Image Optimization and Interpretation

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Outline:
• Basic Physics
• Ultrasound Equipment
• Scanning Technique
• Image Interpretation
• Pathology Examples

Sound Wave Frequencies
• Human hearing: 20 Hz to 20KHz
• Low frequency, low intensity treatment: 40 KHz
  – Non-contact wound treatment
• Low intensity pulsed (1.5 MHz): bone healing
• High intensity focused ultrasound: HiFU
  – 200 KHz – 4 MHz: tissue necrosis
• Diagnostic imaging: 1 – 20 MHz

Sound Wave
• Reflection:
  – Specular: mirror-like
  – Scattering or diffuse
• Refraction
• Absorption
• Attenuation

Probe: piezoelectric crystal
• Electricity converted to vibrations
• Sound wave reflects at interfaces
• Bright echo: high impedance differences
  – Bone – soft tissue
  – Air – soft tissue
• Crystal receives echo => image
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Equipment: probe selection
- Frequency determines resolution
  – High frequency = high resolution
  – Poor depth penetration
- Superficial structures: 10 – 17 MHz
  – Distal extremities and peripheral nerves
- Deep: 5 – 7 MHz linear or curvilinear
  – Thigh or hip

Ultrasound Probes

12 - 5 MHz
Linear

15 - 7 MHz
Compact linear

9 - 4 MHz
Curvilinear

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Scanning: basics
- Holding transducer:
  – Anchor hand/transducer
  – 5th finger or hand on patient
- Coupling gel
- Imaging plane:
  – Long axis of transducer

Scanning: basics
- Beam is focused
  – Narrower than transducer width
  – < 2 mm
- Sweep transducer slowly
  – Only millimeters at a time
Scanning: basics
1. Select appropriate transducer
2. Adjust depth
3. Optimize focal zone location
4. Adjust gray scale gain

Image Appearance:
• Top of image: skin surface
• Bottom of image: deep away from transducer
• When imaging long axis of structure:
  – Left side of image: proximal
  – Right side of image: distal

Ergonomics
• Transducer hand lower than shoulder
• Elbow near side (arm not extended)
• Hand touching patient
• Chair
• Monitor with 45 degrees of patient to avoid excessive back torsion
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Ultrasound Appearance:
- Tendon: hyperechoic, fibrillar
- Muscle: relatively hyperechoic
- Bone cortex: hyperechoic, shadowing
- Fluid: anechoic, posterior enhancement

Artifacts:
- Anisotropy
- Shadowing
- Attenuation
- Reverberation
- Increased through transmission
- Refraction

Anisotropic Effect:
- Tendon not imaged perpendicular to sound beam
- Appears artifactually hypoechoic
- May simulate pathology
- Tendon, ligament, muscle
Scanning: basics

- Heel-toe maneuver
  - Evaluating long axis of tendon
  - Eliminate anisotropy

- Toggle
  - Evaluating short axis of tendon
  - Help identify tendon
  - Eliminate anisotropy

Shadowing

- Occurs at interface with high impedance differences
- Surface of object is irregular
- Sound beam is absorbed
- Bone, calcification, gas
- Foreign bodies

Attenuation

- Occurs where soft tissues are dense or many interfaces
- Sound beam is partially absorbed
- Fibrous tissue
- Fatty infiltration of muscle
- Consider low frequency transducer

Reverberation

- Occurs when sound beam hits smooth surface
- Sound beam reflected back and forth between object and transducer
- Ring down linear echoes
- Metal, glass, bone cortex

Increase Through Transmission

- Occurs when sound beam passes through fluid or homogeneous mass
- Sound beam brighter deep to object
- Fluid
- Solid mass: nerve sheath tumor, metastasis, etc.
**Refraction**

- Occurs when sound beam hits edge of tendon at site of tear
- Oblique shadow
- Patellar and Achilles tendon tears

**Color and Power Doppler**

- Increased blood flow or hyperemia
  - Neovascularity: tumor, tendinosis
  - Inflammation
- Not seen in normal tendon, ligament, or peripheral nerve
- Pitfall:
  - Avoid too much transducer pressure
  - Obscure flow

**Color Doppler Imaging**

- Vascular Tumor
- Synovitis

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**Tendon: supraspinatus**

- Tear
- Normal

**Muscle: triceps**

- Tear
- Normal
**Take Home Points**

- Optimize image
- Scanning technique:
  - Stabilize transducer on patient with hand
  - Move transducer small amount at a time
  - Beware: anisotropy

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