Introduction to Ultrasound: Physics and Knobology
Echolocation
Definition of Ultrasound

- Infrasound
- 20 Hz
- Sound
- 20 kHz
- Ultrasound
Definitions

- Sound waves: a series of repeating mechanical pressure waves that propagate through a medium.
- Waves consist of compression of the medium (positive component of the wave) and rarefaction of the medium (negative component).
Making Waves
Wavelength = distance for a complete cycle
Frequency

Frequency = # Cycles per second = Hertz (Hz)

Time = 1 Second

2 Hertz

6 Hertz
Diagnostic Ultrasound

• 1 KHz = 1,000 cycles per second

• 1 MHz = 1,000,000 cycles per second

• Diagnostic ultrasound 2-15 MHz
The Two Main Components of an Ultrasound Unit
Ultrasound Transducer
Modes of Ultrasound

• A-mode: Amplitude
• B-mode: Brightness
• M-mode: Motion
• Doppler
  • Color Doppler
  • Spectral Doppler
  • Power Doppler
Echogenicity

- **Echogenicity**: the amplitude / brightness of the image
- **Hyperechoic**: more echogenic than surrounding tissue
- **Hypoechoic**: less echogenic than surrounding tissue
- **Isoechoic**: same echogenicity as surrounding tissue
- **Anechoic**: absence of echoes
Echogenicity

- Hyperechoic
- Isoechoic
- Hypoechoic
- Anechoic
Important Imaging Principles

- Piezoelectric effect
- Brightness of the image is a function of ultrasound waves that are reflected back to the transducer
- Waves are reflected back to the transducer from the interface of tissues with different physical properties
- Position of a structure on the screen is a function of how long it takes the wave to return to the transducer
- There are some false assumptions that are made by the machine about the returning waves that lead to artifacts
Orientation

Transverse View
Marker points to patient right side

Longitudinal View
Marker points to patient head
Scanning Planes
Transverse View
Transverse View
Sagittal View
Longitudinal view

Cephalic end

Caudal end

Cephalic end

Caudal end
Coronal
Abdominal Ultrasound B-Mode
Frequency: resolution and depth

- Higher Frequency = Greater Resolution
- Lower Frequency = Greater Depth
What happens to the wave once it leaves the transducer?

- Attenuation
- Refraction
- Scatter
- Reflection
Attenuation
Scattering
Reflection
Doppler

- Color Doppler
- Pulse Wave Doppler
- Power Doppler
Color Doppler: normal carotid artery and internal jugular vein
Pulse Wave Doppler
**Power Doppler**
Normal right elbow and lateral epicondylitis of the left elbow (tennis elbow)

Right  |  Left
Ultrasound Knobology

- On-Off
- Preset
- Depth
- Focus
- Gain – overall
- Freeze
- Time Gain Compensation (TGC)
- Frequency
- Measurements
- Color Doppler
- Power Doppler
- Spectral Doppler
- M Mode
- Print / Save
Gain Knob
(Controls overall brightness of the image)
Time Gain Compensation (TGC)
(Allows adjustment of image brightness at selective depth)
Depth Knob
(Allows adjustment of the depth of field of view)
Focus Knob
(Allows focus of ultrasound beam to area of interest)
**Frequency Knob**

(Adjust Frequency to balance depth and resolution needs)
Student Lab Video
Neck Scan

- Transverse of Carotid
- Freeze and Measure Carotid
- Carotid/Internal Jugular with Valsalva
- Color Doppler - Transverse and Longitudinal Carotid
- Thyroid Gland