Physics and Knobology

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SOUND: Series of pressure waves traveling through a medium

- Physics Words
  - WAVELENGTH: Distance traveled in one cycle
  - FREQUENCY: Number of cycles per sec (Hertz)

What is “ULTRASOUND”

- Diagnostic US: 2.5-14 MHz
Fancy Words

- **PIEZOELECTRIC EFFECT:** crystals vibrate at a given frequency when an alternating current is applied

- **PULSE-ECHO MODE:** signal generation <1% of pulse cycle

Pulsed Wave Output

How it works

**ATTENUATION:** Reduction of intensity and amplitude

- **Absorption:** Most common, creates heat
- **Reflection:** “Echo”
ATTENUATION: Reduction of intensity and amplitude

- **Scattering**: non-homogeneous surface
- **Refraction**: Different densities

ALARA
“As low as reasonably achievable”

- No confirmed biological effects on patients or operators have been reported
- Intensities typical of diagnostic ultrasound

Ultrasound Modes

- **B-mode**: Brightness Mode: Different shades of gray
- **Motion Mode**: Displays returning echo’s along one line of B-mode over time
Color Doppler
The doppler shift

Direction and velocity are color-coded and projected on the B-mode image

Power Doppler

Does NOT examine flow velocity or direction of flow

Pulsed Wave Doppler

Displays "spectrum" of returned doppler frequencies

Transducers (aka: Probes)

Increasing frequency improves resolution at the expense of penetration

Increase 5-10 MHz

3.5-5 MHz

2-4 MHz

5-10 MHz
Transducer basics

**Convex Array:**
Sector Scanning - Resolution becomes poorer at greater depths

**Phased Array:**
Flat Head, crystals fire at variable time

**Transducer basics**

**Linear Array**

**Transducer Indicator**
“Probe Dot”
**Resolution:** Ability to delineate between 2 different objects

**Axial Resolution:**
The ability to separate objects linear to the ultrasound beam

**Lateral Resolution:**
Ability to separate 2 structures side by side

**Temporal Resolution:**
- Frames per second
- Higher the frame rate, the less “jerky” the image

**Echogenicity**
- **Hyperechoic**
- More echogenic than surrounding tissue
- Object has lots of echo’s, appears brighter
Echogenicity

- **Hypoechoic**
  - Less echogenic than surrounding tissue
  - Very few echo's, appears darker

Echogenicity

- **Anechoic / Echolucent**
  - Absence of returning echo's
  - Area is black

Probe Position and Image Orientation

- In relation to probe dot
  - Transverse
  - Longitudinal
  - Coronal / Sagittal

Image Orientation

- Longitudinal
- Transverse
Button Basics

Depth

- Shallower
- Deeper
• Gain
• Strength of returning echoes
• Amplifier
• Gain is adjusted differently depending on the machine
Goldilocks and the 3 Bears

Top overgained, Bottom undergained

Bottom overgained, Top undergained

Entire field overgained

Entire field undergained
Perfect gain top to bottom

Goldilocks and the 3 Bears

Make Gain Uniform

“I have messed around with the gain knobs, and now I can’t see anything...”

AUTO GAIN

Artifacts:
Attenuation Artifacts

• Shadowing
  • Partial or total reflection of sound
  • Weak or no transmission posterior

• Shadowing
  • High attenuating tissue leaves an acoustic shadow
Artifacts: Attenuation Artifacts

- **Posterior Enhancement**
- Area behind echo-weak or echo-free structure appears brighter

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Artifacts: Attenuation Artifacts

- **Posterior Enhancement**
- Echoes enhanced posteriorly behind low attenuating tissue

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Artifacts: Attenuation Artifacts

- **Edge Artifact** aka “Side Lobe”
- Sound waves are scattered when they encounter cystic wall or curved surface
- Energy loss

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**Artifacts: Propagation Artifacts**

- **Reverberation**
  - Sound encounters 2 highly reflective layers
  - Sound is bounced back and forth
  - Probe detects a longer traveling time

**Artifacts: Propagation Artifacts**

- **Reverberation**
  - Recurrent bright arcs at equidistant intervals

**Artifacts: Propagation Artifacts**

- **Comet Tail**
  - Narrowly spaced reverb
  - Very strong reflector

**Artifacts: Propagation Artifacts**

- **Mirror Imaging**
  - Sound glances off highly reflective surface (diaphragm)
  - Returning sound waves have longer travel time
  - Misinterpretation of “more liver”
Artifacts:
Mirror Image

Artifacts:
Propagation Artifacts
- Mirror Imaging
**Artifacts:**
Propagation Artifacts

- Mirror Imaging

- Troubleshooting

- Know your anatomy
- Define boundaries
- Choose the proper transducer
- Learn acoustic windows
- Go from wider view and zoom in
- Visualize the anatomy in two planes
- Maximize system controls - depth/gain/frequency
Image Acquisition Tips

- “I am having a hard time finding ____, do you have any tips?”
- Use more gel!
- Transducer movements
  - Fan
  - Angle
  - Rotate
  - Translocate / Try a new location (window)
- Only try one movement at a time

Questions?