

EXTENDED REPORT

Painful shoulder: comparison of physical examination and ultrasonographic findings

E Naredo, P Aguado, E De Miguel, J Uson, L Mayordomo, J Gijon-Baños, E Martin-Mola

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See end of article for authors' affiliations

Correspondence to: Dr E Naredo, Calle Arturo Soria 259, portal 4, 4^o A, 28033 Madrid, Spain; enaredo@eresmas.com

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Background: High frequency ultrasonography is an accurate non-invasive imaging technique for evaluating patients with painful shoulder.**Objective:** To compare the clinical diagnosis established by a physical examination with high frequency ultrasonographic findings in patients with painful shoulder.**Methods:** Thirty one consecutive patients with a first flare of shoulder pain were prospectively included in the study. All had a physical examination performed by two blinded rheumatologists. Ultrasonographic examination was carried out within one week of the physical examination by a third rheumatologist experienced in this technique who had no knowledge of the clinical findings. Ultrasonography was considered the optimal diagnostic technique.**Results:** Clinical assessment showed low accuracy in the diagnosis of periarticular shoulder lesions.**Conclusion:** Ultrasonography should be used wherever possible to improve diagnosis and treatment of painful shoulder.

Shoulder pain is one of the most common complaints encountered in rheumatological practice and often leads to considerable disability. There are many causes of a painful shoulder, but periarticular soft tissue lesions involving tendons and bursae are the most common and are often associated with chronic impingement of the rotator cuff on the anterolateral margin of the acromion. Although a number of clinical tests used for the diagnosis of painful shoulder are considered accurate in determining the location of the periarticular lesions,¹ these entities may be difficult to differentiate by physical examination.^{2,3}

To the best of our knowledge, no studies have compared the result of physical examination (PE) with the findings of an accurate imaging technique for a broad spectrum of periarticular shoulder disorders. Given the great improvement in musculoskeletal imaging achieved by high frequency ultrasonography (US)^{4,5} and its present availability in rheumatological practice, it can be used to evaluate the accuracy of clinical diagnosis of painful shoulder.

The aim of this study was therefore to prospectively compare the clinical diagnosis established by PE with US findings in patients with painful shoulder.

PATIENTS AND METHODS

We studied prospectively 31 consecutive patients referred to our rheumatology unit with a first flare of shoulder pain clinically diagnosed as periarticular disorders. Patients with previous trauma or chronic inflammatory arthritis were excluded. Each patient had a PE performed independently by two blinded rheumatologists (PA and EM), who assessed the active and passive range of motion, performed 10 shoulder manoeuvres, and explored the acromioclavicular joint. Three clinical tests (Neer's, Hawkins's, and Yocum's) were used to detect shoulder impingement syndrome.^{6–8} Seven manoeuvres for determining the location of the tendon lesion, Jobe's test for supraspinatus,⁹ Patte's test for infraspinatus and teres minor,¹ Gerber's lift off test and resisted internal rotation assessment for subscapularis,¹⁰ and Yergason's test,¹¹ palm up test,¹² and Popeye's sign for the long head of the biceps brachii,¹¹ were also performed. Clinical diagnosis was established by consensus. Within a week of the PE, a US examina-

tion was carried out by a rheumatologist experienced in this technique without knowledge of the PE findings. US was considered to be the optimal diagnostic test as surgical results were not available for most of the patients.

Physical examination

For the impingement manoeuvre of Neer,⁶ the examiner stands behind the seated patient and uses one hand to prevent rotation of the scapula while passively raising the patient's arm with the other hand to produce both forward elevation and abduction in order to reduce the space between the greater tuberosity and the anteroinferior aspect of the acromion. In Hawkins's test,⁷ the examiner stands facing the patient, and, after raising the patient's arm to 90° of strict forward elevation with the elbow in 90° flexion, rotates the arm medially by lowering the forearm. For Yocum's test,⁸ the patient is asked to place the hand on his or her other shoulder and to raise the elbow without elevating the shoulder. These tests are positive when they elicit the pain usually experienced by the patient.

For Jobe's manoeuvre,⁹ the examiner stands facing the patient, who places both arms in 90° abduction and 30° horizontal adduction, in the plane of the scapula, with his thumbs pointing downward in order to produce medial rotation of the shoulder; the examiner then pushes the patient's arms downward while asking the patient to resist the pressure. In Patte's manoeuvre,¹ the examiner supports the patient's elbow in 90° of forward elevation in the plane of the scapula while the patient is asked to rotate the arm laterally in order to compare the strength of lateral rotation. Jobe's and Patte's manoeuvres can produce three types of response: (a) absence of pain, indicating that the tested tendon is normal; (b) the ability to resist despite pain, denoting tendinitis; (c) the inability to resist with gradual lowering of the arm or forearm, indicating tendon rupture.

In Gerber's lift off test,¹⁰ the patient is asked to place the hand against the back at the level of the waist with the elbow

Abbreviations: US, ultrasonography; PE, physical examination.

Table 1 Ultrasonographic diagnostic criteria of shoulder abnormalities

Shoulder abnormality	Diagnostic criteria
Biceps sheath effusion	Thickness of the hypoechoic halo of fluid surrounding the biceps tendon greater than 2 mm
Biceps tendinitis	Increased fluid within the synovial sheath and tendon hypoechoogenicity and/or thickening
Biceps tendon rupture	Partial or complete interruption of the tendon fibres, separation of the ends and hypoechoic fluid filling the defect
Biceps tendon subluxation	Empty bicipital groove and identification of the displaced tendon
Biceps tendon degeneration	Tendon hypoechoogenicity and tendon thinning
Rotator cuff tendinitis	Tendon hypoechoogenicity or tendon thickening with or without internal hypo or hyperechoic foci
Subscapularis full thickness tear	Non-visualisation of tendon or complete fibres discontinuity
Subscapularis partial thickness tear	Partial fibre discontinuity
Supraspinatus and infraspinatus full thickness tear	Non-visualisation of tendon or fibre discontinuity from the humeral head to the subacromial-subdeltoid bursa or superior convexity instead of concavity
Supraspinatus and infraspinatus partial thickness tear	Hypoechoic fibre discontinuity involving the bursal or articular surface or intrasubstance hypoechoic defect or focal tendon thinning
Subacromial-subdeltoid bursitis	Hypoechoic fluid filled bursa greater than 2 mm thick
Acromioclavicular degenerative changes	Cortical irregularities or osteophytes, usually accompanied by intra-articular hypoechoic fluid displacing joint capsule
Glenohumeral effusion	Distance from the posterior labrum to the posterior infraspinatus tendon greater than 2 mm
Rotator cuff calcifications	Hyperreflective foci or lines with acoustic shadowing
Rotator cuff impingement	A buckling of the cuff/rippling effect as the cuff passes beneath the coracoacromial arch or fluid distending the subacromial-subdeltoid bursa or thickened bursa in front of the acromion while the arm is abducted

in 90° flexion. The examiner pulls the hand to about 5–10 cm from the back while maintaining the 90° bend in the elbow. The patient is then asked to hold the position without the examiner's help. This test is positive if the hand cannot be lifted off the back, detecting complete rupture of the subscapularis tendon.

In Yergason's test,¹¹ pain along the course of the biceps tendon produced by resisted supination of the forearm denotes bicipital tendinitis. For Yergason's test, the patient is also asked to perform a combined movement of flexion at the elbow along with medial rotation of the arm while the examiner resists it. If the biceps tendon is subluxated, it will slip out of the groove and elicit the patient's abnormal sensation. For the palm up test,¹² the patient is asked to elevate the arm anteriorly against resistance, with the elbow extended and the palm facing upward. The test is positive if the patient feels pain at the anterior aspect of the arm along the course of the long head of the biceps brachii. Popeye's sign shows a prominence in the distal arm due to the distal displacement of the biceps muscle belly, indicating rupture of the biceps tendon.¹¹

The presence of previous symptoms in the opposite shoulder was recorded in the clinical assessment of the patients. However, opposite shoulders were not clinically evaluated.

US examination

All patients were examined with commercially available real time equipment (Sonoline, Versa; Siemens, Seattle, Washington, USA) using a 7.5 MHz linear phased array transducer. Transverse and longitudinal planes from the biceps tendon groove, rotator cuff, and subacromial-subdeltoid bursa and transverse planes from the posterior glenohumeral recess and glenoid labrum were scanned. In all patients, comparable images of the opposite shoulder were obtained in order to compare US findings. US examination of the opposite side is routinely performed to facilitate detection of subtle abnormalities. The normal sonographic anatomy of the shoulder has been widely described.^{13–14} The biceps tendon groove, the subscapularis tendon, and the acromioclavicular joint are examined with the patient seated with the arm held in neutral position, the elbow flexed to 90°, and the forearm in a supinated position on the thigh. On the anterior aspect of the shoulder, the long head of biceps tendon is imaged as a fibrillar hyperechoic structure into the humeral groove, surrounded by a 1–2 mm thick hypoechoic halo of fluid within the synovial sheath. Medial to the biceps tendon, the hyperechoic subscapularis tendon is identified inserting on the lesser tuberos-

ity with some fibres continuing across the bicipital groove to form the transverse humeral ligament. A more extensive and dynamic view of the subscapularis tendon is obtained when the shoulder of the patient is moved into external rotation. In the acromioclavicular joint, small amounts of intra-articular fluid can be detected, and in younger patients the hyperechoic intra-articular fibrocartilage can be seen.

Next, the transducer is moved laterally to scan the rotator cuff. The supraspinatus and infraspinatus tendons are examined with the patient's shoulder in hyperextension and internal rotation in order to expose the supraspinatus from underneath the acromion.¹⁴ This position allows the maximal length of tendons to be visualised.¹⁵ These tendons appear as a hyperechoic homogeneous fibrillar layer, convex shaped on transverse images and curved triangular shaped on longitudinal views, deep to the deltoid muscle covering the humeral head. The subacromial-subdeltoid bursa is imaged as a hypoechoic line, 1–2 mm thick with a variable amount of peribursal echogenic fat, between the deltoid muscle and the supraspinatus and infraspinatus tendons. The humeral articular cartilage is seen as a thin hypoechoic layer between the supraspinatus and infraspinatus tendons and the humeral head.

After the examination of the lateral rotator cuff is completed, the posterior infraspinatus and teres minor tendons are evaluated from a posterior view with the arm in neutral position and the elbow flexed at 90°. A normal small amount of fluid is seen in the glenohumeral joint. The cartilaginous posterior labrum is viewed as a hyperechoic triangle separating the infraspinatus and teres minor tendons from the glenoid.

Impingement syndrome is evaluated by dynamic examination.¹⁶ A dynamic view of the supraspinatus tendon is obtained by moving the patient's arm from a neutral position to 90° abduction in order to detect encroachment of the acromion into the rotator cuff.

Table 1 lists the US diagnostic criteria for shoulder abnormalities, which are based on those widely described in the literature.^{4, 13, 14, 17–19} US findings from the clinically evaluated painful shoulders and the asymptomatic opposite shoulders were recorded.

Statistical analysis

A 2 × 2 table was used to evaluate the PE sensitivity, specificity, positive, and negative predictive value for the diagnosis of shoulder lesions.

Table 2 Physical examination/
ultrasonographic findings in patients
with painful shoulder

	PE	US
SS lesion	24	29
SS tendinitis	21	18
SS tear	3	16
IS lesion	14	17
IS tendinitis	11	7
IS tear	5	11
SB lesion	9	12
SB tendinitis	6	6
SB tear	4	7
Biceps tendinitis	19	19
SASD bursitis	8	14
ACCL involvement	15	24
Impingement	16	20
Biceps tendon subluxation	0	3
Biceps tendon rupture	0	1
Glenohumeral effusion	0	3

Values are number of patients.

PE = physical examination;

US = ultrasonography; SS = supraspinatus;

IS = infraspinatus; SB = subscapularis;

SASD = subacromial-subdeltoid;

ACCL = acromioclavicular.

RESULTS

There were 27 women and four men of mean age 57.5 years (range 21–77). Mean duration of symptoms was 12.5 months (range 1–48). Table 2 lists PE and US findings for the painful shoulders. Clinical diagnosis included supraspinatus, infraspinatus, and subscapularis tendinitis, tear or unspecific lesion when a more accurate diagnosis was not possible by PE, biceps tendinitis, subluxation, and rupture, subacromial-subdeltoid bursitis, acromioclavicular involvement, rotator cuff impingement, and glenohumeral effusion.

Most patients showed sonographic involvement of various different periarticular structures. Of the 34 rotator cuff tears detected by US, 29 were full thickness and five were partial thickness. All patients had an asymptomatic opposite shoulder at entry. Twenty one patients had no history of pain in the opposite shoulder, whereas 10 reported previous mild symptoms in the opposite shoulder. US examination of these asymptomatic shoulders showed a supraspinatus partial thickness tear in eight patients, acromioclavicular degenerative changes in seven patients, and mild impingement in six patients.

Table 3 Comparison of physical examination and ultrasonographic findings

	S (%)	Sp (%)	PPV (%)	NPV (%)
SS lesion	79.3	50	95.8	14.2
SS tendinitis	72.2	38.4	61.9	50
SS tear	18.7	100	100	53.5
IS lesion	70.5	90	85.7	70.5
IS tendinitis	57.1	70.8	36.3	85
IS tear	36.3	95	80	73
SB lesion	50	84.2	66.6	72.7
SB tendinitis	50	88	50	88
SB tear	50	95.4	75	87.5
Biceps tendinitis	73.6	58.3	73.6	58.3
SASD bursitis	42.8	88.2	75	65.2
ACCL involvement	58.3	85.7	93.3	37.5
Impingement	65	72.7	81.2	53.3

SS = supraspinatus; IS = infraspinatus; SB = subscapularis; SASD = subacromial-subdeltoid; ACCL = acromioclavicular; S = sensitivity; Sp = specificity; PPV = positive predictive value; NPV = negative predictive value.

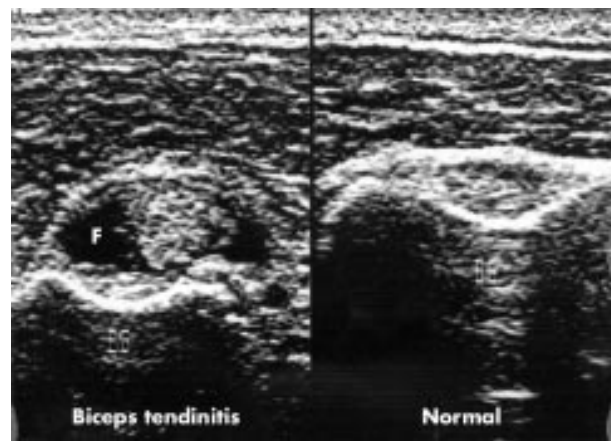


Figure 1 Ultrasonographic transverse imaging of biceps tendinitis (left) compared with normal biceps tendon (right). Note the increased hypoechoic fluid (F) within the biceps tendon sheath, surrounding the hyperechoic tendon. BG = Bicipital groove.

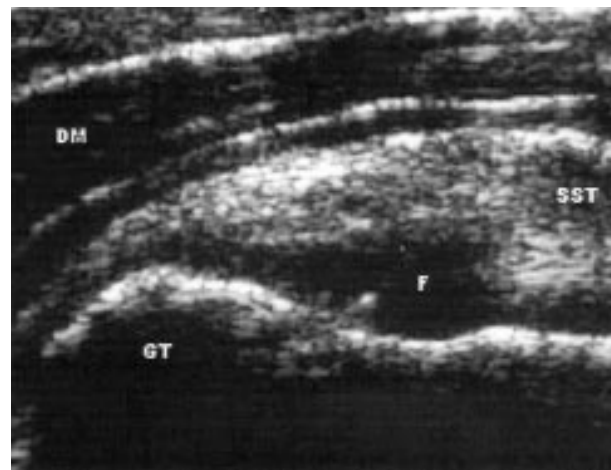


Figure 2 Ultrasonographic longitudinal imaging of a deep surface supraspinatus partial thickness tear. Note the hypoechoic fluid (F) filling the fibre defect. GT = Greater tuberosity of the humerus; SST = supraspinatus tendon; DM = deltoid muscle.

Table 3 shows the sensitivity, specificity, positive predictive value, and negative predictive value of PE in the detection of the above lesions. Sensitivity was low in the clinical diagnosis of all shoulder lesions, especially rotator cuff tear and subacromial-subdeltoid bursitis. However, specificity was high for some of these lesions such as rotator cuff tear and fairly good for infraspinatus lesion, subscapularis lesion and tendinitis, subacromial-subdeltoid bursitis, and involvement of the acromioclavicular joint. However, it was very low for the detection of supraspinatus lesion, biceps tendinitis, and rotator cuff impingement. PE was unable to differentiate rotator cuff tendinitis from tear, and partial thickness tear from full thickness tear. Moreover, it missed one biceps tendon rupture, three biceps tendon subluxations, and three glenohumeral effusions.

Figures 1 and 2 show examples of US images.

DISCUSSION

Painful shoulder is a very common rheumatological condition. In most patients, it results from periarticular lesions involving the rotator cuff, the biceps tendon, and the subacromial-subdeltoid bursa.²⁰ The differential diagnosis includes several entities of similar clinical picture. Tendinitis and tears of the rotator cuff, biceps tendinitis, and subacromial-subdeltoid bursitis are the most common lesions found.²⁰ It has been

established that tendon degeneration occurs as part of the aging process.²¹ Progressive tendon failure then leads to rotator cuff rupture.²² Consequently, tendinitis and tears of the rotator cuff usually occur in patients over 50 years of age.²³ The cause of these lesions is thought to be tendon degeneration, repetitive trauma, or both.^{21, 24} The impingement concept is a unification of this spectrum of disorders.^{16, 21, 24, 25} In 1972, Neer proposed his concept of impingement of the rotator cuff on the anterolateral margin of the acromion as a three stage classification of tendon pathology ranging from the stage I rotator cuff tendinitis seen in the young adult to the stage III condition of tendon rupture seen in older patients.²⁶ Subacromial-subdeltoid bursitis, biceps tendinitis (occasionally associated with biceps subluxation), and acromioclavicular degenerative changes often accompany rotator cuff lesions and impingement syndrome.²⁷

Biceps tendon involvement has been reported to be present in about 85% of patients with a painful rotator cuff tear.²⁴ Moreover, increased fluid in subacromial-subdeltoid bursa usually accompanies impingement syndrome or rotator cuff full thickness tears.^{28, 29} The explanation for these findings is that the biceps tendon and the subacromial-subdeltoid bursa are exposed to the mechanical forces that contribute to cuff impingement because of its anterior location in the impingement area. Furthermore, the synovial sheath of the biceps tendon is an extension of the glenohumeral synovial membrane, and the subacromial-subdeltoid bursa communicates with the glenohumeral joint after rotator cuff full thickness tears.

The clinical diagnosis of periarticular shoulder conditions depends on a number of physical manoeuvres designed to increase the encroachment of the acromial arch on to the rotator cuff or to determine the location of tendon lesions by testing the motion against resistance. Clinically it may be difficult to differentiate the pain patterns of the rotator cuff lesions, biceps tendon pathology, and subacromial-subdeltoid bursitis. Obviously, any position in which the rotator cuff is compressed by the acromial arch causing pain during examination is highly diagnostic of rotator cuff lesion. However, this finding could be indicative of any rotator cuff condition, such as tendinitis, partial thickness tear, or full thickness tear. Moreover, many of these positions also compress or stretch the biceps tendon and the subacromial-subdeltoid bursa. Therefore the induced pain is not diagnostic of one rather than another disorder.

Our results show that the clinical diagnosis of periarticular conditions in the painful shoulder is not very accurate compared with US diagnosis. Other authors have also reported the low accuracy of clinical assessment compared with intra-operative anatomic lesions in the diagnosis of periarticular shoulder conditions.^{1, 30, 31} In contrast with our results, Leroux *et al*¹ reported satisfactory sensitivity but poor specificity for clinical tests, particularly for determining the location and type of rotator cuff lesions; the probable explanation is the difference in populations. Norwood *et al*³¹ tried to define the clinical signs and symptoms that indicate the presence of a rotator cuff tear and predict its severity. They found that the characteristics of the pain and the site of tenderness were not helpful, nor was weakness to resisted abduction. Our and other results are to be expected because most patients with chronic shoulder pain have impingement syndrome and several periarticular lesions, usually involving different tendons and the subacromial-subdeltoid bursa.

A possible explanation for the low accuracy of the clinical assessment in our series could be an absence of correlation between clinical findings and anatomical abnormalities in the shoulder. A variable prevalence of periarticular shoulder lesions, especially rotator cuff tears, has been reported in asymptomatic shoulders.^{32, 33} However, among 31 patients, we found supraspinatus partial thickness tears in eight, cortical irregularities or osteophytes in the acromioclavicular joint in

seven, and mild US signs of supraspinatus impingement in six asymptomatic shoulders. No asymptomatic shoulder showed rotator cuff full thickness tear, subscapularis or infraspinatus tears, rotator cuff tendinitis, biceps tendon lesions, or subacromial-subdeltoid bursitis. Therefore the presence of asymptomatic US abnormalities in the painful shoulders may partially explain the low sensitivity of the clinical evaluation of rotator cuff lesions, but does not explain the low specificity of PE in their detection nor the low accuracy of PE in diagnosing all shoulder lesions.

Clinical examination is usually supplemented by plain radiography. However, the ability of this technique to show only non-specific indirect signs of chronic rotator cuff lesions limits its use for ruling out osteoarthritis, periarticular calcifications, and other bone causes of shoulder pain. Other diagnostic procedures such as computed tomography, arthrography, and arthroscopy cannot be considered for routine examination because of their invasiveness. Currently, both magnetic resonance imaging (MRI) and high frequency US are used to evaluate soft tissue disorders of the shoulder. The diagnostic value of MRI for shoulder pathologies has been widely reported.^{25, 34-37} However, it is expensive, time consuming, and not widely available.

High resolution imaging afforded by the current generation of high frequency (greater than 7.5 MHz) linear transducers allows us to effectively assess superficial tendon and muscle lesions and bursitis.³⁸⁻⁴⁴ This technique has also been shown to be accurate for detecting intra-articular fluid and synovitis and abnormalities of articular cartilage.^{4, 40, 45-49} Furthermore, US can be used as a guide in performing periarticular and intra-articular fluid aspirations, infiltrations, and biopsies, making these procedures more accurate than when carried out blind. US has considerable advantages over other imaging techniques: it can routinely be used for dynamic examination of the musculoskeletal system; it is quick and easy to perform; it has no secondary effects⁵⁰; the costs are low. It has proved to be accurate and reliable in diagnosing a wide range of shoulder disorders compared with arthrography,^{13, 17, 18, 51-57} MRI,^{58, 59} arthroscopy,^{19, 36, 60, 61} and surgical findings.^{17, 18, 51, 52, 55, 56, 60, 62} Several studies have shown an accuracy for US detection of rotator cuff lesions compared with surgical findings of greater than 0.85^{17-19, 51, 60-62} and an interobserver reliability of 0.63.⁶¹

Disadvantages of US include lack of visualisation of the posterior aspect of the supraspinatus and infraspinatus tendons and a limited view of the glenohumeral joint and the glenoid labrum. However, most rotator cuff lesions involve the "critical zone" in the anterior aspect of the tendons.²³ Furthermore, US is considered to be the most operator dependent imaging technique. However, the results of any imaging technique depend on the skill of the examiner.

Initial conservative treatments of periarticular shoulder disorders are quite similar relying on the use of non-steroidal anti-inflammatory drugs, physiotherapy, and local injections of corticosteroids. The overall prognosis for patients with these conditions is considered to be good.^{22, 63} However, previous studies of the effectiveness of conservative therapeutic approaches have relied largely on clinical assessment. Patient groups have been rather heterogeneous and not matched, making interpretation of results difficult. In addition, few studies have evaluated the outcome of the different periarticular lesions diagnosed by an accurate imaging technique.²⁰ It would therefore be desirable to obtain an exact diagnosis of the different periarticular shoulder lesions in order to evaluate their prognosis and their response to various conservative treatment options. The availability of US in rheumatological practice offers the possibility of establishing a more accurate diagnosis of the painful shoulder and therefore improving the treatment of this common disorder.

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Authors' affiliations

E Naredo, P Aguado, E De Miguel, J Uson, L Mayordomo, J Gijon-Baños, E Martín-Mola, Department of Rheumatology, La Paz Hospital, Autonoma University of Madrid, Spain

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