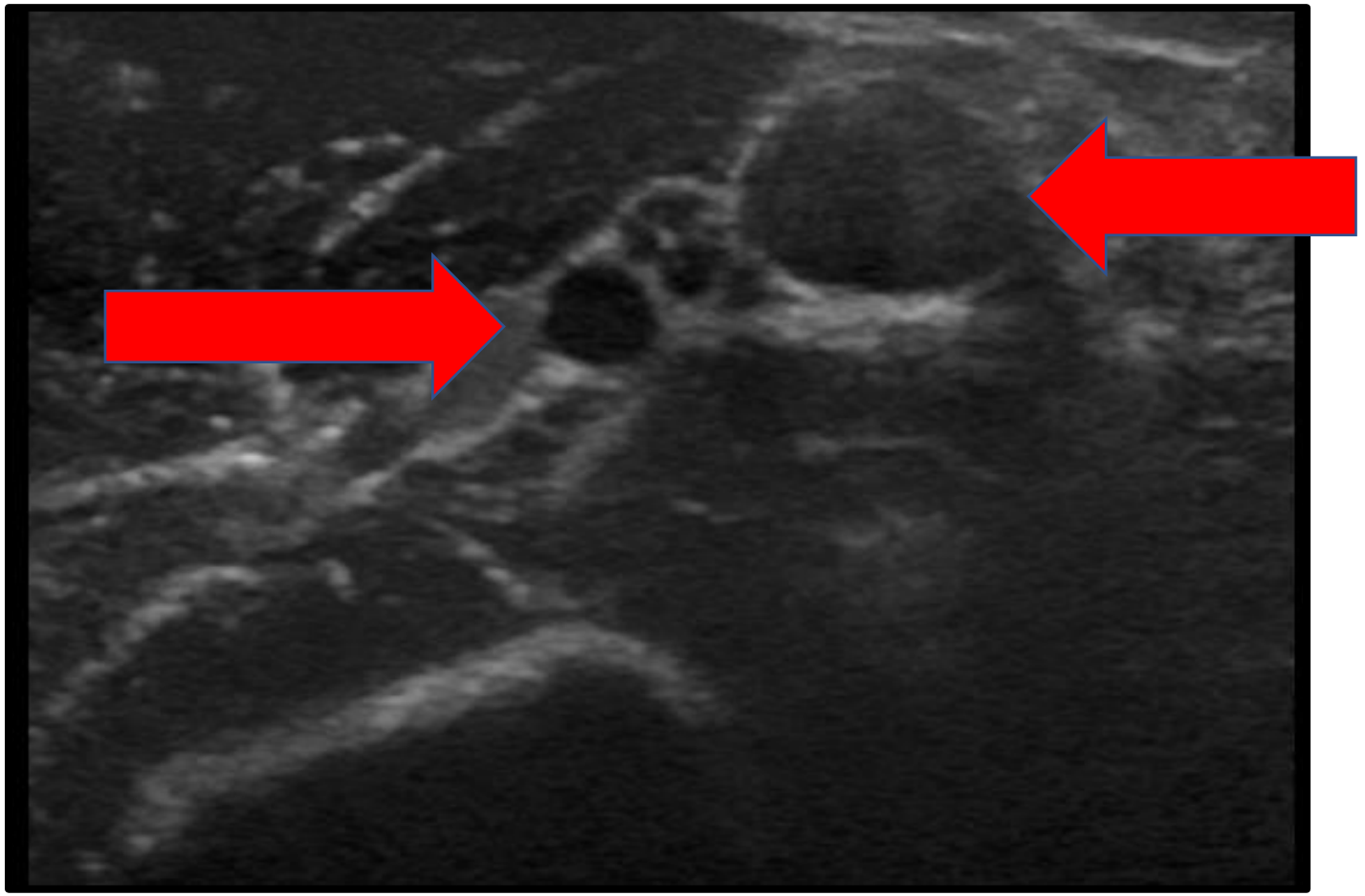
Hypovolemia, dehydration, hypoglycemia… Oh my!

- You try for a line and you fail
- Your partner tries and fails
- You left your IO kit back at the station

Introduction to vascular access!

- You are looking for a vein that is likely small given patient's dehydration
- Use the linear probe and identify your structures
- Try to make the procedure as sterile as possible
- Center your needle in the center of the screen and watch the tip as you advance it

Identify your structures



- Vessels are black (hypoechoic) because they are full of fluid aka blood
- Usually very round with hyperechoic (bright white) outer circle

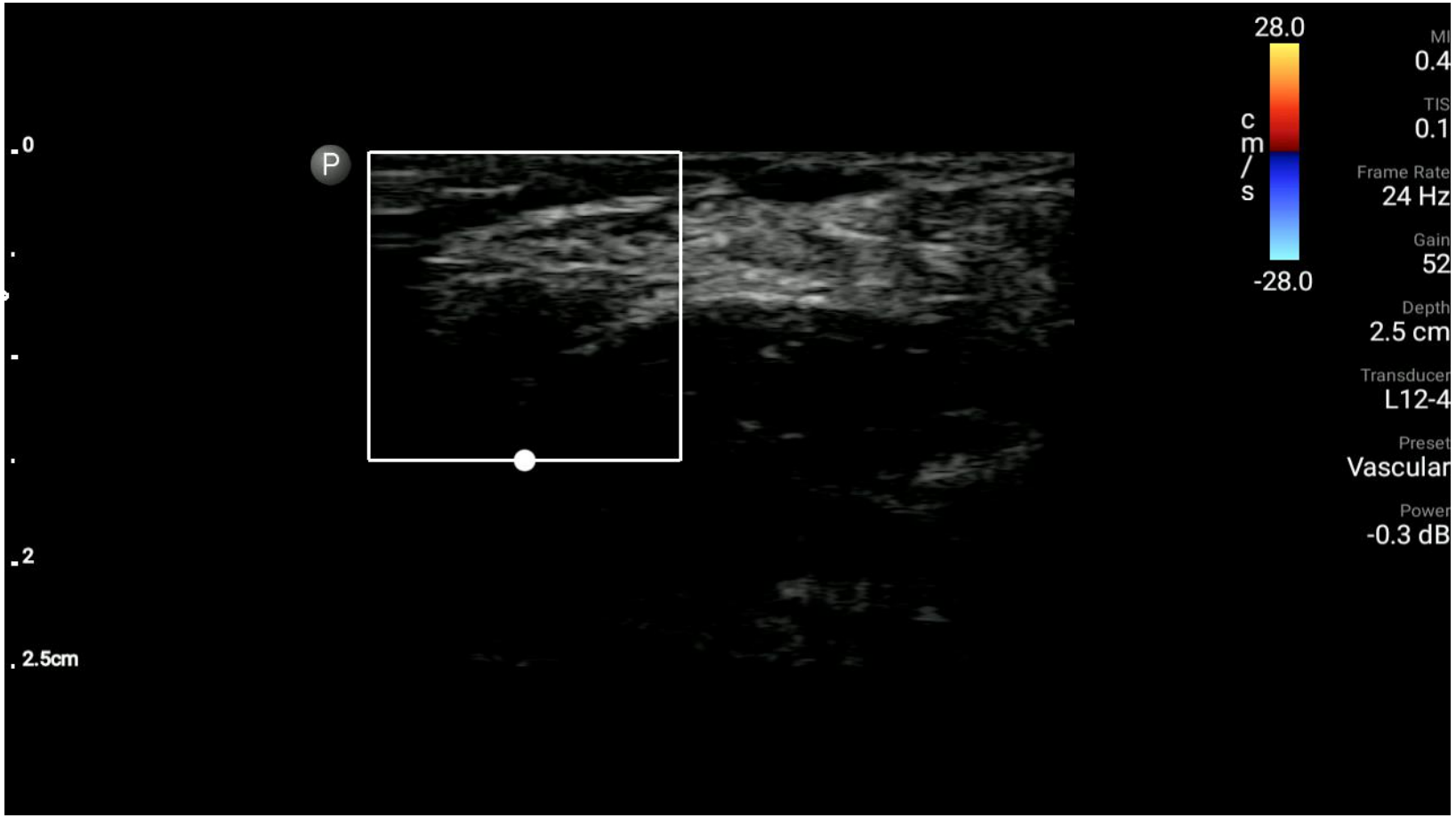
How do you distinguish artery from vein?

- Use color flow to identify vasculature
- Veins are easily compressible! Apply gentle pressure until you are able to collapse the vessel completely

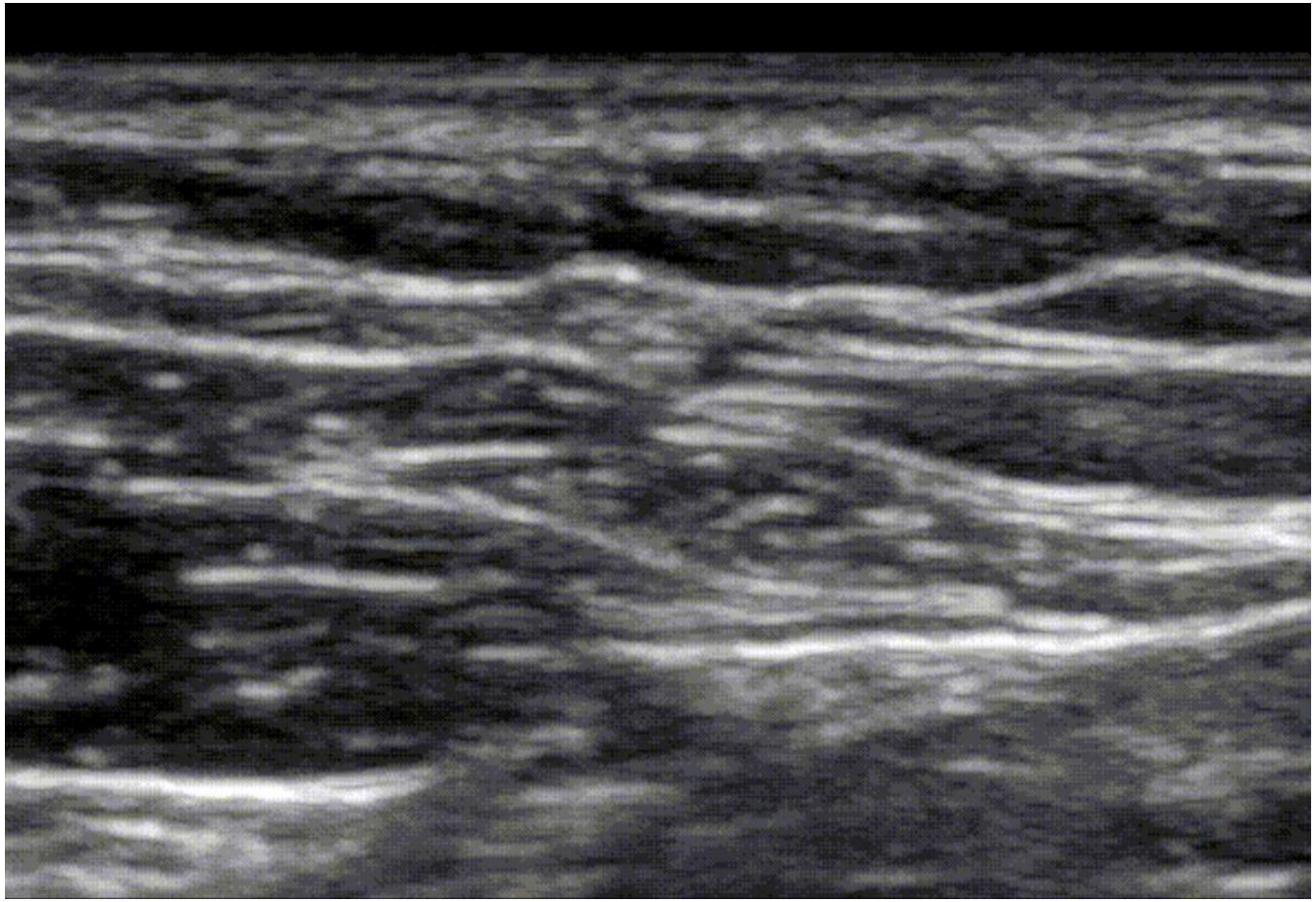
- Pitfalls
  - All arteries will collapse with enough pressure
  - The color is not associated with artery or vein
    - Blue is away from the probe, NOT vein
    - Red is toward the probe, NOT artery

Artery vs Vein

Color flow

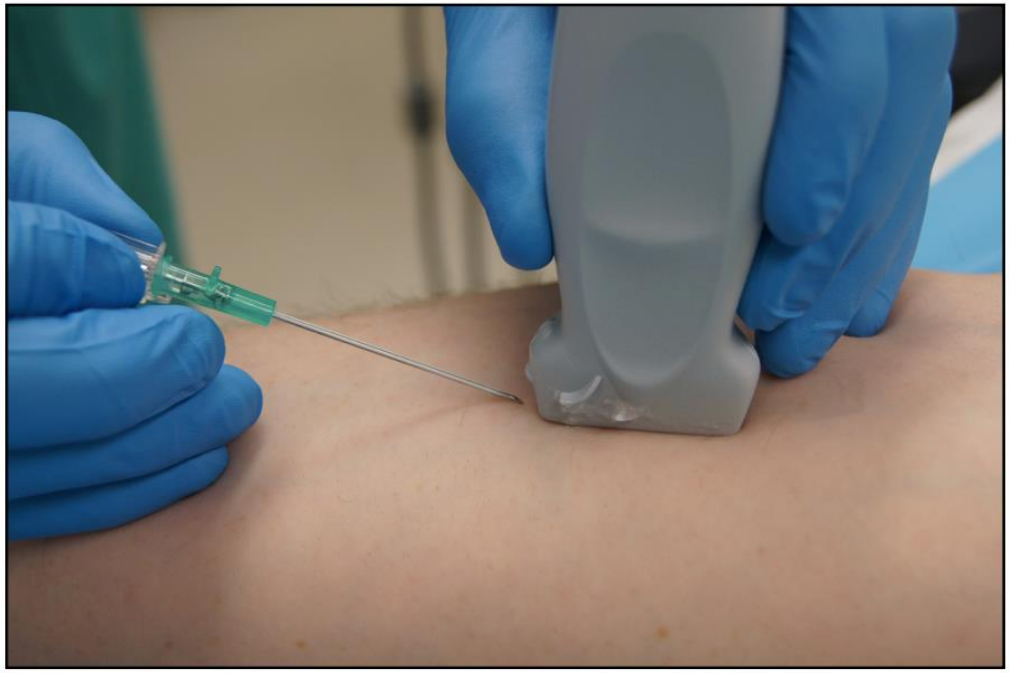

28.0
cm/s
-28.0
MI
0.4
TIS
0.1
Frame Rate
24 Hz
Gain
52
Depth
2.5 cm
Transducer
L12-4
Preset
Vascular
Power
-0.3 dB
P
0
2
2.5cm

Which is which?

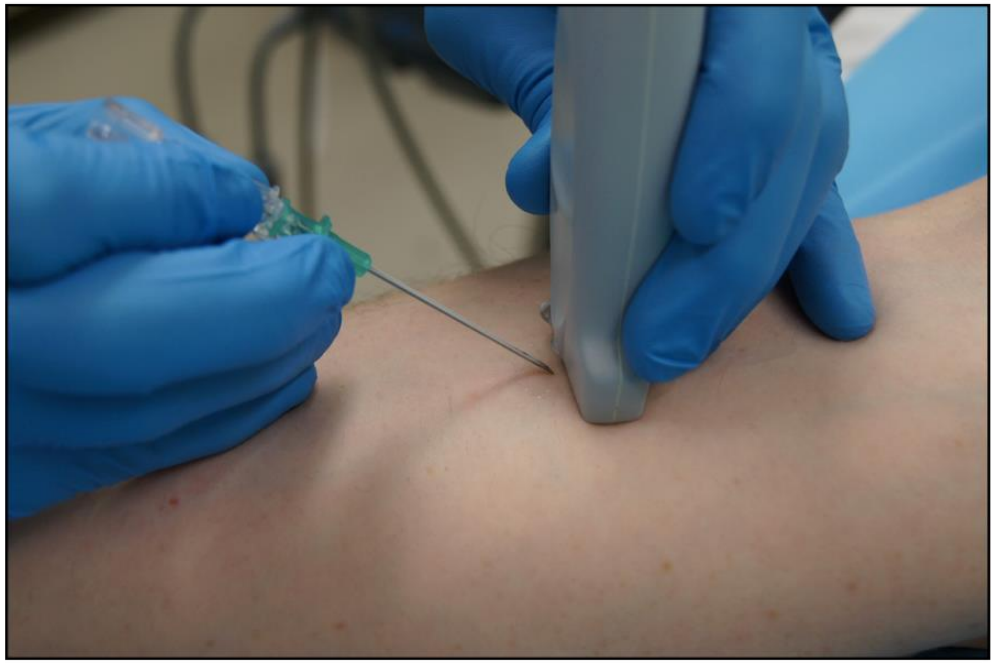


Two ways to insert needle

In-plane technique



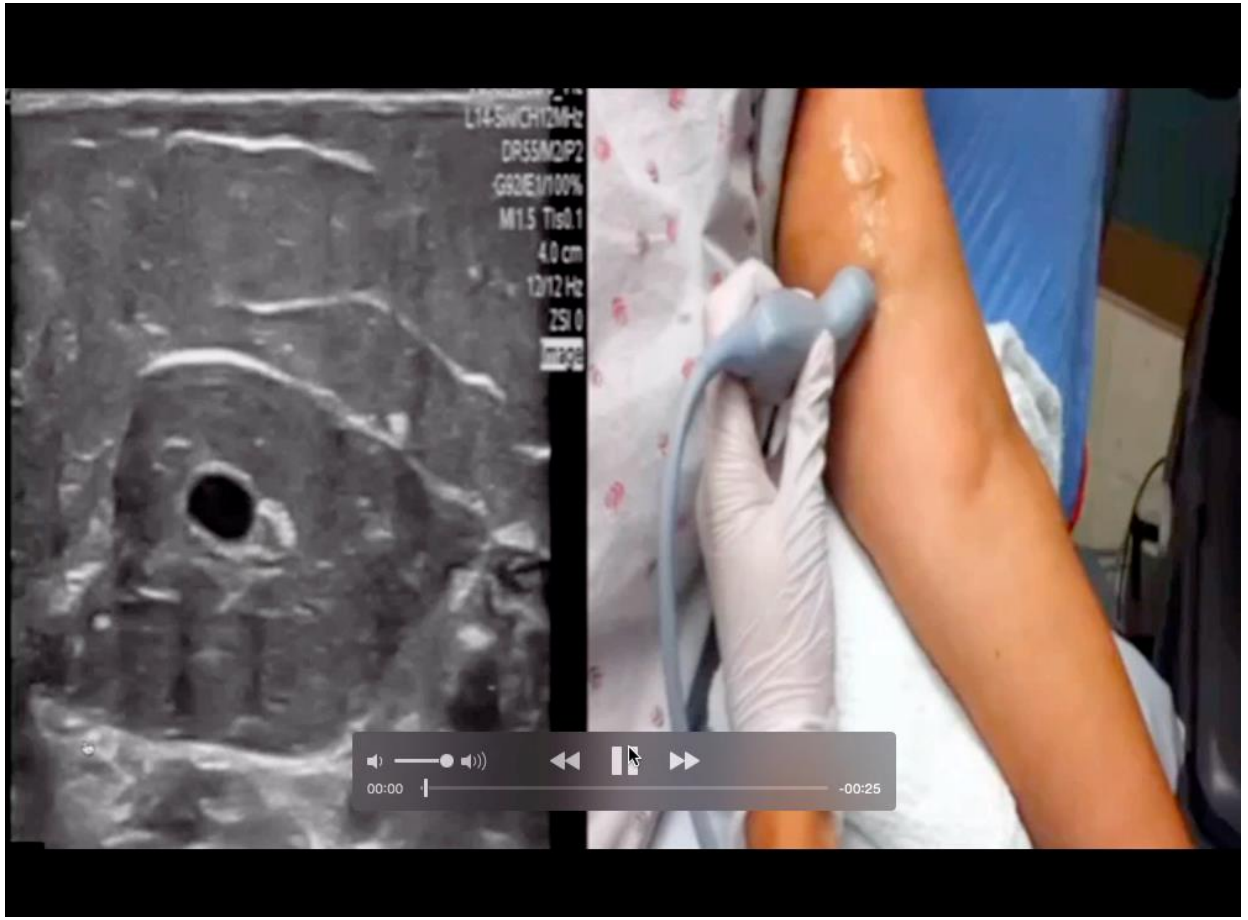
Out of plane technique



Out of plane

In plane

Out of plane video



Take home points for vascular access

- If the patient is sick and needs access, POCUS is a great option
- Do not delay access; if you do not feel comfortable with US and you have an IO, just get access
- Look for black round structures surrounded by a white circle
- Veins are collapsible and do not pulsate
- Use color flow but remember, blue ≠ vein and red ≠ artery

Case 3

- You are called to find an 18yo in cardiac arrest, empty pill bottles beside her
- You cannot get pulses
- She has been down for an unclear amount of time

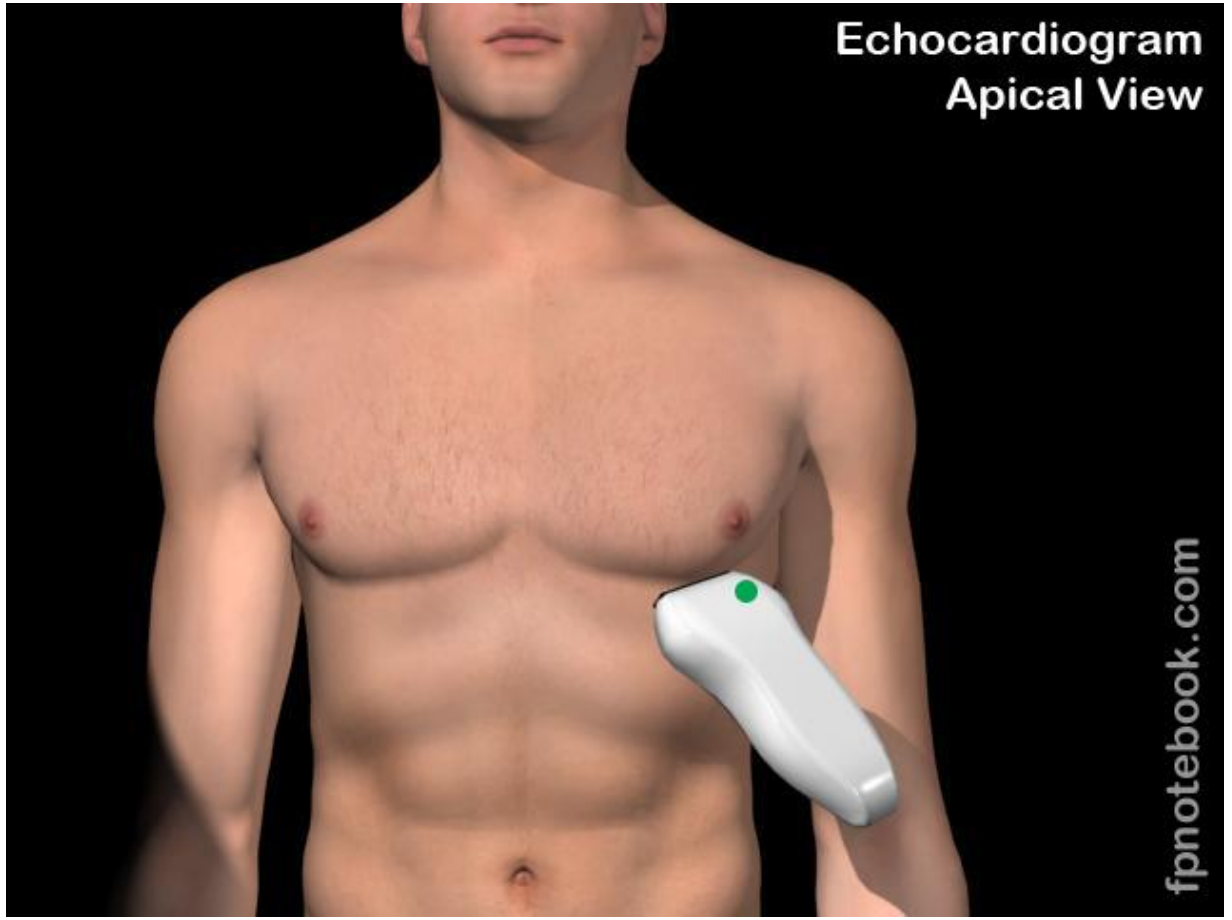
What do you do? What do you know?

- Start CPR
- Patient down for unclear amount of time
- What are patient survival rates for out of hospital arrests?
- When do you call the code?

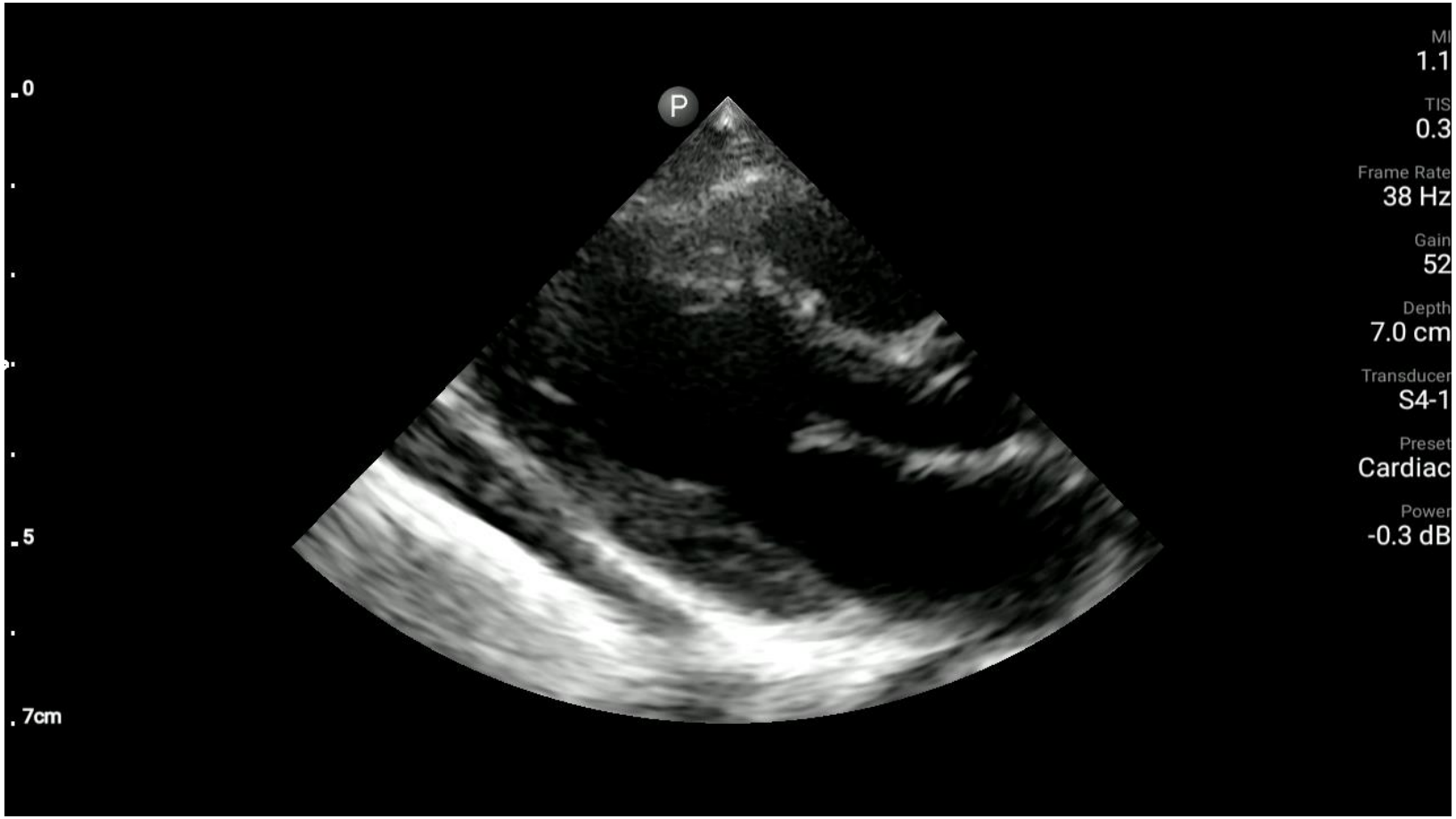
(Brief) Introduction to Cardiac Ultrasound

- Use phased array or cardiac probe
- Place on the left side of the chest along the nipple line or just below
- Answers a question: is there cardiac activity?
- Can support termination of resuscitation

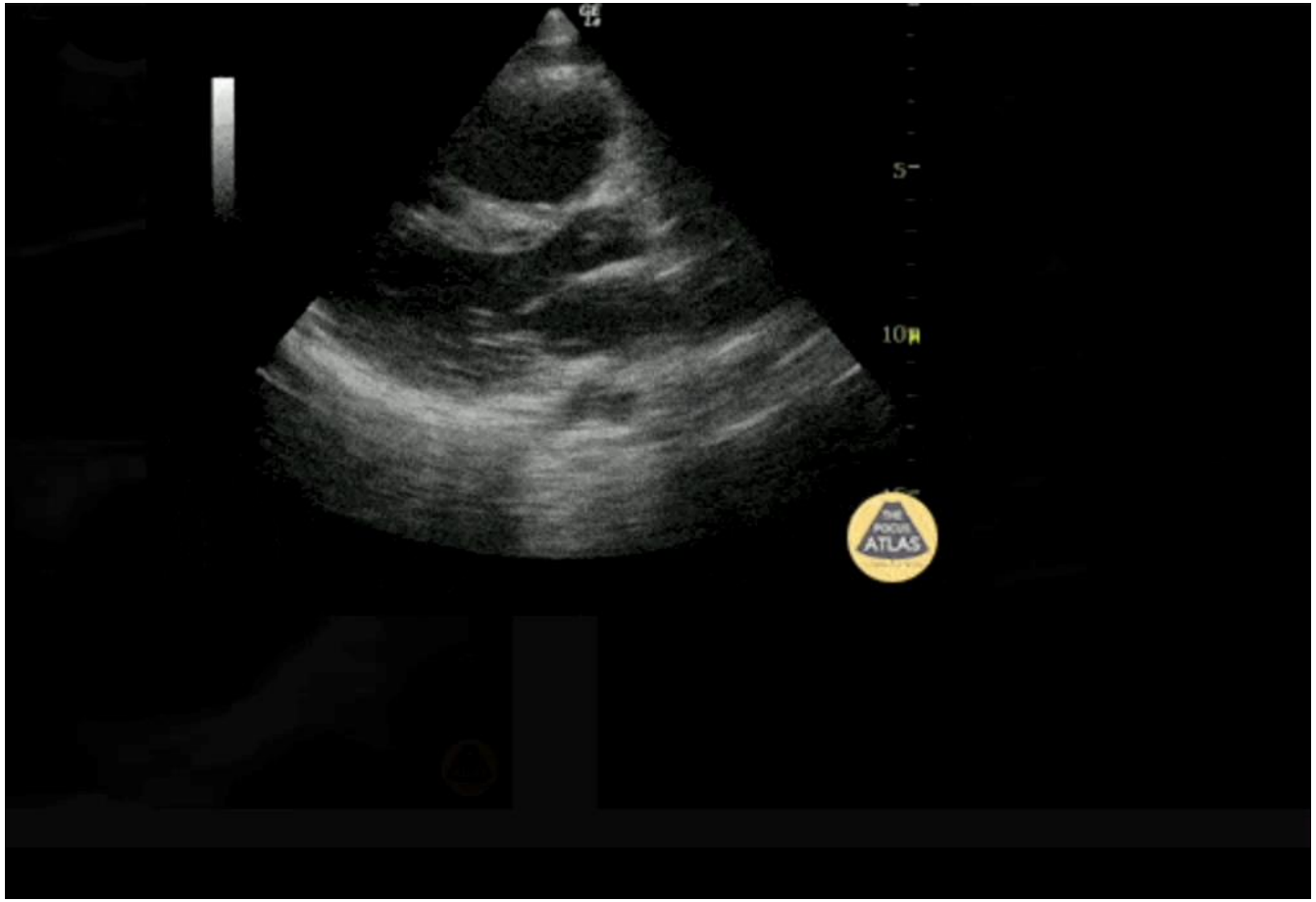
Probe position



Normal cardiac function



No cardiac activity



Think about your **POCUS Hs&Ts**

Hypovolemia

Hypoxia

Hydrogen Ion (acidosis)

Hypo/Hyperkalemia

Hypoglycemia

Hypothermia

Toxins

Tamponade

Tension Pneumothorax

Thrombosis

Trauma

Take home points for cardiac POCUS

- Cardiac ultrasound can tell you
  - Is the heart beating?
  - Is there a large effusion? Tamponade? Thrombus?

- But…do NOT delay CPR to obtain an image

CPR saves lives, cardiac ultrasound does NOT

Barriers in P-POCUS

- No consensus for scope of use in EMS
- No consensus for training needed for proficiency
- Need initial education, hands on experience
- Expensive
- Supervision is needed by ultrasound expert
- Need for continued training—Use it or lose it!

Acknowledgements

- The POCUS Atlas
- NYSORA
- Dr. Jonathan Orsborn
- Dr. Maria Mandt
- All first responders—THANK YOU!

Thank you!

Children's Hospital Colorado

University of Colorado

Boulder | Colorado Springs | Denver | Anschutz Medical Campus

References

- Amaral CB, Ralston DC, Becker TK. Prehospital point-of-care ultrasound: A transformative technology. *SAGE Open Med*. 2020;8:205031212093270 6. Published 2020 Jul 26. doi:10.1177/205031212093270 6
- American College of Surgeons Committee on Trauma; American College of Emergency Physicians Pediatric Emergency Medicine Committee; National Association of EMS Physicians; American Academy of Pediatrics Committee on Pediatric Emergency Medicine, Fallat ME. Withholding or termination of resuscitation in pediatric out-of-hospital traumatic cardiopulmonary arrest. Ann Emerg Med. 2014 Apr;63(4):504-15. doi: 10.1016/j.annemergmed.2014.01.013. PMID: 24655460.
- Arts L, Lim EHT, van de Ven PM, Heunks L, Tuinman PR. The diagnostic accuracy of lung auscultation in adult patients with acute pulmonary pathologies: a meta-analysis. Sci Rep. 2020 Apr 30;10(1):7347. doi: 10.1038/s41598-020-64405-6. PMID: 32355210; PMCID: PMC7192898.
- Berger S. Survival From Out-of-Hospital Cardiac Arrest: Are We Beginning to See Progress? J Am Heart Assoc. 2017 Sep 22;6(9):e007469. doi: 10.1161/JAHA.117.007469. PMID: 28939721; PMCID: PMC5634321.
- Bøtker MT, Jacobsen L, Rudolph SS, Knudsen L. The role of point of care ultrasound in prehospital critical care: a systematic review. *Scand J Trauma Resusc Emerg Med*. 2018;26(1):51. Published 2018 Jun 26. doi:10.1186/s13049-018-0518-x
- Lee, J., Yang, WC., Lee, EP. *et al.* Clinical Survey and Predictors of Outcomes of Pediatric Out-of-Hospital Cardiac Arrest Admitted to the Emergency Department. *Sci Rep* **9,** 7032 (2019). https://doi.org/10.1038/s41598-019-43020-0
- Rooney KP, Lahham S, Lahham S, et al. Pre-hospital assessment with ultrasound in emergencies: implementation in the field. *World J Emerg Med*. 2016;7(2):117-123. doi:10.5847/wjem.j.1920-8642.2016.02.006
- Sanders S, Kaylor J (2016, July 12). Diagnosing Pneumothorax With Bedside Ultrasound [NUEM Blog. Expert Commentary by Dearing E]. Retrieved from http://www.nuemblog.com/blog/diagnosing-pneumothorax-ultrasound/
- Schoeneck JH, Coughlin RF, Baloescu C, Cone DC, Liu RB, Kalam S, Medoro AK, Medoro I, Joseph D, Burns K, Bohrer-Clancy JI, Moore CL. Paramedic-performed Prehospital Point-of-care Ultrasound for Patients with Undifferentiated Dyspnea: A Pilot Study. West J Emerg Med. 2021 Mar 24;22(3):750-755. doi: 10.5811/westjem.2020.12.49254. PMID: 34125056; PMCID: PMC8203026.