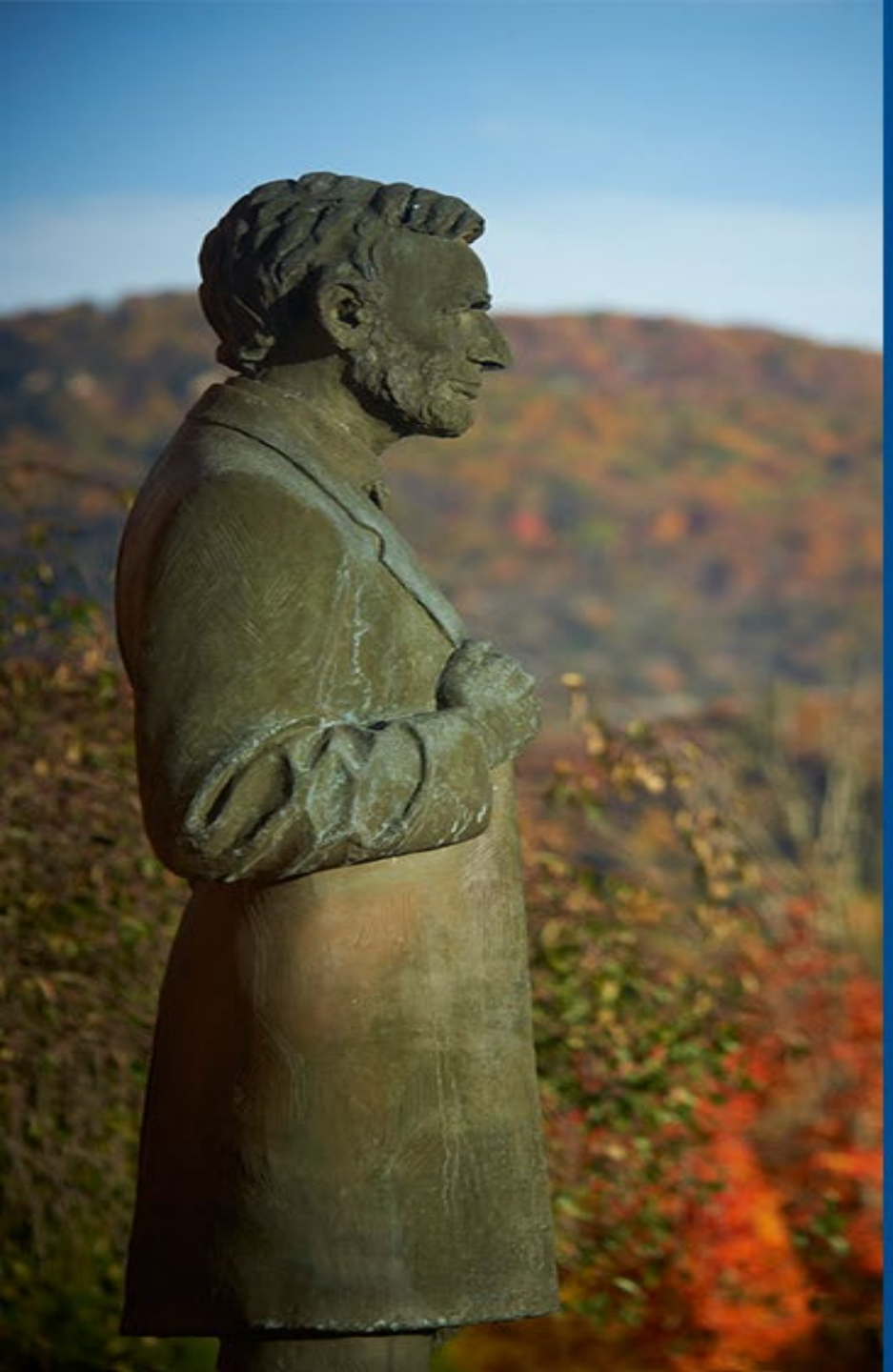

Point-of-Care Ultrasound (POCUS) and the e-FAST Exam

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LMU

DeBusk College *of* Osteopathic Medicine

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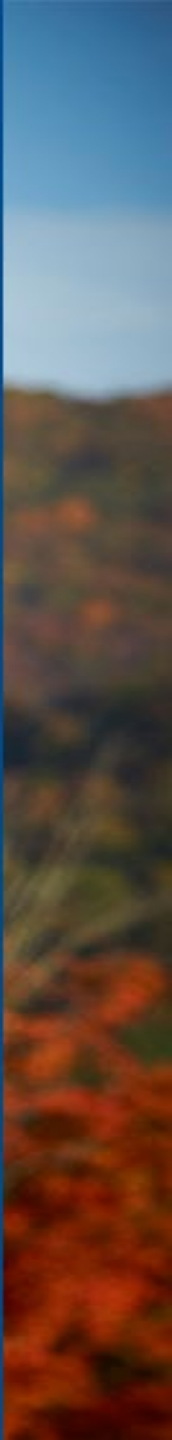
VALUES | EDUCATION | SERVICE



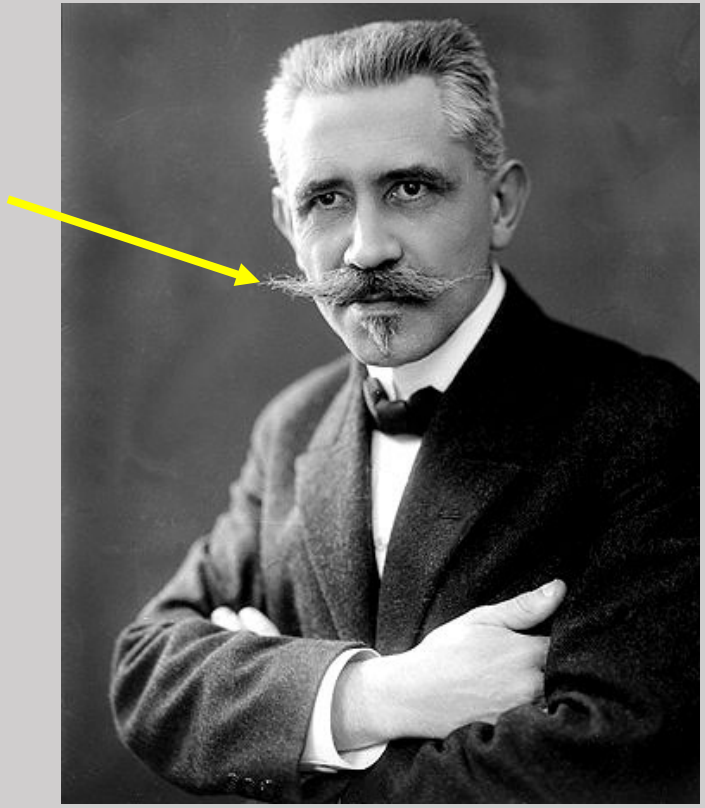
Disclosure – I own about $250 (100 shares) of stock in Butterfly Network Inc.

Butterfly manufactures handheld ultrasound devices that are plugged into smartphones and provides training and storage plans for images. Their mission is to “democratize healthcare by making medical imaging available to everyone around the world. Nothing in this presentation should be considered an endorsement of Butterfly or its products.

Quick history of ultrasound

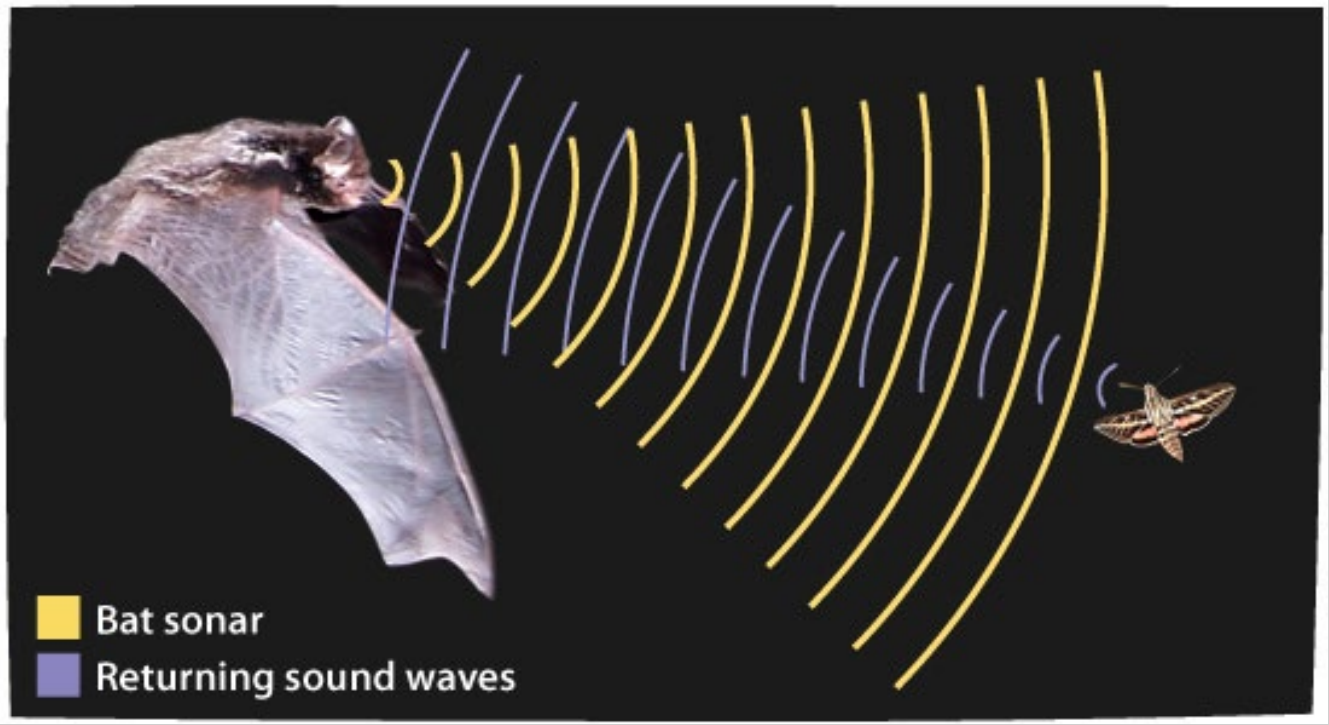
On April 14-15, 1912, the HMS Titanic hit an iceberg and sank.

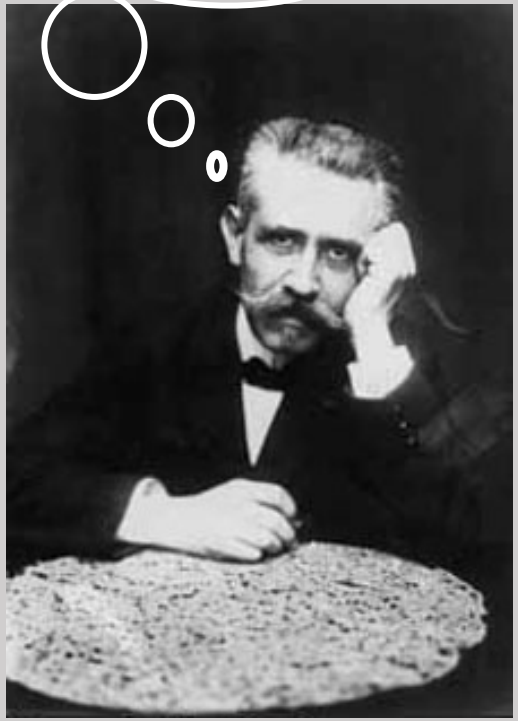
In 1915, French physicist Paul Langevin was commissioned by a group of investors to invent a device to detect structures on the ocean floor in order to find the Titanic. He invented the hydrophone, while rocking a killer mustache.



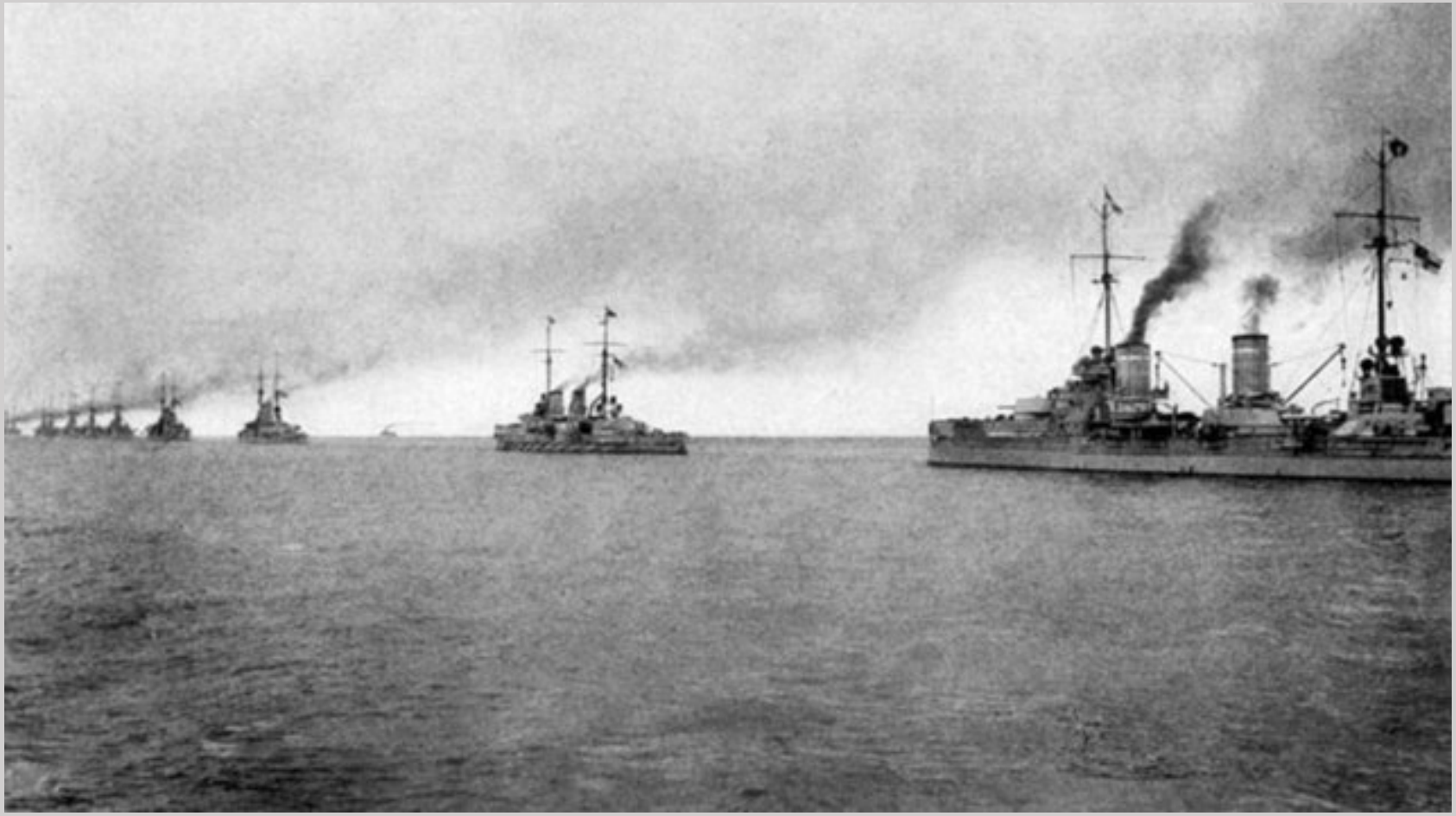
Langevin based his hydrophone on echolocation, used by bats and sea mammals.

$$B = \frac{\Delta P}{\frac{\Delta V}{V}} \quad ; \quad v = \sqrt{\frac{B}{p}} \quad ; \quad \frac{v}{\Lambda} = f$$

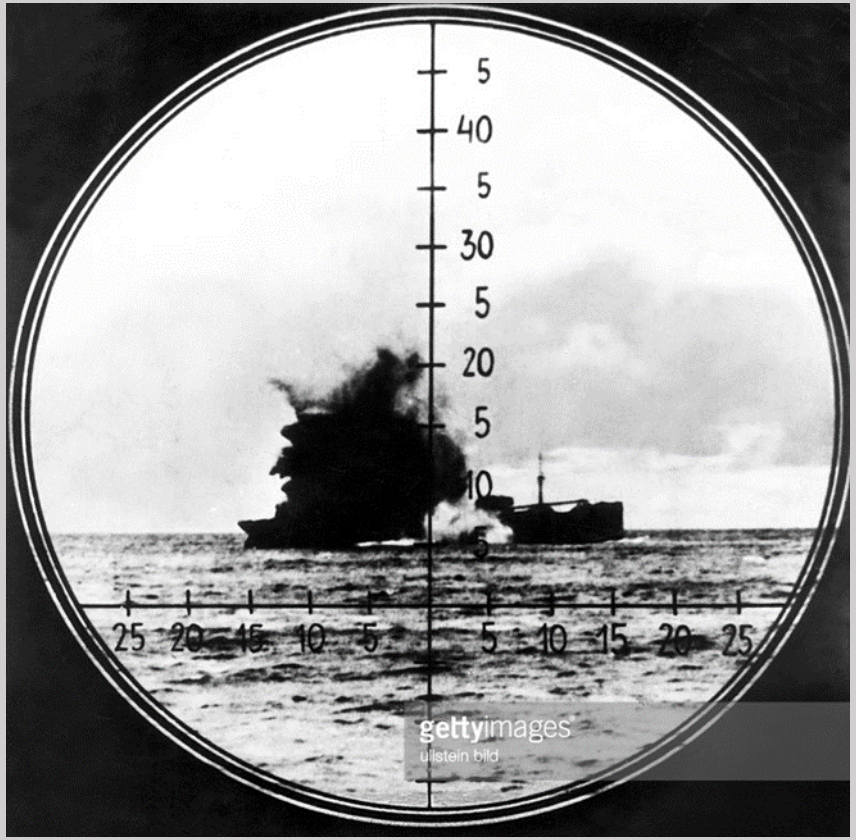




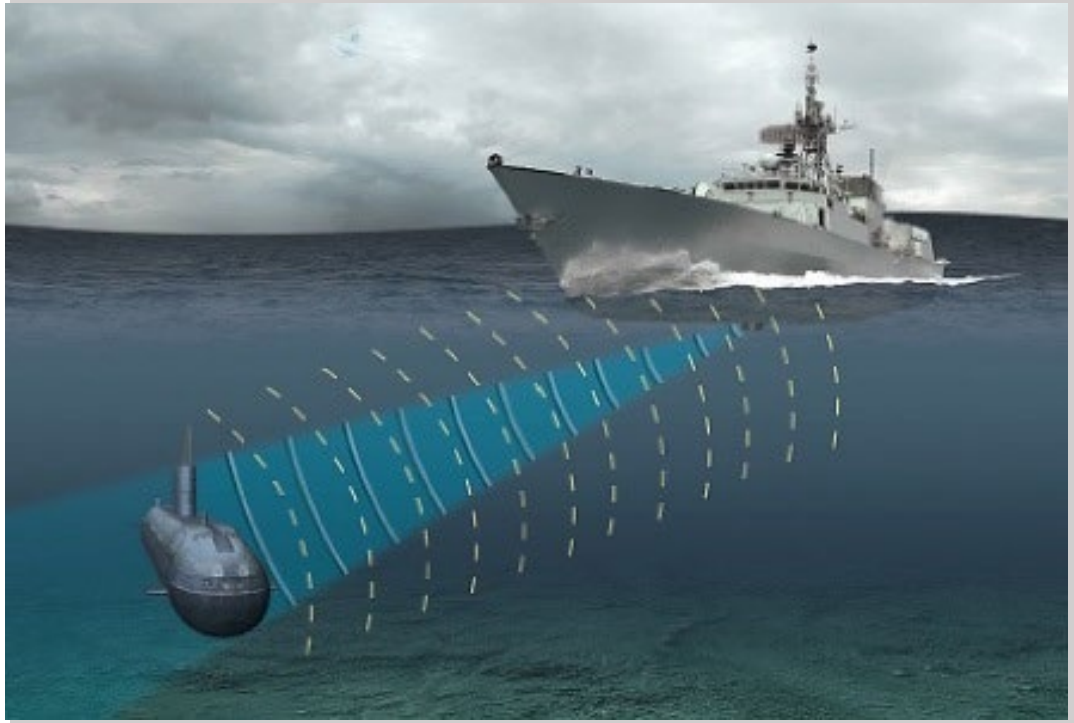
Just when the hydrophone was ready to be put to use, WWI broke out, and the North Sea became too dangerous for exploration

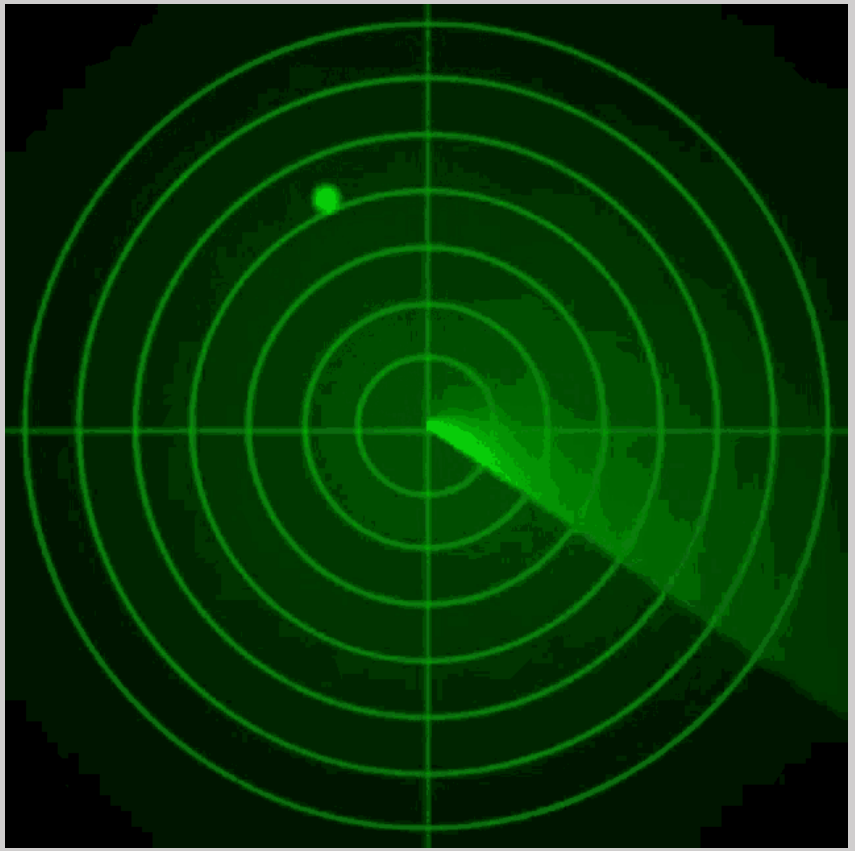


Later in WWI, British shipping was being decimated by German U-Boats (submarines) and Britain was in danger of starvation.



The British adapted the hydrophone to search for U-Boats and that led to SONAR

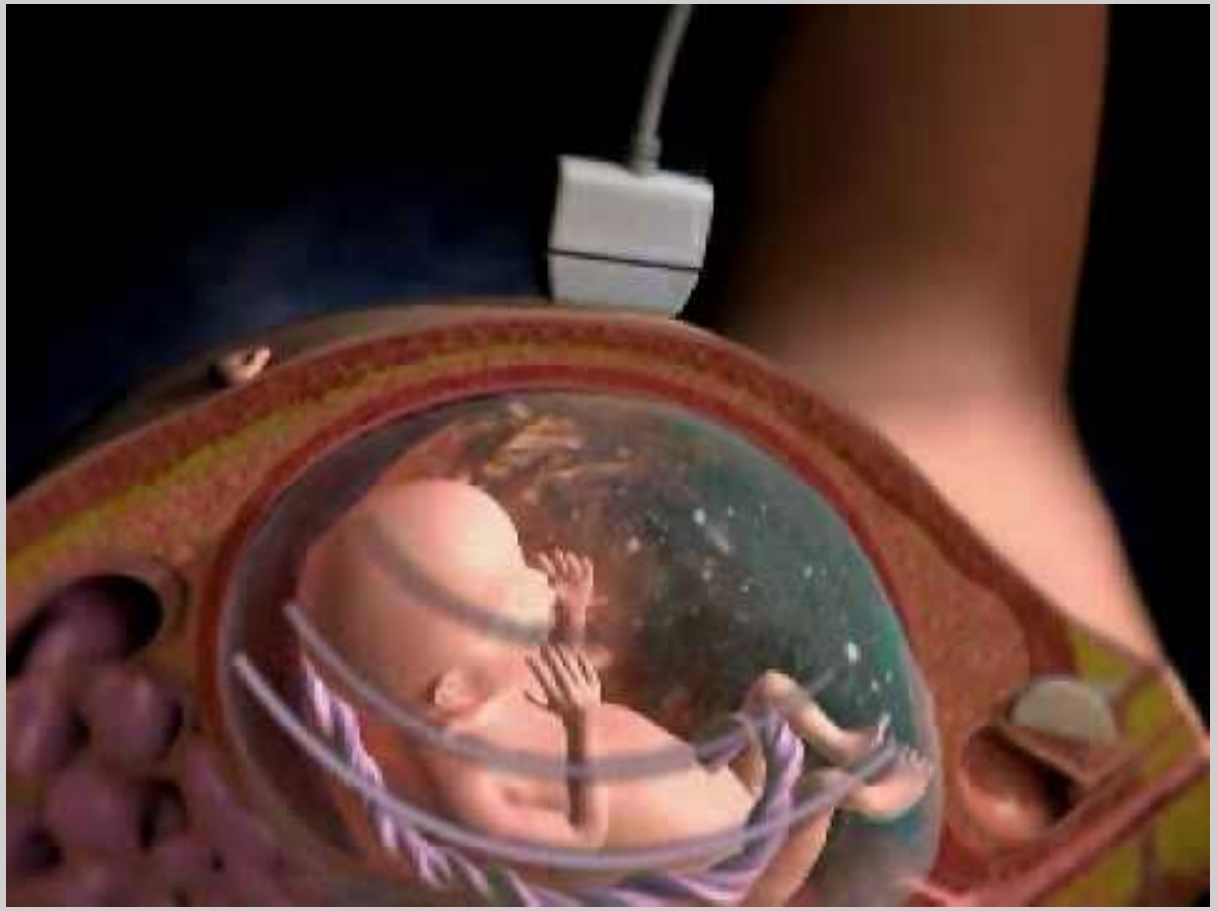




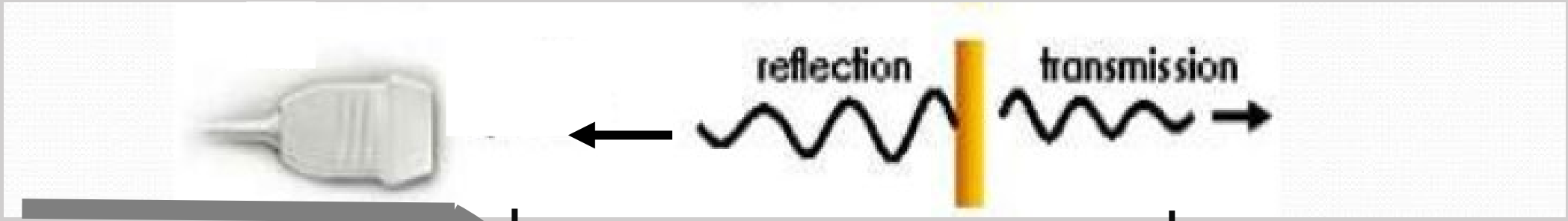
After the war, someone thought, “Hey, let’s use this technology to find little torpedoes in humans,” and ultrasound was born

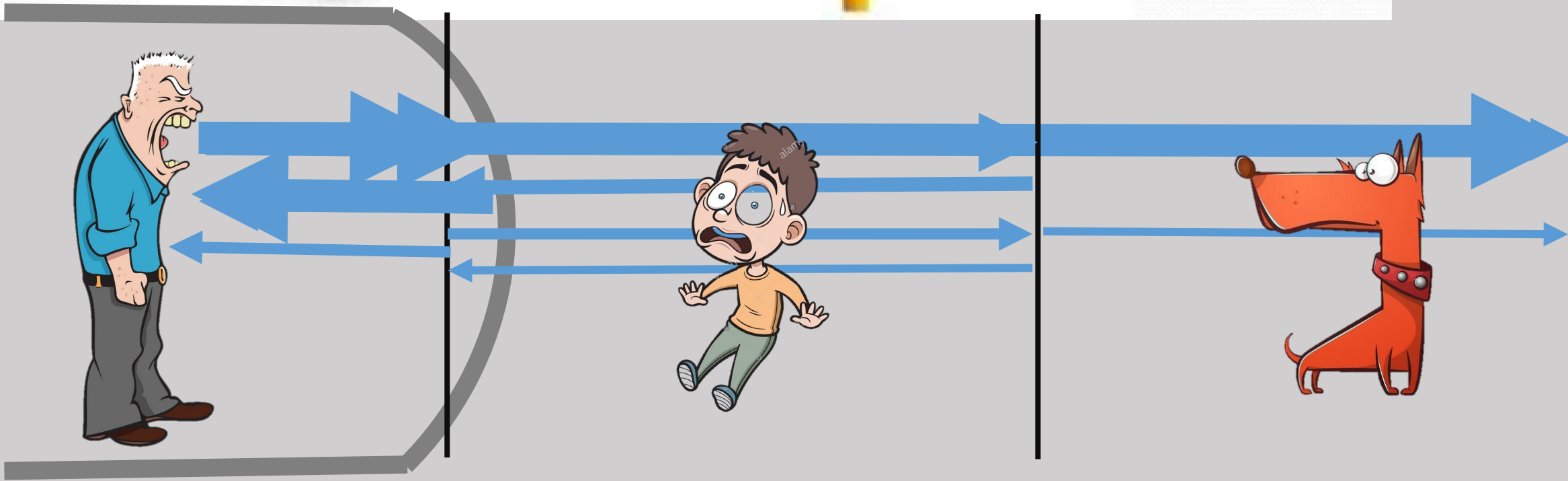
Very basic physics

In ultrasound, the transducer sends sonic waves into the body and receives the return waves.

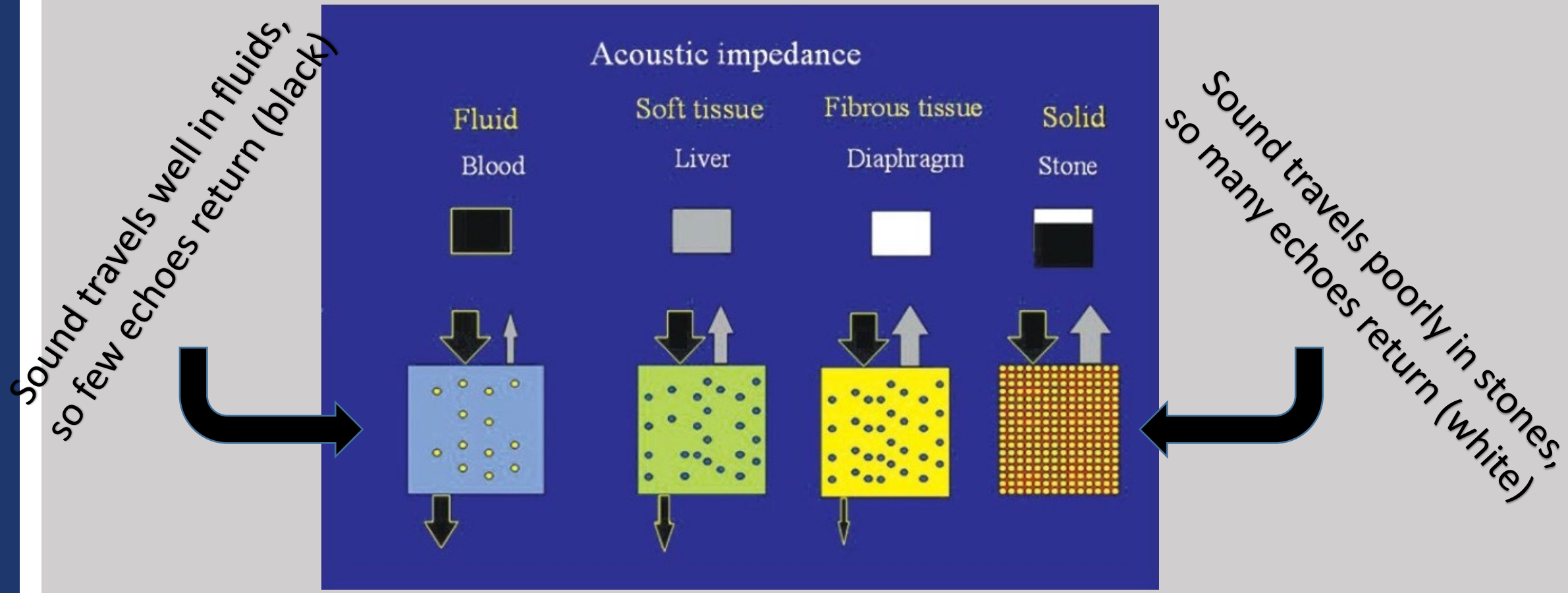


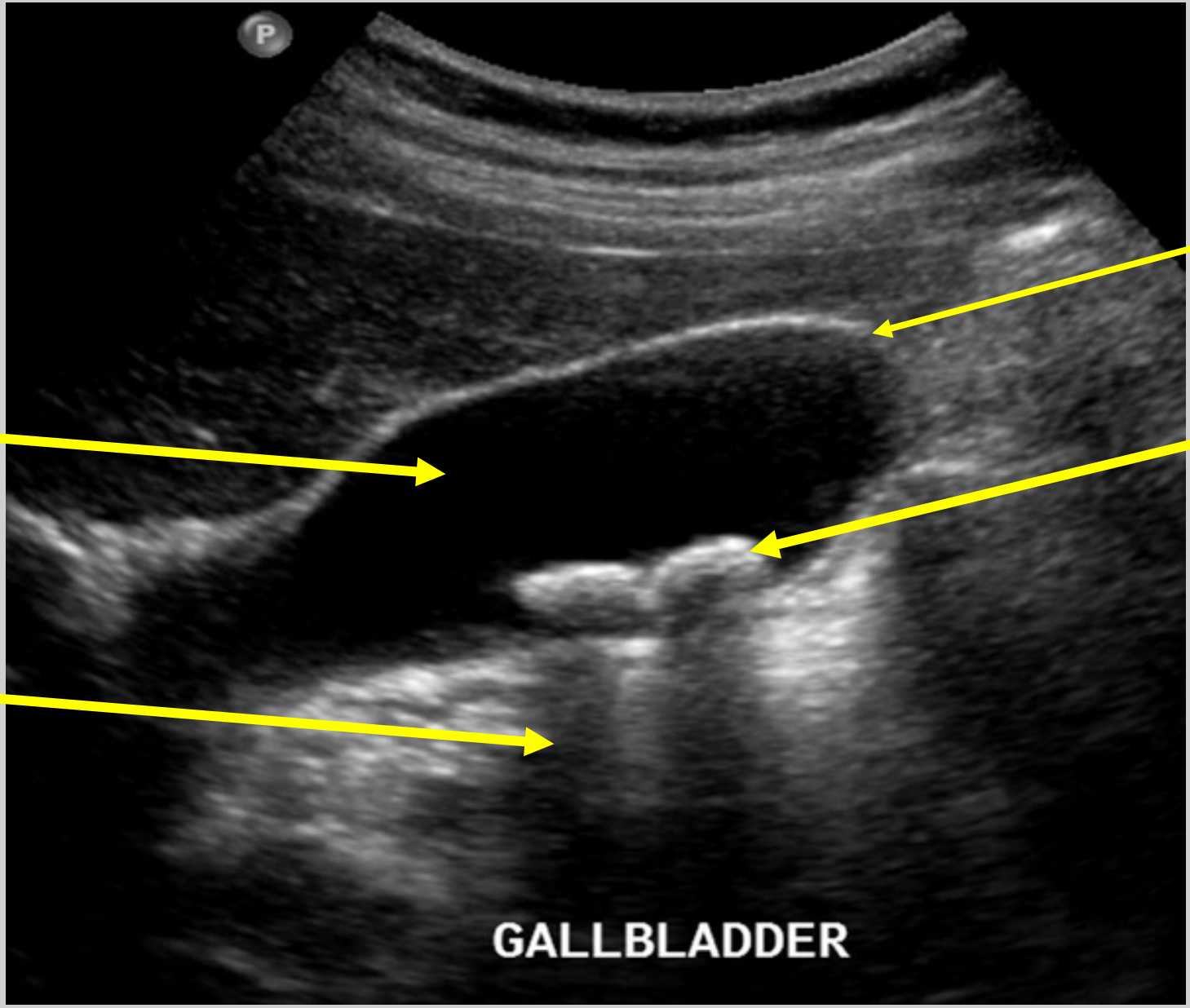
When the sound wave hits an interface between tissues, all or some sound is reflected, while other sound moves on (transmission).





The more poorly sound is transmitted within a substance, the more return echoes are produced.





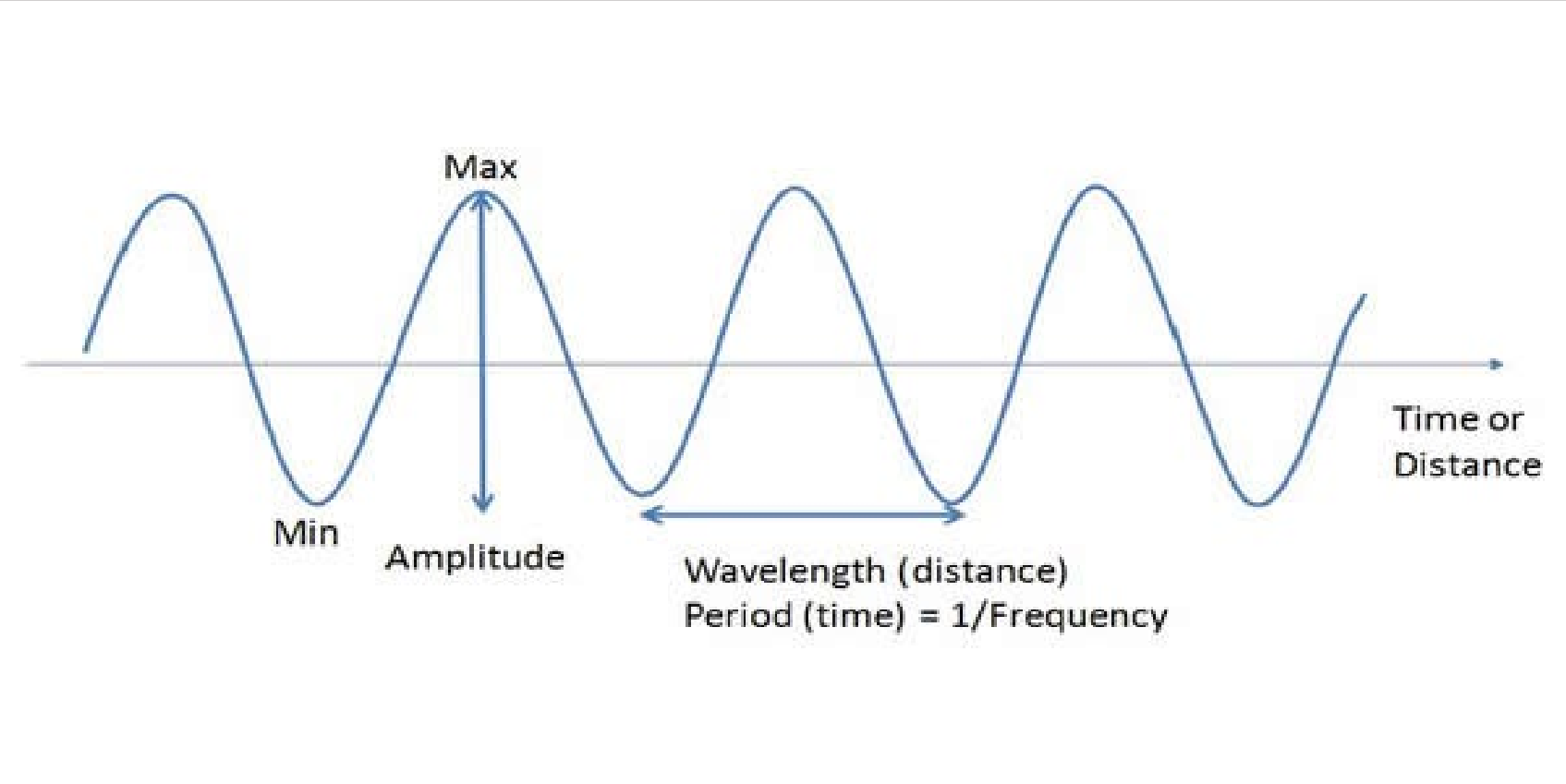
Interface

Gallstones - white

Bile (fluid) black

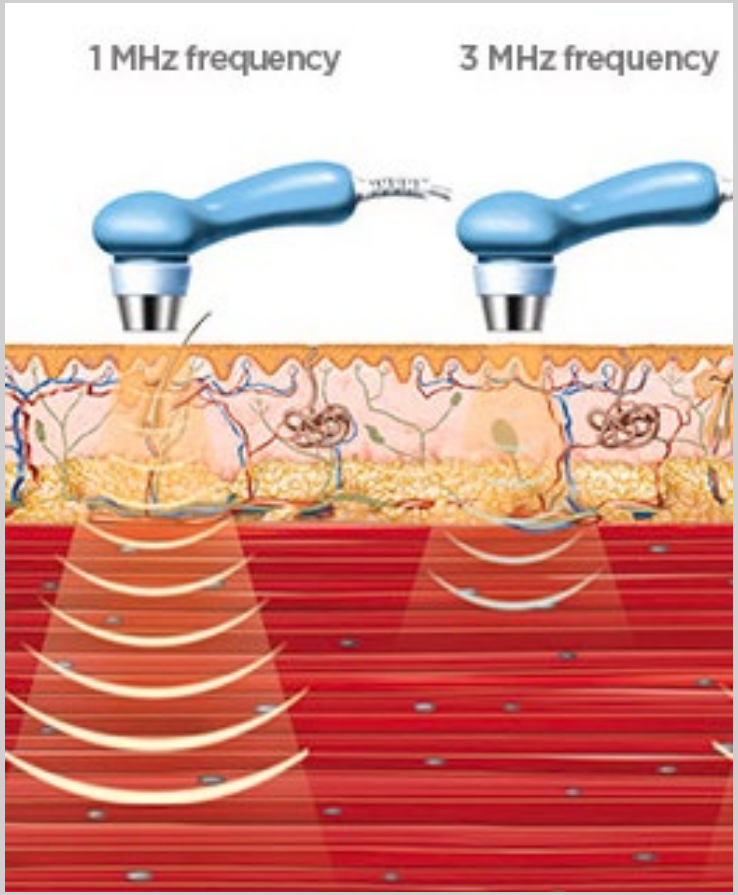
Posterior acoustic shadowing

Penetration into tissues depends on the inverse of the length of the sound wave (MHz).

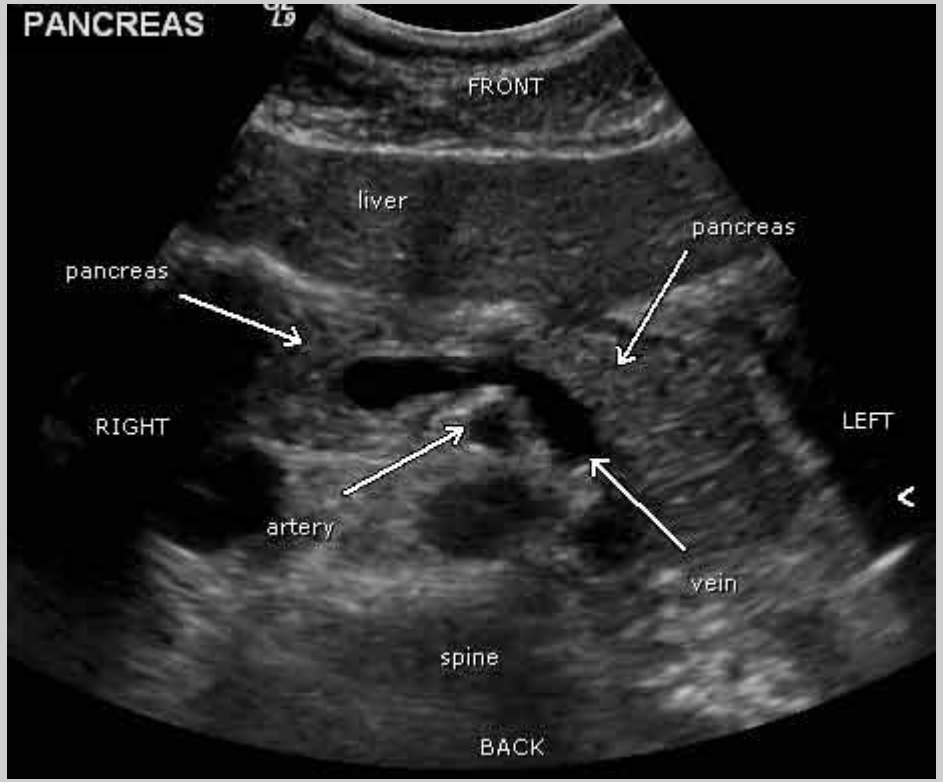


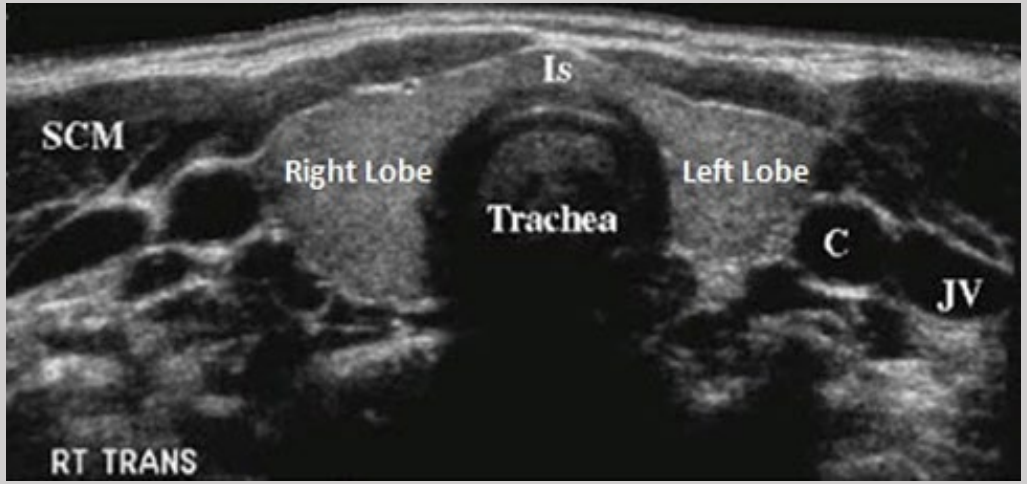
Lower frequency = better penetration, but poorer resolution

Higher frequency = poorer penetration, but better resolution



Therefore, we might use a 3.5 MHz transducer to image structures deep in the abdomen, but a 12 MHz transducer for a superficial structure like the thyroid.



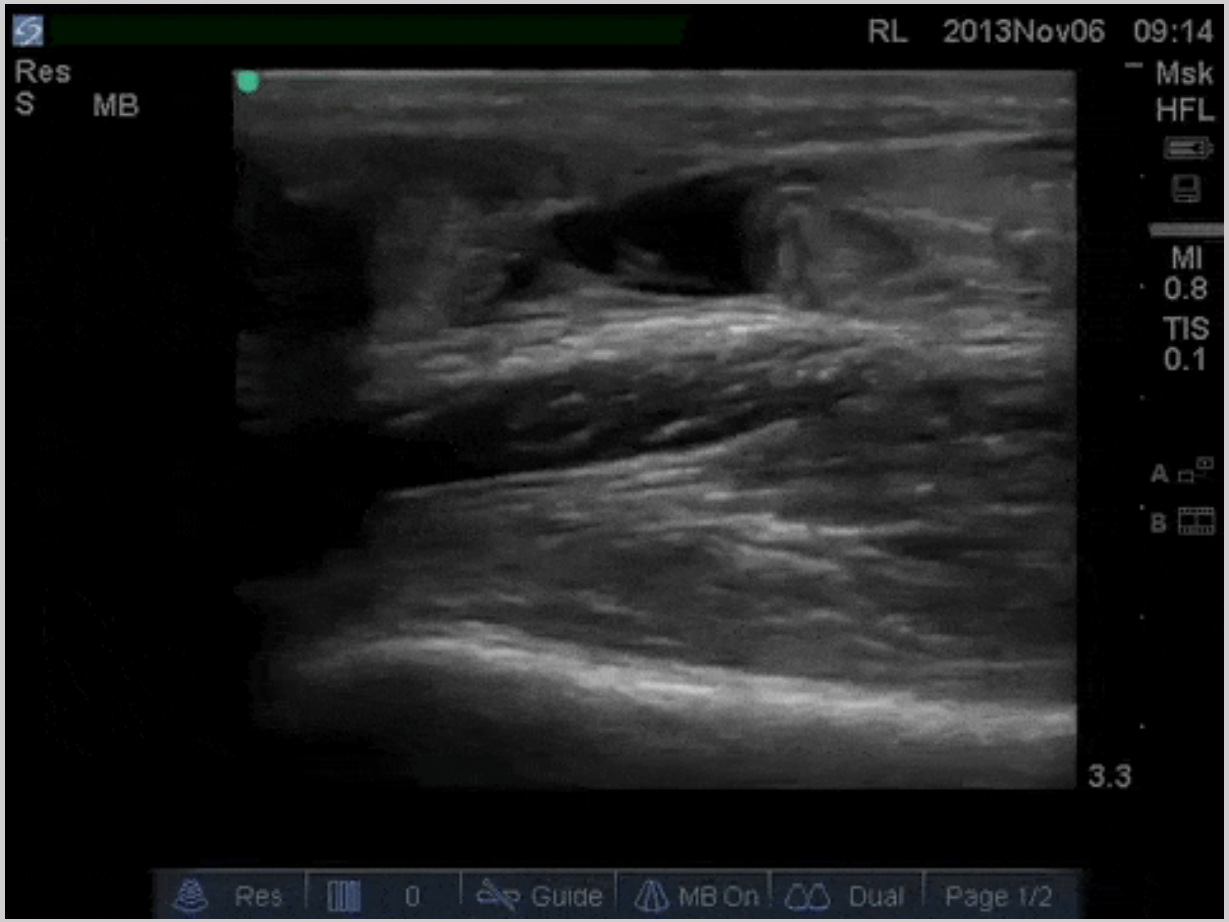


In general, we like to use the highest frequency transducer that will adequately penetrate so we get optimal resolution.

Point of Care Ultrasound

Advantages of diagnostic ultrasound

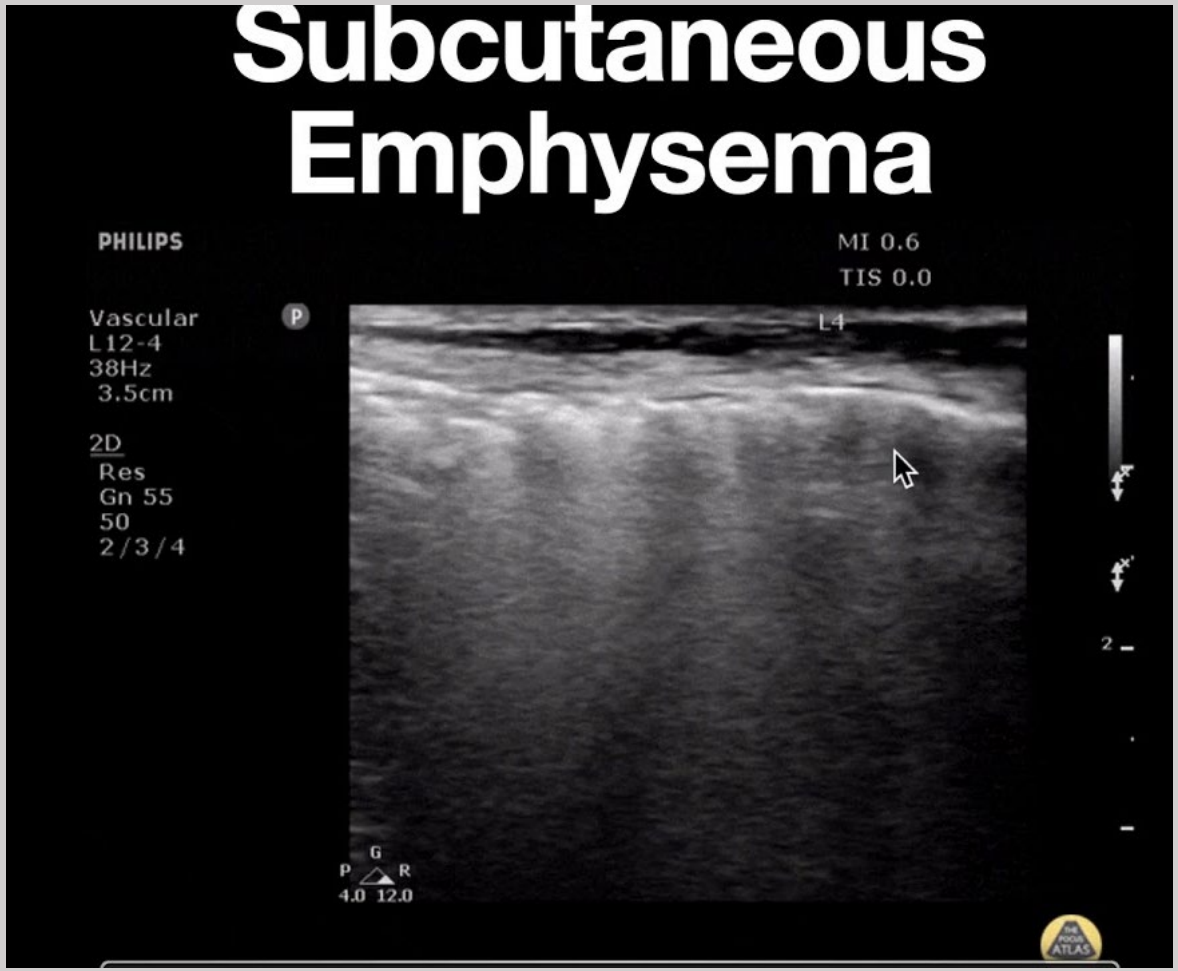
- Dynamic examination in real-time
- Safe and non-invasive
- No ionizing radiation
- Relatively inexpensive and available
- ~~Relatively~~ portable
- Can image in almost any plane
- Usually more comfortable for the patient



Dynamic ultrasound images of an Achilles tendon rupture while plantar and dorsi-flexing the foot

Disadvantages of ultrasound

- Ultrasound doesn't penetrate bone well
  - Very limited for bone pathology
  - Limits structures that are overlain or surrounded by bone
- Ultrasound doesn't propagate well in air
  - Limits visualization of air containing structures (lungs, bowel)
  - Gas can limit visualization of underlying structures
- Ultrasound may be limited in very large patients due to tissue attenuation of the ultrasound waves
- It may be difficult to visualize some structures in immobile patients due to limitations of getting them into proper position
- Generally less spatial and imaging resolution than CT scan




CMC-L MENU 1/2
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NAV RAD
PREV PAGE
NEXT PAGE
ACTIVE
STANDBY
BRT
AUTOBRAKE


Quick ID
END EXAM
Fast Flow
MMode
Depth
Gain
Slow Flow
Save Loop

Point-of-care ultrasound (POCUS) – The stethoscope of the 21st century

Comparison of Effectiveness of Hand-Carried Ultrasound to Bedside Cardiovascular Physical Examination by Kobal, et al (Am Jour Cardio, vol. 96, issue 7, 1 Oct 2005)

- Studied 61 patients with clinically significant heart disease with 239 separate abnormal findings detected
- 2 first-year medical students with 18 hrs. training in HCU without Doppler capability vs. 5 board-certified cardiologists
- Accuracy determined by standard echocardiography

- Correctly identified pathology
  - Students 75%
  - Cardiologists 49%
- Diagnostic specificity
  - Students 87%
  - Cardiologists 76%
- Non-valvular path sensitivity
  - Students 61%
  - Cardiologists 47%
- Valvular pathology sensitivity
  - Students 93%
  - Cardiologists 62%

Handheld Ultrasound Versus Physical Examination in Patients Referred for Transthoracic Echocardiography for a Suspected Cardiac Condition by Mehta, et al (J Am Coll Cardiol Img 2014 Oct, 7 (10))

- 250 patients with 142 abnormal findings on standard echo
- Underwent both HHU and PE by different cardiologists

- Correctly identified pathology
  - HHU 82%
  - PE 67%
- Presence of substantial valve disease
  - HHU 71%
  - PE 31%
- Further testing suggested for those who showed no abnormal findings
  - HHU 56%
  - PE 82%
  - Cost modeling analysis showed average of $63/patient savings when HHU was used vs. PE

Chest ultrasonography versus supine chest radiography for diagnosis of pneumothorax in trauma patients in the emergency department by Chan, et al (Cochran database of systematic reviews 23 July 2020)

- Meta-analysis of 13 studies
- 410 traumatic pneumothoraces out of 1271 patients

- Sensitivity
  - CUS 91%
  - Supine x-ray 47%
- Specificity
  - CUS 99%
  - Supine CXR 100%

What is point of care ultrasound?

- ”The acquisition, interpretation, and immediate clinical integration of ultrasonographic imaging performed by a treating clinician at the patient’s bedside rather than by a radiologist or cardiologist.” *(N Engl J Med Oct. 21, 2021; 385:1593-1602)*
  - More encompassing than merely “bedside sonography”
    - In the office or the field
    - Developing countries
    - Battlefield
    - International Space Station
- Answers a “Yes-or-No” question
- Different specialties may have different studies that are appropriate for that specialty

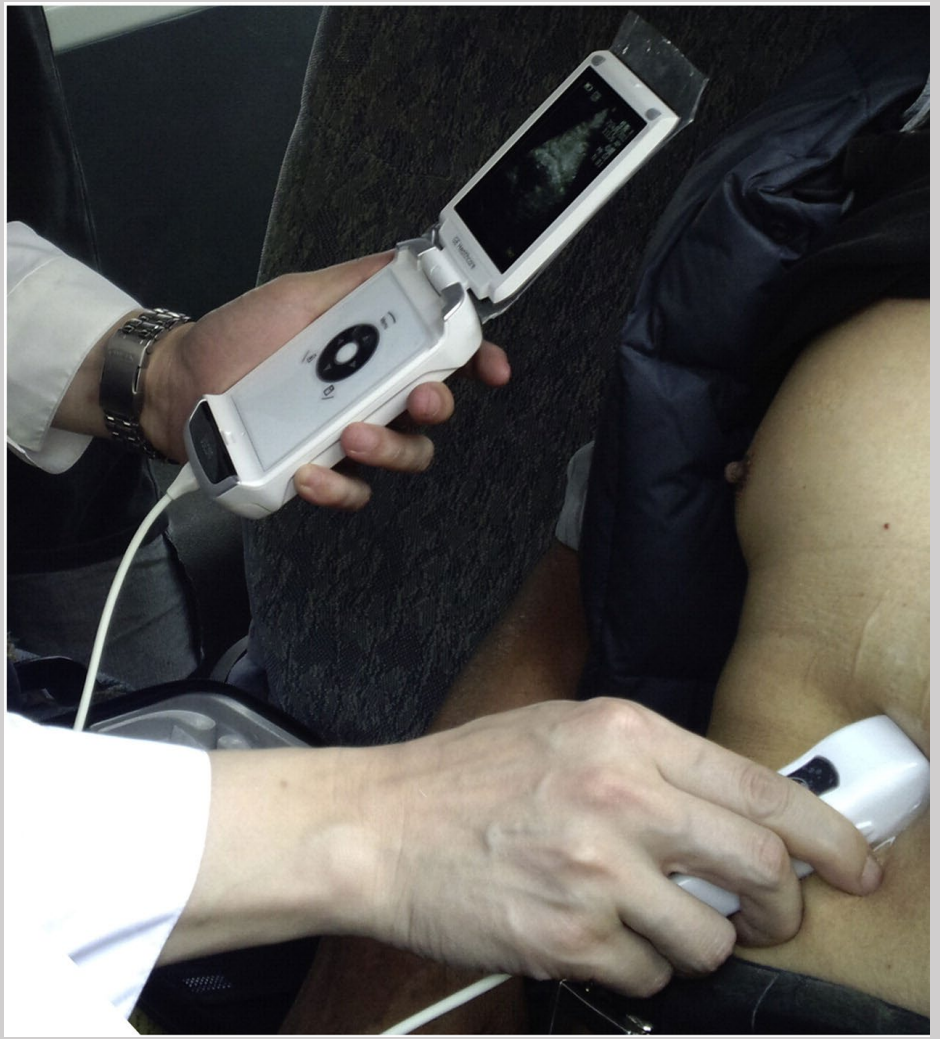


Table 1. Selected Applications of Point-of-Care Ultrasonography, According to Medical Specialty.*

Specialty	Ultrasound Applications
Anesthesia	Guidance for vascular access, regional anesthesia, intraoperative monitoring of fluid status and cardiac function
Cardiology	Echocardiography, intracardiac assessment
Critical care medicine	Procedural guidance, pulmonary assessment, focused echocardiography
Dermatology	Assessment of skin lesions and tumors
Emergency medicine	FAST, focused emergency assessment, procedural guidance
Endocrinology and endocrine surgery	Assessment of thyroid and parathyroid, procedural guidance
General surgery	Ultrasonography of the breast, procedural guidance, intraoperative assessment
Gynecology	Assessment of cervix, uterus, and adnexa; procedural guidance
Obstetrics and maternal–fetal medicine	Assessment of pregnancy, detection of fetal abnormalities, procedural guidance
Neonatology	Cranial and pulmonary assessments
Nephrology	Vascular access for dialysis
Neurology	Transcranial Doppler, peripheral-nerve evaluation
Ophthalmology	Corneal and retinal assessment
Orthopedic surgery	Musculoskeletal applications
Otolaryngology	Assessment of thyroid, parathyroid, and neck masses; procedural guidance
Pediatrics	Assessment of bladder, procedural guidance
Pulmonary medicine	Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance
Radiology and interventional radiology	Ultrasonography taken to the patient with interpretation at the bedside, procedural guidance
Rheumatology	Monitoring of synovitis, procedural guidance
Trauma surgery	FAST, procedural guidance
Urology	Renal, bladder, and prostate assessment; procedural guidance
Vascular surgery	Carotid, arterial, and venous assessment; procedural assessment

* FAST denotes focused assessment with sonography for trauma.

N Engl J Med Feb 24, 2011; 364:749-757

Traditional ultrasound vs. POCUS

Traditional consultative ultrasound

- Patient is referred to radiology department where scan is performed by technologist and interpreted by radiologist
- Information lost
- More complete exam
- Delayed answers
- Increased cost

Point-of-care ultrasound

- Treating physician = technologist = interpreter of ultrasound
- Information retained and utilized in the interpretation
- Not as complete exam
- Immediate answers (maybe)
- Less cost

POCUS - Advantages

- Ultrasound is a very portable imaging modality.
- Performed at the point of care, so the result of the scan is immediate
  - Doesn’t need to be performed in the radiology department, or even the hospital.
  - Treatment or referral may begin immediately
  - Saves the patient from having to make an appointment with another provider or department
- Make you more money for doing the procedure yourself
- Saves the healthcare system money
- Radiologists doesn’t have to decide what to do with all of their extra money.

What is the real purpose of the stethoscope?

A. To auscultate heart, lungs, and bowel sounds?
B. To let people know we are doctors?
C. To give us a chance to think without the patient talking?
D. To give us opportunity to connect with our patients?

From "Point of Care Ultrasound: Stethoscope of the 21st Century" by Donald F. Zimmer, MD FACEP
https://www.beaconhealthsystem.org/medical-professionals/wp-content/uploads/sites/26/2020/08/POCUS-Stethoscope-of-21st-Century.pdf

J Emerg Med. 2014 Jan;46(1):46-53. doi: 10.1016/j.jemermed.2013.05.044. Epub 2013 Aug 12.

Bedside ultrasound maximizes patient satisfaction

Zoe D Howard [1], Vicki E Noble [1], Keith A Marill [1], Dana Sajed [2], Marcio Rodrigues [1], Bianca Bertuzzi [1], Andrew S Liteplo [1]

Conclusions: Patients who had a bedside US had statistically significant higher satisfaction scores with overall ED care, diagnostic testing, and with their perception of the emergency physician. Bedside US has the potential not only to expedite care and diagnosis, but also to maximize satisfaction scores and improve the patient-physician relationship, which has increasing relevance to health care organizations and hospitals that rely on satisfaction surveys.

Research | Open Access | Published: 18 June 2021

Patients' experiences of the use of point-of-care ultrasound in general practice – a cross-sectional study

Camilla Aakjær Andersen, John Brodersen, Torsten Rahbek Rudbæk & Martin Bach Jensen

BMC Family Practice **22**, Article number: 116 (2021) | Cite this article

The majority of patients felt that they had been more thoroughly examined (92%) and taken more seriously (58%) when POCUS was part of the consultation. They felt POCUS gave them a better understanding of their health problem (82%), made them feel more secure (86%) and increased their trust in the physician's assessment (65%). Moreover, the patients reported that POCUS use improved the level of service (95%) they experienced and the quality of care (94%) in general practice.

POCUS pitfalls

- Initial outlay of the equipment
- Training is required
- Necessity of archiving images
- Potential of legal liability
  - No increased liability seen so far
  - As use increases, there may be increased liability for NOT performing ultrasound

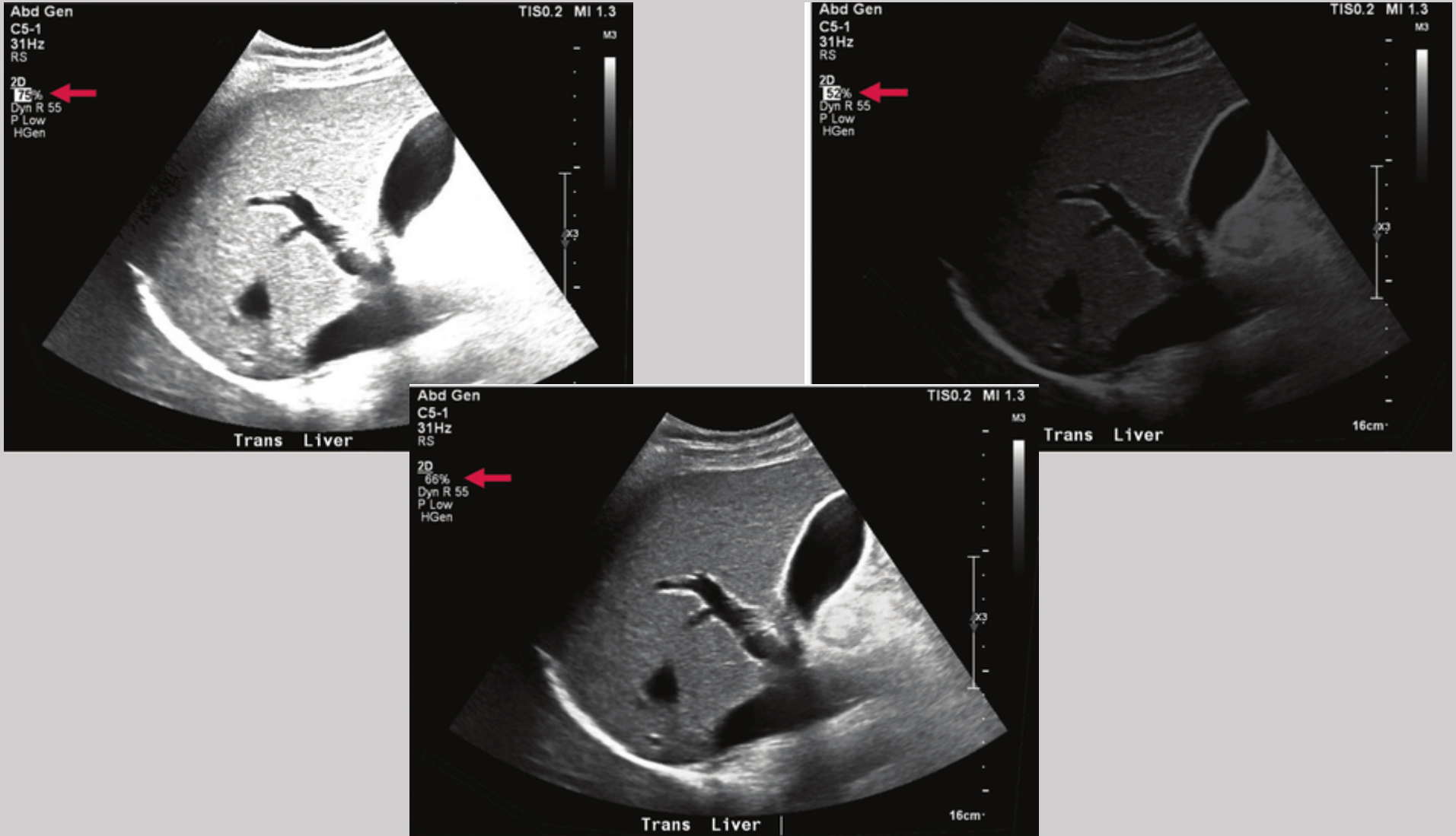
Knobology

Today we will be using Sonosite Edge II portable ultrasound machines (simply because these are the machines that are available at LMU-DCOM)

The 4 most important controls to know on any ultrasound machine

The 4 most important controls to know on any ultrasound machine

Gain controls the brightness/darkness of the image

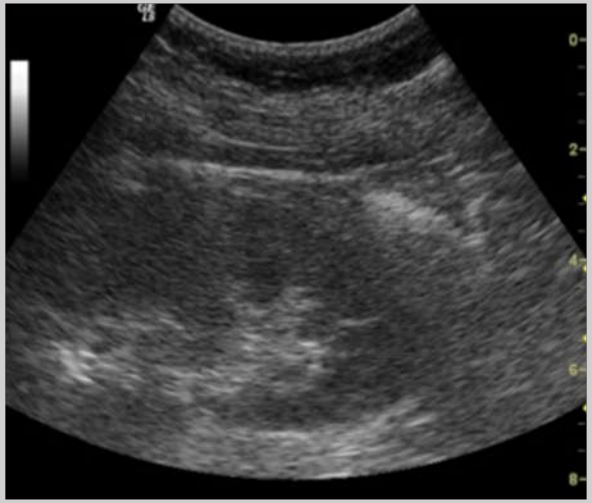


The 4 most important controls to know on any ultrasound machine

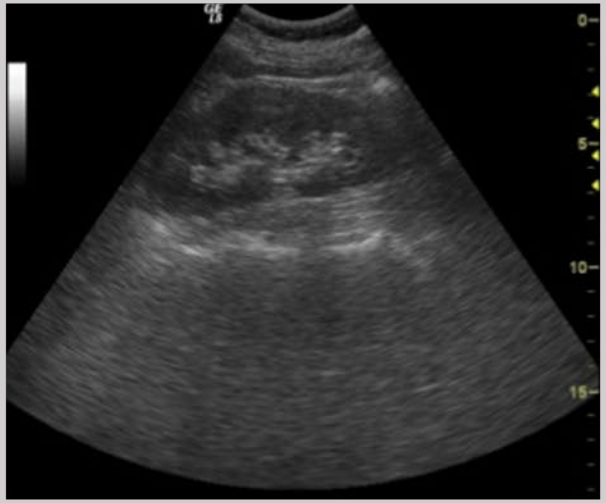
Depth

Depth controls the size of the image on your screen (think of it as zoom)

Too little depth



Too much depth



Depth just right

We generally want our organ of interest to occupy the middle 1/3 of the screen.

The 4 most important controls to know on any ultrasound machine

Transducers

Transducers

Transducer handling

Transducer marker goes towards patient's right or their head

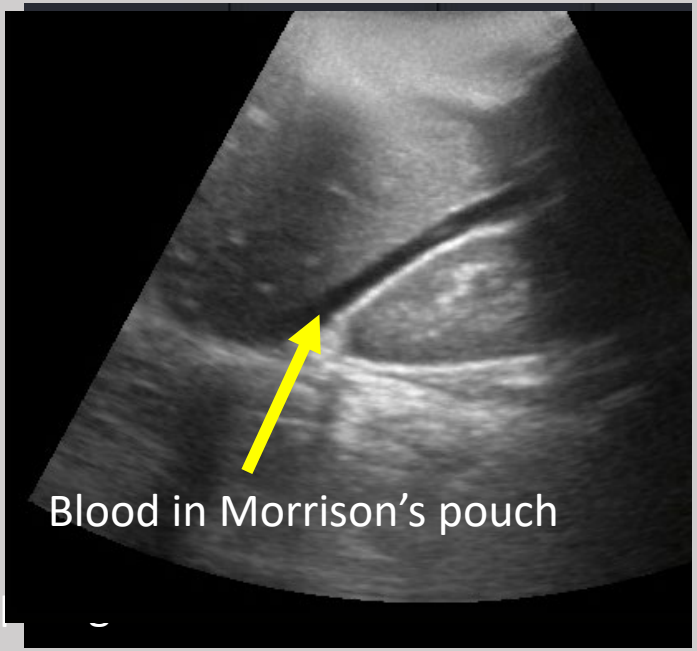
Apply generous dollop of goo

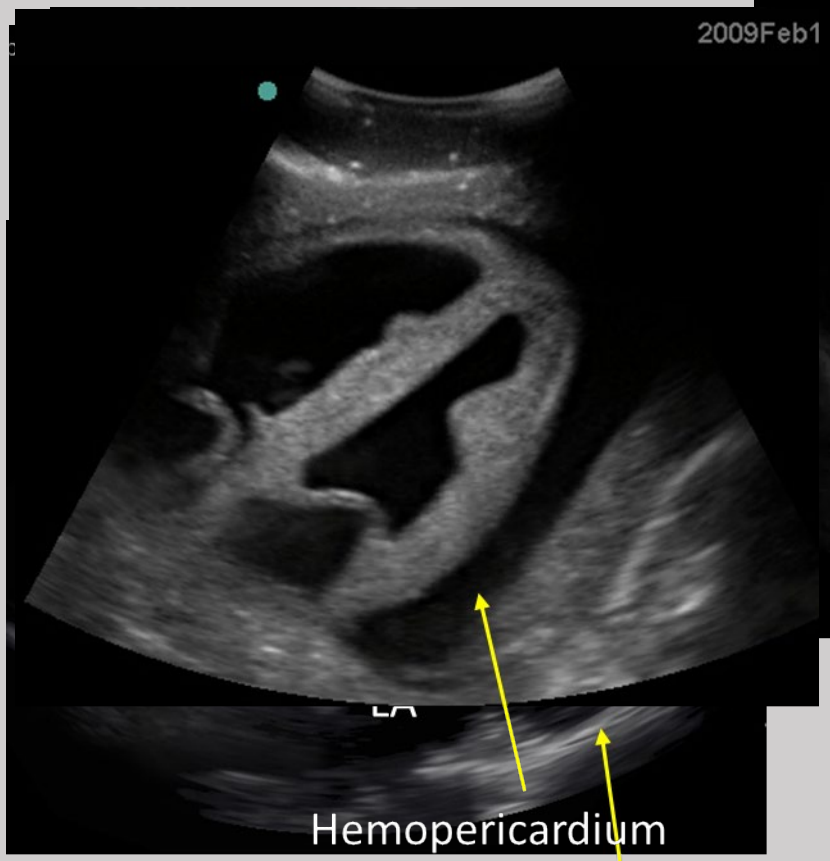
The FAST exam

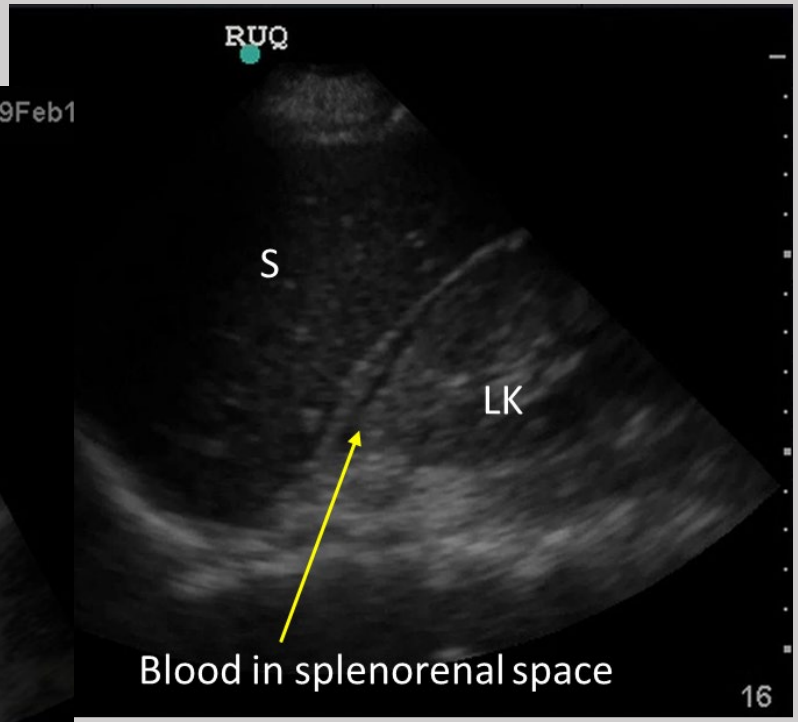
FAST Scan as POCUS prototype

- Focused
- Assessment
- Sonography
- Trauma

FAST scan looks in 4 places for blood or other fluid







FAST as POCUS

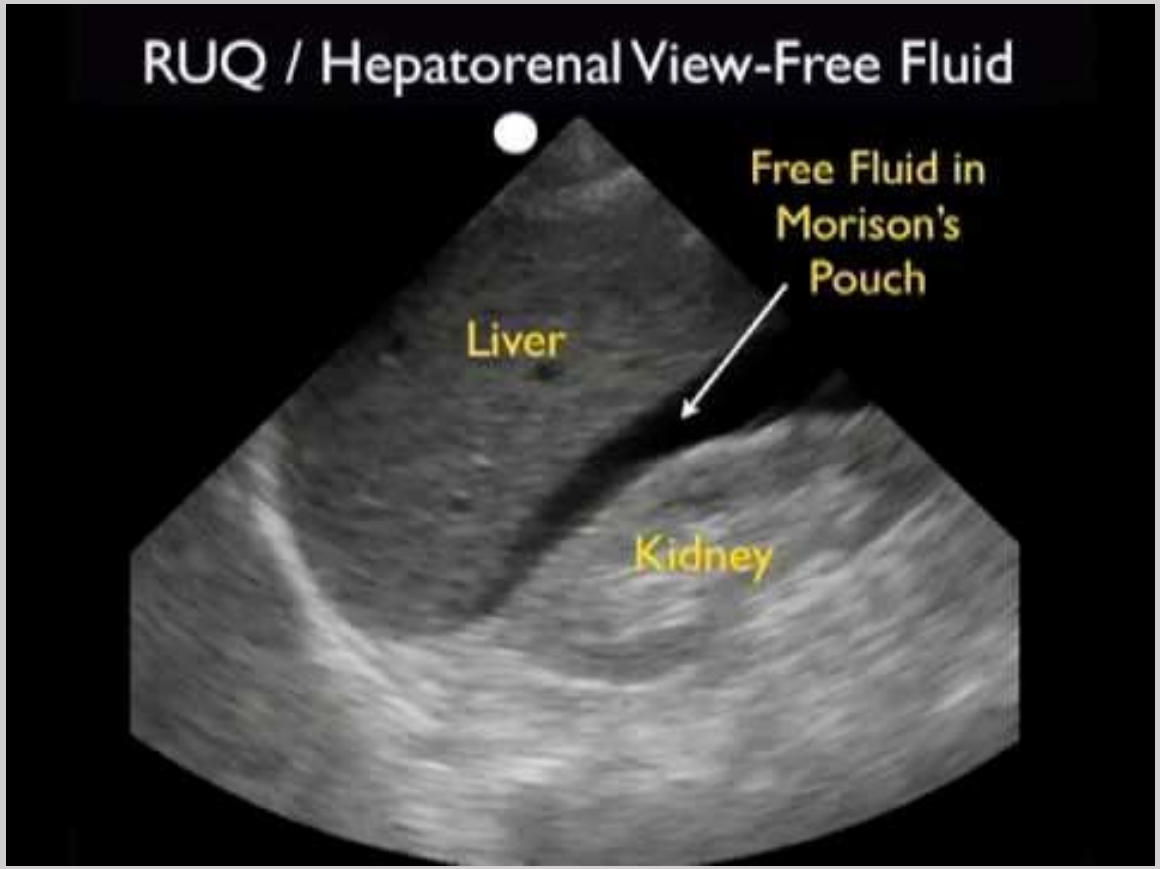
- Performed at bedside
- Answers yes-or-no questions
  - Is there peritoneal blood?
  - Is there pericardial blood?
- Advantages of FAST over CT
  - May be performed on unstable patient
  - May be performed as other activities with the patient are occurring
  - Answers are immediate. No waiting on radiology
- Limitations of FAST
  - Not nearly as good at assessing organ injuries as CT scan
  - CT can see smaller collections of blood
  - Impossible to assess bowel injuries

FAST EXAM IS NOT JUST FOR TRAUMA!

- Any patient in shock
- Suspected cardiac tamponade
- Suspected pneumothorax
- Suspected pleural effusions
- Suspected ascites
- Establish a window for pericardiocentesis, paracentesis or thoracentesis

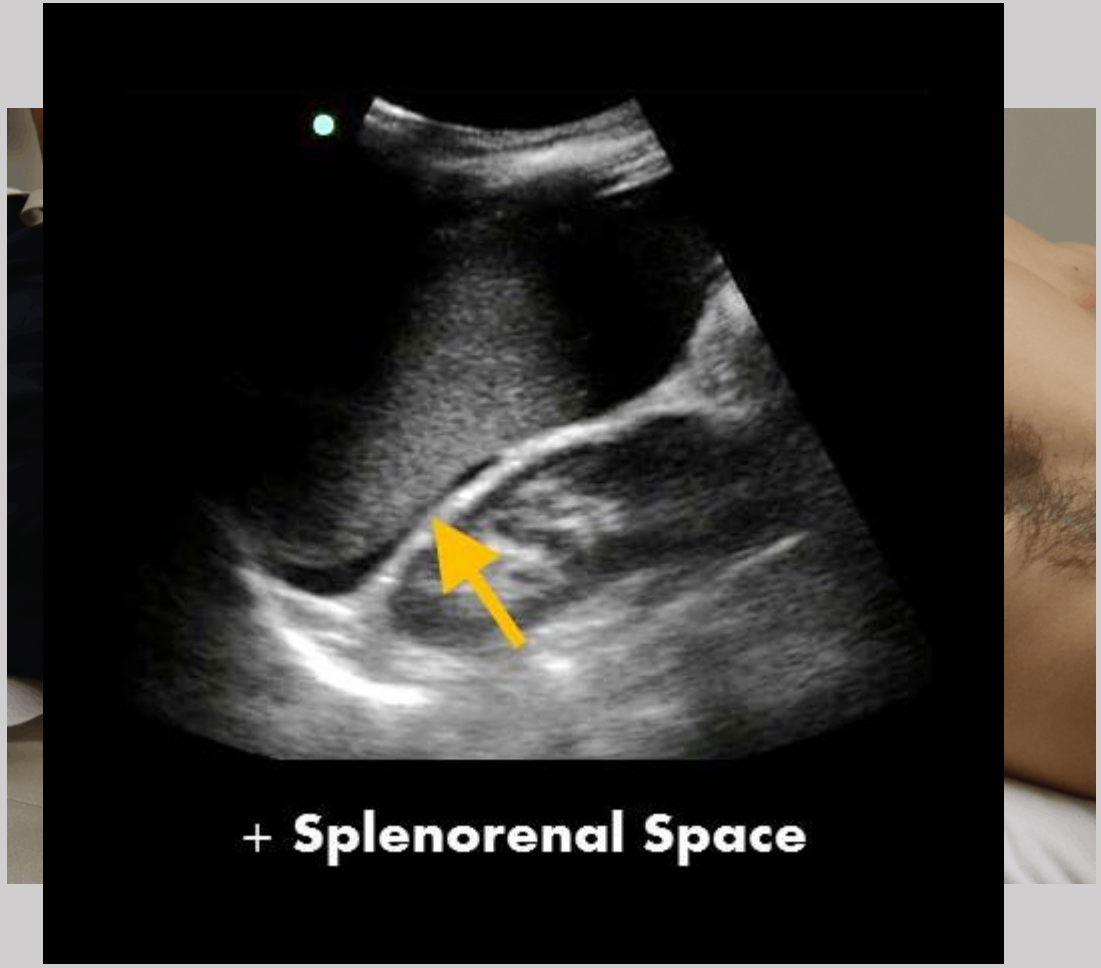
RUQ – Is there blood in the hepatorenal recess (Morrison's pouch)?

- Point the transducer maker toward the head
- Place the transducer on the anterior axillary line just below the rib cage
- (I think it is easier, when standing on the patient's right to "backhand" the transducer)
- May need to fan the transducer face slightly toward the spine



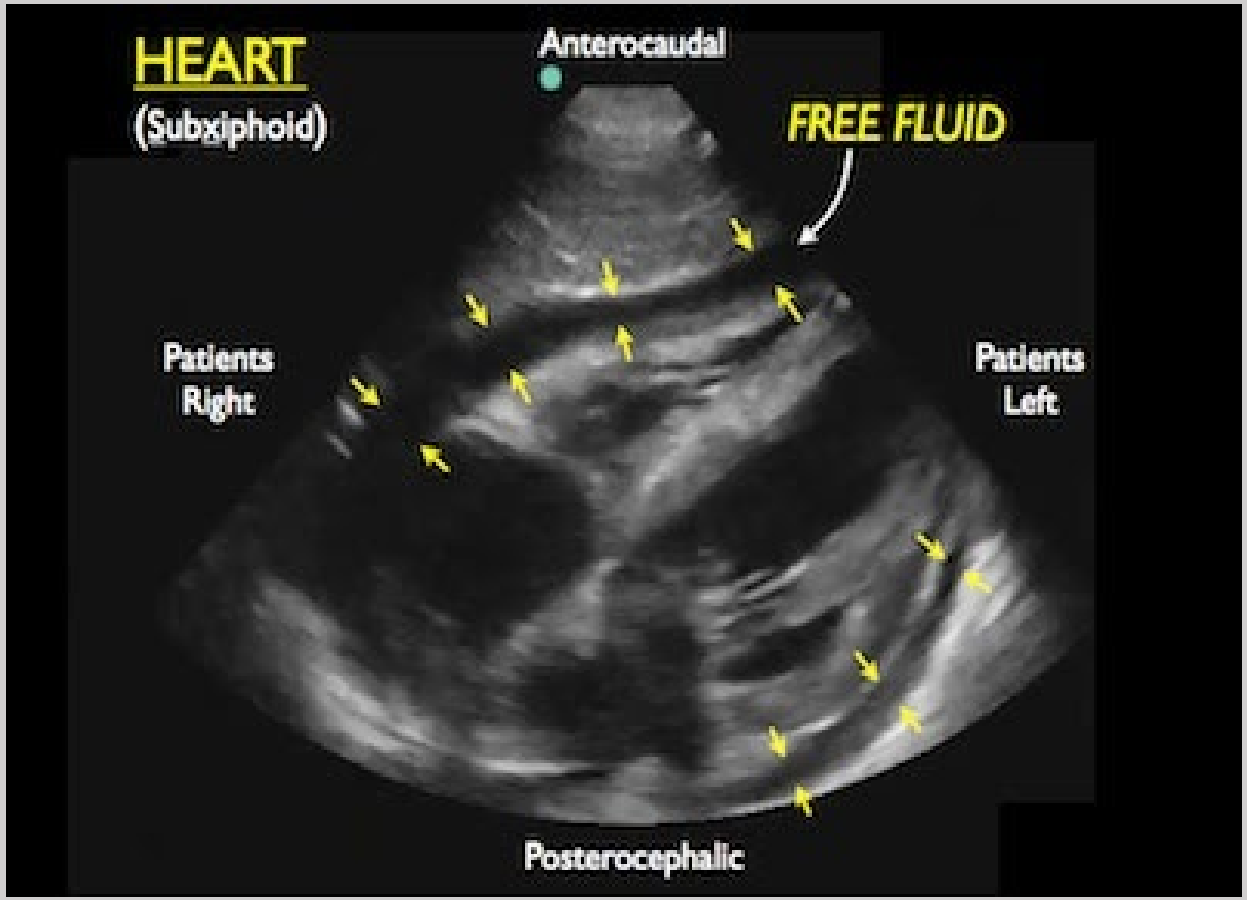
LUQ – Is there blood in the splenorenal recess?

- Point the transducer marker toward the head
- Place the transducer on the posterior axillary line. You may have to go over the bottom couple of ribs.
- (I lay the transducer in the palm of my hand and lay the back of my hand on the table)



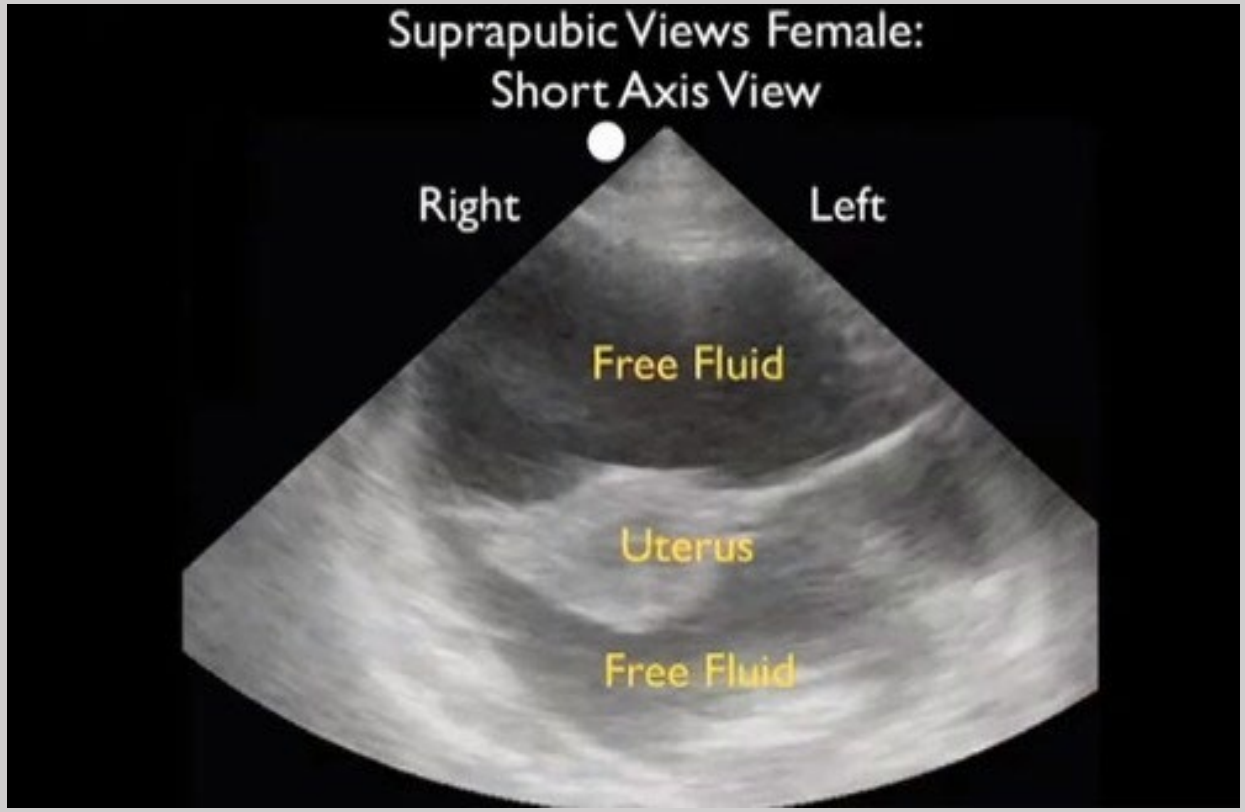
Subxiphoid – Is there blood in the pericardial sac?

- Position transducer marker to the patient's right
- In the subxiphoid space, press down and angle the face of the transducer waaay up ("scoop".) You may almost lie the transducer down on the patient.
- It will be easiest if you place your hand completely on top of the transducer.
- It will probably require a lot of gel
- It is usually easier to use a cardiac probe.



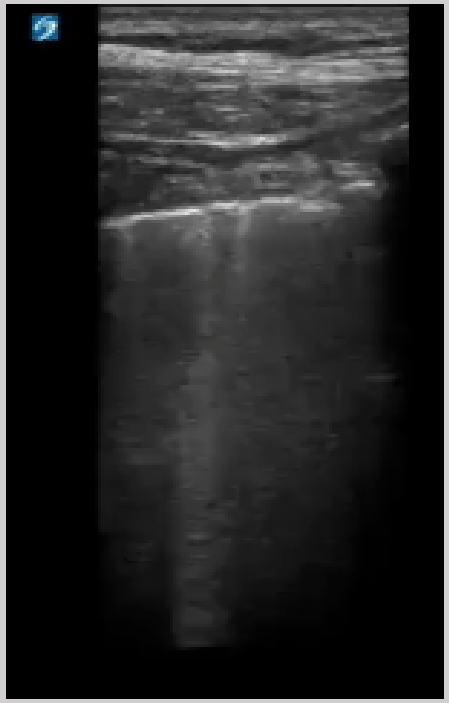
Suprapubic – Is there blood in the retrovesicular space?

- Position transducer marker to the patient's right.
- Place transducer in the suprapubic region and angle the face of the transducer toward the patient's toes
- It will be easiest to have your hand on top of the transducer
- Most common problems, not enough pressure and/or not inferior enough with the transducer.

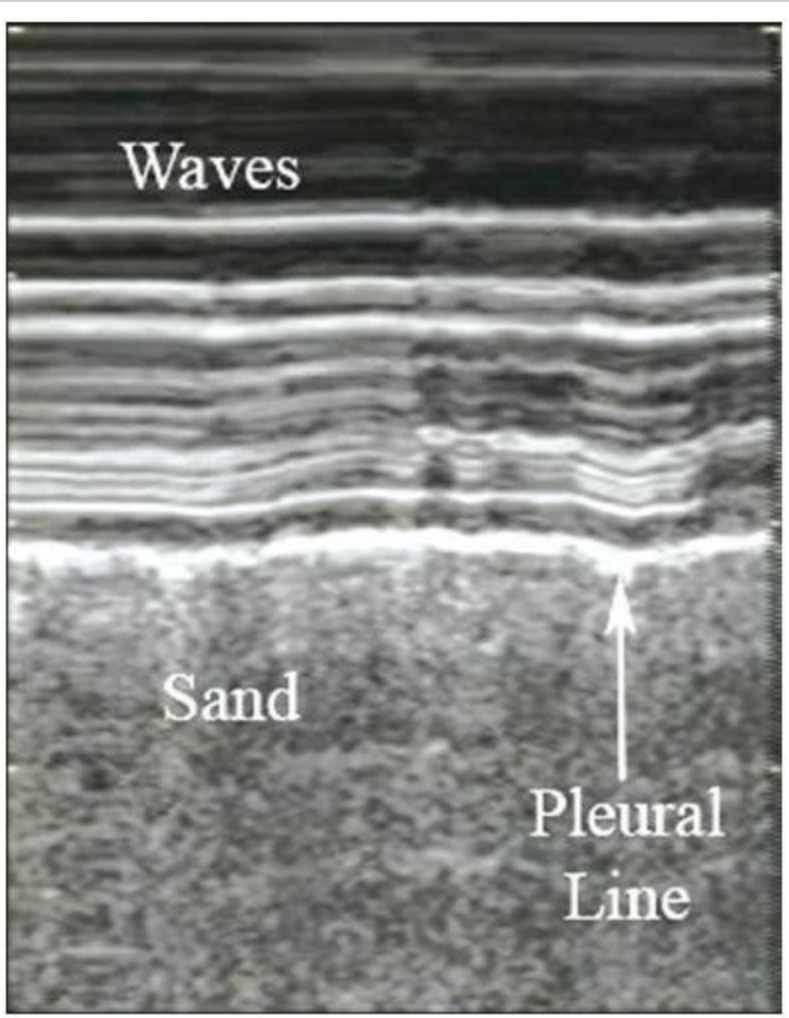


Extended FAST exam (e-FAST)

- The “extended” part is to evaluate for pneumothorax
- Ultrasound is more sensitive for pneumothorax on a supine patient than chest x-ray
- CT scan is more sensitive than ultrasound
- This is, for the most part, a dynamic scan
- Requires a little more expertise



e-FAST exam for pneumothorax, M-mode



Normal “seashore sign”

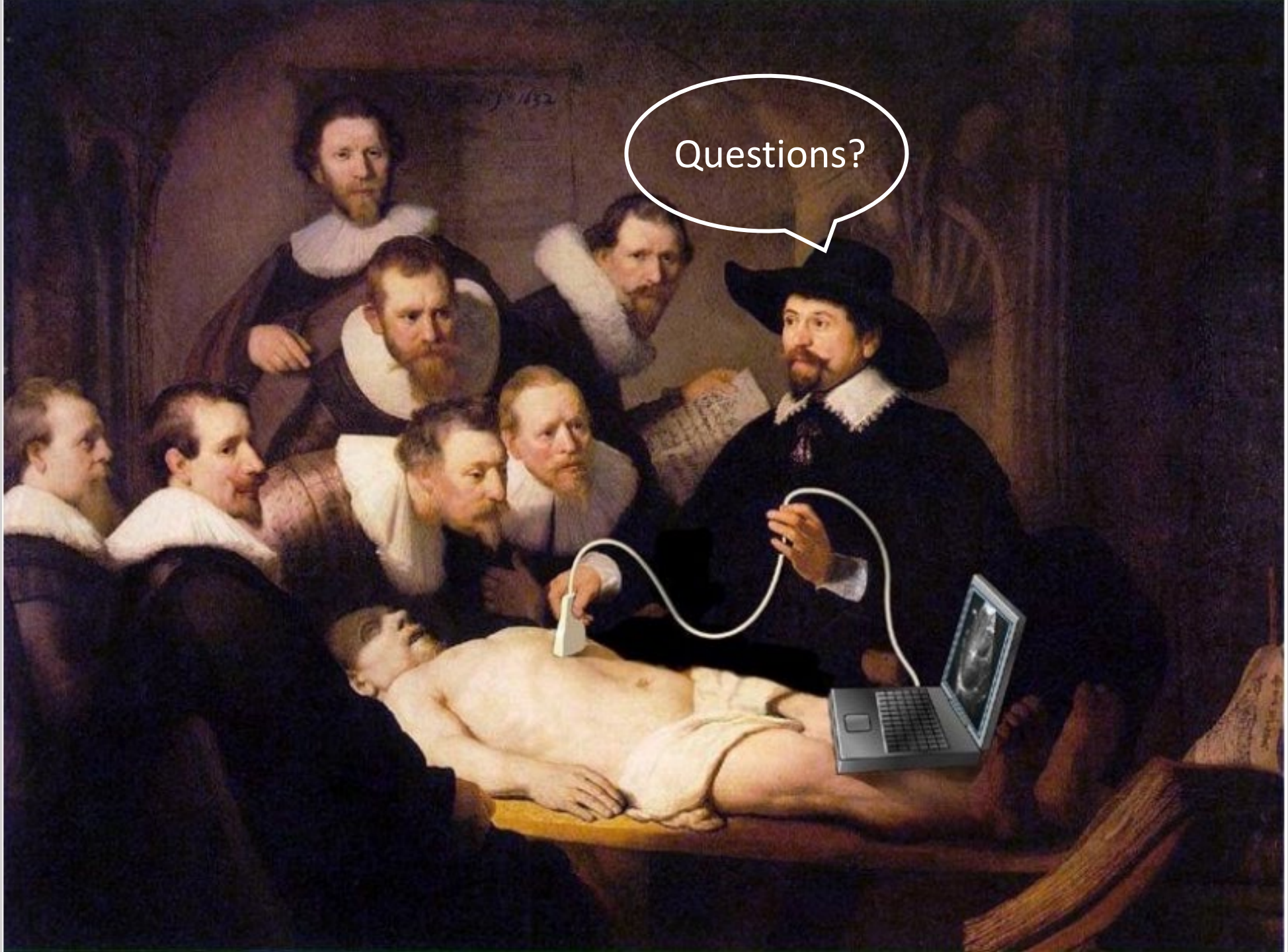
“Barcode sign” of pneumothorax

References

1. Andersen CA, Brodersen J, Rudbæk TR, Jensen MB. Patients' experiences of the use of point-of-care ultrasound in general practice - a cross-sectional study. *BMC Fam Pract*. 2021 Jun 18;22(1):116. doi: 10.1186/s12875-021-01459-z. PMID: 34144701; PMCID: PMC8214303. https://pubmed.ncbi.nlm.nih.gov/34144701/
2. Babic RR, Stankovic Babic G, Babic SR, Babic NR. 120 years since the discovery of x-rays. *Med Pregl.* 2016 Sep;69(9-10):323-330. doi: 10.2298/mpns1610323b. PMID: 29693857
3. Chan KK, Joo DA, McRae AD, Takwoingi Y, Premji ZA, Lang E, Wakai A. Chest ultrasonography versus supine chest radiography for diagnosis of pneumothorax in trauma patients in the emergency department. *Cochrane Database Syst Rev*. 2020 Jul 23;7(7):CD013031. doi: 10.1002/14651858.CD013031.pub2. PMID: 32702777; PMCID: PMC7390330. https://pubmed.ncbi.nlm.nih.gov/32702777/
4. Conlon, T.W, Nishisaki, A., Singh, Y., Bhombal, S., De Luca, D, Kessler, D.O., Su, E., Chen, A.E., Fraga, MV; Moving Beyond the Stethoscope: Diagnostic Point-of-Care Ultrasound in Pediatric Practice. *Pediatrics* October 2019; 144 (4): e20191402. 10.1542/peds.2019-1402. https://pubmed.ncbi.nlm.nih.gov/31481415/
5. Díaz-Gómez JL, Mayo PH, Koenig SJ. Point-of-Care Ultrasonography. *N Engl J Med*. 2021 Oct 21;385(17):1593-1602. doi: 10.1056/NEJMra1916062. PMID: 34670045. https://pubmed.ncbi.nlm.nih.gov/34670045/
6. DUSSIK KT. Ultraschall-Diagnostik, insbesondere bei Gehirnerkrankungen, mittels Hyperphonographie [Ultrasound diagnostics, especially for brain diseases, using hyperphonography]. Z Phys Ther Bader Klimanheikd. 1948 Sep-Oct;1(9-10):140-5. German. PMID: 18128879. https://pubmed.ncbi.nlm.nih.gov/18128879/
7. Feilchenfeld Z, Kuper A, Whitehead C. Stethoscope of the 21st century: dominant discourses of ultrasound in medical education. *Med Educ*. 2018 Dec;52(12):1271-1287. doi: 10.1111/medu.13714. Epub 2018 Oct 18. PMID: 30334276. https://pubmed.ncbi.nlm.nih.gov/30334276/

References

8. Gillman, L.M., Kirkpatrick, A.W. Portable bedside ultrasound: the visual stethoscope of the 21st century. *Scand J Trauma Resusc Emerg Med* **20,** 18 (2012). https://doi.org/10.1186/1757-7241-20-18
9. Howard ZD, Noble VE, Marill KA, Sajed D, Rodrigues M, Bertuzzi B, Liteplo AS. Bedside ultrasound maximizes patient satisfaction. *J Emerg Med*. 2014 Jan;46(1):46-53. doi: 10.1016/j.jemermed.2013.05.044. Epub 2013 Aug 12. PMID: 23942153. https://pubmed.ncbi.nlm.nih.gov/23942153/
10. Kobal SL, Trento L, Baharami S, Tolstrup K, Naqvi TZ, Cercek B, Neuman Y, Mirocha J, Kar S, Forrester JS, Siegel RJ. Comparison of effectiveness of hand-carried ultrasound to bedside cardiovascular physical examination. *Am J Cardiol*. 2005 Oct 1;96(7):1002-6. doi: 10.1016/j.amjcard.2005.05.060. PMID: 16188532. https://pubmed.ncbi.nlm.nih.gov/16188532/
11. Lewiner J. Paul Langevin and the Birth of Ultrasonics. *Japanese Journal of Applied Physics* 1991 30(5). https://doi.org/10.7567/jjaps.30s1.5
12. Mehta M, Jacobson T, Peters D, Le E, Chadderdon S, Allen AJ, Caughey AB, Kaul S. Handheld ultrasound versus physical examination in patients referred for transthoracic echocardiography for a suspected cardiac condition. *JACC Cardiovasc Imaging*. 2014 Oct;7(10):983-90. doi: 10.1016/j.jcmg.2014.05.011. Epub 2014 Sep 17. PMID: 25240450. https://pubmed.ncbi.nlm.nih.gov/25240450/
13. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med*. 2011 Feb 24;364(8):749-57. doi: 10.1056/NEJMra0909487. PMID: 21345104. https://pubmed.ncbi.nlm.nih.gov/21345104/
14. Speciale, C.M. Portable Ultrasound: "The Stethoscope of the 21st Century". *The Objective Standard* 2014.1.26 https://theobjectivestandard.com/2014/01/portable-ultrasound-the-stethoscope-of-the-21st-century/
15. Shampo MA, Kyle RA. Karl Theodore Dussik--pioneer in ultrasound. *Mayo Clin Proc*. 1995 Dec;70(12):1136. doi: 10.4065/70.12.1136. PMID: 7490912. https://pubmed.ncbi.nlm.nih.gov/7490912/
16. Stephens, K. Could a Handheld Ultrasound Device Become the 21st Century Stethoscope? *Axis Imaging News* 2021.3.25 https://axisimagingnews.com/radiology-products/imaging-equipment/ultrasound/handheld-ultrasound-device-21st-century-stethoscope
17. Wennergren G. René Laennec and the origins of the stethoscope. *Acta Paediatr*. 2018 Jul;107(7):1118-1119. doi: 10.1111/apa.14330. Epub 2018 Apr 19. PMID: 29566438. https://pubmed.ncbi.nlm.nih.gov/29566438/
18. Zimmer, DF. Point of Care Ultrasound: Stethoscope of the 21st Century. https://www.beaconhealthsystem.org/medical-professionals/wp-content/uploads/sites/26/2020/08/POCUS-Stethoscope-of-21st-Century.pdf


Questions?