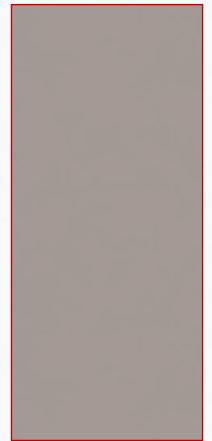


USES OF MUSCULOSKELETAL ULTRASOUND IN THE OFFICE SETTING

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DISCLOSURES

- Neither I, **Claudia Dal Molin**, nor any family member(s), have any relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation.

ULTRASOUND BASICS

- Machine that uses a transducer containing piezoelectric crystals that convert an electrical current into sound waves. Those sound waves are used to generate an image of underlying soft tissue structures.
- Maximal reflection of sound waves, and thus generation of superior image quality, occurs at a perpendicular angle. Reflection and absorption can create artifact.
- Higher frequencies have higher resolution, but at the expense of sound beam penetration. Lower frequencies have better penetration, but with lower resolution.

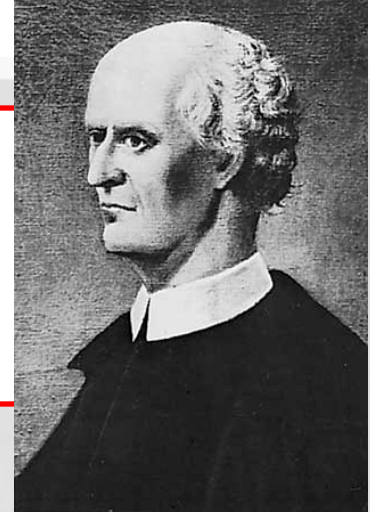
ULTRASOUND BASICS: TRANSDUCERS

- Linear
 - Sound wave is propagated in a linear fashion
 - Higher frequency range
 - Optimal for MSK imaging – comprised mostly of linear structures
- Curvilinear
 - Sound wave is propagated in a fan shape and offers larger field of view
 - Lower frequency range
 - Optimal for deeper imaging – MSK large joints and abdominal structures
- Compact linear
 - Even higher frequency range
 - Ideal for smaller MSK joints (ex, hands, wrists, feet, ankles)



HISTORY AND DEVELOPMENT

- 1794 – Lazzaro Spallanzani – studied spatial orientation of bats and discovered their use of sound waves in echolocation



- 1880 – Pierre and Jacques Curie – discovery of the piezoelectric effect

- 1915 – Paul Langevin – Invented the hydrophone to detect icebergs and submarines



HISTORY AND DEVELOPMENT



- 1942 – Karl Dussik – first physician to try to use US for medical diagnosis (brain tumors)

- Late 1940s - George Ludwig – used US to diagnose gallstones at the Naval Medical Research Institute in Bethesda, MD



- 1972 – Daniel G. McDonald and George R. Leopold – first clinical use of MSK US – differentiating Baker's cysts from thrombophlebitis

ULTRASOUND TODAY

- Abdomen (AB)
- Breast (BR)
- Cardiac (AE)
- **Musculoskeletal** (MSK)
- Neurosonology (NE)
- Obstetrics (OB)/Gynecology
- Vascular Technology (VT)

COMPARING IMAGING MODALITIES

MSKUS

- Excellent superficial soft tissue resolution
- No known contraindications
- Portable
- Dynamic imaging
 - Provocative testing
 - Flexible field of view
 - Bilateral comparison
- Opportunity for immediate therapeutic intervention

MRI

- Superior deep tissue resolution
- Allows for visualization of intra- and extra-articular structures simultaneously
- Can visualize bone marrow
- More uniform equipment quality and thus resolution
- Not operator dependent

COMPARING IMAGING MODALITIES

Table 1.
Applications of MRI and ultrasound for the shoulder.

	MRI	Ultrasound
Labrum	+++	+
Articular cartilage	+++	0
Bone marrow	+++	0
Deep soft tissues	+++	+
Foreign bodies	+	+++
Soft tissues around hardware	+	+++
Dynamic imaging	0	+++
Guided procedures	0	+++
Cyst versus solid	++	+++
Focal tendon abnormality	+++	+++

+++, excellent; ++, good; +, limited; 0, suboptimal/not applicable.

COMPARING DIAGNOSTIC EFFICACY: THE SHOULDER

- Many studies demonstrate that the diagnostic accuracy of ultrasound can approach that of MRI in the evaluation of rotator cuff tears (RCT)
 - De Jesus et al – meta-analysis – 2009
 - 65 articles
 - Evaluated sensitivities and specificities of MRI, ultrasound, and MR arthrography for the diagnosis of RCT with surgery as a reference standard
 - Reported sensitivities and specificities for ultrasound varied between 60-100% with similar varied ranges for MRI and MR arthrography
 - No statistical difference in sensitivity or specificity between MRI and ultrasound for the diagnosis of partial or full-thickness RCT

COMPARING OBSERVER VARIABILITY: THE SHOULDER

- Studies have suggested experience matters
 - Middleton et al – prospective study in WU SOM – 2004
 - 2 radiologists scanned 61 patients
 - Full agreement in 92% of cases categorizing lesions as normal, partially torn, or fully torn
 - Le Corroller et al – prospective study in France – 2008
 - 2 radiologists (6 mos vs 15 yrs of experience) scanned 65 patients
 - MR arthrogram was used as a standard
 - Low level of variability for full thickness tears and moderate for partial or intratendinous tears
 - O' Connor et al – prospective study in UK – 2005
 - 3 MSK radiologists with different levels of experience scanned 24 patients
 - Agreement was high among radiographers with higher levels of experience
- These studies have limitations – size, country of training, limited to radiologists

CLINICAL APPLICATIONS FOR COMMON CONDITIONS

PROCEDURAL MSKUS

THE SHOULDER

- AC Joint Injections
- Long head of biceps brachii tendon sheath
 - Hashiuchi et al. – 2011 –
 - 86.7% of US-guided injections achieved contrast within the tendon sheath compared to 26.7% performed with the blind technique.
 - 33% of blind injections were completely outside the tendon sheath compared to 0 % when ultrasound was used

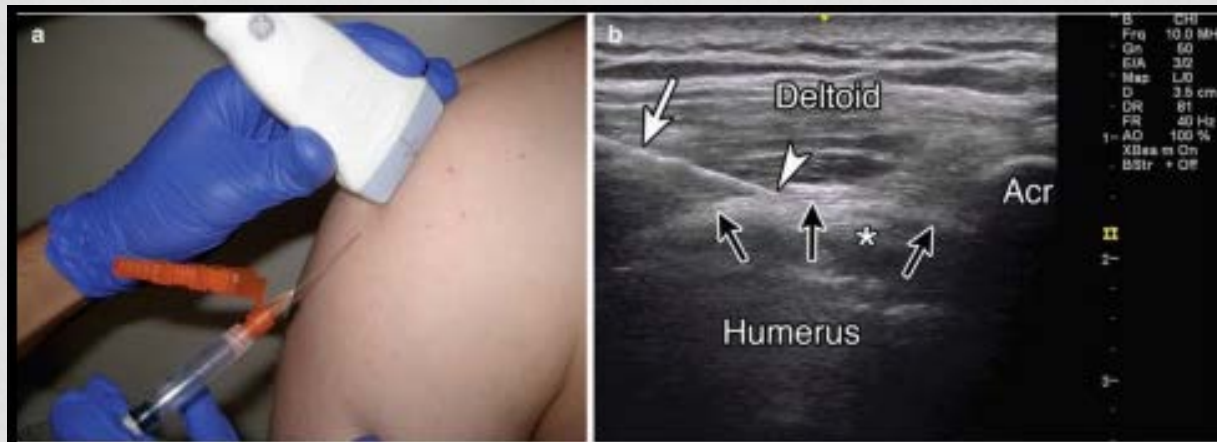
Author	Specimen	Guidance	Accuracy	Verification
Partington, 1998	Cadaver	Blind	67 %	Dissection
Peck, 2010	Cadaver	Blind/US	Blind (40 %)	Dissection
			US (100 %)	
Pichler, 2009	Cadaver	Blind	57 %	Dissection
Bisbinas, 2006	Clinical	Blind	39.4 %	Fluoroscopy
Sabeti-Aschraf, 2011	Cadaver	Blind/US	Blind (72 %)	US expert
			US (95 %)	



THE SHOULDER

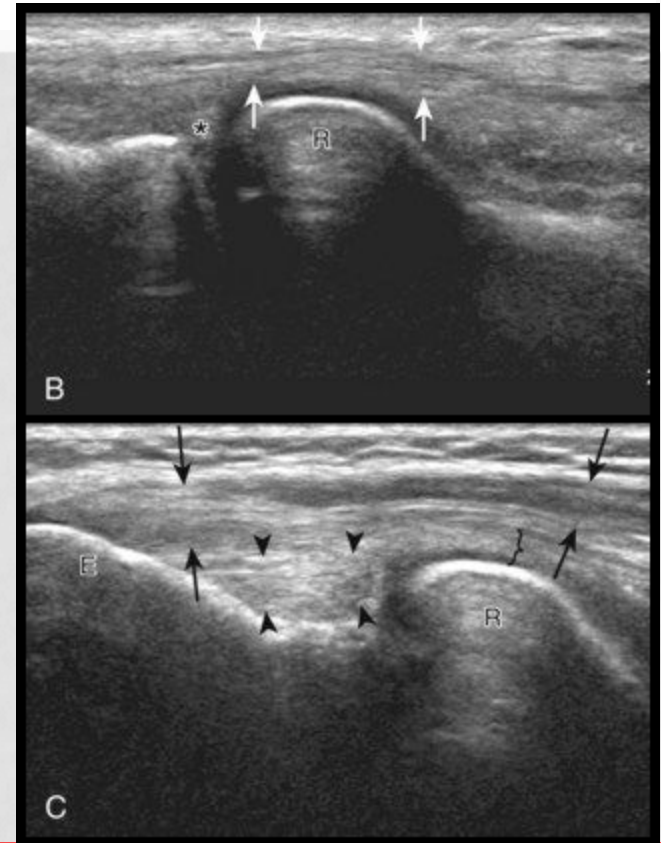
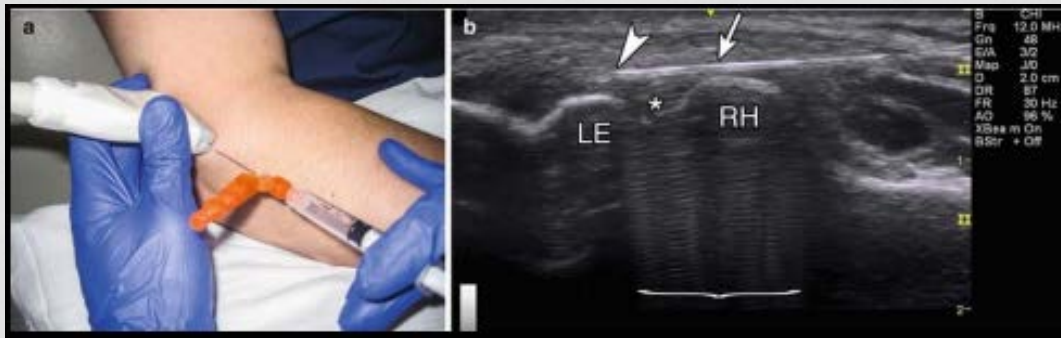
- Sub AC Injection
 - Accuracy varies from 60-100% when done blindly

Author	Specimen	Guidance	Accuracy	Verification
Yamakado, 2002	Clinical	Blind	Anterolateral (70 %)	Radiographs
Henkus, 2006	Clinical	Blind	Posterior (76 %)	MRI
			Anteromedial (69 %)	
Kang, 2008	Clinical	Blind	Posterior (75 %)	Radiographs
			Anterolateral (75 %)	
			Lateral (60 %)	
Park, 2010	Clinical	Blind	Anterolateral (49 %)	Radiographs
Rutten, 2007	Clinical	Blind/US	Posterior blind (100 %)	MRI
			Posterior US (100 %)	
Hanchard, 2006	Cadaver	Blind	Posterior lateral (91 %)	Dissection
Mathews, 2005	Cadaver	Blind	Anterolateral (90 %)	Dissection
			Posterior (80 %)	



THE ELBOW

- US-guided percutaneous needle tenotomy



Lateral imaging in long axis over the radial head shows (B and C) the radial head (R), common extensor tendon (arrows), radial collateral ligament (arrowheads), and annular ligament (bracket). Note triangular synovial fold (asterisk) in B.

THE WRIST & HAND

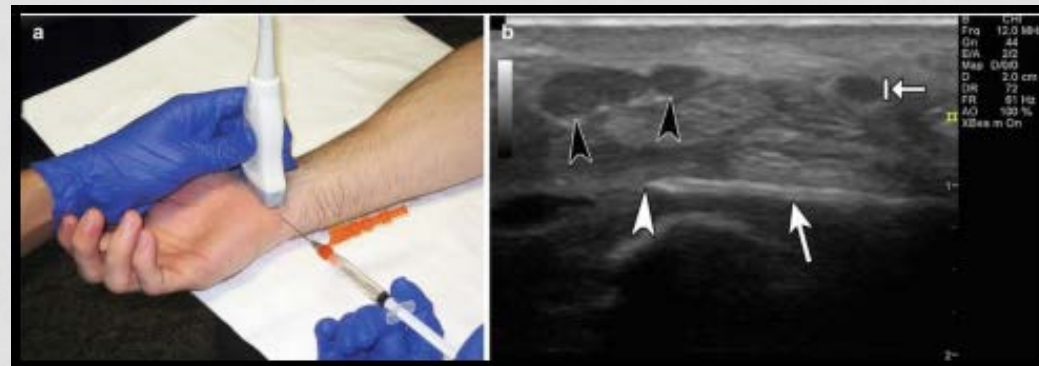
- Trigger Finger Injection

- Dae-Hee Lee et al – 2011

- 40 fingers were used to inject methylene blue into the flexor tendon sheath
- Accuracy – 70% (USG) vs 15% (blind)
- Injection of the tendon was found in 30% of blind injections

Study – trigger finger	Author	Success rate at 1 year (%)
Blind	Fleisch et al. [39]	57
Blind	Peters-Veluthamaningal et al. [40]	56
Ultrasound guided	Bodor et al. [41]	90

- Carpal Tunnel Syndr. – hydro dissection and steroid injection



CLINICAL APPLICATIONS FOR COMMON CONDITIONS

DIAGNOSTIC MSKUS

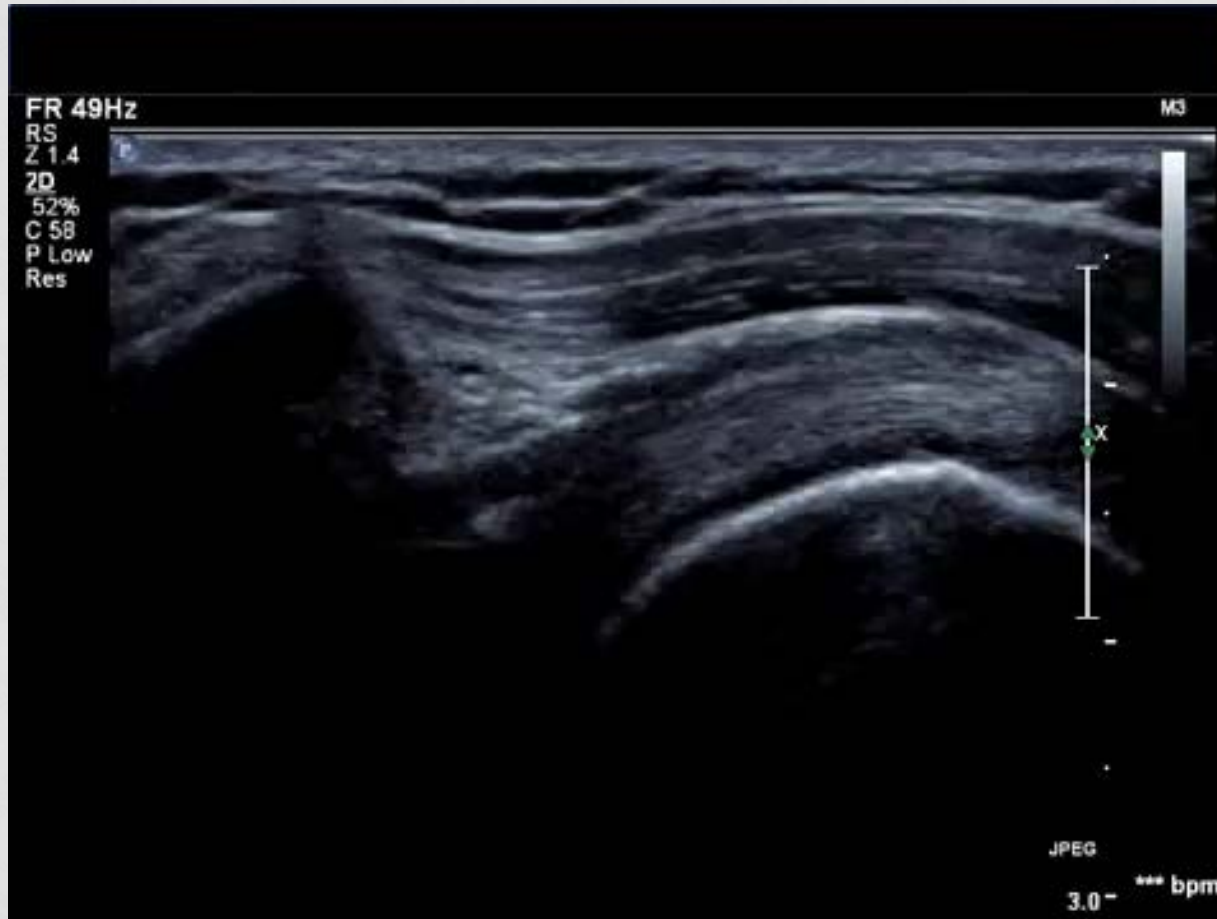
THE SHOULDER

- Extra-articular shoulder assessment for people that can't have an MRI
 - Metallic implant or foreign bodies
 - Claustrophobia
- Biceps tendon instability
- Subacromial impingement

BICEP TENDON DISLOCATION



SUBACROMIAL IMPINGEMENT



THE ANKLE

- Peroneal tendon subluxation/dislocation



THE ELBOW

- Ulnar nerve subluxation and snapping triceps syndrome



PRACTICE IMPLEMENTATION

THINGS TO CONSIDER...

COST

- Ultrasound machines start at about **\$10,000 and range up to \$200,000**. The price depends largely on the level of technology and your needs.
- Reimbursement data for Medicare rates in the greater Baltimore area:
 - Dx US: complete - \$127.50
 - Dx US: limited - \$38.83

 - Small jt asp/inj w/USG – 20604 – \$74.35
 - Intermediate jt asp/inj w/USG – 20606 – \$86.75
 - Major jt asp/inj w/USG – 20611 – \$100.36
 - Tendon Sheath w/USG – 76492 + 20550 – \$65.06 + \$64.18

TIME

- Time for education
 - Sports fellowship – generally 1 year, 2 years if research is included
 - Multiple courses during the year
- Scheduling considerations
 - Can your clinic accommodate a few longer procedure slots? The day goes more smoothly when you can bring the patient back...
 - A “younger” clinician will generally need more time allotted for these slots until they become more efficient
- Staff education
 - An assistant is generally needed (taking pictures, obtaining supplies mid-procedure)
 - Assistants need to be oriented to equipment and set-up

TRAINING AND CERTIFICATION

- Steep learning curve– **diagnostic** >> procedural
 - Without a sports fellowship including US education, expert diagnostic skill generally takes years with attendance to multiple courses annually.
 - Sports fellowship + early exposure in residency (EM and ICU rotations) – even the most diligent physician graduates with a basic level of competency. Often there are many areas within advanced MSK ultrasound that still need development.
 - Post-surgical exams
 - Shoulder (suggested by data presented earlier)
 - Nerve entrapments
 - Smaller joints (ex, intra-carpal ligament injuries)
 - Severe acute injuries not previously seen?
 - Caseload requirement to sit for the certification exam is generally completed after graduation.

TRAINING AND CERTIFICATION

- ARDMS grants R-MSK certification to individual physicians
 - Performed and/or authorized diagnosis of a minimum of 150 MSK ultrasound studies within the preceding 36 months of application.
 - No more than 5% (8 cases) of the 150 case log requirement can be labeled as therapeutic (injection or aspiration)
 - Recommended to earn a minimum of 30 MSK ultrasound specific CMEs to assist in taking the exam.
- AIUM can accredit a practice
 - For each site with 5 or fewer physicians, 1 diagnostic, comprehensive joint exam*, PLUS 4 MSK ultrasound-guided interventional procedure cases per site

QUESTIONS?

THANK YOU!