Ultrasound of Shoulder Joint Another Diagnostic Modality

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Abstract

Shoulder is an important joint, in fact the most important joint which needs an ultrasound evaluation for not only the diagnosis of the pathology but also its follow-up during treatment. Ultrasound is also an important modality needed for the treatment of joint pathologies like fluid aspiration or intra-articular injections. It is gaining more importance now, due to availability of the high-end digital ultrasound machines with their superior image quality, using high frequency ultrasound probes. So that now even very superficial and very thin muscle fibers, tendons and ligaments can be very well visualized. Diagnosis of small tears, inflammations and small fluid collections can now be made easily. In this paper there is technique for the ultrasound of the shoulder joint with a discussion and review of its importance.

Key words: Ultrasound, shoulder, technique.

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Introduction

Musculoskeletal ultrasound is relatively a newer field compared to abdominal ultrasound. The shoulder joint is an important joint. It is quite a complicated joint as well, with many muscles, tendons, ligaments and bursae making it up.

The shoulder joint is a ball and socket joint which is very shallow unlike the hip joint. This gives it a wide range of movements but at the cost of being very unstable. So, nature has stabilized it with a host of tendons and ligaments. The rotator cuff muscles play an important role. Still, it is prone to get easily hurt, injured or dislocated.

The radiologists and sonologists role is increasing day by day in this field, as more and more people are reaching old age, also their sports and other activities are also increasing day by day. Ultrasound being simple, readily available, cheap, without any ionizing radiation whatsoever and with the scope of being performed dynamically, is much appreciated by the clinicians including the orthopedic surgeons.

Materials and Methods

A high-frequency transducer of 12 to 15 MHz linear-array, fitted in a digital ultrasound machine is ideal for a good and accurate examination of the shoulder joint.

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The sonologist stands behind the patient or in his/her side, whichever is more convenient to him/her. Taking history before or during the scan is always helpful. Materials were collected after researching and reviewing many papers online.

Technique of Shoulder examination

The rotator cuff muscles are the main group of muscle tendons which surround and support the shoulder joint and are prone to injury. This group consists of four muscle tendons, the subscapularis, supraspinatus, infraspinatus and teres minor, of less importance, than the former three. Biceps brachii is also an important muscle of this joint. It consists of a long and a short head.

There should be a systematic approach. First, examine the long head of biceps tendon. Both in the tendon's short and long axis. The position of the patient should be that his/her hand rests on thigh and elbow is flexed in 90 degree. With the probe horizontally placed in the anterior aspect of shoulder or head of humerus, one can see in short axis the long head of biceps lying in the bicipital groove. Then the probe is rotated to its right angle and one can see the fibrillar pattern of the long axis, of the long head of biceps tendon, in the bicipital groove.

Next, the subscapularis is scanned in its long and short axis. With the elbow still at right angle, patient externally rotates his/her forearm. The subscapularis can be seen in its long axis, with the probe in the same position as

before. Now with the turning of probe vertically the short axis of the tendon becomes visible with the hyperechoic tendon slips between hypoechoic muscle fibers. In this position examiner can also look for biceps tendon subluxation or dislocation from the groove.

Then scan the supraspinatus tendon, also in its long and short axis. Patient puts his hand on his back pocket, preferably the contralateral one. This abducts and internally rotates the shoulder and the tendon is scanned in its long and short axis. If not possible by the patient then internal rotation of shoulder with the arm in extension is done. Any ultrasound guided injection, into the subacromial and subdeltoid bursa can also be given in this position.

Then comes infraspinatus examination in its long axis. This is examined with the probe placed on the back of the shoulder with the arm in its neutral position as before or across the front of the chest resting on the opposite shoulder. A curvilinear transducer is placed below scapular spine on posterior glenohumeral joint. Posterior joint space can also be examined in this position and any aspiration of joint effusion or injection can also be given into the glenohumeral joint.

Lastly, scan the acromioclavicular joint. This is examined with the arm in neutral position, hand on thigh, with the probe in the coronal plane, on the top of the shoulder, after palpating the end of clavicle. A hypoechoic triangular space is seen between the lateral end of clavicle and the acromion. An increase in space will indicate pathology. To assess impingement, scan may be done in dynamic abduction and by moving the transducer over the lateral edge of the acromion.[1]

Pathology

When scanning the tendons especially supraspinatus one has to learn to recognize anisotropy. These are hypoechoic areas inside the tendons due to low reflectivity resulting from different directions of the tendon fibers. The ultrasound waves do not strike all fibers perpendicularly, resulting in hypoechoic areas. So, angling or movement of the probe will make it disappear. This should always be practiced before diagnosing a tendon tear.

It is important not to confuse anisotropy due to probe angulation, with tendinopathy. Small amount of fluid can normally be seen surrounding the tendons this can be differentiated from tenosynovitis where there are internal echoes within the fluid with areas of increased Doppler flow.[1]

Tendon tears and ruptures are identified as irregularities in the tendon with surrounding hypoechoic or anechoic areas of fluid. Irregularities are also seen in tendinopathy. Diagnosis can be aided by asking patients to supinate and flex the forearm. If there is effusion in shoulder joint, fluid may collect around the biceps tendon which can be misinterpreted as biceps pathology.

Shoulder Pathologies

- Tendinosis
- Tears can be partial or complete/full thickness.
- Partial can be
    1. Articular surface
    2. Bursal surface
    3. Intrasubstance
- Abnormalities of Biceps Brachii
    1. Subluxation, Dislocations or Tears
    2. Tenosynovitis
- Acromio-clavicular joint arthritis
- Frozen Shoulder/ Adhesive capsulitis.
- Post-operative conditions.

Partial thickness tears

Tendon tears are characterized by hypoechoic areas of irregular margins.

Partial thickness tears of tendons are of three types.

On bursal side, on articular side and intrasubstance or within the muscle substance.

Partial tear is a focal defect either in articular or bursal surface. The former is commoner. These have been classified by the depth as Grade 1, for tears <3mm, grade 2 for 3-6mm, and grade 3 for >6mm. Also, as high-grade (>50% thickness) or low grade (<50% thickness).[2] A cortical irregularity of greater tuberosity is a sensitive sign of articular side partial thickness tear.[3]

An irregular hypoechoic or anechoic area within the muscle substance indicates an intrasubstance tear.

Full-thickness rotator cuff tears

A full thickness tear is a defect in the tendon that reaches from the bursal to the articular surface.[4] Usually these occur at the greater tuberosity where it inserts. The

normal tendon shows a hypoechoic or an anechoic defect.

There are some indirect signs too. When fluid is present in the subacromial/subdeltoid bursa and in the glenohumeral joint the probability of a rotator cuff tear is 95%. Other indirect signs of partial or full thickness tears are the sagging of bursa and a bright aspect of the humeral cartilage (uncovered cartilage sign), caused by enhancement of ultrasound signals due to fluid and loss of cuff tissue above the cartilage.[1]

Frozen Shoulder

Frozen shoulder is a common yet poorly understood musculoskeletal condition, which for many, is associated with substantial and protracted morbidity. Understanding the pathology associated with this condition may help to improve management.

Pathological changes in the anterior shoulder joint capsule and related structures were commonly reported. Imaging identified pathological changes occurring in the coracohumeral ligament, axillary fold and rotator interval. Obliteration of the subcoracoid fat triangle also appeared to be pathognomonic. Histological studies were inconclusive but suggested that immune, inflammatory and fibrotic changes are associated with primary frozen shoulder.[5]

Discussion

Ultrasound reliably answers the questions that a surgeon has about the rotator cuff. Ultrasound has high sensitivity and specificity for full thickness rotator cuff tears and is as accurate as magnetic resonance imaging (MRI) in the detection of cuff tears and the assessment of tear size and can identify fatty infiltration in muscles. Although it does not have the 'global' capability of MRI, ultrasound is quick, cheap and more acceptable to patients than MRI. Ultrasound guided procedures can be used for diagnostic and therapeutic purposes.[6]

Foci of hyperechoic microcalcifications without acoustic shadows are the common features of calcific tendinitis. However large foci of hard calcifications appear as hyperechoic convex contours without acoustic shadow.[6]

The life time prevalence of shoulder pain approaches 70% which is mostly attributed to rotator cuff lesions such as inflammation, calcific tendinitis and tears. On clinical examination, shoulder ultrasound is recommended for the detection of lesions. However there exists inter-operator variability in diagnostic accuracy because of differences in the experience and expertise of operators. A computer-aided diagnosis (CAD) was developed to assist ultrasound operators in diagnosing rotator cuff lesions and to improve the practicality of ultrasound examination. The proposed CAD achieved an accuracy of 87.9%. The individual accuracy of this CAD system was 88.4% for inflammation, 83.3% for calcific tendinitis and 92.3% for tears. On the basis of its diagnostic performance, clinical use of this CAD technique has promise.[7]

The most common indication for shoulder ultrasonography is the diagnosis of rotator cuff disease. However, there is a spectrum of non-rotator cuff abnormalities that are amenable to ultrasound (US) examination, including instability of the biceps tendon, glenohumeral joint, and acromioclavicular joint; arthropathies and bursitis (inflammatory diseases, degenerative and infiltrative disorders, infections); nerve entrapment syndromes; and space-occupying lesions. Many of these conditions may be overlooked clinically or can even mimic rotator cuff tears, and US can help redirect the diagnosis if a complete shoulder examination rather than a simple rotator cuff assessment is performed. In addition, US can be remarkably helpful in guiding either needle aspiration procedures or local injection therapy in patients with synovial processes. Although radiography, magnetic resonance (MR) imaging, and computed tomographic and MR arthrography are effective modalities for the evaluation of non-rotator cuff disorders, US is both less costly and less invasive and will likely be used more frequently in this setting as experience increases. Once adequate radiographs have been obtained to exclude apparent bone disorders, high-resolution US should be the first-line imaging modality in the assessment of non-rotator cuff disorders of the shoulder, assuming the study is performed with high-end equipment by an experienced examiner.[8]

US has been proven to be useful in a wide range of rotator cuff diseases (tendon tears, tendinosis, and bursitis) as well as non-rotator cuff abnormalities (instability problems, synovial joint diseases, and nerve entrapment syndromes). Diagnostic accuracy of shoulder US when evaluating rotator cuff tears can reach 91-100% for partial

and full thickness tears detection, respectively, having been reported to be as accurate as magnetic resonance imaging in experienced hands. US is cheap, readily available, capable to provide high-resolution images, and does not use ionizing radiations. In addition, US is the only imaging modality that allows performing dynamic evaluation of musculoskeletal structures that may help to further increase diagnostic performance. In this setting, a standardized imaging protocol is essential for an exhaustive and efficient examination, also helping reducing the intrinsic dependence from operators of US. Furthermore, knowledge of pitfalls that can be encountered when examining the shoulder may help to avoid erroneous images interpretation.[9]

A case report - Two weeks after a one-hour weight bearing exercise in the gym, after a long 2 years pandemic break, pain started developing slowly within only the right shoulder joint, though both the shoulders were equally exercised. So, in this lady of 64 years age it was difficult to say if this was age related pain or due to the heavy exercise. Slowly this excruciating pain increased, in 20 to 160 degrees abduction, shoulder movement. But on ultrasound scan of the joint there was no pathology in the supraspinetus tendon or Acromio-Clavicular joint as found in impingent, but only an elongated subdeltoid and subsupraspinetus fluid collection was seen. Fluid was thin and clear. It was subdeltoid and subsupraspinetus bursitis by ultrasound.

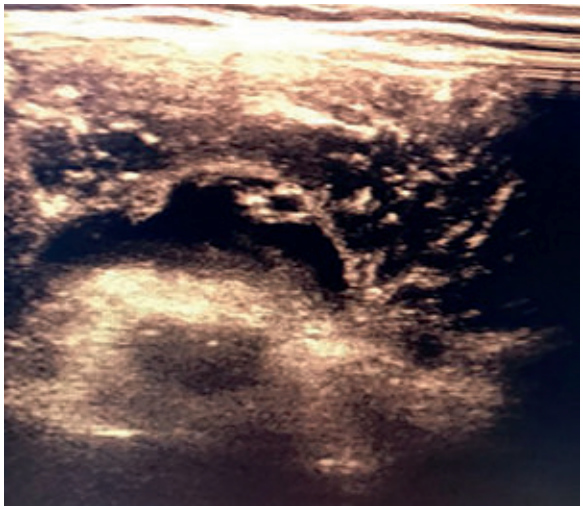

Fig.-1: *After weight bearing exercise in the gym, deltoid muscle is hypoechoic and subdeltoid bursal margins are thick and irregular. With fluid collection in the bursa.*

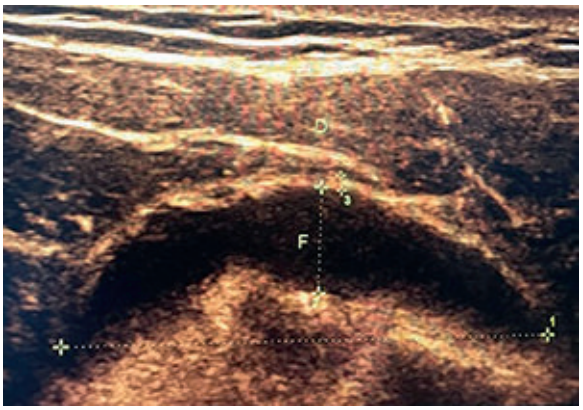

Fig.-2: *Subdeltoid bursitis. With moderate fluid collection in the bursa and thick and irregular bursal margins.*

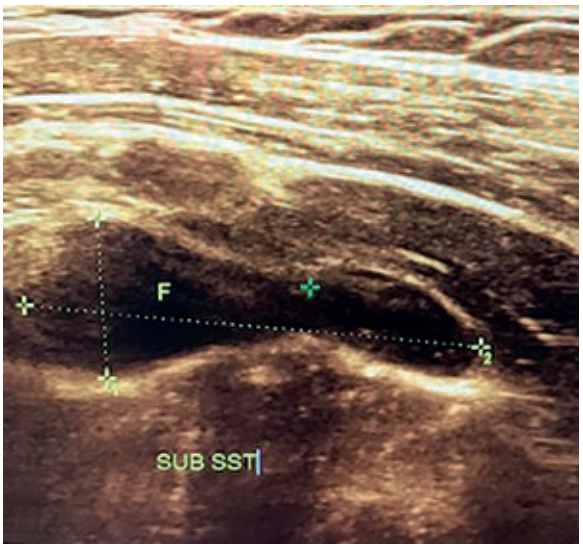

Fig.-3: *Subsupraspinetus bursitis with moderate thin and clear fluid collection in the bursa.*

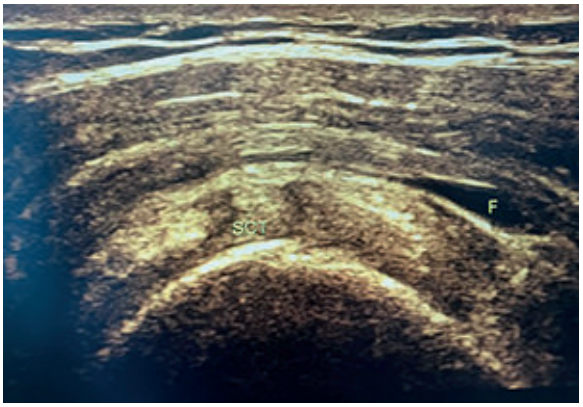

Fig.-4: *Subdeltoid bursitis decreased with only a small amount of fluid still not absorbed.*

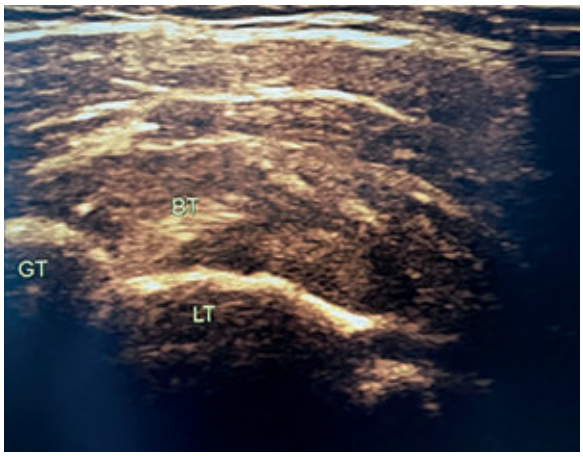

Fig.-5: *Biceps tendon, long head, in the bicipital groove, in normal position. Between the greater and lesser tuberosities.*

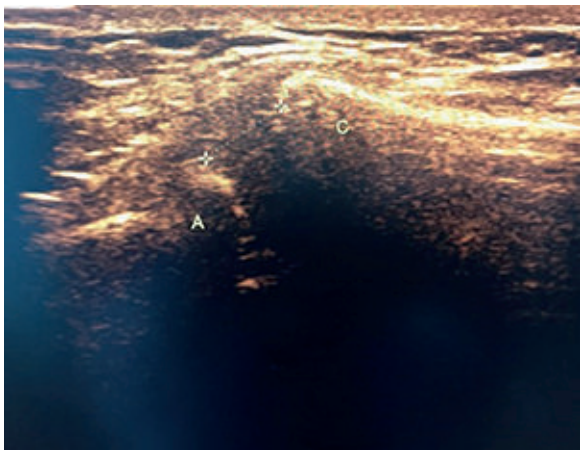

Fig.-6: *Acromio-clavicular joint space is normal. If increased, it indicates pathology.*

Accuracy

US and MRI are comparable in both sensitivity and specificity. Ultrasound has 92.3 % sensitivity and 94.4% specificity for full thickness and 66.7% sensitivity and 93.5% specificity for partial thickness tears, MR arthrography is the most sensitive and specific technique for diagnosing both full and partial thickness rotator cuff tears.[10]

The majority of studies showed conflicting results. where are they? (Reply- statement from Ref. 11 & also mentioned here). There was no significant association between most imaging features and symptoms among high-quality, cross-sectional studies. There was low-quality evidence that enhancement of the joint capsule on MRI and increased uptake on PET were associated with symptoms in adhesive capsulitis. Based on high-quality longitudinal studies, enlarging rotator cuff tears were associated with an increased incidence of symptoms.[11]

US predicted patients with SSP tendinopathy, with accuracy, sensitivity, specificity, PPV (positive predictive value) and NPV (negative predictive value) was 55.6%,100%, 72.7%, 70% and 100% respectively ($p < 0.001$). US was able to predict patients with SSP partial tear, with accuracy, sensitivity, specificity, PPV and NPV was 88.9%,80%,100%, 100% and 80% respectively ($p < 0.001$). US was able to predict patients with SSP full thickness tear, with accuracy, sensitivity, specificity, PPV and NPV was 100%,100%, 100%, 100% and 100% respectively ($p < 0.001$). US was able to predict patients with Biceps long head tenosynovitis with accuracy, sensitivity, specificity, PPV and NPV was 94.4%,100%, 91.7%, 85.7% and 100% respectively ($p < 0.001$).[12]

Abnormalities other than rotator cuff

There is a spectrum of non-rotator cuff abnormalities that are amenable to ultrasound examination. Once radiographs have been obtained to exclude bone disorders high-resolution ultrasound should be the first line of imaging modality, assuming that it is performed with high-end equipment by an experienced examiner.[13]

Subacromial impingement syndrome [14] is the result of chronic irritation of the supraspinatus tendon against the under surface of the acromion, the coracoacromial ligament and the acromio-clavicular joint. This process leads to tendinopathy and tears of the rotator cuff as well as SASD (subacromial/subdeltoid) bursitis. While shoulder impingement (sudden severe stabbing pain inside the shoulder joint during certain movements) is a clinical diagnosis, ultrasound is routinely used to evaluate the condition by demonstrating supportive findings, discovering the alternative causes of shoulder pain and directing therapeutic injections. The SASD bursitis is demonstrated by the presence of increased fluid in the bursa and thickening of the bursal wall. Gathering of SASD bursa seen during dynamic ultrasound, reported as a useful feature in diagnosing impingement by some authors [15,16] does not always indicate painful impingement of the bursas as it is also found in healthy volunteers.[17]

Ultrasound is helpful in evaluating the superior aspect of the acromio-clavicular joint. Bone erosion, fluid, cysts, and hypertrophic changes represent degeneration. An acromio-clavicular joint cyst may present as a tumor mass. They are associated with extensive rotator cuff tears and there is usually communication of the cyst with the joint space.[18-20]

In another study sonography, using multiple parameters, revealed a high sensitivity and specificity (100 and 87%, respectively) for diagnosis of adhesive capsulitis of the shoulder and in differentiating it from other causes of painful shoulder. It, thus, has the potential to be adopted as a preferred imaging modality.[21]

Moreover, it is the only imaging technique that allows dynamic evaluation of musculoskeletal structures, which is important for the evaluation of impingement. Also, due to the shoulder's superficial anatomical position, ultrasound can also be helpful in guiding interventional percutaneous procedures, both for diagnostic (e.g. magnetic resonance arthrography) and therapeutic purposes (e.g. percutaneous treatment of calcific tendonitis). Contrast-enhanced ultrasound and speckle tracking offer complimentary evaluations of shoulder anatomy and biomechanics. Moreover, the advent of ultra-high-frequency US, with probes up to 70 MHz allowing for a resolution as low as 30 ìm, is a promising tool for further evaluation of the shoulder anatomy, and diagnostic and therapeutic strategies.[22]

Conclusion

With the advent of the digital high-end ultrasound equipment, we are able to see the muscles, joints, tendons and even ligaments in much details which was not possible before. Therefore, ultrasound has contributed immensely not only to the diagnosis but also treatment of joint pathologies. Maximum use should be made by the radiologists, sonologists and the clinicians of this cheap, readily available and non-invasive modality.

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