High-resolution Dynamic Ultrasound (D-HRUS) of the Shoulder: How We Do It

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Learning objectives

The rotator cuff of the shoulder can be easily examined with ultrasound (US). This technique allows for a high-resolution and dynamic evaluation of tendinous and periarticular structures.

The following structures will be depicted and coupled with educational images, schemes and videos about "how to do" a d-HRUS of the shoulder:

1 long head of the biceps brachii tendon
2 rotator interval
3 subscapularis tendon
4 supraspinatus tendon
5 subacromial impingement
6 infraspinatus tendon and teres minor tendon
7 posterior joint recess
8 coraco-acromial ligament
9 acromion-clavear joint
Background

Ultrasonography (US) is an established and well-accepted modality for the evaluation of articular and peri-articular structures around the shoulder. It is useful in a wide range of rotator cuff diseases as well as non-rotator cuff abnormalities. Diagnostic accuracy of shoulder US when evaluating rotator cuff tears has been reported to be as accurate as magnetic resonance imaging. Compared to other imaging modalities, US has the advantage to allow dynamic evaluation of musculoskeletal structures. To reduce individual accuracy variability, it is usually recommended to follow a scanning protocol that includes a list of main structures. There are several pitfalls related to US technique that may mislead the operator, so that it is important to become familiar with them to avoid erroneous exam interpretations.
LONG HEAD OF BICEPS BRACHII TENDON

The long head of biceps brachii tendon (LHBBT) arises from the supraglenoid tuberosity of the scapula and from the glenoid labrum as a long and cylindrical tendon, which runs into the joint cavity of the shoulder, between the humeral head and the joint capsule. Then it runs in the bicipital groove, surrounded by an extension of the synovial capsule.

How to do

Holding the transducer in a horizontal position, localize the bicipital groove (between small and large tuberosity of the humerus). This structure shall be used as a landmark to assess the long head of biceps brachii tendon on an axial scan.

The probe must then slide caudally to evaluate the vertical part of the LHBBT up to the myotendinous junction, located under the humeral insertion of the pectoralis major tendon (video 4).

Then the probe must be rotated 90° clockwise to evaluate the LHBBT along its long axis. Note that the LHBBT has an oblique course, from up to down and from anterior to posterior.

For such reason, optimal visualization of the tendon can be obtained by slightly pressing the distal edge of the probe on the skin.

Always remember that to avoid any anisotropy artifacts, the transducer must be kept as perpendicular as possible to tendon surface (video 7).

Figs 1 to 7

ROTATOR INTERVAL - LHBBT PULLEY

The rotator interval is a triangular portion of the capsule through which the LHBBT enters the intra-articular space and lies between the supraspinatus and the subscapularis tendons.

Here, the LHBBT is stabilized by the superior gleno-humeral ligament (inferiorly) and the coracohumeral ligament (superficially).

How to do
At sonography, the rotator interval is a hypoechoic area surrounding the cross-sectioned long head of the biceps tendon.

The rotator interval is best evaluated with the arm in external rotation or by externally rotating the glenohumeral joint slowly.

Figs 8 and 9

**SUBSCAPULARIS TENDON**

The subscapularis muscle arises from the subscapular fossa; most fibers are directed upwards and laterally, running under the coracoid, anterior to the glenohumeral joint, and insert on the humeral lesser tuberosity.

*How to do*

Keeping the probe on the bicipital groove, the forearm should be extrarotated to expose the subscapularis tendon.

On the long axis, the subscapularis tendon should be evaluated sliding the US transducer caudally; to best evaluate the tendon along its entire length, perform dynamic scans (video 15).

The subscapularis must then be evaluated on the short axis, turning the probe 90° clockwise. This scan shows the complex anatomy of the subscapularis tendon, formed by an alternation of tendinous and muscular fibers.

Figs 10 to 15

**SUPRASPINATUS TENDON**

The supraspinatus arises from the medial third of the supraspinata fossa and from the homonymous fascia. Its bundles are directed laterally, run behind the clavicle lateral edge, behind the acromion and the coracoacromial ligament, inserting on the superior border of the humeral greater tuberosity.

*How to do*

Ask the patient to put the hand on the posterior region of the iliac wing (on his "back pocket").

Note that the flexed elbow should be as medial as possible.
Once the tendon is identified, the probe should be oriented along the long axis of the tendon.

A correct scan is obtained when the humeral head cartilage, the anatomical neck of the humerus and the greater humeral tuberosity are seen together; it is possible to perform dynamic scans in order to best evaluate the tendon along its entire length (video 19).

Anisotropy artifacts could particularly affect the insertional area of the tendon on the humeral neck. To avoid these artifacts, slightly tilt the probe laterally to have the US beam as perpendicular as possible to tendon fibers.

After evaluating the supraspinatus tendon along its longitudinal axis, the probe should be rotated 90° clockwise to assess the short axis.

Figs 16 to 21

**SUBACROMIAL IMPINGEMENT**

The patient sits opposite the examiner, with the arm in a neutral position.

Position the probe with its medial edge at the lateral margin of the acromion, obtaining a coronal-oblique scan.

Abduct and elevate the patient’s arm internally rotated.

With this manoeuvre, the supraspinatus and the bursa can be seen passing deep to the coracoacromial arch.

So the subacromial (antero-superior) impingement can be demonstrated (video 22).

**INFRASPINATUS AND TERES MINOR TENDONS**

The infraspinatus is a flat, triangular shaped muscle, arising from the medial part of the fossa infraspinata and from the infraspinatus fascia.

Its fascicles run laterally and the muscle becomes a tendon that courses under the acromion, inserting on the posterior face of the humeral greater tuberosity.

The teres minor is a long, flat muscle.

It arises from the fossa infraspinata and runs up and laterally, inserting on the posteroinferior face of the humeral greater tuberosity. Some fibers also merge with the glenohumeral joint capsule.
How to do

The patient sits opposite the examiner, with their elbow flexed and palm on the opposite shoulder.

The probe should be oriented vertically to localize the scapular spine, which separates the fossa supraspinata from the fossa infraspinata.

Within the fossa infraspinata, infraspinatus and teres minor muscles can be seen.

The probe should then be slid laterally to assess both tendons on a short axis view.

Turn the probe by 90° and assess each tendon along its longitudinal axis (video 28).

For a better view of insertional region of the tendon it is useful to have the patient's arm slightly externally rotated.

Figs 23 to 30

GLENO-HUMERAL POSTERIOR JOINT RECESS

For a correct demonstration of the glenohumeral joint posterior recess, slide the probe medially on the posterior side of the joint and extrarotate patient's arm (in the same position used to evaluate the subscapularis tendon).

The axial US image over the posterior joint recess shows the glenoid bone, the posterior glenoid labrum, the posterior joint space and the humeral head.

How to do

For a correct demonstration of the glenohumeral joint posterior recess, slide the probe medially on the posterior side of the joint and extrarotate patient's arm (in the same position used to evaluate the subscapularis tendon).

The axial US image over the posterior joint recess shows the glenoid bone, the posterior glenoid labrum, the posterior joint space and the humeral head.

Fig 31

CORACO-ACROMIAL LIGAMENT
The coraco-acromial ligament is a thin triangular fibrous band, which links the acromion with the lateral edge of the coracoid, being part of the bony-fibrous roof above the glenohumeral joint.

The superficial side of the ligament is covered by the deltoid muscle, while the lower is adjacent to the subacromial-subdeltoid bursa and the supraspinatus tendon and muscle.

How to do

The patient sits opposite the examiner, with the arm along the body.

Position the probe with the medial edge on the coracoid and turn the lateral edge medially and cranially to the acromion to see the coracoacromial ligament.

Figs 32 to 34

ACROMIO-CLAVICULAR JOINT

The acromion-clavicular joint can be assessed by placing the probe on a coronal-oblique plane on the top of the shoulder.

From this position, abduct the patient's upper limb flexed to 90 degrees to evaluate the presence of subacromial impingement of the supraspinatus tendon.

Figs 35 and 36
Fig. 1: Long head of biceps brachii tendon.

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Fig. 2: Long head of biceps brachii tendon. Short axis: probe placement.

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Fig. 3: Short axis US scan of LHBBT

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**Fig. 4:** Long head of biceps brachii tendon. Short axis dynamic US evaluation

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Fig. 5: Long head of biceps brachii tendon. Long axis: probe placement

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Fig. 6: Long axis US scan of LHBBT

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Fig. 7: Anisotropy. The probe must be placed orthogonal to the tendon in order to properly visualize it.

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Fig. 8: Rotator interval. Probe placement

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Fig. 9: oblique US scan of the rotator interval

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Fig. 10: Subscapularis

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Fig. 11: Subscapularis tendon. Short axis: probe placement.

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**Fig. 12:** Short axis US scan of subscapularis tendon

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**Fig. 13:** Subscapularis tendon. Long axis: probe placement.

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**Fig. 14:** Long axis US scan of subscapularis tendon

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Fig. 15: Subscapularis tendon. Long axis dynamic US scan

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Fig. 16: Supraspinatus, subacromial-subdeltoid bursa, deltoid muscle.

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Fig. 17: Supraspinatus tendon. Long axis. probe placement.

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Fig. 18: Long axis US scan of supraspinatus tendon

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**Fig. 19:** Supraspinatus tendon. Long axis dynamic US evaluation

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Fig. 20: Supraspinatus tendon. Short axis. probe placement.

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Fig. 21: Short axis US scan of supraspinatus tendon

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Fig. 22: Subacromial impingment. Dynamic US scan to evaluate the antero-inferior impingment.

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Fig. 23: Infraspinatus and teres minor tendons

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Fig. 24: Posterior tendons. Short axis: probe placement.

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Fig. 25: Infraspinatus and teres minor. Short axis US scan

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**Fig. 26:** Infraspinatus tendon. long axis: probe placement

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**Fig. 27:** Long axis US scan of infraspinatus tendon

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Fig. 28: Infraspinatus tendon. Dynamic US scan to evaluate the tendon on its short and long axis.

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Fig. 29: teres minor tendon. long axis: probe placement

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**Fig. 30:** Long axis scan of teres minor tendon

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**Fig. 31:** Transverse US scan of posterior gleno-humeral joint recess

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Fig. 32: coraco-acromial ligament

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Fig. 33: coraco-acromial ligament. probe placement

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**Fig. 34:** US scan of coraco-acromial ligament

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**Fig. 35:** Acromio-clavicular joint. probe placement

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Fig. 36: acromio-clavicular joint. US scan

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Conclusion

Utrasonography is a valuable method that can be used to depict the anatomy of the structures located in and around the shoulder. This imaging modality has the great advantage of high-resolution capabilities and the possibility of examining the patient in different positions and using dynamic maneuvers. Following a standardized imaging protocol is essential for an exhaustive and efficient examination. However, a deep knowledge of anatomy, scanning technique, and normal image findings are mandatory to achieve optimal diagnostic results. Finally, knowledge of pitfalls that can be encountered when examining the shoulder may help to avoid erroneous images interpretation.
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