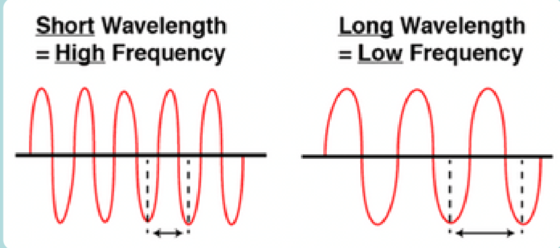
LESSON SUMMARY

ULTRASOUND FUNDAMENTALS

Introduction

- **Ultrasound beams** are **sound waves** emitted from a probe that "echo" back off the structure(s) of interest in the body and create real-time images of them.
- **Higher frequency probes** provide **better resolution** because they emit shorter wavelengths.
- The **stiffness** and **density** of a medium affect the speed of sound traveling through it. (Sound waves travel faster the stiffer and denser the medium is - i.e. **faster in solids** than liquids or gases, **fastest in bone**, slowest in lungs.

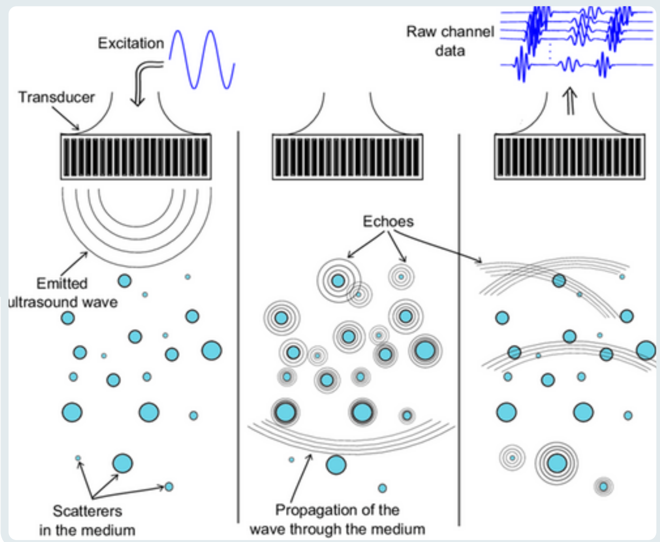


Ultrasound propagation speed, from slowest to fastest:
Lung (air) << Fat << Soft tissue << Bone

Piezoelectric effect

https://www.researchgate.net/figure/General-ultrasound-scanning-process_fig6_316125009

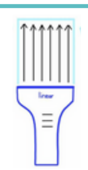
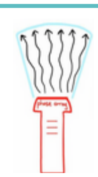
- With traditional ultrasound probes, energy/current is applied to **crystals**, causing them to vibrate.
- The ultrasound wave created by the vibrations is sent into the body, where it bounces off a structure, and returns to the probe.
- The probe converts the returned wave into energy and projects it into an image.



vs. Butterfly effect

Instead of crystals, butterfly probes use thousands of tiny **drumheads** to send and receive sound.

Probe selection

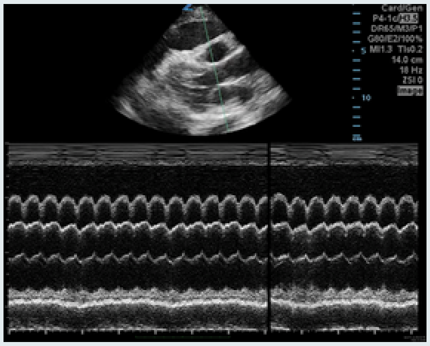
Linear		superficial structures	high frequency (5-15 MHz)	soft tissue, musculoskeletal, pediatric, ocular, trachea, thyroid, thoracic, most procedures, DVT appendicitis, testicular
Curvilinear		usually for deeper structures	lower frequency (2-5 MHz)	general abdominal (gallbladder, liver, etc.), eFAST, renal, aorta, IVC, bladder, bowel, OB/GYN
Phased Array		deeper structures	low frequency (1-5 MHz)	cardiac, abdominal, eFAST, renal, bladder, bowel, IVC

https://rk.md/2017/principles-ultrasound/

Modes

B-mode (brightness mode/2D mode) – **Standard/default** · Two-dimensional · Greyscale

M-mode (motion mode)

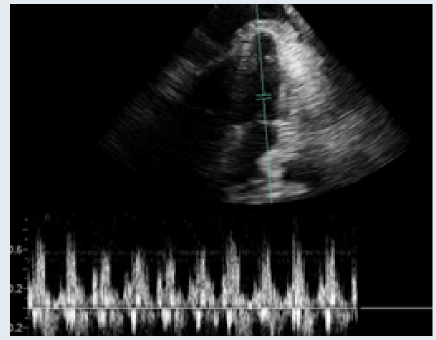


Motion (Y-axis) vs. **time** (X-axis) display of B-mode

Color flow doppler

Provides real-time info about wave flow direction using color
BART: **B**lue = **A**way, **R**ed = **T**owards

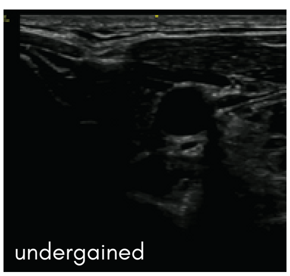
Continuous wave doppler



Demonstrates wave flow direction as peaks and troughs
Detects very high velocities

Knobs

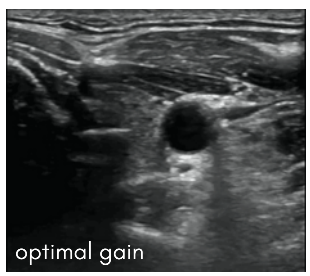
- **Depth**: adjusts depth and range of structures evaluated
- **Gain**: adjusts echogenicity
  - Structures absent of echogenicity appear black (**anechoic**)



Decreasing gain

darker, less enhanced image

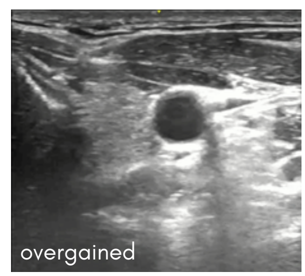
(**HYPOECHOIC**)



Increasing gain

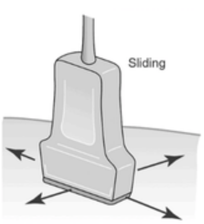
lighter, more enhanced image

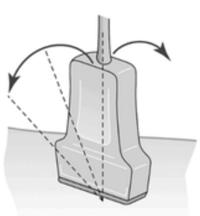
(**HYPERECHOIC**)

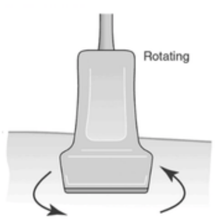


Positioning and transducer movement

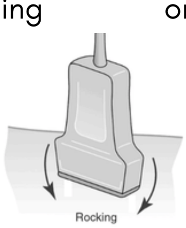
- Indicator towards **patient's head** or **right side**







- **Sliding** up & down or L to R
- **Tilting** or fanning
- **Rotating** or twisting
- **Rocking**: anchored but pivoting side to side or top to bottom



Common encounters

- **Impedance**: resistance to ultrasound propagation as it passes through tissue

  Density x propagation speed of sound wave

- **Attenuation**: loss and absorption of ultrasound energy through a medium

  Air and bone are the highest

- **Reflection**: occurs with large differences in impedance between two tissues

  A lines: air and bone

- **Refraction**: occurs with slight differences in impedance between two tissues

  Usually fluid-filled structures (e.g. gallbladder, cyst, vessels, bladder)

Image credits: pocus101.com

Acoustic shadowing

- Sound does not pass as easy, so images are obstructed and diminished in response
- Example of high attenuation

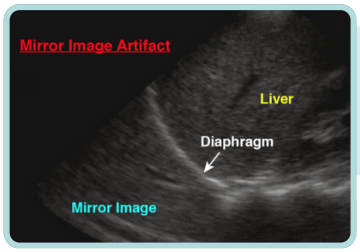
Sound waves return to the probe based on the structure encountered...

← Less dense: **less waves** return

More dense: **more waves** return →

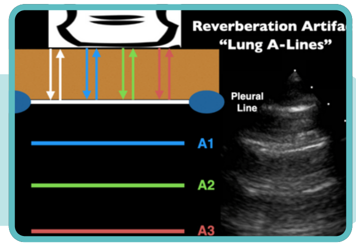
Acoustic enhancement

- Sound passes easier, so images may become "enhanced" and easier to visualize
- Opposite of shadowing



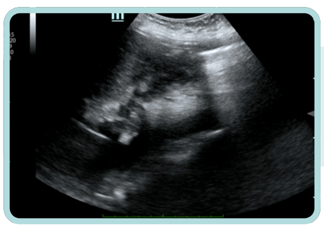
Mirror imaging

- Highly reflective surface
- Best example of this is found in region between liver and diaphragm



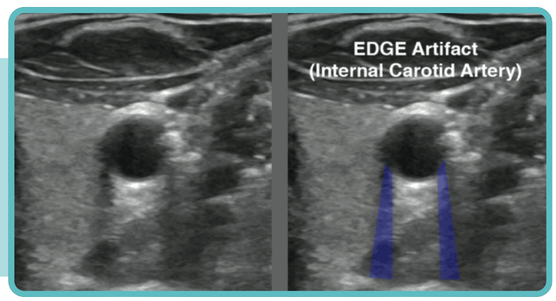
Reverberation artifact

- When ultrasound waves bounce back and forth between an image structure
- Due to the time delay, the resulting image can appear "echoed" on screen



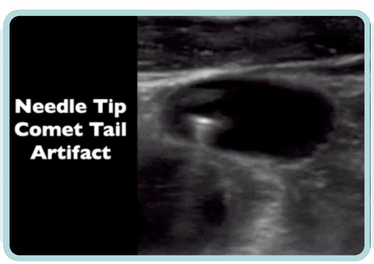
Gas scatter

- Air distributes and scatters light, so the ultrasound waves cannot be transmitted



Refraction/Edge artifact

- When sound crosses the boundary of a tissue with different densities, so the sound waves return at different speeds
- Can look like a "ringed" effect
- Commonly can see in the gallbladder and bladder

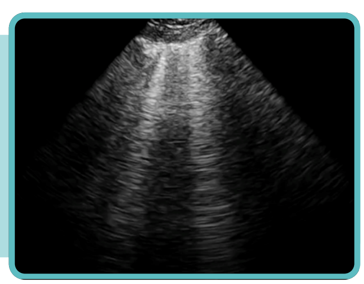


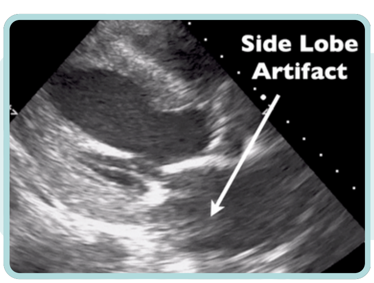
Comet tail artifact (subtype of reverberation artifact)

- When reflective surfaces are so close together, it's hard to differentiate
- More triangular in shape
- Dissipates as depth increases
- Seen with strongly reflected surfaces

Ring down artifact

- Ultrasound waves reflect infinitely and result in an infinitely long vertical echogenic line (example: B lines on lung ultrasound)
- Wider shaped and more beam-like in appearance
- Unlike comet tail artifact, the ultrasound echoes do NOT lessen with depth





Side lobe artifact

- When the beam of an off-axis side lobe hits a structure but then returns this off-axis object as if it is coming from the main beam.
- Appears like a duplicate structure on the screen, but in a different area

Image credits: pocus101.com