Ultrasound and operative evaluation of arthritic shoulder joints

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Abstract

***Objective*—To assess the diagnostic value of ultrasonography (US) in the evaluation of arthritic shoulder joints.**

***Methods*—Twenty shoulders of 20 inpatients with arthritis were evaluated by US one day before the shoulder operation. Changes in the subacromial-subdeltoid bursa, biceps tendon and tendon sheath, rotatof cuff, and glenohumeral joint were recorded and compared with findings at operation.**

***Results*—In the detection of effusion/hypertrophy in the subacromial-subdeltoid bursa, US had a sensitivity of 93% and a specificity of 83%. For a biceps tendon rupture US had a sensitivity of 70% and a specificity of 100%. US missed three intra-articular biceps tendon ruptures. For effusion/hypertrophy in the biceps tendon sheath US had a sensitivity of 100% and a specificity of 83%. For a rotator cuff tear US had a sensitivity of 83% and a specificity of 57%. US missed two small longitudinal rotator cuff tears. Three thin membranous, but intact, rotator cuff tendons were classified as full thickness tears by US. Synovial effusion/hypertrophy was detected by US and at operation in all of the 12 glenohumeral joints that were evaluable at surgery.**

***Conclusion*—US is a reliable method in experienced hands for the evaluation of inflammatory changes of an arthritic shoulder. In advanced stages of rheumatoid shoulder joints, however, US is not useful, because destructive bone changes and tendon ruptures change the normal anatomy and restrict shoulder motions, limiting the visibility of US.**

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The shoulder girdle consists of the glenohumeral (GH), acromioclavicular (AC), and sternoclavicular joints. The proliferative synovitis of rheumatoid arthritis (RA) commonly involves not only the GH joint, but also the other joints and bursae of the shoulder complex, particularly the subacromial-subdeltoid (SA-SD) bursa. Persisting proliferative synovitis at the GH joint may result in cartilage destruction, erosive changes of the joint margins, and eventual rupture of the rotator cuff and biceps tendons.[1] According to the earlier studies, as many as 90% of RA patients suffer shoulder symptoms at some point.[2] Although the shoulder joint seems to become involved later than the other upper limb joints in RA, the shoulder has been found to be involved already during the first two years in nearly 50% and during 14 years in 83% of patients.[3]

Clinically, shoulder joint arthritis may often go unrecognised because of several reasons: the onset of the disease in the shoulder is often insidious, the shoulder joint is deeply seated, and synovial tissue swelling is difficult to detect.[4] Plain radiography depicts rheumatoid involvement late. Ultrasonography (US) can reveal early soft tissue changes in the shoulder, such as effusions in the SA-SD bursa,[5 6] biceps tendon sheath (BTS),[7] and GH joint,[8 9] and can also show bone erosions on the humeral head.[10]

The purpose of this study was to evaluate the ability of US to detect shoulder abnormalities in patients with chronic arthritis and to compare the information thus gained with the operative findings. To the best of our knowledge, this is the first study comparing preoperative US findings of arthritic shoulders with operative findings.

Methods

Twenty shoulders of 20 inpatients with chronic arthritis were evaluated by US one day before the shoulder operation. Fourteen patients were female and six were male. Their mean age was 57 (range 26–77) years. Sixteen patients had RA,[11] 12 being seropositive and four seronegative, three had ankylosing spondylitis,[12] and one had psoriatic arthritis.[13] The mean duration of the disease was 10 (range 1–18) years and the mean duration of the shoulder symptoms was four years (range 4 months–10 years).

The US examination was made by the author (EA), who has special training in shoulder sonography. A 7.5-MHz linear-array transducer (Aloka 2000, Tokyo, Japan) was used. Standard techniques were used for static and dynamic longitudinal and transverse scanning of the rotator cuff (RC), biceps tendon, BTS and SA-SD bursa.[5 7 14] Synovial effusion/hypertrophy of the GH joint was evaluated using the techniques reported in earlier studies.[9 15] The sonographic findings were recorded on a data sheet during real time imaging and documented on high density printing paper with a thermal printer.

The following criteria for the classification of the US findings were used: bursal thickness >2 mm or effusion were considered as effusion/hypertrophy of the SA-SD bursa, a hypoechoic zone completely surrounding the biceps tendon and thickening with an irregular surface of the BTS as effusion/hypertrophy of the tendon sheath. Changes in the RC were classified as a full thickness tear, a partial thickness tear or a

Table 1 US and operative findings, diagnoses, and types of surgery for the 20 patients

Bursal E/H		*Biceps tendon*		*BTS E/H*		*Rotator cuff*		*GH joint E/H*			
US	*operation*	*US*	*operation*	*US*	*operation*	*US*	*operation*	*US*	*operation*	*DG*	*Type of surgery*
yes	yes	normal	normal	yes	yes	FT tear	FT tear	yes	NA	RA+	BE,TSE,SRCT
no	no	thinned	thinned	yes	yes	normal	thinned	yes	NA	RA+	APL,TSE
yes	yes	rupture	rupture	yes	yes	FT tear	FT tear	yes	yes	RA+	HA
yes	yes	normal	NA	no	NA	normal	FT tear*	no	NA	RA−	BE,APL,SRCT
yes	yes	thinned	rupture	yes	NA	PT tear	PT tear*	yes	yes	RA+	ASC,SE,APL,SRCT
no	yes/H	thinned	thinned	yes	yes	thinned	FT tear*	yes	yes	RA+	ASC,SE,APL,SRCT
yes	yes	thinned	rupture	no	no	FT tear	FT tear	yes	NA	RA+	APL,BE,RDC
no	no	thinned	rupture	yes	yes	FT tear	membranous	yes	yes	RA+	HA
yes	yes	rupture	rupture	no	no	FT tear	membranous	yes	yes	RA+	HA
no	no	normal	normal	yes	no	FT tear	FT tear	yes	yes	RA−	ReSRCT,EXPL
yes	yes	normal	normal	yes	yes	FT tear	FT tear	yes	yes	RA+	APL,SRCT
yes	yes	normal	normal	yes	yes	thickened	normal	yes	NA	AS	APL,BE
yes	yes	normal	normal	yes	NA	FT tear	FT tear	no	NA	RA−	APL,SRCT
yes	yes	normal	normal	yes	yes	thinned	NA	no	NA	AS	BE,DCAL
yes	yes	rupture	rupture	yes	NA	FT tear	FT tear	yes	yes	RA+	HA
no	no	rupture	rupture	no	no	FT tear	membranous	yes	yes	RA+	TJRA
yes	yes	normal	normal	yes	yes	normal	normal	yes	yes	PSA	SE,TSE,APL
no	no	rupture	rupture	no	no	FT tear	FT tear	yes	yes	RA+	HA
yes/H	no	rupture	rupture	yes	yes	thinned	thinned	yes	yes	RA−	HA
yes	yes	rupture	rupture	no	no	FT tear	FT tear	yes	NA	AS	APL,SRCT

E = effusion, H = hypertrophy, BTS = biceps tendon sheath, GH = glenohumeral, DG = diagnoses, NA = not applicable, FT = full thickness, PT = partial thickness, * = small longitudinal tear, RA+ = seropositive rheumatoid arthritis, RA− = seronegative rheumatoid arthritis, AS = ankylosing spondylitis, PSA = psoriatic arthritis, BE = bursectomy, TSE = tenosynovectomy of the biceps tendon sheath, SRCT = suturation of RC tear, APL = acromioplasty, HA = hemiarthroplasty, ASC = arthroscopy, SE = synovectomy, RDC = resection of the distal clavicle, ReSRCT = resuturation of RC tear, EXPL = exploration, DCAL = discision of the coracoacromial ligament, TJRA = total joint replacement arthroplasty.

thinned or thickened tendon. A full thickness tear was diagnosed when a defect (hypoechoic zone) extended through the tendon substance, when there was focal thinning with visible margins of the tear, or when there was a complete loss of tendon substance. A partial thickness tear was recorded when the echostructure of the tendon was heterogeneous with mixed hyperechoic and hypoechoic regions. The RC tendon was considered to be thinned when the thickness of the supraspinatus tendon (measured 2 cm proximal to the insertion of the distal supraspinatus) was < 3.5 mm, and thickened when it was > 8.5 mm; the normal thickness is 6 mm with a standard deviation of 1.1 mm.[16] Effusion/synovial hypertrophy of the GH joint was evaluated on the posterior sagittal imaging plane perpendicular to the humeral head, and in the axilla, using the criteria presented in the earlier studies.[9 15] When the ultrasonographic distance between the head of the humerus and the joint capsule was > 3.0 mm in the axilla or on the posterior scan, it was considered as effusion/synovial hypertrophy of the GH joint.

The following types of surgical operations were made: bursectomy, tenosynovectomy of the BTS, suturation or resuturation of the RC tear, acromioplasty, hemiarthroplasty, arthroscopic synovectomy, open synovectomy, discision of the coraco acromial ligament, exploration, total joint replacement arthroplasty. Not all of the shoulder structures were evaluable at every operation. The operative findings were documented on the patient's records and data sheet. We used the operative findings as a "gold standard".

Sensitivity was calculated by dividing the number of true positive results by the total number of true positive and false negative results. Specificity was calculated by dividing the number of true negative results by the total number of true negative and false positive results. Accuracy was calculated by dividing the total number of true positive and true negative results by total number of results. The predictive value of positive test was calculated by dividing the number of true positive results by the total number of true positive and false positive results. The predictive value of a negative test was calculated by dividing the number of true negative results by the total number of true negative and false negative results.

Table 2 Percentage validity of diagnoses by US for the 20 patients

Validity	*Bursa E/H (n=20*)*	*BT rupture (n=19*)*	*BTS E/H (n=16*)*	*RC rupture (n=19*)*
Sensitivity	93	70	100	83
Specificity	83	100	83	57
Accuracy	90	84	94	74
PVPT	93	100	91	77
PVNT	83	75	100	67

BT = biceps tendon, PVPT = predictive value of positive test, PVNT = predictive value of negative test, * = the number of patients in whom the diagnosis was confirmed at operation. Other abbreviations as table 1.

Results

In the detection of effusion/hypertrophy in the SA-SD bursa, US had a sensitivity of 93%, a specificity of 83%, an accuracy of 90%, a predictive value of positive test of 93%, and a predictive value of negative test of 83%. In two cases, a mild synovial thickening of the SA-SD bursa classified as synovial hypertrophy without effusion detected by one method (US or surgery) was not confirmed by the other (table 1 and table 2). Table 2 shows the number of patients in whom the shoulder structure in question was evaluable at operation.

In the assessment of biceps tendon ruptures, US had a sensitivity of 70%, a specificity of 100%, an accuracy of 84%, a predictive value of positive test of 100%, and a predictive value of negative test of 75%. US missed three intra-articular biceps tendon ruptures. In the detection of effusion/hypertrophy in the biceps tendon sheath, US had a sensitivity of 100%, a specificity of 83%, an accuracy of 94%, a predictive value of positive test of 91%, and a predictive value of negative test of 100%.

In the assessment of RC tears, US had a sensitivity of 83%, a specificity of 57%, an accuracy of 74%, and a predictive value of positive test of 77%, and a predictive value of negative test of 67%. US missed one small longitudinal partial thickness tear and one small longitudinal full thickness tear. In three cases, thin membranous, but intact, RC tendons reported at surgery were classified as full thickness tears by US because of the loss of tendon substance. One RC tendon normal by US was classified as thinned at surgery, and one normal RC tendon at surgery was evaluated as thickened by US.

Synovial effusion/hypertrophy was detected by US and at surgery in all the 12 GH joints that were evaluable at surgery. Thus US had a sensitivity of 100%, but its specificity, accuracy, and predictive value of negative test were not assessable.

Discussion

This study shows that US had a high sensitivity in the detection of synovial effusion/hypertrophy in the SA-SD bursa, BTS, and GH joint, whereas in the assessment of biceps and RC tendons the sensitivity and accuracy of US were lower.

Although operation can be considered the "gold standard" of the investigation methods of the shoulder, it also has some limitations. Firstly, depending on the procedure, not all structures are visible, and blind palpation of the structures does not yield exact information. Secondly, the assessments of the quality and quantity of tissues are subjective without histological tissue samples or distinct measuring instruments.

In RA, the ruptured biceps tendon is usually adherent to the bicipital groove.[17] In this study, we found that in advanced stages of RA, the intra-articular tendon area was not evaluable by US because of the upward subluxation of the humeral head. In three cases where US missed intra-articular biceps tendon ruptures, the tendons appeared to be in the groove in US.

Effusion in the BTS is non-specific finding and may reflect a pathological process elsewhere in the shoulder joint.[7] As the BTS is merely an extension of the synovial membrane of the joint, generalised joint effusion in arthritis can lead to fluid in the sheath.[18] Effusion caused by isolated biceps tendinitis is rare.[19] The BTSs of 16 shoulders were evaluable at surgery; effusion/hypertrophy in the BTS was identified in 10 of these shoulders by both US and operation. Of these 10 shoulders nine had RC abnormalities and in nine shoulders concomitant effusion/hypertrophy in the GH joint was visualised by US. Some cases with a RC rupture had no effusion/hypertrophy either in the BTS or in the GH joint. In one shoulder US depicted distinct effusion around the biceps tendon, but at operation (resuturation of the RC) no effusion was seen after incision into the subacromial space, when synovial fluid had already poured out.

The diagnostic accuracy of US in detecting RC tears seems to be controversial.[20–23] US has some limitations in the evaluation of the RC. Sonograms can depict only the distal part of the RC, which is not obscured by the acromion.[14] Some RC tears may not be of sufficient size or not have an appropriate configuration or differential echogenity to be detected by US. Thus, a small longitudinal tear without any retraction of the torn edges or any focal alteration in RC echogenity may not be revealed by US.[22] In this study, we missed two such small longitudinal RC tears by US. Conversely, three US classified full thickness RC tears were intact at surgery, but very thin and membranous. The GH joints of these three shoulders were totally destroyed with the humeral heads migrated proximally and medially, greatly limiting the visualisation of the RC in US. Kelly has described three patterns of the disease in a rheumatoid shoulder.[24] The most severe group comprises large erosions of the AC and GH joints with a significant loss of glenoid bone stock and medialisation of the shoulder. The RC may be thinned, but is intact in at least 80% of these patients. On the basis of plain radiographs it would appear logical to postulate that proximal migration of the humeral head and a diminished subacromial space are a result of a rupture of the RC, although an intact but thinned RC has been seen in many instances.[24 25] The above mentioned three cases represent Kelly's group III. US failed to depict visible RC tendon substance, and these cases were thus classified as full thickness tears.

In the past 10 years, US and magnetic resonance imaging (MRI) have been introduced into the clinical practice of diagnosing shoulder problems. MRI is superior to US in depicting effusions,[26 27] synovial thickening and pannus tissue formation,[4] cartilage damage and intraosseus abnormality,[4 28] and RC pathology.[29] However, in comparison with US, MRI is less available, more expensive and time consuming, and less convenient to the patients.

The operator dependency of US and the small number of patients in this series may somewhat limit the generaliseability of our results. We, however, conclude that US is a reliable method in experienced hands for the evaluation of inflammatory changes of the arthritic shoulder. It is to be noted that in advanced stages of RA, the destructive bone changes and tendon ruptures cause upward and medial migration of the humeral head and restricted shoulder motions limiting the usefulness of US in the evaluation of the shoulder in these cases.

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