BASIC ULTRASOUND

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Overview

- Advantages/Disadvantages
- Generation of Image
- Ultrasound Machine/Transducer selection
- Modes of Ultrasound
- Terminology
- Tissue Appearance
- Scanning Technique
Advantages

- Real-time
- Portable
- No ionizing radiation
- Inexpensive?
- Side-side comparison
- Patients love it!
- Guide procedures
Disadvantages

- Operator dependent
- Expensive?
- Limited penetration through bone and air
- Imaging deep structures
Electric field applied to piezoelectric crystals located on transducer surface
- Mechanical vibration of crystals creates sound waves
- Each crystal produces an US wave
- Summation of all waves forms the US beam
- Wave reflects as echo that vibrates transducer
- Vibrations produce electrical pulses
- Scanner processes and transforms to image
- Frequency 1-18 megahertz (mHz)
  - Lower frequencies = less resolution but deeper penetration
    - E.G. kidney, liver 1-6 mHz
  - Higher frequencies = smaller wavelength
    - capable of reflecting from smaller structures
    - Readily absorbed by tissue = less penetration
    - Higher frequency = higher resolution
    - E.G. Muscles, tendons 7-18 mHz
Basic Components of Ultrasound Machines

- **Pulser** - applies high amplitude voltage to energize crystals
- **Transducer** – Converts electrical energy to mechanical (ultrasound) energy and vice versa
  - **Two types of transducers**
    - **Linear** - sound wave is propagated in a linear fashion parallel to the transducer surface
      - Ideal for MSK US
    - **Curvilinear** – increases field of view.
      - Ideal for visualization of deeper structures
- **Receiver** – detects and amplifies signals
Which probe to pick?
- Surface area of skin/transducer
- Frequency of emitted sound wave
Ultrasound Probe

- Which probe to pick?
  - Surface area of skin/transducer
  - Frequency of emitted sound wave
Curvilinear Probe

- Large foot print
- Low Frequency = Increased Depth
- Abdominal US
Phased Array Probe

- Smaller foot print
  - (fits between the ribs)
- Low frequency
- Echo or abdominal US
Linear Probe

- Flat foot print
- High frequency
  - Maximum depth 10-13 cm
- Musculoskeletal or vessel US
Hockey Stick Probe
B-mode (2D mode) — linear array of transducers simultaneously scan a plane through the body
  – Two-dimensional cross-section of tissue
– Doppler mode – Measuring and visualizing blood flow
– Duplex – simultaneous presentation of 2D and doppler information
Acoustical impedance – Sound wave encounters material with different density, and wave is reflected back as an echo.

- Gas or solids – Most of the acoustic energy is reflected -> impossible to see deeper
Reflection – some of sound energy strikes a boundary between media and is returned to the transducer
  - degree of impedance mismatch at tissue interface
    - amount of reflection

Refraction - change in direction of wave propagation when traveling from one medium to another
Angle of incidence

- US wave hitting a smooth interface at 90 angle will result in a perpendicular reflection
  - Strong, bright signal
- US wave hitting the surface at an angle < 90 will result in the wave being deflected away from the transducer an an angle equal to the angle of incidence but in the opposite direction (angle of reflection)
  - Weak, darker image
Terminology

- **Incident Beam**
- **Reflected Beam**
- **Transmitted Beam**

- $\theta_i$
- $\theta_r$
- $\theta_t$
Echogenicity – a method of describing the reflecting echos

- Hypoechoic – Darker (less reflection)
- Hyperechoic – Brighter (more reflection)
- Anechoic – Black (No echos)
- Isoechoic – Equal
Attenuation: A decrease in intensity, power and amplitude as a sound wave travels

Gain: Adjusting the intensity of the acoustic pulse, with the result being a stronger echo
Terminology

- Near field – Top of screen
- Far field – Bottom of screen
Anisotropy

- Tissue NOT imaged perpendicular to the sound beam
- Appears artifactually hypoechoic
- Can be confused with pathology
**TISSUE**

- **Veins**
  - Anechoic, compressible

- **Arteries**
  - Anechoic, pulsatile

- **Fat**
  - Hypoechoic with irregular hyperechoic lines

- **Muscle**
  - Hypoechoic, but separated with hyperechoic septa

- **Tendon**
  - Hyerechoic & fiber-like

- **Ligaments**
  - Like tendons, but more compact

- **Bone**
  - Hyperechoic lines with a hypoechoic shadow

- **Nerves**
  - Starry night appearance: transverse
Tissue Appearances
TissueAppearances
Basic Scanning Technique

- Select transducer
  - Hold transducer between thumb and fingers of dominant hand.
  - Stabilize transducer on the patient with the small finger of the heel of the imaging hand

- Apply gel to the transducer
  - Eliminates air between the probe and skin surface
  - “Air is the enemy”

- Palpate area of interest and identify what you are looking for
Locate area of interest with ultrasound

Adjust the depth of the sound beam
- Structure of interest is visible and centered in the image

Select desired optimization setting from on-screen menu
- Res = best resolution possible
- Gen = balance between resolution and penetration
- Pen = best penetration possible
Basic Scanning Technique

- Adjust gain
  - Amplifies return echos (adjusts brightness of the image)
    - May use autogain
    - May adjust for near or far field
Basic Scanning Technique

- Image orientation
  - Index Mark
    - Orientates probe to your screen
    - Keep on left side of the screen
  - Proximal aspect of a structure on the left side of the image and the distal aspect on the right

- Describing orientation
  - Two views
    - Transverse
    - Cross section
    - Longitudinal
    - Long axis
Scanning Technique

- Heel-toe when transducer is rocked or angled along the long axis of the transducer
- Toggle – transducer is angled from side to side
Practical Tips:

- Use highest frequency that allows US to image the depth of the structures of clinical interest
  - Image depth decreases as frequency of US increases
  - Move focal zone on screen to level at area of interest
- Youtube
  - Excellent source for Sonsosite product information and instruction on ultrasound
Ultrasound Curriculum

- Four parts
  - Introduction to US
  - OB US
  - MSK US
  - FAST (Focused Assessment with Sonography for Trauma)
    - Will include venous US
- gfresidency.com
References

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- Wikipedia “Medical Ultrasonography”