Overview

- Advantages/Disadvantages
- Image generation
- Machine/Transducer selection
- Ultrasound modes
- Terminology
- Tissue appearance
- Scanning technique
Advantages

- Real-time
- Portable
- No ionizing radiation
- Relatively inexpensive
- Side-side comparison
- Patient acceptability
- Procedure guidance

Disadvantages

- Operator dependent
- Expensive?
- Limited penetration through bone and air
- Imaging deep structures
Generation of Image

- Electric field applied to piezoelectric crystals on transducer surface
- Mechanical vibration of each crystal creates sound wave
- Summation of all waves forms US beam
- Returning echoes vibrate transducer
- Vibrations converted to electrical pulses
- Scanner processes to form image
Physics

- Frequency 1-18 megahertz (mHZ)
- Lower frequency = less resolution, deeper penetration
  - E.G. kidney, liver 1-6 MHz
- Higher frequency = shorter wavelength
  - More resolution, greater absorption, less penetration
  - E.G. muscles, tendons 7-18 MHz
Machine Components

- **Pulser** - applies high amplitude voltage to energize crystals
- **Transducer** - converts electrical to mechanical energy and vice versa
  - 2 types
    - Linear - sound wave propagated in linear fashion parallel to transducer surface - ideal for MSK
    - Curvilinear - increased field of view - ideal for deeper structures
- **Receiver** - detects and amplifies signal
Probes (Transducers)

- Which probe to pick?
  - Surface area of skin/transducer
  - Frequency
  - Scan depthless interest
Curvilinear

- Large footprint
- Lower frequency
- Greater depth
- Abdominal US

Curvilinear Probe: General OB and Abdominal applications

Linear, High Frequency Probe: vascular, small parts and MSK applications

Endo-Cavity Probe: Vaginal, Rectal applications. Very useful in early pregnancy

Cardiac Probe: Used for Echocardiography applications
Phased Array (cardiac)

- Small footprint
- Fits between ribs without rib shadows
- Lower frequency
- Cardiac, lung, abdominal

Curvilinear Probe: General OB and Abdominal applications

Linear, High Frequency Probe: vascular, small parts and MSK applications

Endo-Cavity Probe: Vaginal, Rectal applications. Very useful in early pregnancy

Cardiac Probe: Used for Echocardiography applications
Linear

- Flat footprint
- High frequency
  - Depth = 60/frequency
- MSK, vascular, small parts

Hockey stick
Ultrasound Modes

- B-mode (2D)
  - 2 dimensional cross-section
- Doppler
  - Measuring and visualizing blood flow
- Duplex
  - Simultaneous presentation of 2D and Doppler
Terminology

- Acoustical impedance
  - Wave encounters material with different density
  - Wave reflected as echo
- Gas/solids
  - Most energy is reflected preventing visualization beyond
Terminology

• **Reflection**
  - Some energy strikes a boundary between media and is returned to transducer
  - More impedance mismatch at tissue interface, greater amount of reflection

• **Refraction**
  - Change in direction of wave propagation when traveling from one medium to another
Terminology

• Angle of incidence

  • Wave hitting smooth interface at 90 degrees will result in perpendicular reflection - strong, bright signal

  • Wave hitting interface at less than 90 degrees will result in wave deflection from transducer at angle opposite to angle of incidence (angle of reflection) - weaker, darker image
Terminology

- **Echogenicity** - describes reflecting echoes
  - Hypoechoic - darker (less reflection)
  - Hyperechoic - brighter (more reflection)
  - Anechoic - black (no reflection)
  - Isoechoic - Equal (mid-point of gradient from anechoic to hyperechoic)
Terminology

- **Attenuation**
  - Decrease in intensity, power and amplitude as sound wave travels

- **Gain**
  - Adjusting intensity of acoustic pulse creating stronger echo
Terminology

- Near field
  - Top of screen, nearest transducer
- Far field
  - Bottom of screen, furthest from transducer
Terminology

• **Anisotropy**
  
  • Tissue **NOT** imaged perpendicular to beam
  
  • Appears artificially hypoechoic
  
  • Can be confused with pathology
<table>
<thead>
<tr>
<th>Tissue</th>
<th>US Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veins</td>
<td>Anechoic, compressible</td>
</tr>
<tr>
<td>Arteries</td>
<td>Anechoic, pulsatile</td>
</tr>
<tr>
<td>Fat</td>
<td>Hypoechoic with irregular hyperechoic lines</td>
</tr>
<tr>
<td>Muscle</td>
<td>Hypoechoic but separated with hypoechoic septa</td>
</tr>
<tr>
<td>Tendons</td>
<td>Hyperechoic &amp; fiber-like</td>
</tr>
<tr>
<td>Ligaments</td>
<td>Like tendon but more compact</td>
</tr>
<tr>
<td>Bone</td>
<td>Hyperechoic line with hypoechoic shadow</td>
</tr>
<tr>
<td>Nerves</td>
<td>Starry-night appearance on transverse view</td>
</tr>
</tbody>
</table>
Appearance of normal structures

**Bone/calcification**

- Surface very hyperechoic
- Posterior shadowing
- Posterior reverberation if smooth and flat
Appearance of normal structures

Tendons

- Hyperechoic
  - LAX
    - fibrillar
  - SAX
    - hyperechoic, dense
    - bristle

Fig. 3: Supraspinatus Short Axis
Individual - Interface - Identification

A. Humeral Cortex
B. Hyaline Cartilage
C. Supraspinatus Tendon
D. Bursal Interface between tendon & muscle
Appearance of normal structures

Ligaments

- Hyperechoic
- Not as bright as tendons
- Striated appearance
- More compact than tendon
- Connect bone to bone
Appearance of normal structures

Muscles

- relatively hypoechoic
- separated by hyperechoic bands
- "Bands and bundles"
- **SAX**: speckled echoes with bright curvilinear lines
Appearance of normal structures

Bursa

- Normally not visible
- anechoic/black line
- surrounded by hyperechoic peribursal fat
- can be compressible
Appearance of normal structures

**Hyaline Cartilage**
- hypoechoic and uniform
- covers articular surface
- variable thickness

**Fibrocartilage**
- homogeneous
- Triangular
Artifacts

Anisotropy

- occurs when beam not perpendicular to tissue being interrogated
- mainly tendons & ligaments
- become hypoechoic or anechoic
- can be used to advantage
Artifacts

Shadowing

- occurs when beam reflected, absorbed, or refracted
- anechoic area extending deep to bone, calcification, foreign body
Artifacts

RefRACTile shadowing

- occurs at edge of some structures
- foreign body or torn tendon
Scanning Technique

• Select Transducer

• Hold transducer between thumb and fingers of dominant hand

• Stabilize transducer on patient with ulnar border of hand

• Apply gel to transducer

• Eliminate air (the enemy) between probe and skin surface

• Palpate and identify area of interest
Scanning Technique

- Adjust, frequency, depth (B), focal zone (C) and gain (D).
  (where available)
Scanning Technique

- Image orientation

- Index mark
  - Orientes probe to screen and should be oriented to screen marker (always present, look for it)
  - Proximal aspect will be on left, distal on right (assuming probe marker correctly oriented)

- Orientation
  - Sagittal - marker directed cranial
  - Transverse - marker directed to screen marker (usually patient’s right)
Scanning Technique

- Heeling and Toeing
  - Transducer is rocked or angled along its long axis
- Toggling
  - Transducer is angled from side to side