Ultrasound Knobology

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Objectives

• Physics of ultrasound

• Equipment basics

• Image acquisition and adjustment
Ultrasound Physics in a Nutshell

- Ultra: Higher, greater
- Sound: Mechanical energy transmitted by pressure waves in a material medium
- Medical ultrasound: \( \geq 20,000 \text{Hz} \)
Penetration and Resolution

- Wavelength frequency determines:
  - Depth of penetration
  - Clarity of resolution

- **High frequency**:
  - Excellent resolution
  - Poor penetration
  - “Vascular probe”

- **Low frequency**:
  - Excellent penetration
  - Degraded resolution
  - “Abdominal / Cardiac”
Mechanism of Ultrasound

• Probe is composed of **pizoelectric crystals** arranged in arrays (linear, convex, etc)
• Acts as both generators and receivers of ultrasound energy
• Converts electrical energy to mechanical energy (vibrates crystals) and visa-versa
Wave Propagation

- What can happen to sound waves when they hit a tissue interface?
  - Reflect:
    - Bounces back like a mirror
  - Refract:
    - Penetrates at an angle
  - Scatter:
    - Useless result
  - Attenuate:
    - Absorption / loss of energy
Echogenicity of Targets

- **Hyperechoic**: White
  - Most sound waves reflected
  - Very few transmitted
  - Example: Bone

- **Hypoechoic**: Grey
  - Partial reflection
  - Partial transmission with refraction and attenuation
  - Example: Lymph node

- **Anechoic**: Black
  - No reflection
  - All sound waves attenuated
  - Example: Fluid

Air and Ca2+ are the enemy of ultrasound!!
Understanding the Equipment

- Operator
- "Knobology"
- Keyboard
- "Probe manipulation"
- Transducer
What is Knobology?
Purpose of Knobs

- Fix Image
  - Exam Setting
  - Depth
  - Gain

- Detect Motion
  - M-mode

- Measure
  - Calipers
  - Freeze
  - Save
  - Calculate
Image Acquisition and Adjustment
Measurements and Calculations
What is Gain?

• “Gain” is poorly understood by most beginners
• “Gain” refers to how light or dark the entire screen is
• Turning up the gain does not sharpen the image
  o It may actually make it worse
• Best analogy: Stereo amplifier
  o More gain = more loud
  o Does not help if you are tuned to static rather than a real station

A) Gain just right
B) Too much gain
C) Too little gain
What is Depth?

- Depth function is used to:
  - Magnify a key area for a procedure
    - Vascular access
  - Clarify the edges of the target and the surrounding structures
    - Diaphragm and lung
  - Best analogy:
    - Decreasing depth: zoom in
    - Increasing depth: zoom out
What is B-Mode?

- Brightness mode
- Basic 2-D ultrasound image
- Starting point for almost everything
- “Home base” button if you screw up and need to start over again
What is M-Mode?

- Motion mode
- Builds on B-mode function by adding a 3\textsuperscript{rd} variable which is the change over time
- Useful for detecting subtle movements:
  - Presence or absence of sliding lung
  - IVC diameter variability
  - Cardiac output calculations
What is Color Doppler?

• Detection of vascular structures
• Builds on basic doppler by adding color to indicate direction of flow:
  - **Red**: Does not equal arterial
  - **Blue**: Does not equal venous
• Depends on which direction your probe is facing
  - **Red**: Against flow of traffic
  - **Blue**: With the flow of traffic
Understanding the Probe

- Probe selection
- Probe orientation
- Probe movements
Probe Selection

• Depends on your purpose:
  • High frequency:
    o Excellent resolution
    o Poor penetration
    o “Vascular probe”
  • Low frequency:
    o Excellent penetration
    o Degraded resolution
    o “Abdominal / Cardiac”
Probe Orientation

- Notch on the probe = Dot on the screen
- Where is the dot?
  - Cardiologist: Right upper screen
  - All others: Left upper screen
- Bottom line:
  - Notch = Dot = Cephalad
Probe Movements

• 4 Basic movements
  1. Slide up & down along the target
     o Longitudinal cuts
  2. Rotate perpendicular to target
     o Transverse cuts
  3. Fan through the target
     o Oblique cuts
  4. Pushing in towards & away from target
Summary

- Choose the correct probe
  - Linear or convex
- Choose the correct exam setting
  - Vascular, cardiac or abdominal
- Minimize air interference
  - Gel and press hard
- Pick out artifacts from true pathology
- Adjust gain
  - Turn down is usually better than turning up
- Adjust depth
  - Zoom in on your target
- Be slow and gradual in your probe movements
- Be patient