Ultrasound diagnosis of subacromial impingement for lesions of the rotator cuff

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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 pain (not a static or dynamic grayscale ultrasound appearance) in lesions of the rotator cuff, that occurs during elevation of the arm as a mid-range “painful arc” that, in lesions of the rotator cuff, is believed to reflect compression of the rotator cuff and/or subacromial-subdeltoid (SA-SD) bursa by the overlying 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. 1: Neer impingement test. Pain is elicited during forward flexion of the shoulder while keeping the arm in full pronation (thumb down).

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

### 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
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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 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.

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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. 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 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 diagnosis. 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 sub-acromial 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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