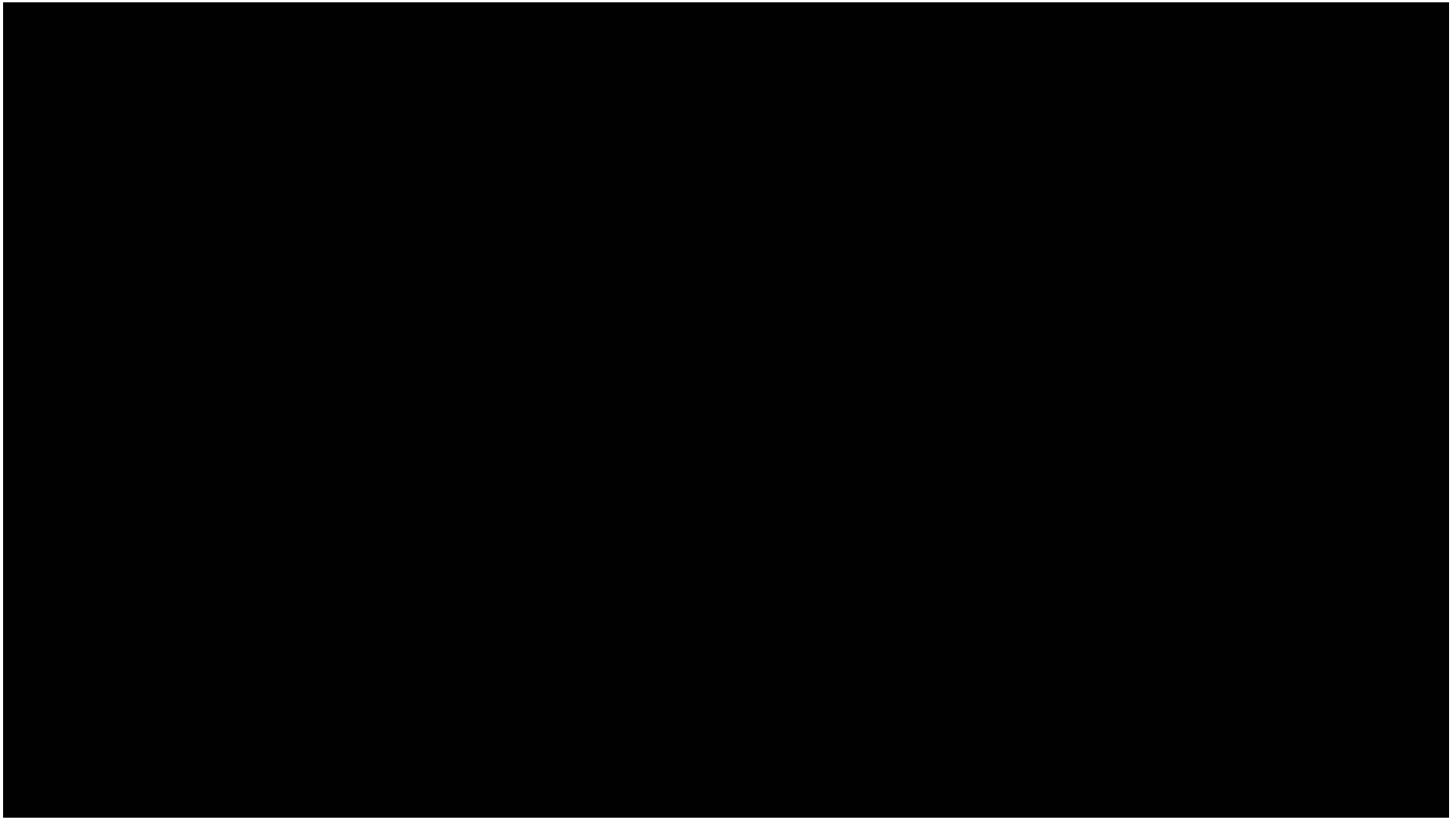
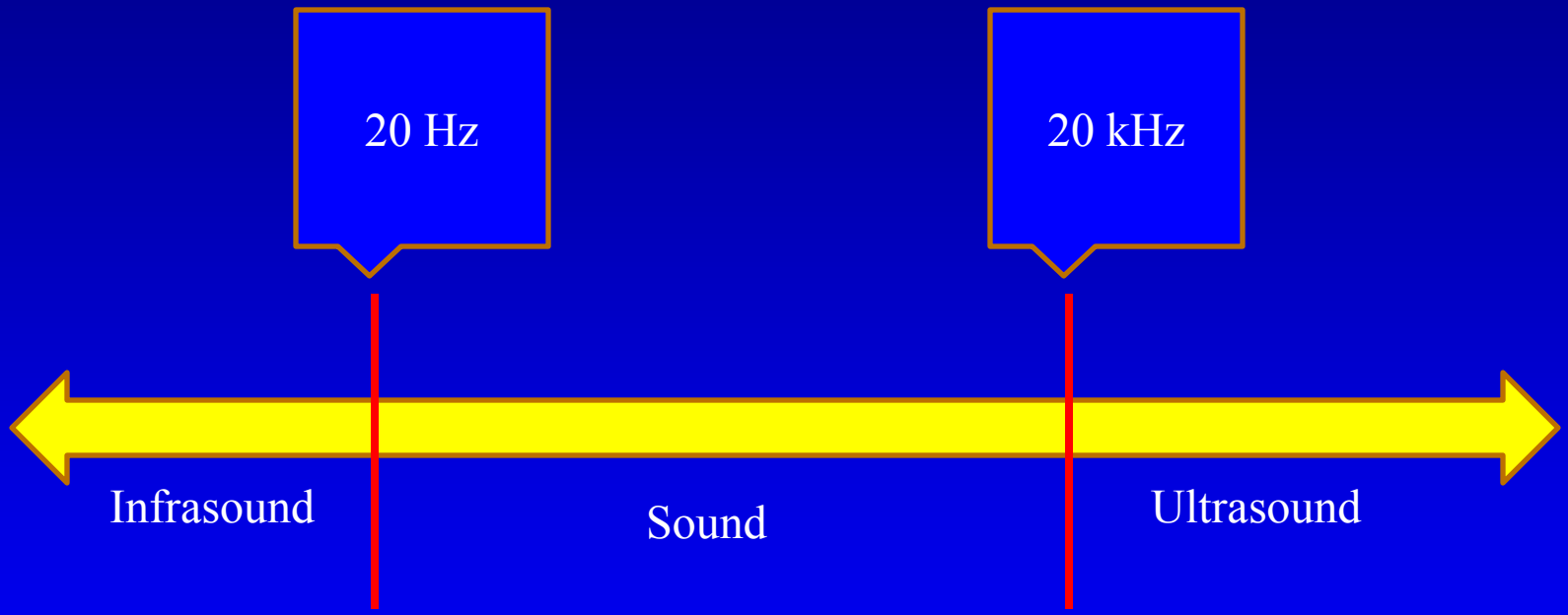
Introduction to Ultrasound: Physics and Knobology

Echolocation

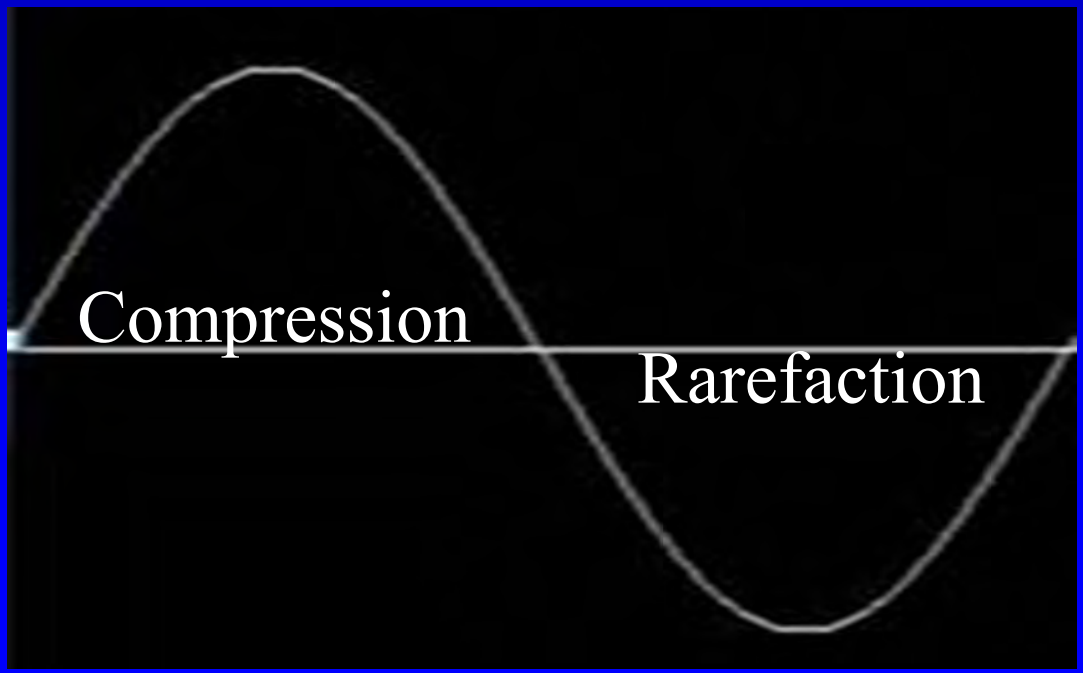


Definition of Ultrasound

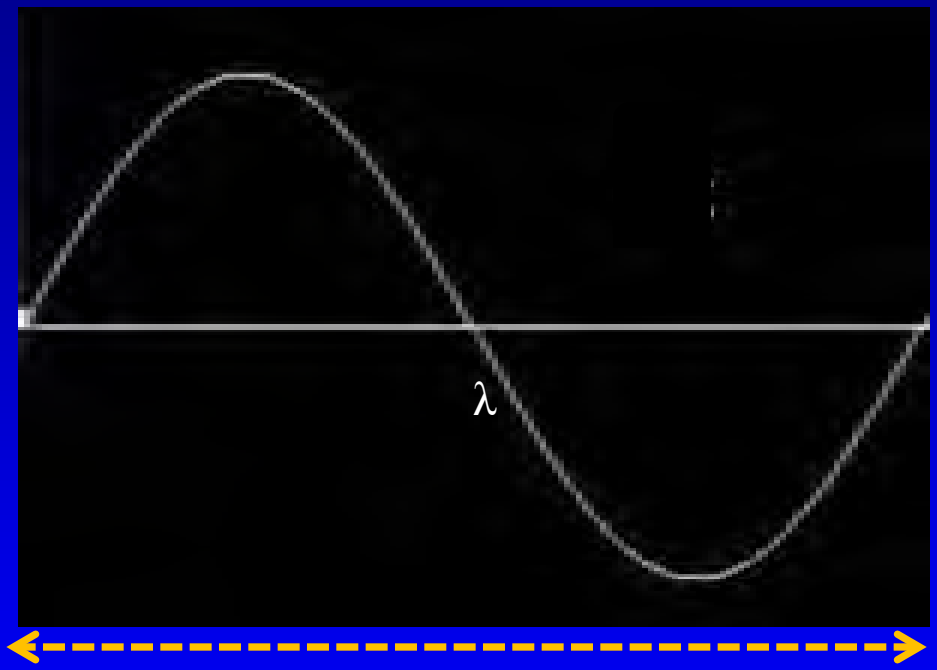


Definitions

- 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).



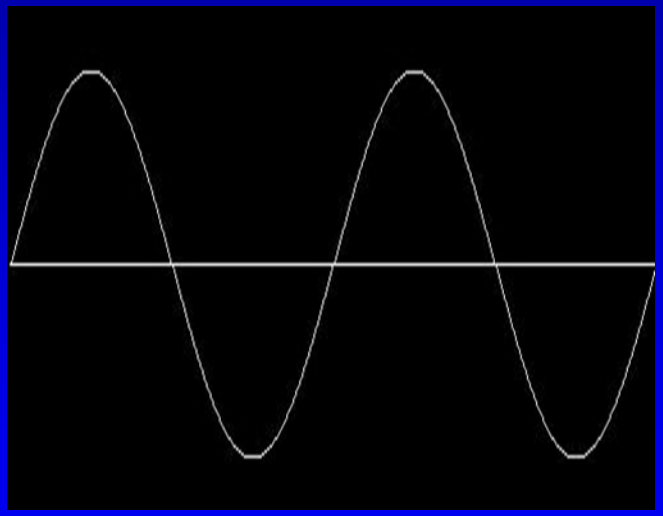
Making Waves



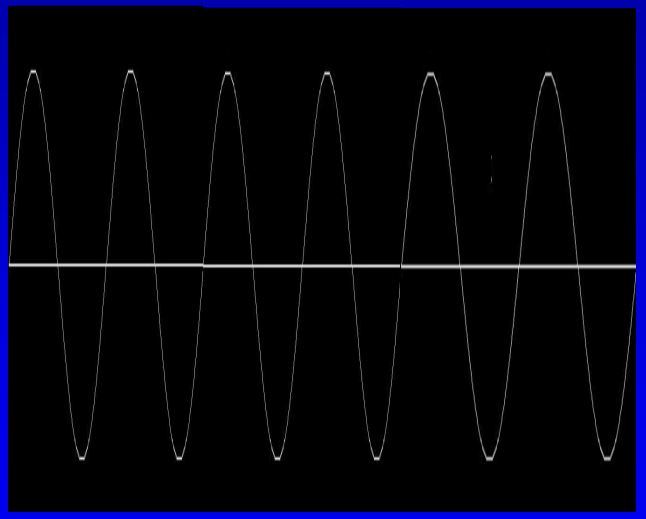
Wavelength = distance for a complete cycle

Frequency

Frequency = # Cycles per second = Hertz (Hz)



2 Hertz



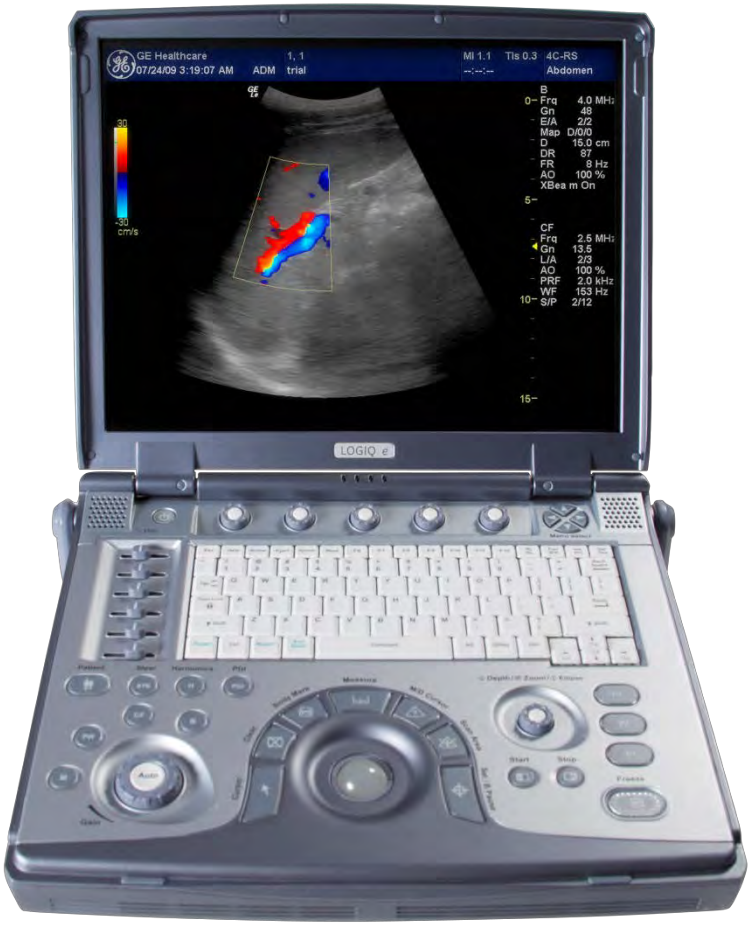
6 Hertz

Time = 1 Second

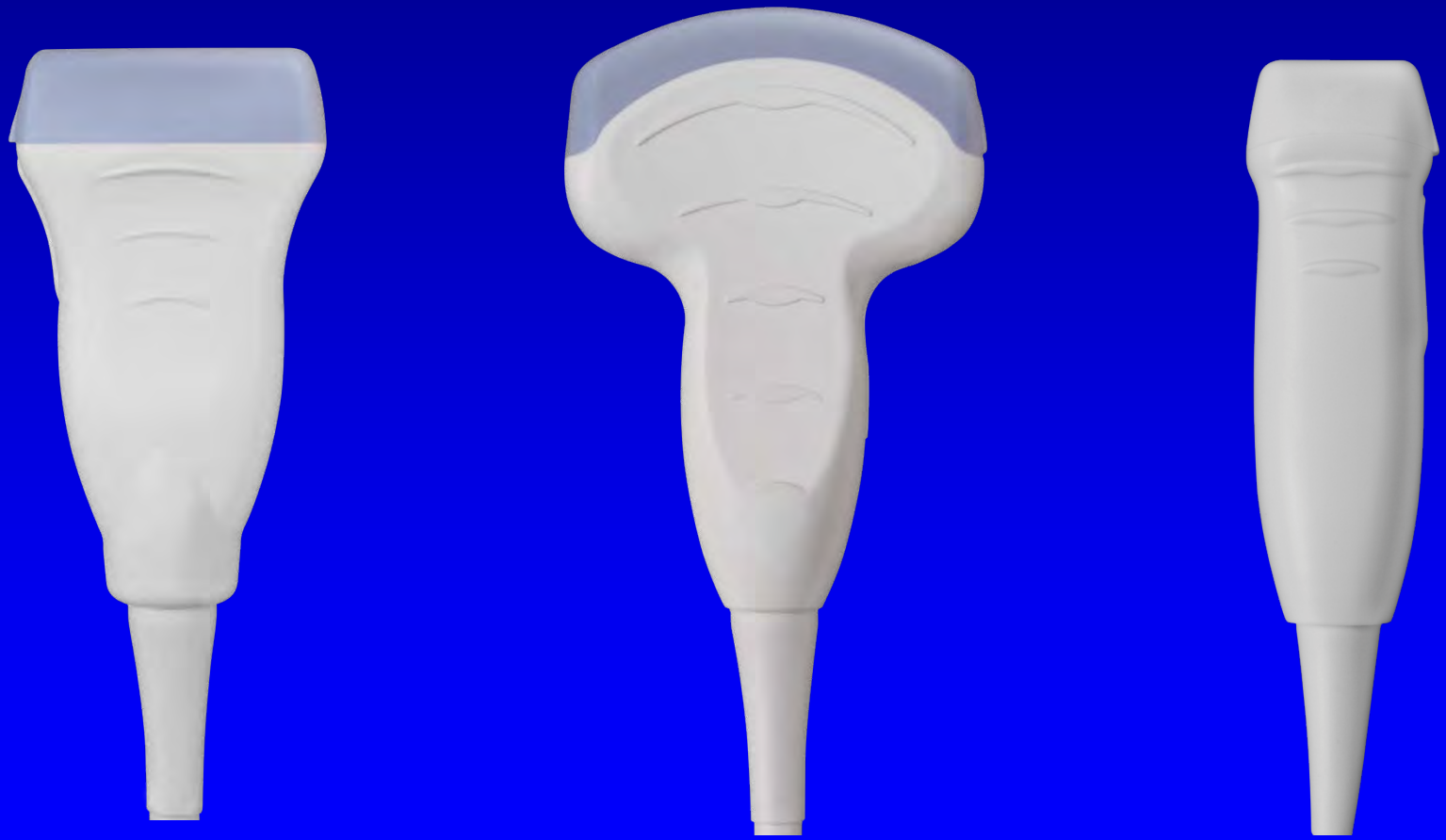
Diagnostic Ultrasound

- 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

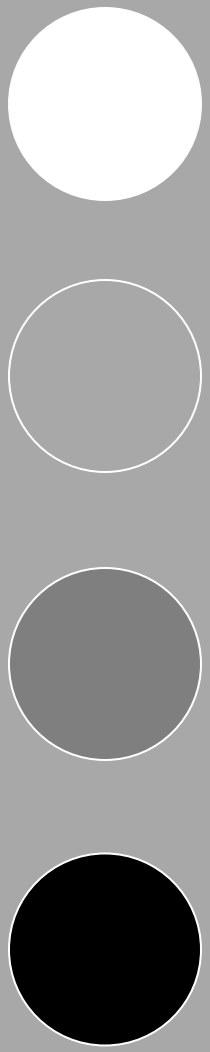
- A-mode :**A**mplitude
- B-mode: **B**rightness
- M-mode: **M**otion
- Doppler
  - Color Doppler
  - Spectral Doppler
  - Power Doppler

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

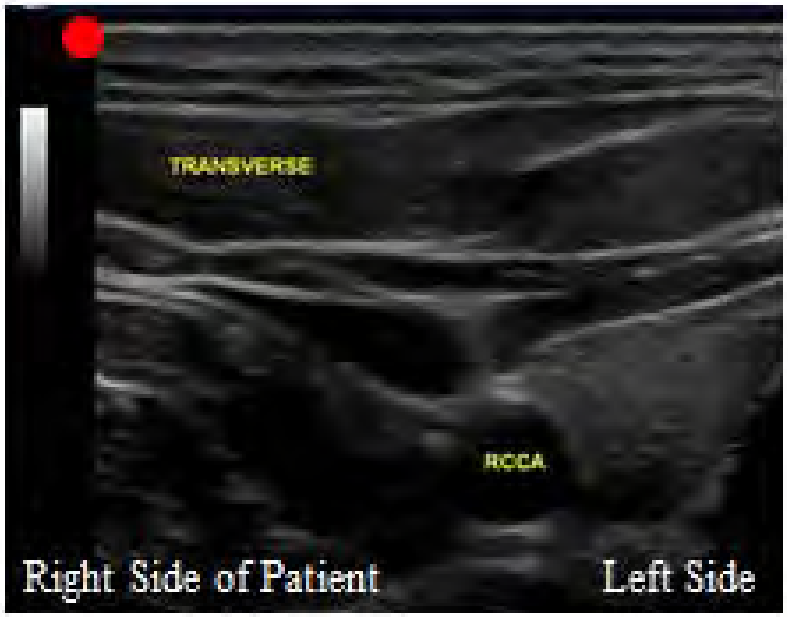


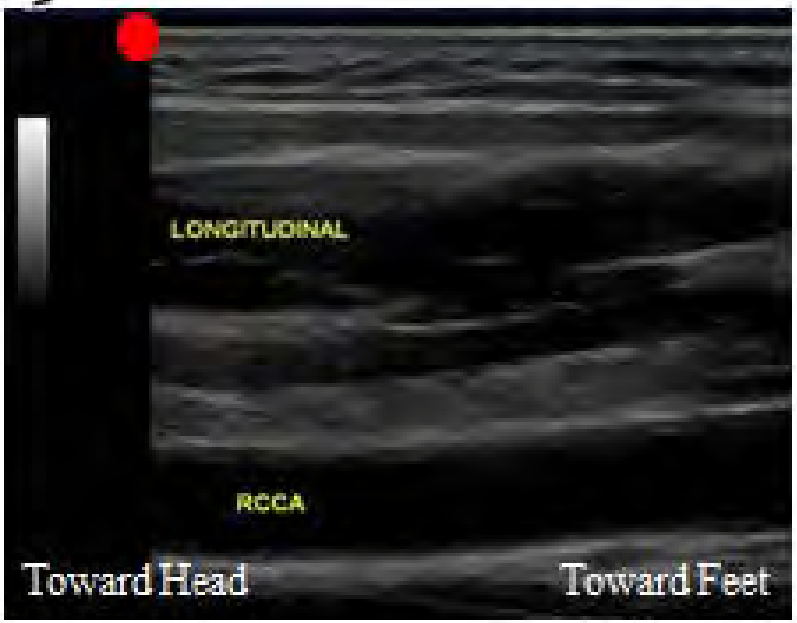
Important Imaging Principles

- 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

Marker /Logo





Transverse View

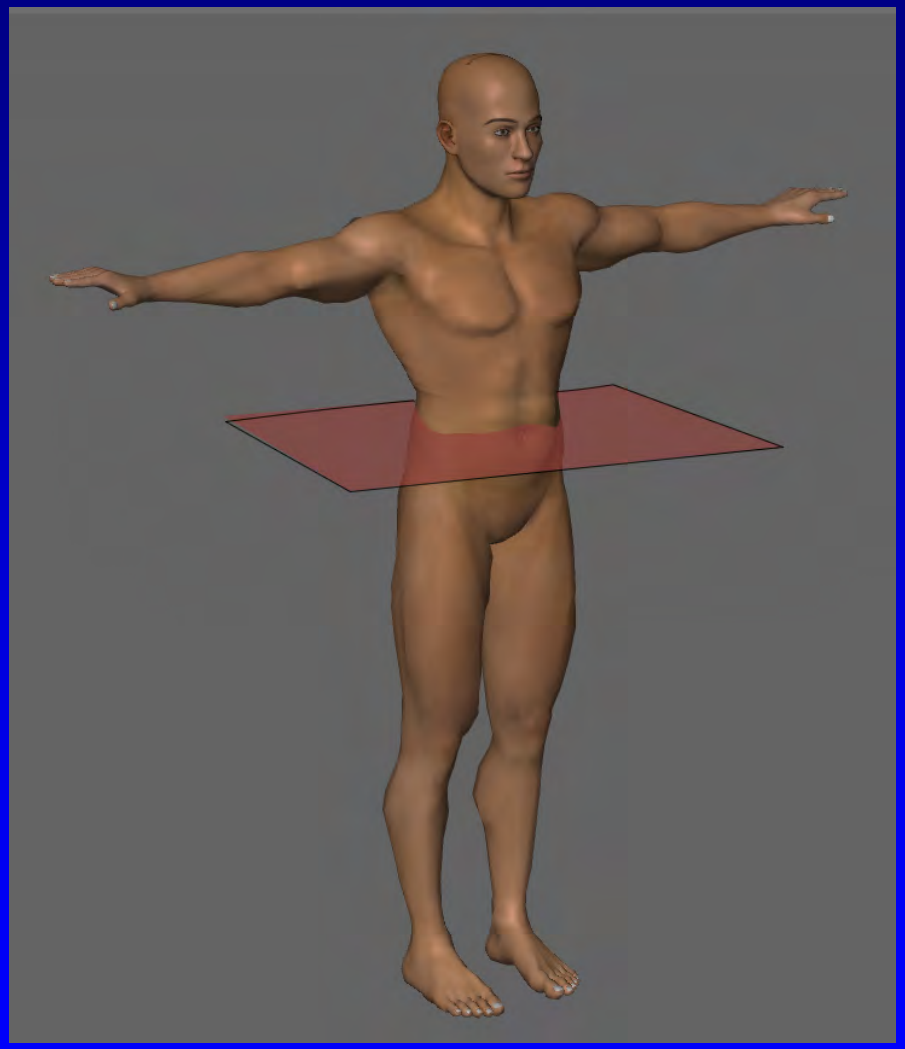
Marker points to patient right side

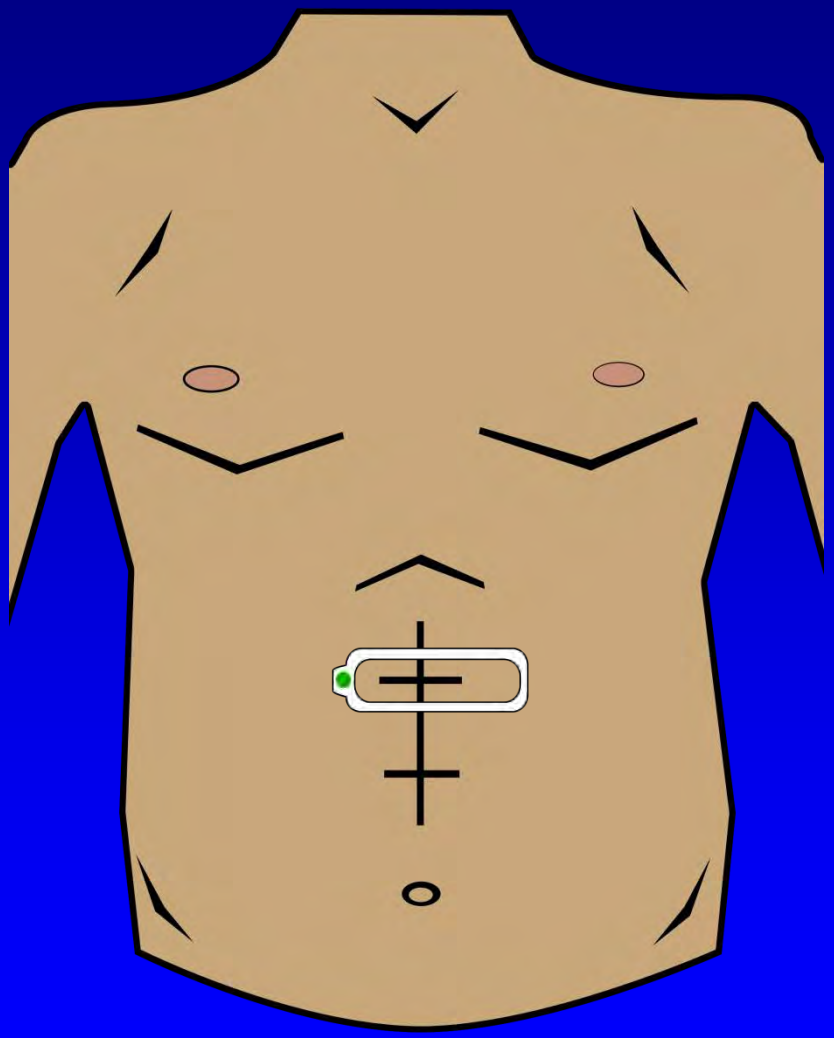
Longitudinal View

Marker points to patient head

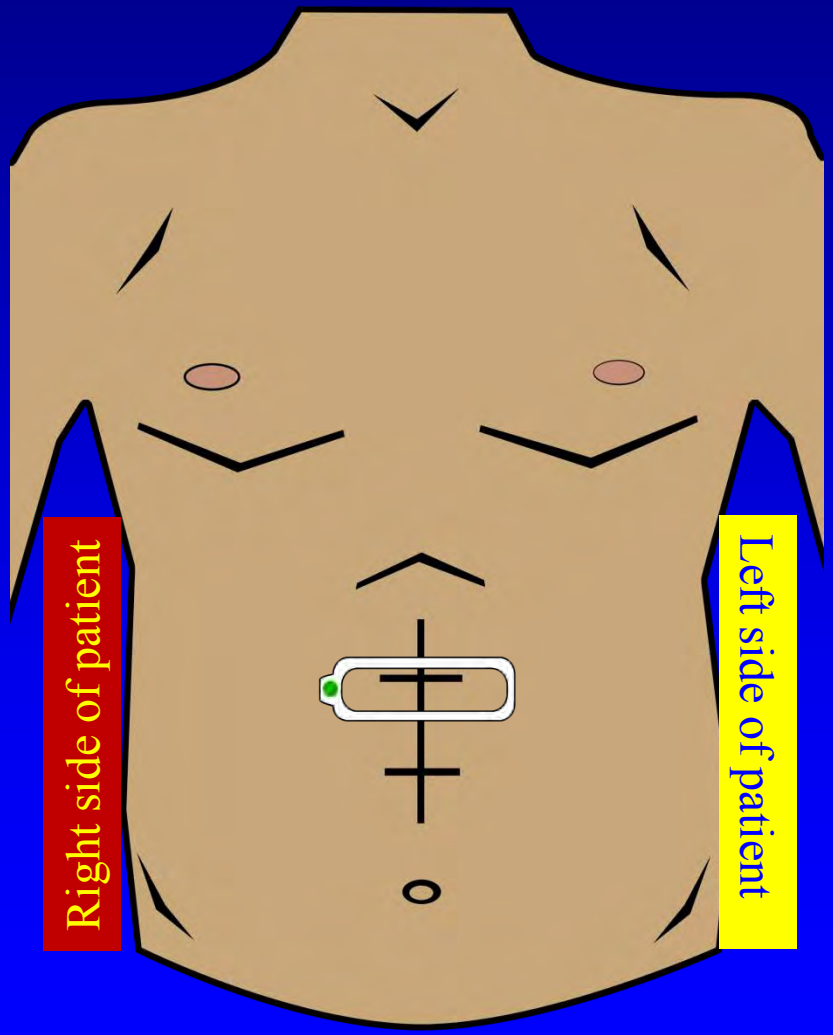
Scanning Planes

Transverse View

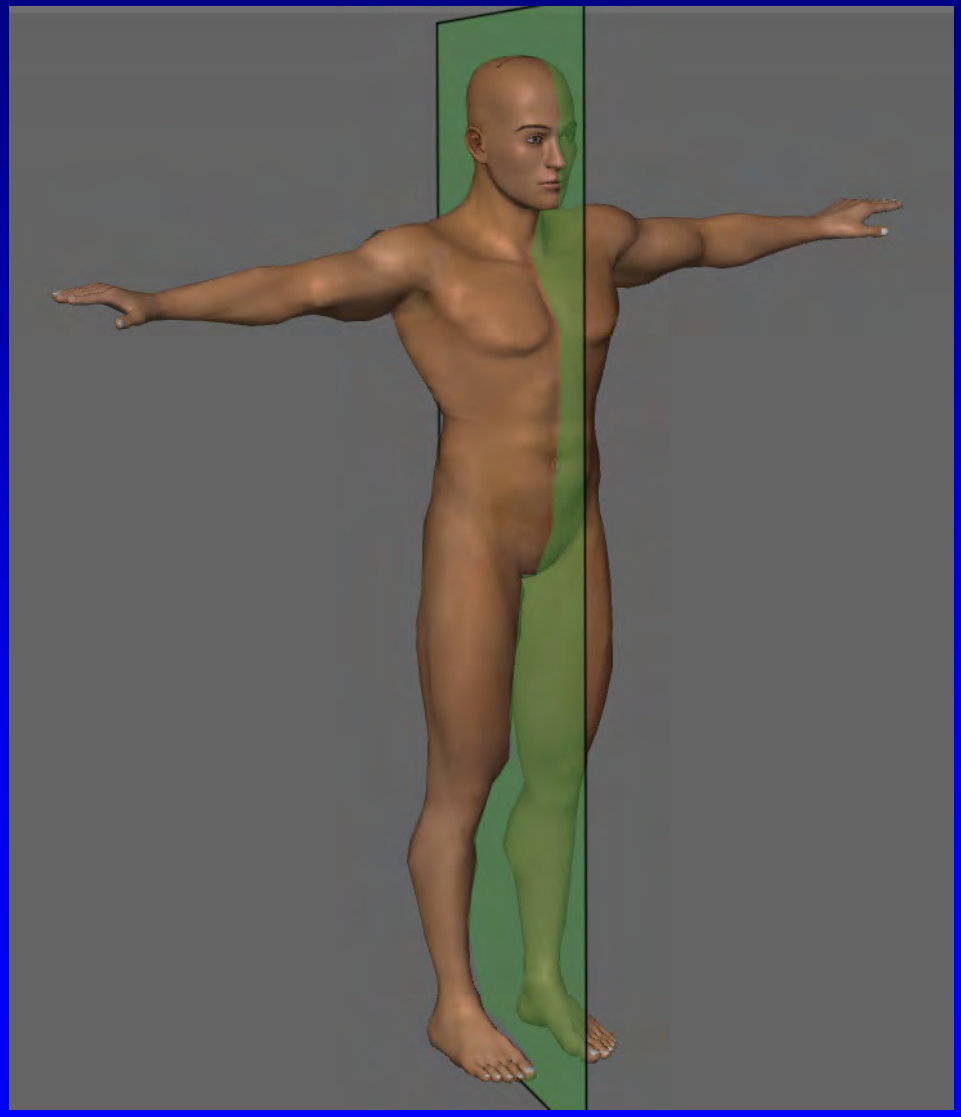


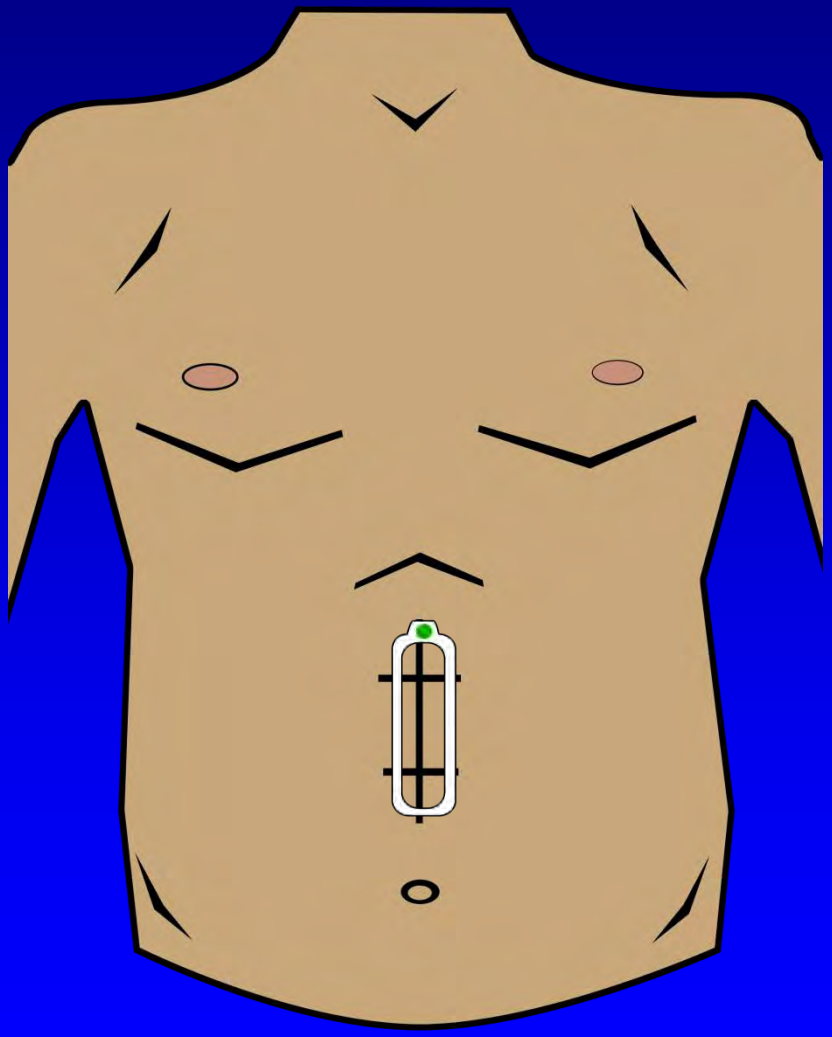


Transverse View

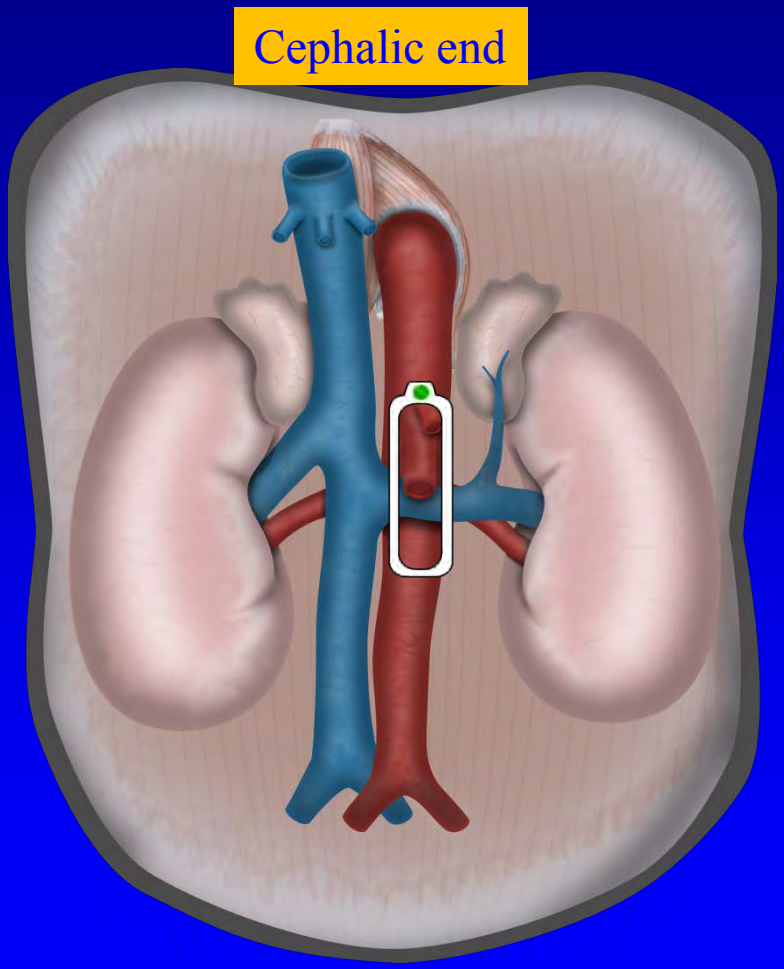


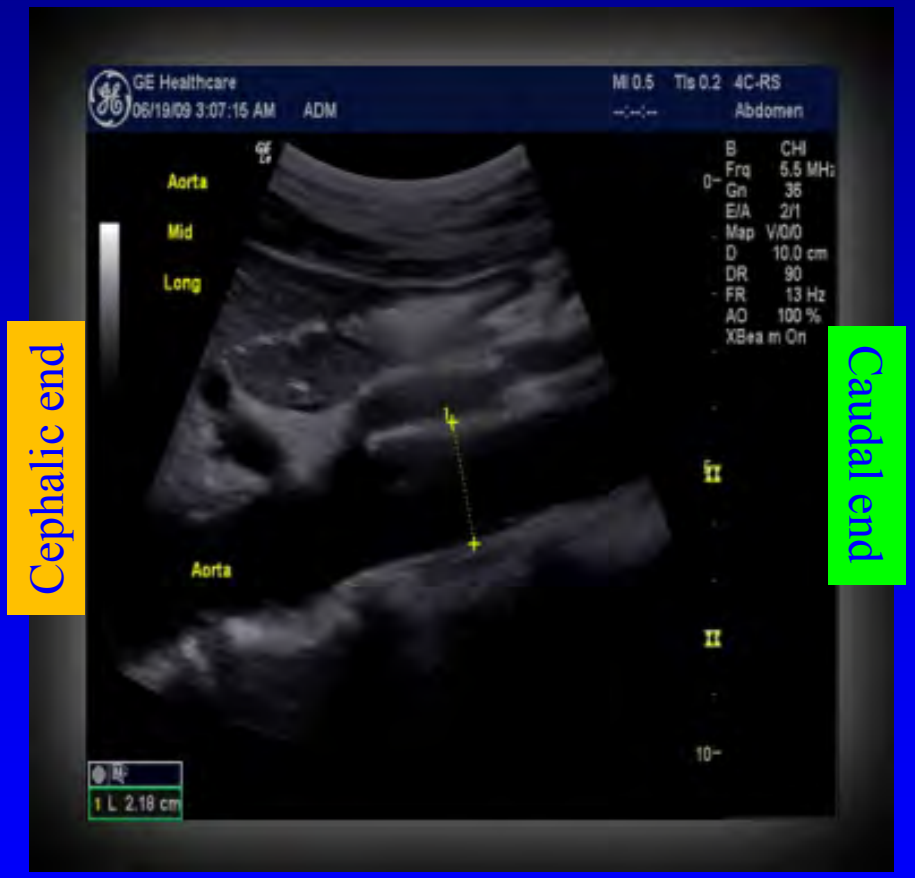
Sagittal View



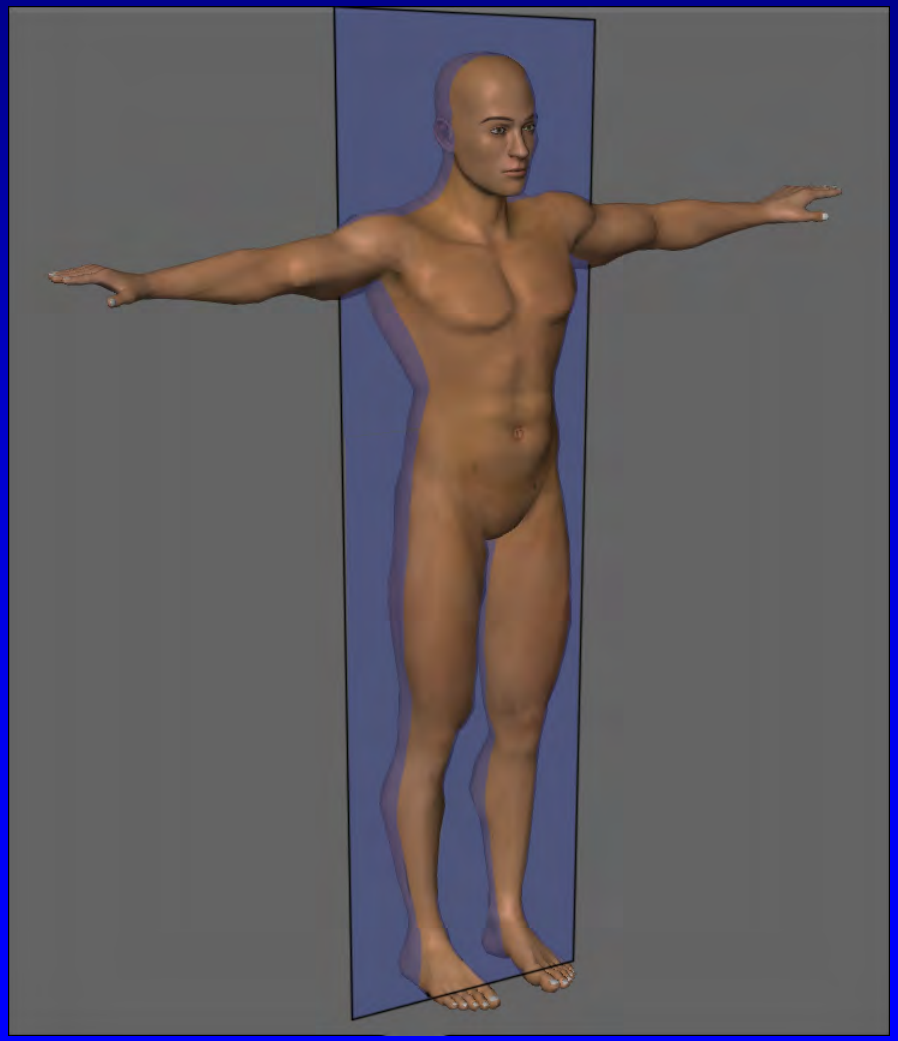


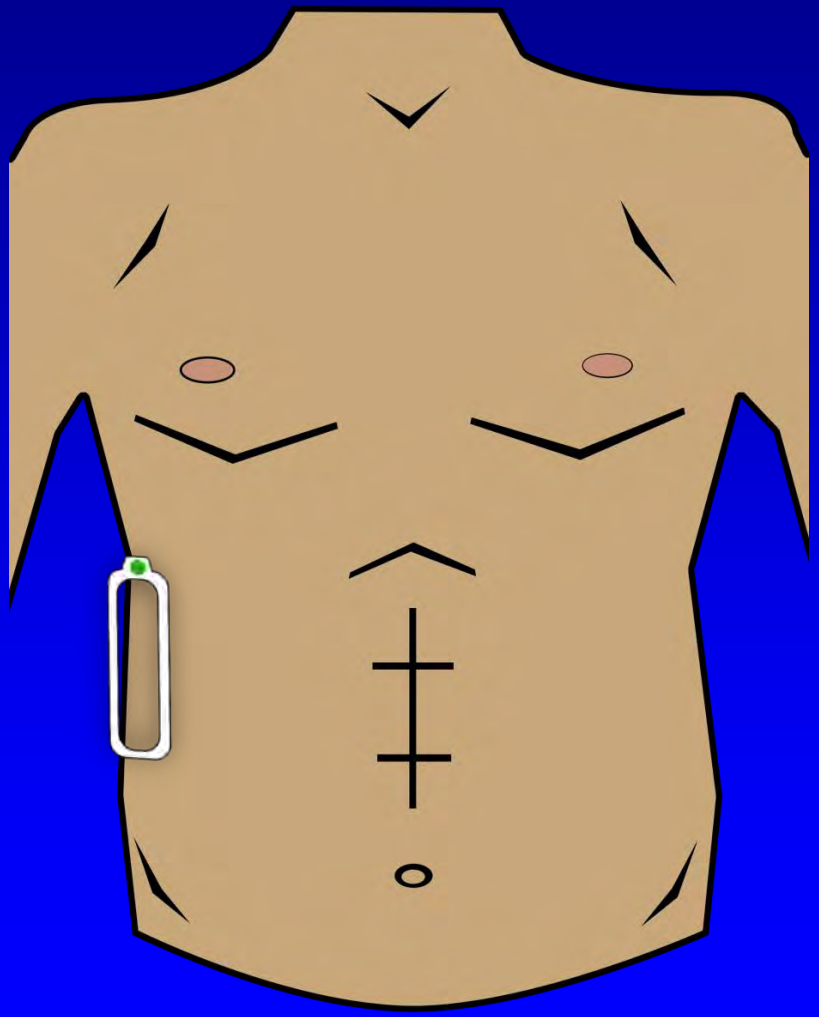
Longitudinal view



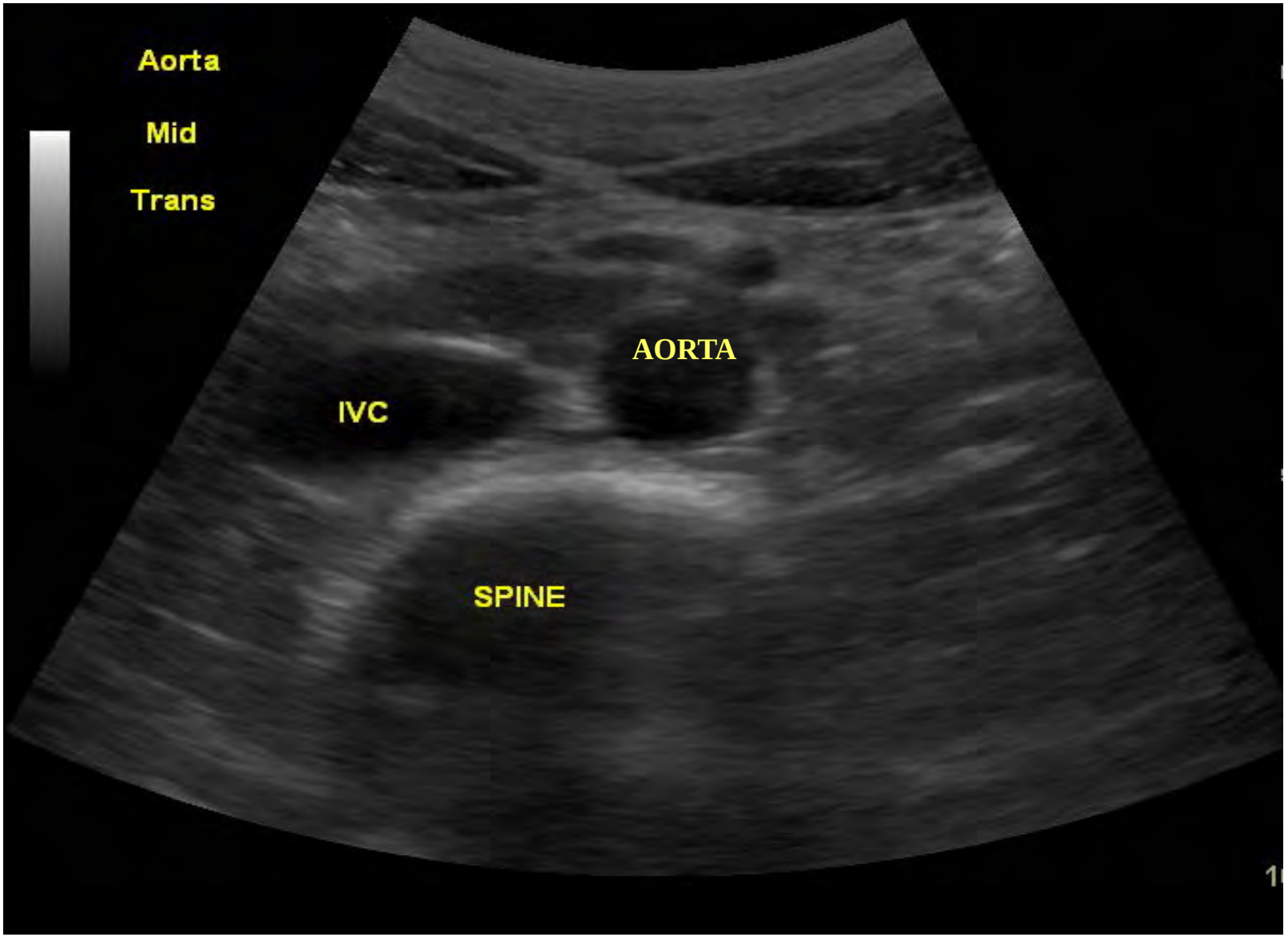


Coronal





Abdominal Ultrasound B-Mode



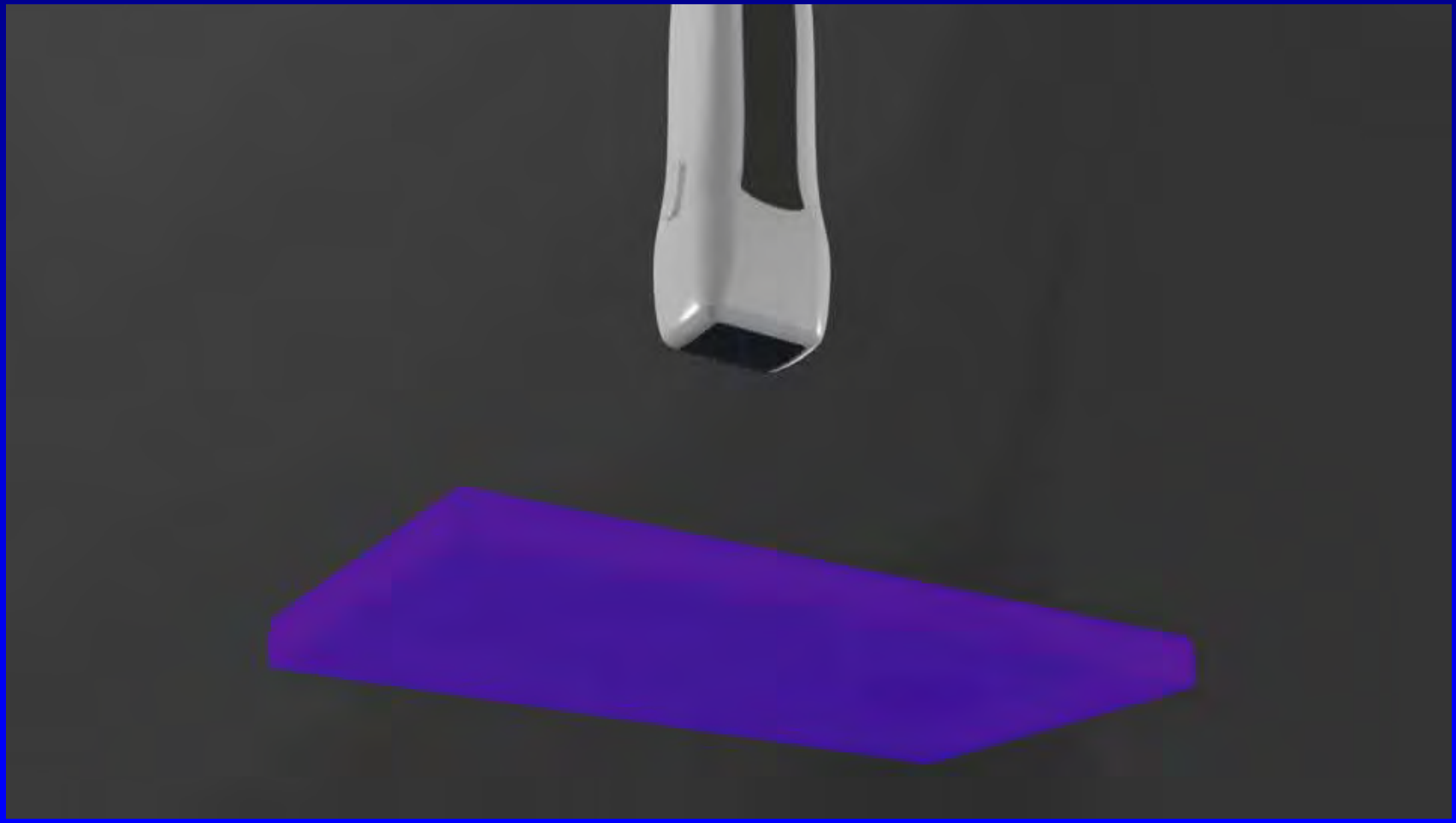
Frequency: resolution and depth

- Higher Frequency = Greater Resolution
- Lower Frequency = Greater Depth

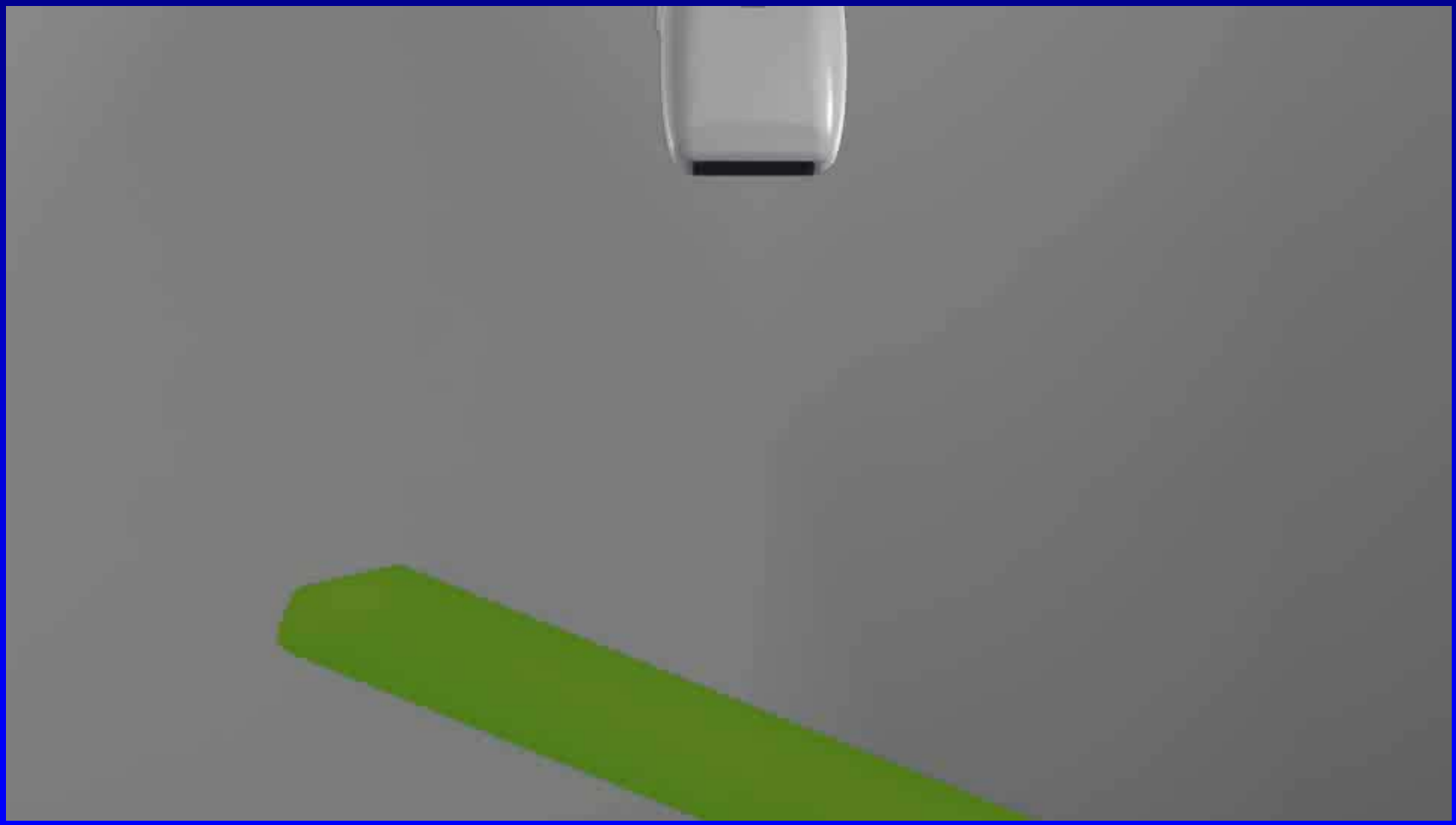
What happens to the wave once it leaves the transducer?

- Attenuation
- Refraction
- Scatter
- Reflection

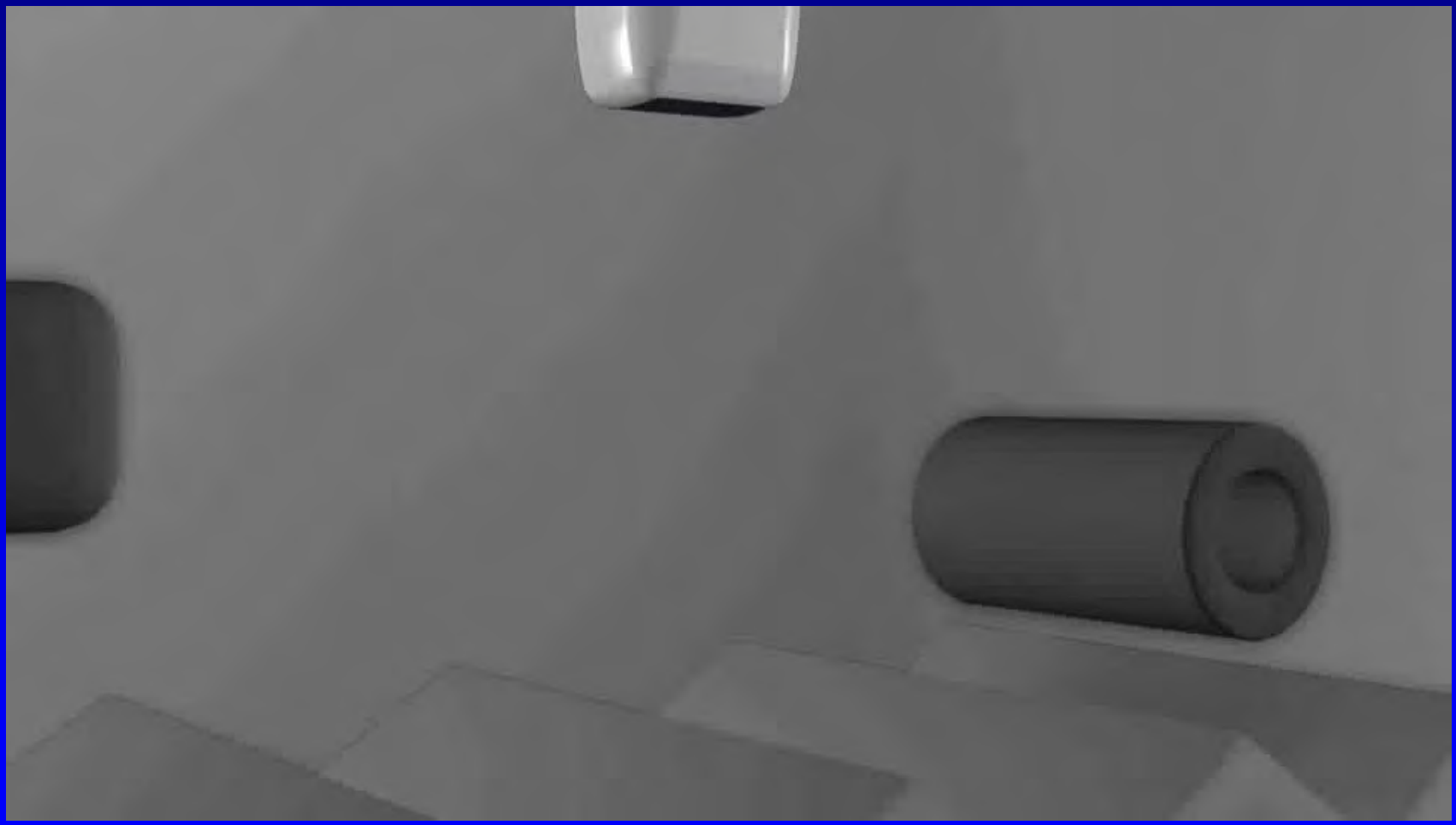
Attenuation



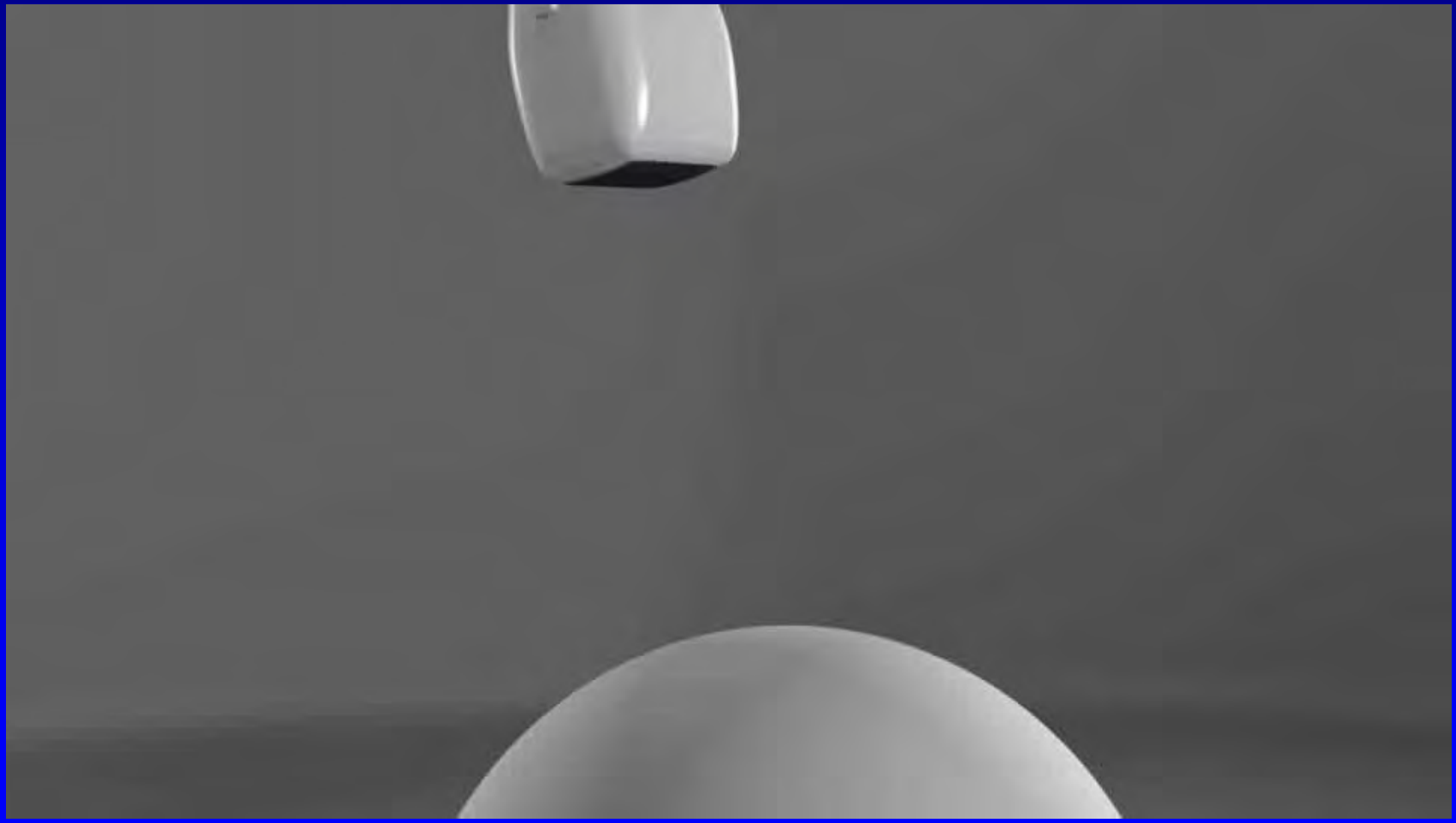
Refraction



Scattering



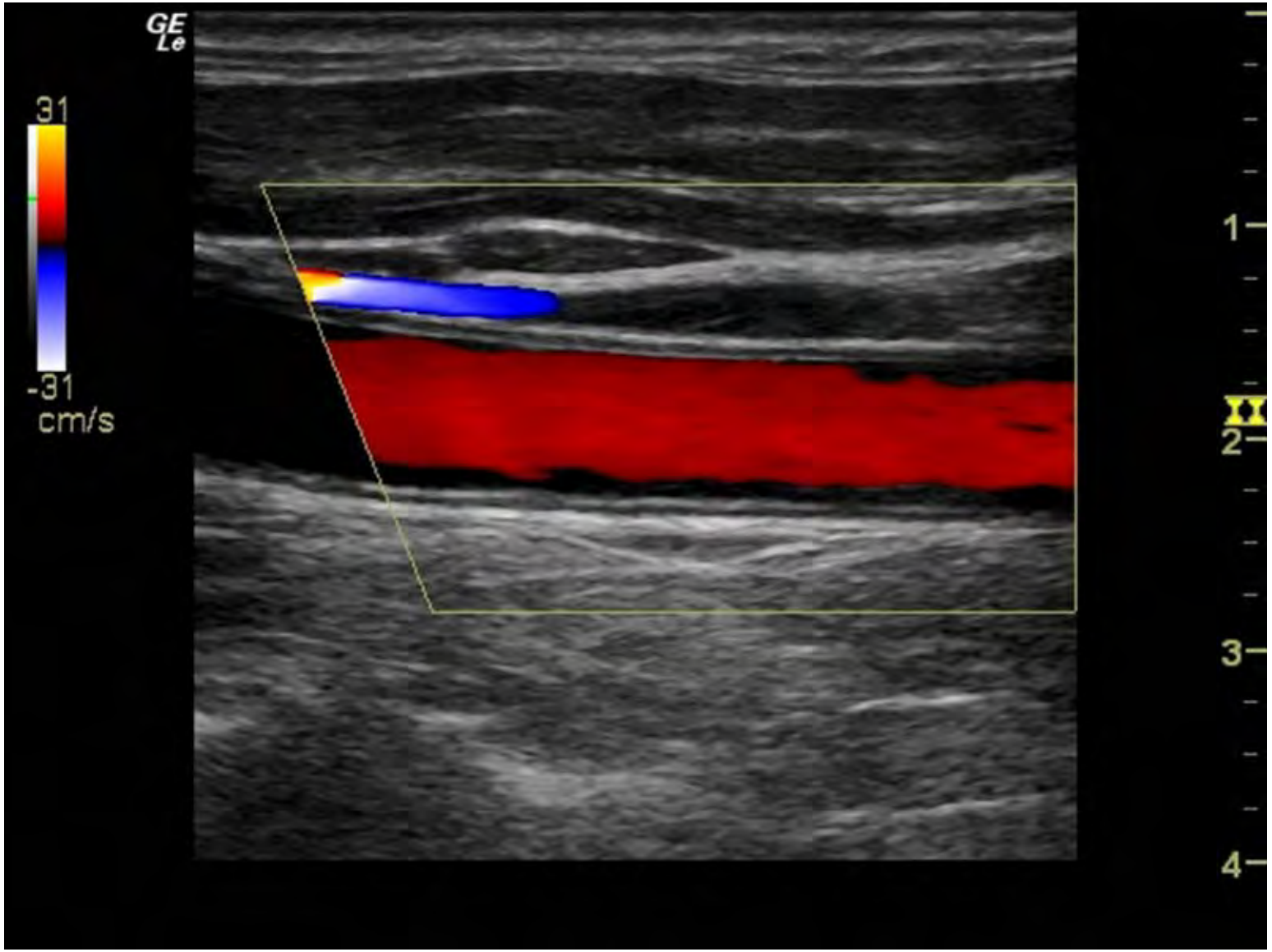
Reflection

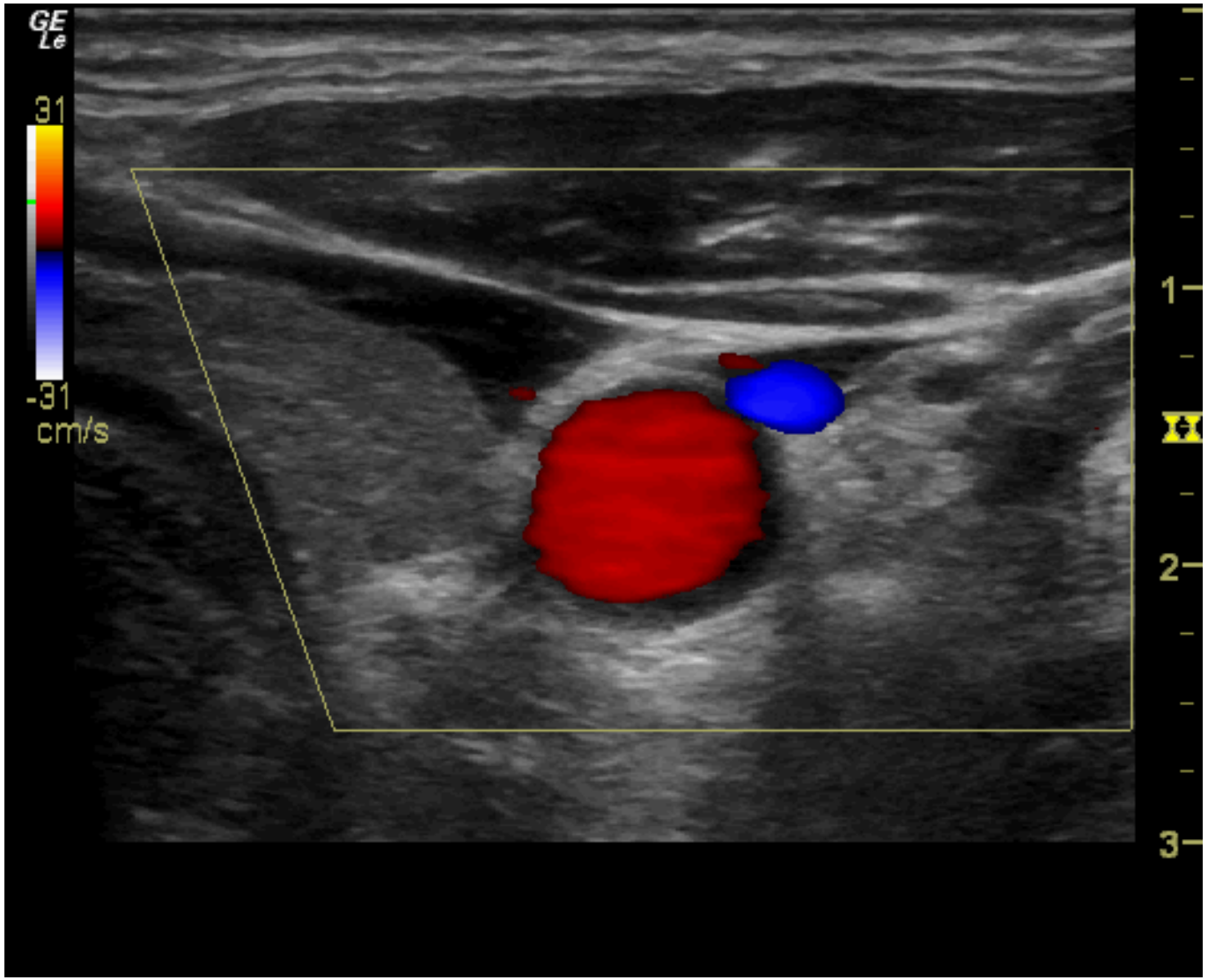


Doppler

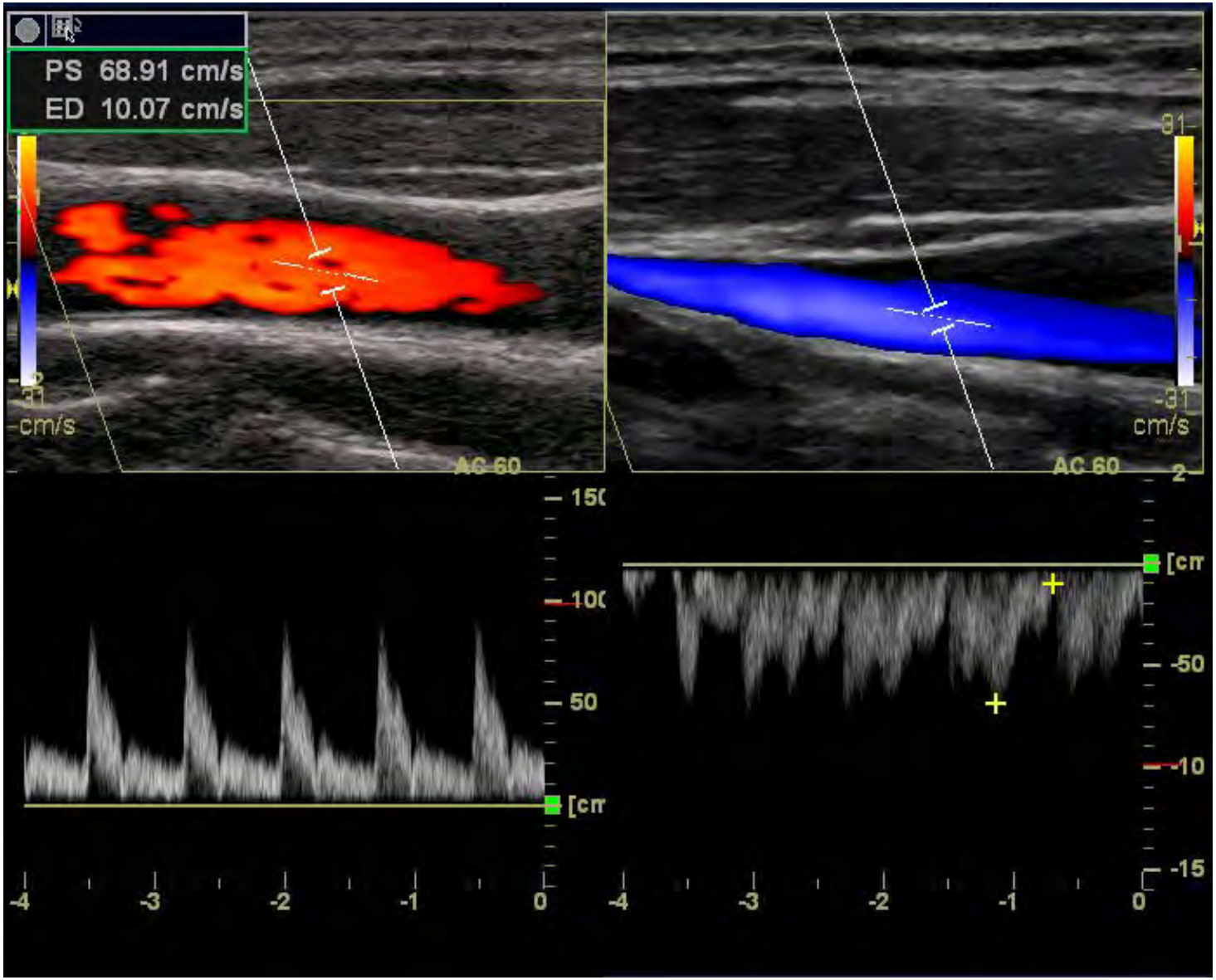
- Color Doppler
- Pulse Wave Doppler
- Power Doppler

Color Doppler: normal carotid artery and internal jugular vein




GE
Le
31
-31
cm/s
1
2
3

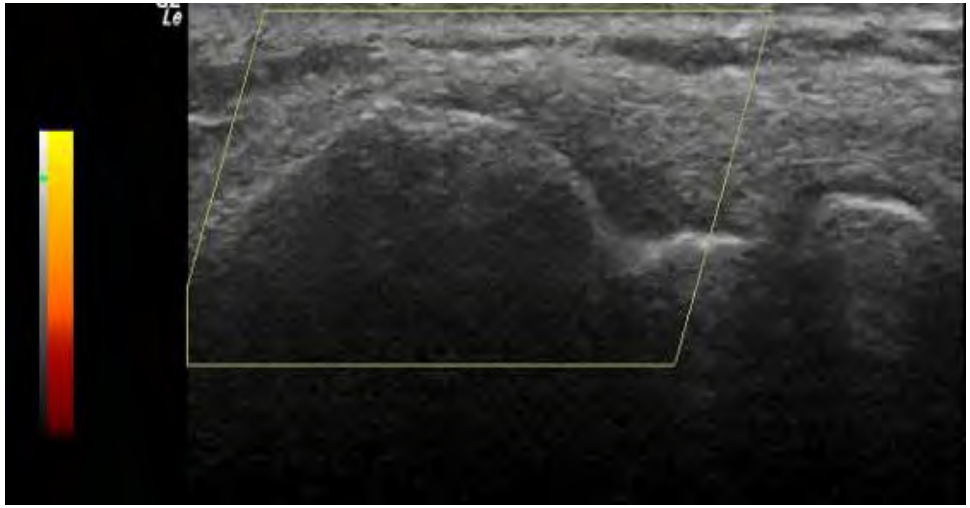
Pulse Wave Doppler



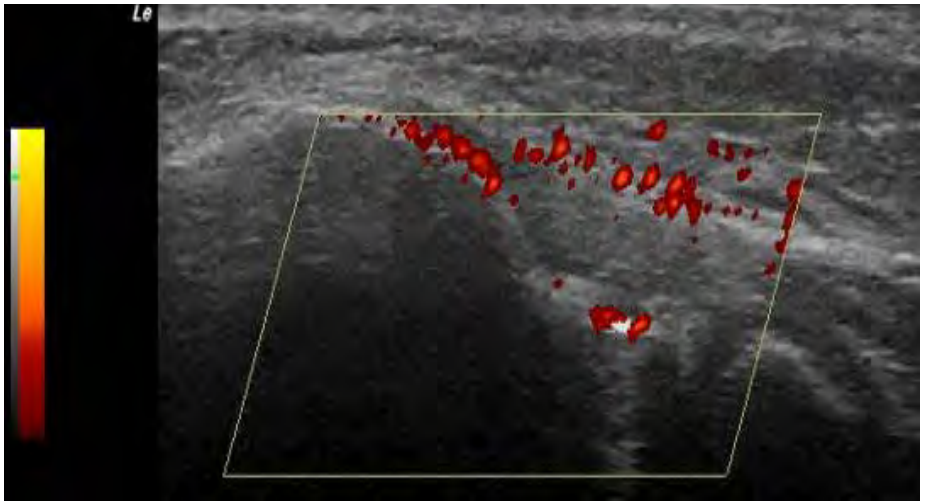
Power Doppler

Normal right elbow and lateral epicondylitis of the left elbow (tennis elbow)

Right



Left

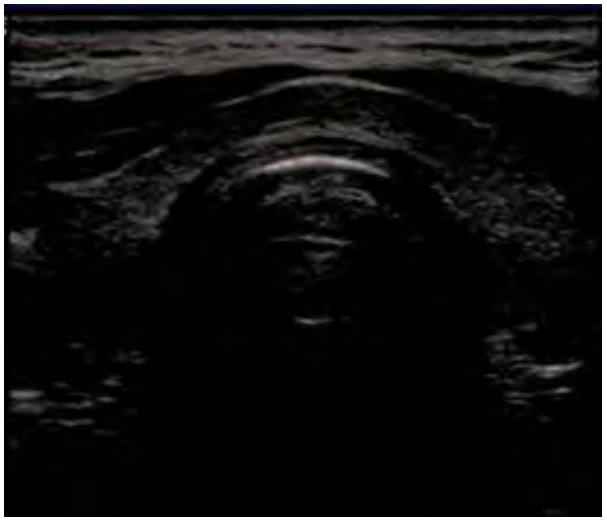


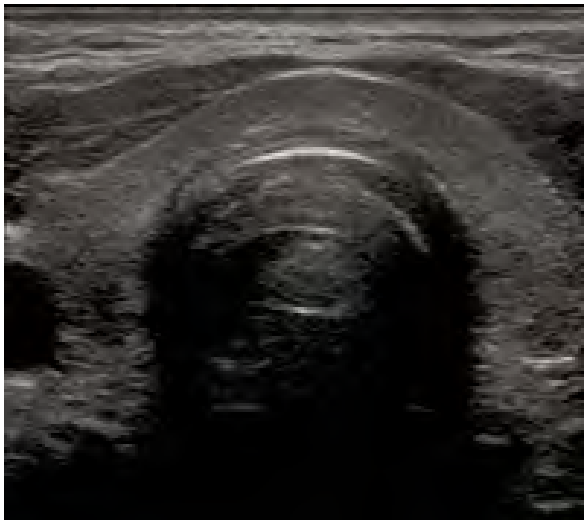
Ultrasound Knobology

- 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

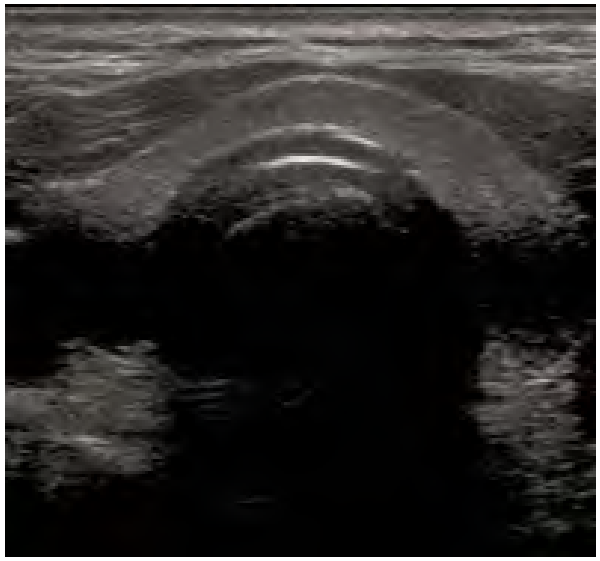
(Controls overall brightness of the image)

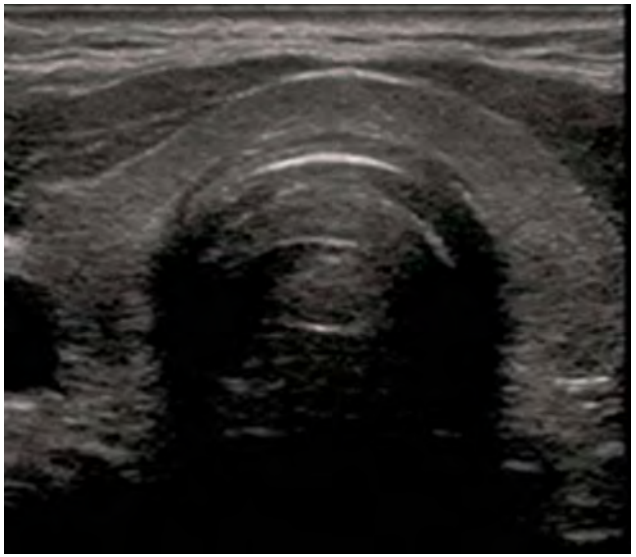


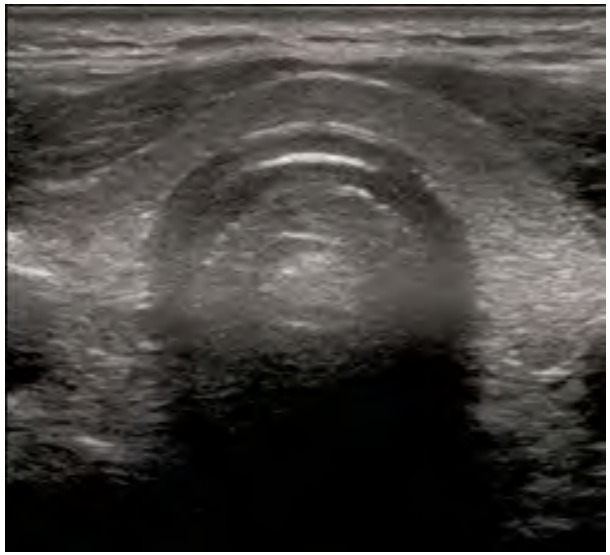


Time Gain Compensation (TGC)

(Allows adjustment of image brightness at selective depth)



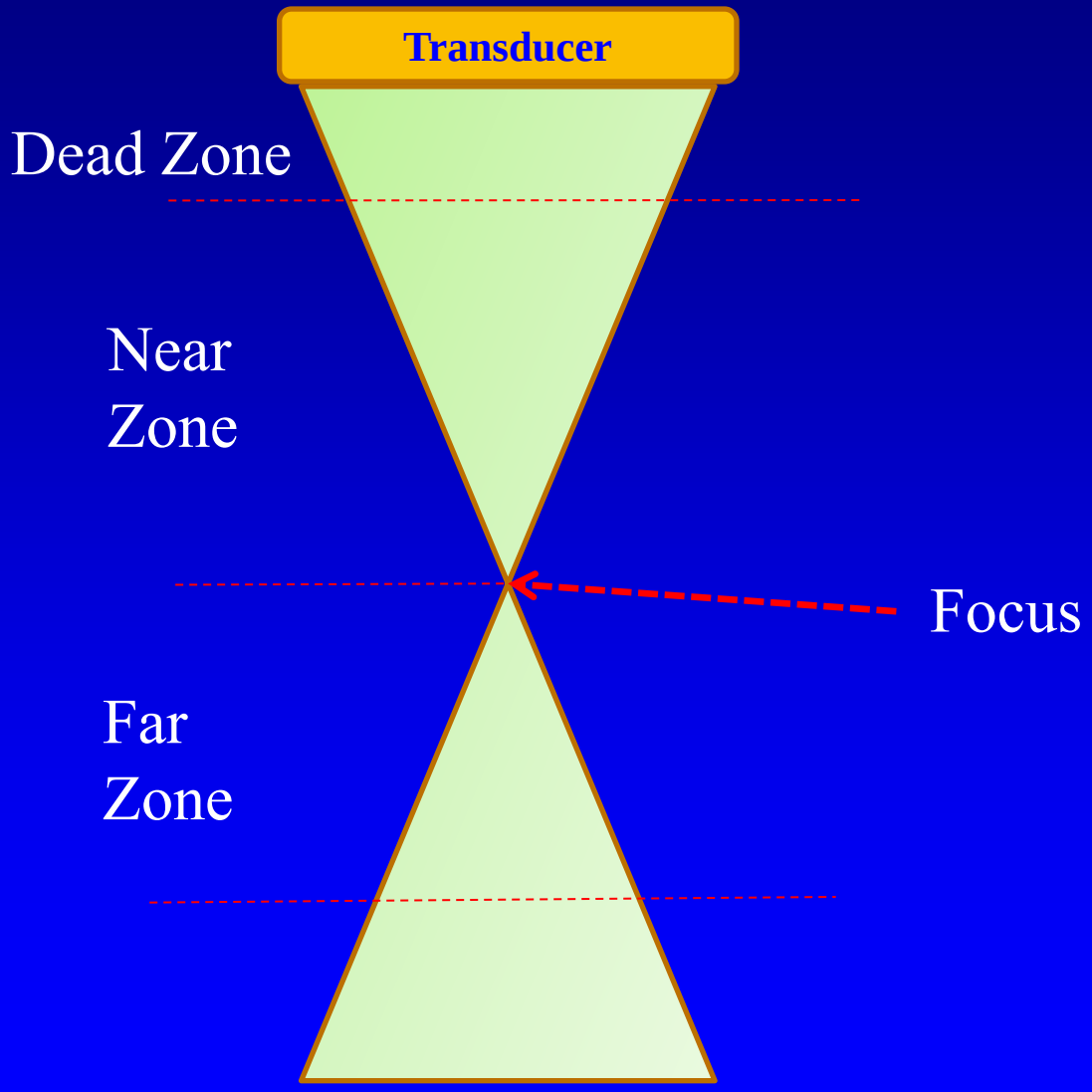




Depth Knob

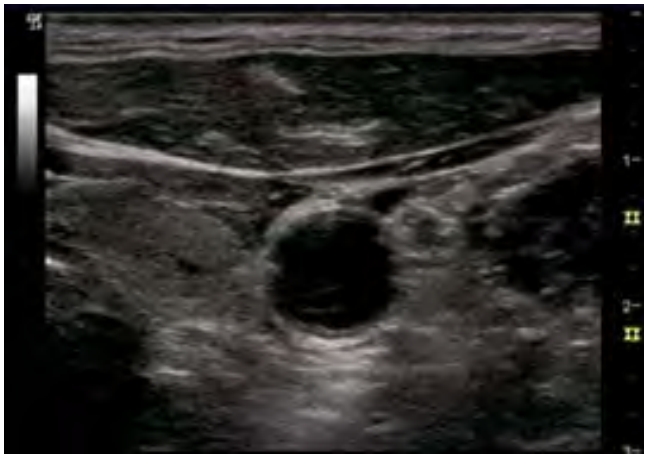
(Allows adjustment of the depth of field of view)

Focus



Focus Knob

(Allows focus of ultrasound beam to area of interest)



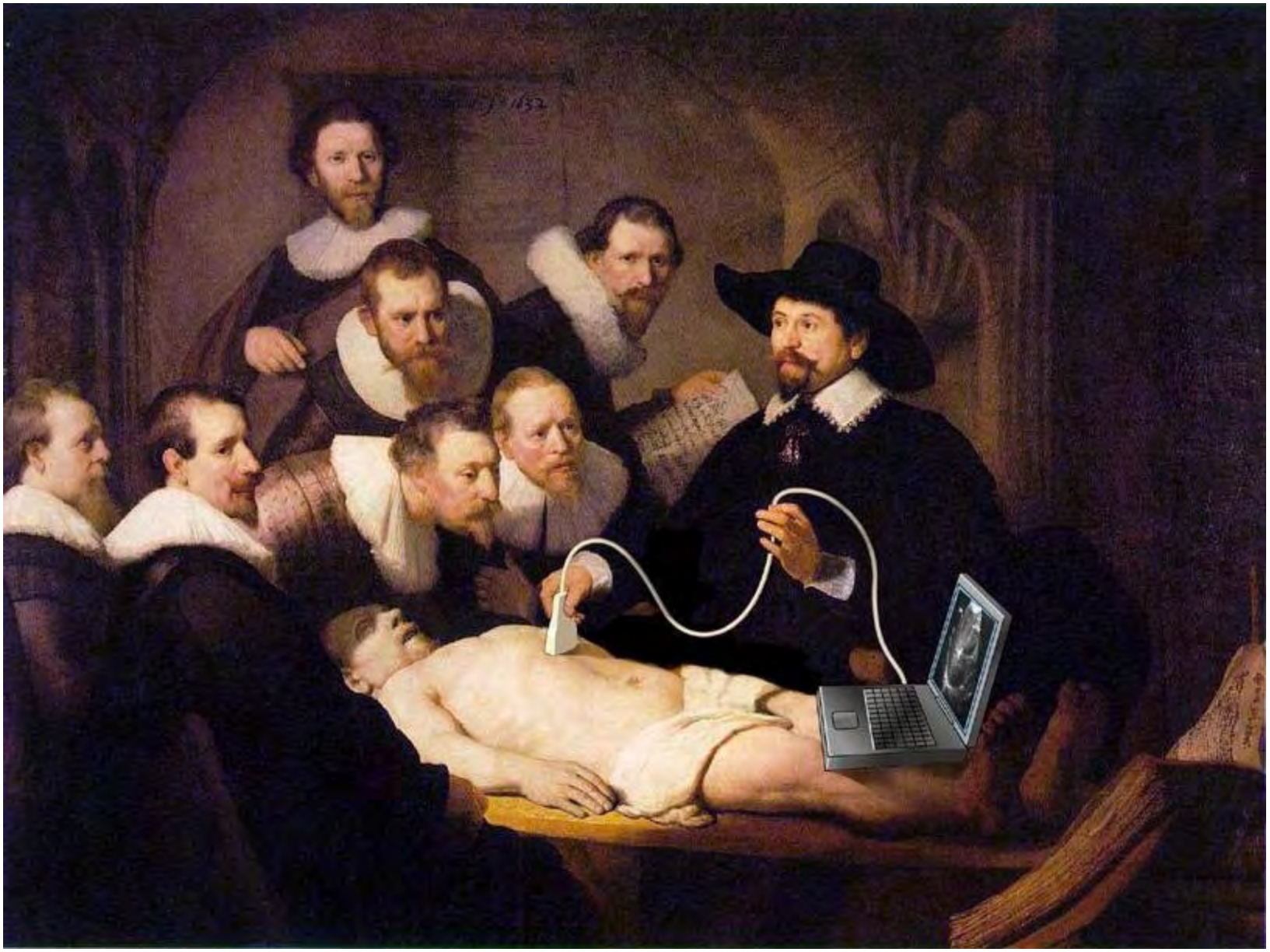
Frequency Knob

(Adjust Frequency to balance depth and resolution needs)

8.0 MHz

10.0 MHz

13.0 MHz



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