Ultrasound diagnosis of subacromial impingement for lesions of the rotator cuff

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Fig. 1: *Neer impingement test.* Pain is elicited during forward flexion of the shoulder while keeping the arm in full pronation (thumb down).

Introduction

Subacromial impingement is a common clinical disorder and a frequent context in which diagnostic ultrasound may be requested. However the reliability of ultrasound for this diagnosis has recently been criticised¹. We therefore attempt to define, explain and suggest guidelines for the reporting of subacromial impingement by ultrasound.

Definition

One of the challenges for the diagnosis of subacromial impingement is the multiplicity of conditions with similar symptoms and variable clinical presentation. With no single aetiology, the clinical diagnosis of subacromial impingement has also suffered from a “lack of consensus on diagnostic criteria, case definition and even nomenclature”¹. For want of clarity, we suggest the following basic definition:

Subacromial impingement is a clinical syndrome of anterolateral shoulder and/or lateral upper arm pain that occurs during elevation of the arm as a mid-range “painful arc” that, in lesions of the rotator cuff, is believed to reflect

Fig. 2: *Hawkins impingement test.* Pain is elicited after first forward flexing the arm to 90° and then applying internal rotation.

compression of the rotator cuff and/or subacromial-subdeltoid (SA-SD) bursa by the overlying coraco-acromial arch.

This definition captures the key features of subacromial impingement:

- The condition is a clinical syndrome of *pain* (not a static or dynamic grayscale ultrasound appearance)
- The pain is felt in the shoulder and/or upper arm through an “arc” of *mid-range* elevation of the arm
- Pain is due to mechanical compression of the rotator cuff and/or SA-SD bursa by the coraco-acromial arch.

However it must be appreciated that these basic concepts still fail to capture the less common clinical presentations of subacromial impingement which may exhibit additional features such as subacromial crepitus or atypical features such as end-range abduction pain.

Pathomechanics

The SA-SD bursa is a normal anatomical structure that exists to minimise friction and help mitigate the compression that occurs during shoulder motion across the large movement interface

Fig. 3: *Ultrasound impingement test.* Pain is elicited as the arm is abducted in the scapular plane (both thumb up and thumb down).

Table 1: Causes of subacromial impingement (abbreviated).

(a) Subacromial soft tissue swelling
SA-SD bursopathy
Calcific rotator cuff tendonitis
Rotator cuff tendonosis secondary to overuse
Rotator cuff tendonosis secondary to glenohumeral instability
Avulsion fracture of greater tuberosity
Rotator cuff contusion
(b) Supraspinatus outlet encroachment
Anterior acromial bone spur
Bigliani Type III (hooked) acromion
AC joint osteophyte
Unfused Os Acromiale
(c) Humeral depressors overpowered by the deltoid
Supraspinatus tendon rupture
Long head of biceps tendon rupture
Suprascapular nerve palsy

between rotator cuff and coraco-acromial arch. To the extent that all shoulders are exposed to such forces acting across this movement interface, a notional concept of very low-grade or “physiological” impingement could be deemed to normally exist.

However, the *clinical syndrome* of subacromial impingement describes an entirely different scenario, a pathological one in which *the patient reports pain*. This syndrome is widely believed to reflect an abnormal degree of compression of the rotator cuff and/or SA-SD bursa by the coraco-acromial arch^{2,3}. Subacromial impingement can have a variety of underlying causes (Table 1). In addition to “intrinsic” causes such as primary rotator cuff or coraco-acromial arch pathology, it is important to understand that impingement may also result from “extrinsic” or “non-outlet” causes such as glenohumeral joint instability, inflammatory disorders, suprascapular nerve palsy or other scapulothoracic neuromuscular dysfunction.

Fig. 4: *Dynamic ultrasound finding of “bursal bunching”.* Comparison long-axis views of the supraspinatus insertion passing beneath the coraco-acromial arch (A) have been obtained. On the symptomatic right side, there is bunching of the SA-SD bursa just lateral to the acromion process (arrow) with associated pain. This compares with absence of bunching (arrowhead) and absence of pain on the asymptomatic left side. Bunching implies mechanical compression by the overlying coraco-acromial arch *but does not alone predict symptomatic impingement*. The critical observation is that, as the supraspinatus insertion passes beneath the coraco-acromial arch, there is *not only bursal bunching but a transient arc of pain*. When these features are all simultaneously present, ultrasound has a high positive predictive value for the diagnosis of subacromial impingement.

Ultrasound technique

Following directly from our stated definition, the cardinal sonographic sign of subacromial impingement is the elicitation of a transient arc of pain during shoulder abduction which coincides with passage of the supraspinatus insertion beneath the coraco-acromial arch. Note the implications:

- If ultrasound is to reliably diagnose impingement, a *dynamic* assessment of shoulder abduction is required.
- The essential diagnostic feature is *pain* rather than a grayscale finding such as “bunching” of the SA-SD bursa.

Thus, the examiner must ask the patient to indicate when pain both appears and disappears during shoulder abduction, and furthermore must objectively show by direct real-time ultrasound observation that this correlates with the supraspinatus insertion passing beneath the coraco-acromial arch. A characteristic arc of “mid-range” pain means that, in most cases, both early-stage and end-stage shoulder abduction should be pain-free. As a variant of this, impingement pain may additionally or even solely occur during *return* of the arm from an abducted position.

Elicitation of impingement pain requires the examiner to move the supraspinatus insertion beneath the coraco-acromial arch. Clinically, this is usually performed using: (a) The Neer test, which involves forward flexion of the arm with the thumb facing down (Fig. 1); and (b) The Hawkins test, which involves axial rotation of the already 90° abducted arm (Fig. 2). The ultrasound test of impingement is performed with the arm abducted in or slightly forward of the scapular plane, as this facilitates simultaneous visualisation of the relevant anatomical landmarks throughout the arc of elevation (Fig. 3). As this test aims to replicate the patient's usual impingement pain, abduction should be performed (a) as an active rather than passive process, and (b) in the manner that typically creates pain, preferably either in or forward of the scapular plane. During this process, the ultrasonographer is

Fig. 5: *Subacromial impingement bursopathy.* There is thickening of the SA-SD bursa (arrowheads) which is confined to the superior recess over supraspinatus tendon (s) and spares the bursal recesses elsewhere. This distribution reflects the zone of compression and is characteristic of chronic impingement *but does not alone predict symptoms*. Other forms of inflammatory bursitis usually result in a more generalised distribution of bursal change. A small bursal effusion may also be seen in acute impingement episodes, but this finding is non-specific as other causes also exist (e.g. inflammatory arthropathies, polymyalgia rheumatica, full-thickness rotator cuff tear). g = greater humeral tuberosity. Image with permission from Atlas of Imaging in Sports Medicine 2e, McGraw-Hill, Sydney, 2008.

Fig. 6: *Supraspinatus "tendonitis".* There is focal hypoechoic swelling of the more superficial fibres of supraspinatus insertion (arrow) and this correlated on real-time examination with localised tenderness to sonopalpation and mild tendon hyperaemia on Doppler interrogation. This finding of localised insertional "tendonitis" predisposes to subacromial impingement. Note the absence of any overlying bursal reaction (arrowhead). The bursa can appear entirely normal in as many as 20% of impinging shoulders. gt = greater humeral tuberosity. Image with permission from Atlas of Imaging in Sports Medicine 2e, McGraw-Hill, Sydney, 2008.

Fig. 7: *Bursal-side partial-thickness tear of supraspinatus tendon.* Chronic subacromial impingement may result in partial or full-thickness tears of the rotator cuff. In the case of impingement shown here, the supraspinatus insertion shows localised tendon surface concavity which indicates focal volume loss caused by an underlying tear, in this case most likely bursal-side partial-thickness in type (arrow). Note the absence of any overlying bursal reaction (arrowheads). g = greater humeral tuberosity; s = supraspinatus tendon; A = acromion process.

able to observe the supraspinatus insertion passing beneath various points along the coraco-acromial arch (with the anterior acromial margin and/or upper end of coraco-acromial ligament usually being the most rewarding).

The ultrasound literature reports an additional four dynamic signs of subacromial impingement: (a) "bunching" or fluid distension of the SA-SD bursa lateral to the impingement point at coraco-acromial arch^{4,5} (Figs. 4 and 9); (b) "bunching" of the supraspinatus tendon lateral to the impingement point at coraco-acromial arch^{5,6}; (c) bulge of the coraco-acromial ligament⁷; and (d) less commonly,

Fig. 8: *Anterior acromial bone spur (arrow).* Radiographs are an essential component of the imaging work-up for subacromial impingement syndrome. This patient also demonstrated features of active symptomatic impingement on ultrasound (same case as shown in Fig. 9).

complete "blocking" of supraspinatus tendon motion due to "migration of the humeral head upward to prevent its passage beneath the acromion"⁵. Although these findings all reflect mechanical compression beneath the coraco-acromial arch and therefore have value, they unfortunately *do not alone* accurately predict subacromial impingement syndrome! For example, if taken in isolation, a dynamic finding of bursal "bunching" quite commonly gives both false positive and false negative results. Bursal "bunching" can be present in at least 30% of asymptomatic shoulders⁸ and absent in as many as 20% of shoulders with symptomatic impingement⁹. The key ultrasound finding in impingement is therefore *pain* rather than visualised soft tissue compression, but diagnostic accuracy is high when *both* findings are simultaneously present.

Additional findings which *may or may not* be present,

Fig. 9: Ultrasound example of subacromial impingement. Static imaging of the supraspinatus tendon showed: (a) features of “tendonitis” which included tenderness, hypoechoic thickening of the insertional fibres (arrowheads, top images) and mild hyperaemia (colour-fill, top right image); (b) thin hypoechoic line of suspected small bursal-side subsurface partial-thickness tear (thin long arrow, top left image); (c) scant effusion in the lateral recess of SA-SD bursa (short thick arrow, bottom left image); and (d) thickening of the superior recess of SA-SD bursa (x calipers). Dynamic assessment during shoulder abduction produced a mid-range arc of pain that corresponded with passage of the supraspinatus insertion beneath the acromial bone spur (s) shown in Fig. 8 and also produced mild “bunching” of the SA-SD bursa at the margin of the impingement point (arrowheads, bottom right image). Tip of greater humeral tuberosity = g.

and which *do not alone predict* but nevertheless indirectly suggest and/or predispose to subacromial impingement, include:

- SA-SD bursopathy, which can occasionally include palpable subacromial crepitus (Fig. 5);
- Supraspinatus “tendonitis” (Figs. 6, 9), bursal surface abrasion, or tendon tear (Figs. 7, 9);
- X-ray features of adverse acromial morphology (e.g. bone spur, Fig. 8) or glenohumeral instability.

Diagnosis

The reliable diagnosis of subacromial impingement by physical examination alone is difficult, as presentation is variable and standard clinical tests can be inaccurate^{1,10}. For this reason, a diagnostic anaesthetic block of the SA-SD bursa using an injection of 5–10 cc lignocaine 1% to confirm relief of symptoms has traditionally been advocated as the more definitive and objective “impingement test”. However, this test is invasive and may also be falsely negative if the actual pain generator is tendon rather than bursa. A dynamic ultrasound examination which includes a clinically correlated and well-performed physical impingement test therefore has value.

However ultrasound should never be used in isolation and requires an operator with adequate training, experience and examination technique. Medical diagnosis is a multifaceted exercise and, if performed, ultrasound is only one element in this process. Clinical judgement is *always* needed to bring the overall picture into perspective. Ultrasound may be falsely negative if impingement is inactive at the time of examination, falsely positive if the diagnosis is based on

Fig. 10: Ultrasound-guided diagnostic/therapeutic injection of SA-SD bursa. The tip of a 25 gauge needle is advanced in the imaging plane of the transducer (arrow) and introduced into the superior bursal recess (arrowhead). A combination of corticosteroid and lignocaine 1% is then instilled with consequent distension of the bursal space. s = supraspinatus tendon; g = greater humeral tuberosity.

grayscale appearances alone, or confusing if atypical features are present. Co-existing pathologies such as glenoid labral tear, glenohumeral capsulitis or osteoarthritis are not uncommon, and may confound both the clinical and sonographic diagnosis¹. Hence the time-honoured clinical dictum that “the physician must treat the patient, not the test”.

The ultrasound specialist must similarly think at a clinical level. Are the sonographic findings appropriately concordant with the history, physical findings and other ancillary tests? Is the underlying aetiology clear or is further investigation required? The individual setting and past medical history should be explored. For example, a patient presenting with impingement at less than 35 years age has a high probability of underlying glenohumeral instability and may warrant further investigation by MRI. Is there a history that would suggest alternate pathology (e.g. rheumatoid arthritis, renal dialysis)?

In order to form an adequate overview, the baseline imaging work-up of subacromial impingement should always include plain radiographs (Fig. 8). These serve to detect or help to rule out a range of considerations including calcific tendonopathy, acromial bone spur, unfused os acromiale, destructive bone lesions, acromioclavicular or glenohumeral arthropathy, and some cases of glenohumeral instability. A trial of ultrasound-guided diagnostic/therapeutic SA-SD bursal injection (using both corticosteroid and local anaesthetic) may be considered, and other investigations may also be indicated in specific circumstances (Fig. 10).

Conclusion

As ultrasound is a *clinical* examination that allows the rotator cuff and the overlying SA-SD bursa to be directly observed during shoulder abduction and correlated with pain reported by the patient, it has the potential to be a powerful tool for the diagnosis of subacromial impingement. However this test requires a careful and well-trained operator. False positive results are possible if the sonologist fails to accurately correlate pain, and false negative results are possible if an inadequate examination technique is used or the patient is only intermittently symptomatic.

The ultrasound specialist must always consider the larger clinical picture, including the underlying aetiology for impingement in any given case. Plain radiographs are an essential component of the imaging work-up. Atypical ultrasound findings must not be ignored but rather explained and reconciled with the clinical setting, as some patients will have unexpected or co-existent pathology of some other kind. In particular, it is not uncommon for glenohumeral capsulitis to either mimic or secondarily complicate subacromial impingement, and a great strength of ultrasound is its ability to differentiate these two conditions at an early stage when the clinical features are non-specific. A trial of ultrasound-guided SA-SD bursal injection may be used for both diagnosis and therapy.

We suggest the following practical guidelines for reporting subacromial impingement:

- Rather than simply stating an opinion, describe the actual real-time appearance (e.g. “the patient reported a mid-range arc of shoulder pain during abduction which correlated with passage of the supraspinatus insertion beneath the coraco-acromial arch and was associated with bunching of the SA-SD bursa”).
- Record a hard-copy image that accurately reflects the real-time impression (e.g. a “bunched” SA-SD bursa with attached label of either “pain” or “no pain” as shown in Fig. 4).
- Qualify the final opinion if necessary – for example, noting that a negative result in the presence of other positive imaging features for impingement such as acromial bone spur may simply reflect quiescence at the time of ultrasound examination and not exclude the clinical diagnosis of impingement.

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