USE OF ULTRASOUND IN MUSCULOSKELETAL MEDICINE

Bradley Bley, D.O., FAAP, RMSK, CSCS
Primary Care Sports Medicine
Internal Medicine/Pediatrics
Delaware State University - Head Team Physician
Christiana Care Health System –
Faculty: Med/Peds Residency Program
Assistant Program Director: Primary Care Sports Medicine Fellowship
OBJECTIVES

• The basics of musculoskeletal ultrasound
• Why use musculoskeletal ultrasound?
• Injections and procedures under ultrasound-guidance
ULTRASOUND BASICS
DISADVANTAGES

• Small field of view
• Poor image presentation
• Difficult to image cartilage and deep joints in their entirety
• Contrast-enhanced MRI provides a better measure of capillary permeability and extracellular fluid
• Limited training opportunities
ADVANTAGES

• Use at point of care
• No radiation exposure
• Cost
• Not limited by patient motion or issues with claustrophobia
ADVANTAGES

• Ability to move and stress musculoskeletal structures
• Guided therapy
• Identification of calcium deposits
• Color flow Doppler studies provide a measure of neovascularization
EFFECTIVE IN VISUALIZING

- Tendinopathy
- Tendon/Ligament Tears
- Bursitis
- Synovitis
- Joint Erosions
- Calcifications
- Muscle Tears
- Loose Bodies
- Foreign Bodies
- Mortons Neuroma
- Nerve Entrapment or subluxation
EFFECTIVE IN VISUALIZING
**TERMINOLOGY**

- Hypoechoic – a structure that contains weak or lower amplitude echoes
- Hyperechoic – a structure that contains strong or higher amplitude echoes
- Anechoic – a structure that has no echoes
- Isoechoic – structure similar in echogenicity
- Homogeneous – a uniform or smooth texture
- Heterogeneous – non-uniform or irregular texture
TYPICAL APPEARANCE OF STRUCTURES ON ULTRASOUND
ANISOTROPY

Tendon

Anisotropy
FLUID/ENHANCEMENT
ATTENUATION

Normal Femoral Condyle

Patellofemoral Arthritis
SKIN AND SOFT TISSUE
MUSCLE
LIGAMENT
NEUROVASCULAR STRUCTURES

Legend: a, ulnar artery; arrowheads, flexor retinaculum; d, flexor digitorum profundus tendons; fcr, flexor carpi radialis tendon; fpl, flexor pollicis longus tendon; s, flexor digitorum superficialis tendons; void arrow, ulnar nerve; white arrows, median nerve

European Society of Musculoskeletal Radiology
BONE AND CARTILAGE

“High-resolution ultrasound is emerging as an important imaging modality in fracture assessment due to its availability, ease of use and multiplanar capabilities.”
- Hoffman, et al. BJSM 2015
Ability to move and stress musculoskeletal structures
Guided therapy
Identification of calcium deposits
Color flow Doppler studies provide a measure of neovascularization

ADVANTAGES
ABILITY TO MOVE AND STRESS MUSCULOSKELETAL STRUCTURES
ABILITY TO MOVE AND STRESS MUSCULOSKELETAL STRUCTURES
ABILITY TO MOVE AND STRESS MUSCULOSKELETAL STRUCTURES

R 1ST MCP ULNAR AT 30 DEG FLEX
ULTRASOUND GUIDED PROCEDURES

- Joint aspiration/injection
- Cyst Aspirations
- Nerve blocks
- Tendon Sheath Injections
- Percutaneous Tenotomy
- Percutaneous Myotomy
- Platelet Rich Plasma (PRP) Injections
- Hydrodissection
- Botox injections
GUIDED THERAPY

Perilabral Cyst - US

Perilabral Cyst - MRI
GUIDED THERAPY
GUIDED THERAPY

Meniscal Cyst
GUIDED THERAPY

Cyst aspiration/injection
IDENTIFICATION OF CALCIUM DEPOSITS

Barbotage Procedure
IDENTIFICATION OF CALCIUM DEPOSITS

Barbotage Procedure

L SHOULDER BARBOTAGE

R SHOULDER BARBOTAGE
IDENTIFICATION OF CALCIUM DEPOSITS

Barbotage Procedure

L ACHILLES LAX DISTAL
IDENTIFICATION OF CALCIUM DEPOSITS

Barbotage Procedure
97% of sonographically placed needles were accurate (Smith et al. 2009)
HIP

LFCN INJ
SHOULDER

R SA BURSA INJ
INTRA-ARTICULAR

Rutten et al. 2009
INTRA-ARTICULAR
INTRAARTICULAR

R GH JOINT
ANKLE
PTT TEAR
PTT TENOSYNOVITIS
ELBOW
ELBOW - ULNAR NERVE INJURY
ELBOW – ULNAR NERVE INJURY
HAND

R TRV AT A2

R TRV AT A2 W RESISTED FLEXION

L A2 LAX

L A2 LAX WITH RESISTED FLEX
WRIST
US GUIDED INJECTION BENEFITS

- Real Time Imaging
- Absence of ionizing radiation
- Use at point of care
- Better visualization of soft tissue structures
- No need for contrast agents
- Decreased injection pain
- Improved accuracy
- ? Improved effectiveness?
- ? Decreased cost?
The use of imaging improved injection accuracy:
- glenohumeral joint: 95% vs 79%
- subacromial space: 100% vs 63%
- acromioclavicular joint: 100% vs 45%
- knee: 99% vs 79%
# GUIDED THERAPY


Table 2. Rates of accurate injections with ultrasound or clinical examination guidance*

<table>
<thead>
<tr>
<th>Joint injected</th>
<th>Ultrasound guided</th>
<th>Clinical examination guided</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>All joints</td>
<td>76/92 (83)</td>
<td>61/92 (66)</td>
<td>0.010</td>
</tr>
<tr>
<td>Shoulder</td>
<td>12/19 (63)</td>
<td>8/20 (40)</td>
<td>0.137</td>
</tr>
<tr>
<td>Elbow</td>
<td>10/11 (91)</td>
<td>7/11 (64)</td>
<td>0.100</td>
</tr>
<tr>
<td>Wrist</td>
<td>11/14 (79)</td>
<td>12/16 (75)</td>
<td>0.817</td>
</tr>
<tr>
<td>Knee</td>
<td>32/35 (91)</td>
<td>27/33 (82)</td>
<td>0.242</td>
</tr>
<tr>
<td>Ankle</td>
<td>11/13 (85)</td>
<td>7/12 (58)</td>
<td>0.131</td>
</tr>
</tbody>
</table>

* Values are the number of joints accurately injected/total number injected (%).
GUIDED THERAPY

• Lee et al. Sonographically Guided Tendon Sheath Injections Are More Accurate Than Blind Injections. Implications for Trigger Finger Treatment. 2011.
  - Cadaver study
  - Dye observed in tendon sheath (optimal outcome) in 70% of UGI and 15% of blind injections
  - Dye observed in tendon proper (unsafe outcome) in 30% of blind injections and 0% of UGI
GUIDED THERAPY

  • Cadaver study
  • Ultrasound-guided injections were 100% (20 of 20) accurate
  • Palpation-guided injections were 60% (12 of 20) accurate (P = 0.008).
    • 2/6 of the partially accurate and 2/2 of the inaccurate injections were intratendinous.
GUIDED THERAPY - OUTCOMES

  - Greater improvement in pain and shoulder function at 6 weeks
  - More adverse events (all mild) with blind injections (not statistically significant)
GUIDED THERAPY - OUTCOMES

  - Shoulder pain of multiple origins
  - 103 patients: 54 accurate, 49 “outside” the capsule as seen on fluoroscopy; 52.4% accuracy rate
  - Accuracy of injection was not related to physician experience
  - 4 week f/u: all patients improved significantly in regards to pain and self-reported function
GUIDED THERAPY
That's nice but what about cost?

- Sibbitt et al. A Randomized Controlled Trial of the Cost-Effectiveness of Ultrasound-Guided Intraarticular Injection of Inflammatory Arthritis. 2011

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Palpation-Guided Injection</th>
<th>Ultrasound-Guided Injection</th>
<th>Difference, %</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. subjects</td>
<td>120</td>
<td>124</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain at outcome, mean VAS at 6 mo., cm</td>
<td>5.3 ± 2.8</td>
<td>4.0 ± 3.2</td>
<td>−25</td>
<td>−39 to −10</td>
<td>0.001*</td>
</tr>
<tr>
<td>Duration of therapeutic effect, mean mo</td>
<td>3.8 ± 1.8</td>
<td>5.0 ± 1.5</td>
<td>+32</td>
<td>−216 to +43</td>
<td>0.0001</td>
</tr>
<tr>
<td>Time to next procedure (reinjection or referral to surgery), mean mo</td>
<td>7.7 ± 3.4</td>
<td>8.6 ± 3.2</td>
<td>+12</td>
<td>+1 to +22</td>
<td>0.034</td>
</tr>
<tr>
<td>Cost per year–physician’s office, mean, $</td>
<td>123 ± 54</td>
<td>369 ± 138</td>
<td>+200 (+$246)</td>
<td>178 to +221</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cost per year–hospital outpatient, mean $</td>
<td>92 ± 41</td>
<td>85 ± 32</td>
<td>−8 (−$7)</td>
<td>−177 to +2</td>
<td>0.14</td>
</tr>
<tr>
<td>Cost per responder per year–physician’s office, mean $</td>
<td>262 ± 115</td>
<td>568 ± 212</td>
<td>+128 (+$336)</td>
<td>100 to +133</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cost per responder per year–hospital outpatient, mean $</td>
<td>195 ± 87</td>
<td>131 ± 49</td>
<td>−33 (−$64)</td>
<td>−42 to −24</td>
<td>0.0001</td>
</tr>
</tbody>
</table>
GUIDED THERAPY

That’s nice but what about cost?

- Chavez-Chiang et al. Sonographic Needle Guidance and Cost-Effectiveness of Intraarticular Injections for Osteoarthritis of the Knee. 2010
  
  - 47.7% reduction in procedural pain (p<0.001)
  - 41.7% reduction in pain scores at outcome (p<0.03),
  - 107% increase in the responder rate (p<0.001)
  - 35.5% increase in therapeutic duration (p =0.01)
  - 14.6% reduction ($48) in cost/patient/year
  - 58.8% ($593) reduction in cost/responder/year for a hospital outpatient (p<0.001).
• Review of literature through November 2013
• 124 articles evaluated for accuracy, efficacy, and cost-effectiveness
  • Major joints: USGI’s are more accurate and efficacious than LMGI’s
    • Research suggests that USGI’s are more cost-effective than LMGI’s but further research is required
  • Intermediate joints: USGI’s are more accurate in the majority of joints
    • Limited research on efficacy and cost-effectiveness
American Medical Society for Sports Medicine Position Statement: Interventional Musculoskeletal Ultrasound in Sports Medicine

Jonathan T. Finnoff, DO,*† Mederic M. Hall, MD,‡ Erik Adams, MD, PhD,§ David Berkoff, MD,¶ Andrew L. Concoff, MD,** William Dexter, MD,††‡‡ and Jay Smith, MD§§¶¶

- Small joints: Research suggests that USGI’s are more accurate than LMGI’s but further research is required
  - Limited research on efficacy and cost-effectiveness
- Soft tissues (tendon sheaths, bursa, tendons or fascia, perineural regions, muscles, cysts, peritendinous regions, wounds, and periarticular spaces):
  - USGI’s are more accurate for most, questions remain regarding difference for Morton’s neuroma and subacromial/subdeltoid bursa
  - USGI SA-SD bursa, carpal tunnel, and first dorsal compartment are more efficacious. Plantar fascia injections appear to have similar outcomes with LMGI.
  - Limited research on cost-effectiveness
Joints with inflammatory arthritis:

- USGI’s are more accurate, less painful, more efficacious, and are less expensive than LMGI’s
- Further research is required due to limited number of studies
THE FUTURE OF MSK ULTRASONOGRAPHY

- 2nd generation techniques: advanced procedures performed with commonly available needles
  - Many developed because of the availability of US guidance:
    - Needle tenotomy/fasciotomy for chronic tendinosis/fasciosis
    - Fenestration of the transverse carpal ligament for carpal tunnel syndrome
    - Neovessel ablation through sclerosing agent injection or mechanical disruption to treat chronic tendinosis
    - Needle release of the A1 pulley for trigger finger
    - Needle aponeurotomy for Dupuytren contracture
    - Hydrodissection to treat peripheral neuritis due to mild compression/adhesions
TENDINOPATHY

Glucocorticoids induce specific ion-channel-mediated toxicity in human rotator cuff tendon: a mechanism underpinning the ultimately deleterious effect of steroid injection in tendinopathy?

Benjamin John Floyd Dean, Sarah Louise Franklin, Richard J Murphy, Muhammad K Javaid, Andrew Jonathan Carr

Effect of Corticosteroid Injection, Physiotherapy, or Both on Clinical Outcomes in Patients With Unilateral Lateral Epicondylalgia

A Randomized Controlled Trial

Coombes, et al. JAMA Feb 2013
TENDINOPATHY

R PLANTAR FASCIA PNT
PERIPHERAL NEUROPATHY
THE FUTURE OF MSK ULTRASONOGRAPHY

- 3rd generation techniques: use of preexisting, specialized surgical tools or specially designed devices to perform a specific US-guided procedure
  - Many duplicate well-accepted surgical procedures using US guidance to improve safety and reduce morbidity:
    - A1 pulley release using hook knives, arthroscopic equipment, or specially designed devices
    - Tenotomy/fasciotomy using specialized devices that not only cut but also debride damaged tissues
Summary:

- USGIs are more accurate than LMGI’s – SORT Evidence A
- USGIs are more efficacious than LMGI’s – SORT Evidence B
- USGIs are more cost-effective than LMGI’s – SORT Evidence B
- USG is required to perform many new procedures – SORT Evidence C


• Coombes et Al. Effect of Corticosteroid Injection, Physiotherapy, or Both on Clinical Outcomes in Patients With Unilateral Lateral Epicondylalgia. A Randomized Controlled Trial. *JAMA*. 2013;309(5):461-469


REFERENCES


• European Society of Musculoskeletal Radiology


REFERENCES


• Sibbitt et al. A Randomized Controlled Trial of the Cost-Effectiveness of Ultrasound-Guided Intraarticular Injection of Inflammatory Arthritis. J Rheumatol 2011;38;252-263.


QUESTIONS???

Bradley Bley, D.O., FAAP, RMSK, CSCS
Primary Care Sports Medicine
Internal Medicine/Pediatrics
Delaware State University - Head Team Physician
Christiana Care Health System –
Faculty: Med/Peds Residency Program
Assistant Program Director: Primary Care Sports Medicine Fellowship

Contact Info: Email: bbley@delortho.com
Secretary: Debbie Abbott; 302/655-9494, x 1125