# 4 Anatomy and sonoanatomy of the shoulder

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## INTRODUCTION

The shoulder joint has to maintain a complex balance between strength and mobility. In occupational or sporting environments, shoulders are often subjected to workloads for which they are not prepared, frequently causing injuries. Moreover, the aging of its components in itself entails changes in its architecture; these reduce its resistance to stress and lesions occur with traumas that are, in many cases, trivial. Understanding the pathology of the shoulder requires clear and precise knowledge of its anatomy, since ultrasound diagnosis of injuries is based on sonographers comparing the images they obtain with their own paradigm of what is normal. This paradigm is acquired through study and experience, supplemented, if in doubt, by comparison with the healthy contralateral side.

High-end ultrasound machines are not necessary for adequate assessment of most of the shoulders that present themselves in the consulting room. Mid-range machines provide sufficient quality to reach a correct diagnosis, since the most important structures are generally not deep and are therefore easily accessible. In this anatomical area, linear probes with frequencies between 7 and 15 MHz are mainly used. In some cases, probes with frequencies from 15 to 18 MHz may be suitable, in very thin patients, for example, or when visualizing the acromioclavicular joint, but convex probes are rarely needed.

To image the shoulder effectively, a comfortable position is recommended, both for the sonographer and for the patient; it is therefore advisable to have the latter seated, ideally on a backless revolving stool, making it easy to examine the anterior and posterior aspects of the shoulder and perform dynamic maneuvers effortlessly.

In this chapter we will start by addressing the bones of the shoulder—with special emphasis on their most significant surface features—and then move on to the joints. Once we have looked at these, the other structures will be examined from a practical point of view, academically speaking. Each of these categories involves placing the patient in particular positions, since certain tendons need to be displaced from their original location, concealed behind the acromion, to make them accessible to ultrasound.

## RELEVANT BONE SURFACES

### Humerus

The proximal third of the humerus has several surface features of great functional importance, as they are the attachment sites for the various tendons. There are two tuberosities or tubercles. The greater tuberosity is located laterally and the lesser in an anterior and somewhat medial position. Between the two lies an indentation known as the bicipital groove, a sonographic landmark, through which the tendon of the long head of the biceps passes (see Fig. 4-1A and B).

The supraspinatus tendon inserts on the superior facet of the greater tuberosity, leaving a very characteristic footprint. It is important to examine this, as it is a common site of pathology (see Fig. 4-2). According to modern anatomical studies, the insertional footprints of the rotator cuff tendons are arranged not in parallel but in continuity with each other. This is especially true of the supraspinatus and infraspinatus. The footprint of the supraspinatus seems to be appreciably smaller than was classically thought and its posterior aspect is covered by the infraspinatus tendon, whose insertion extends, in some cases, as far as the anterosuperior facet of the greater tuberosity (Fig. 4-2A, B, and C).

### Scapula

The scapula is a flat posterior bone with a complex shape. It has a large anterior protuberance, the coracoid process, and another, even larger, superior to the rotator cuff: the acromion (see Fig. 4-1C). In some cases, the secondary acromial ossification center does not fully fuse with the rest of the scapula by the end of the growth phase, giving rise to what is known as an os acromiale. It should be borne in mind that this is one of the ossification centers

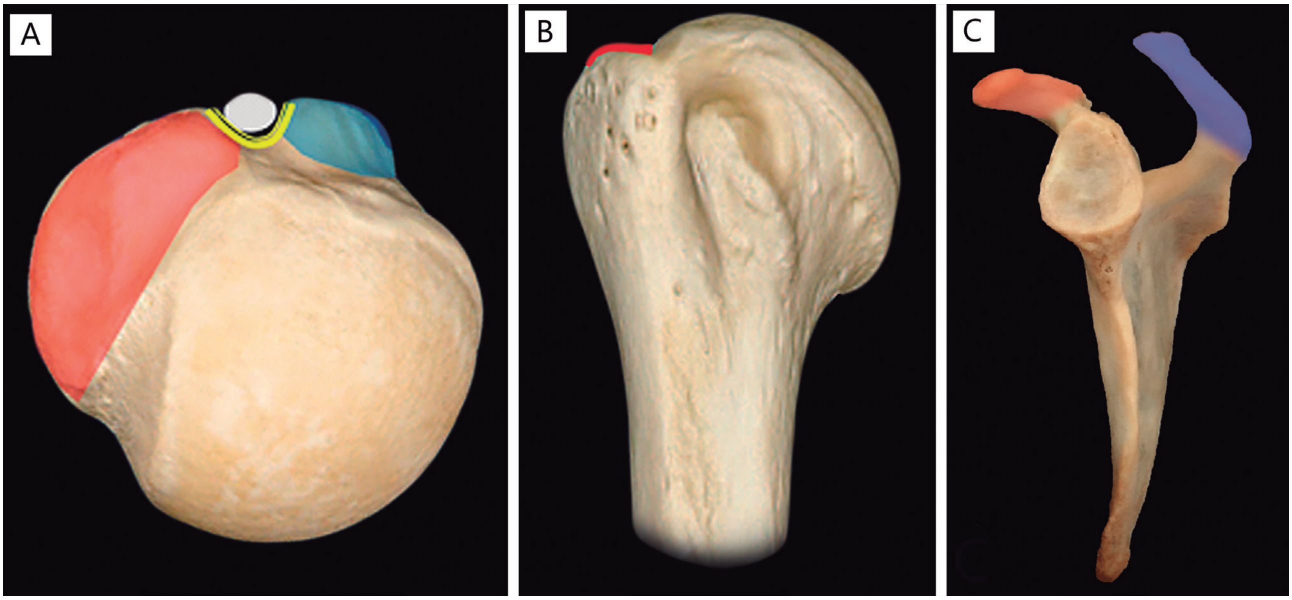


Figure 4-1. Relevant cortical surfaces in the shoulder joint. (A) Greater tuberosity (orange); lesser tuberosity (blue); bicipital groove (yellow line); long head of biceps tendon (white circle). (B) Coronal section of the humerus: footprint of the supraspinatus (red line). (C) Scapula with the coracoid process (orange) and the acromion (mauve).

that take longest to fuse (typically around the age of 18 or even later), so we must be cautious in evaluating imaging tests in young patients.

In the most anterior part of the supraspinous fossa is the suprascapular or supraspinous notch, which is converted into a foramen by the presence of the superior transverse scapular ligament. Through this hole, the suprascapular nerve enters the supraspinous fossa to supply sensory and motor innervation to various structures.

## JOINTS AND LIGAMENTS

The shoulder joint actually consists of five articulations: three synovial and two virtual or physiological. The first three are the glenohumeral, acromioclavicular, and sternoclavicular joints. The other two are the scapulothoracic and subacromial joints (or "gliding planes"). Anatomical details of the first two are presented in the following sections.

### Glenohumeral joint

The glenohumeral joint is largely incongruent; the glenoid cavity is shallow so as to allow the shoulder its wide range of motion. However, so much joint freedom predisposes to instability. To counteract this, there is the labrum, a fibrocartilaginous rim that surrounds the bony edge of the glenoid cavity, thus increasing the congruence of the joint and therefore its stability (Fig. 4-3A).

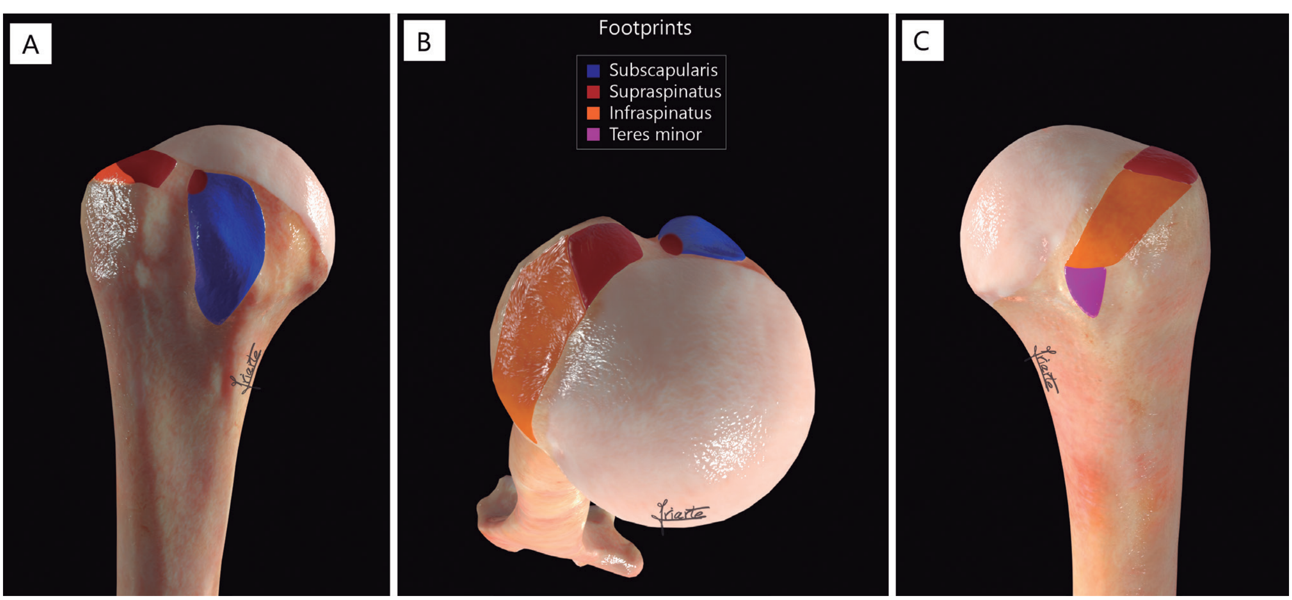


Figure 4-2. Insertional footprints of the rotator cuff tendons.

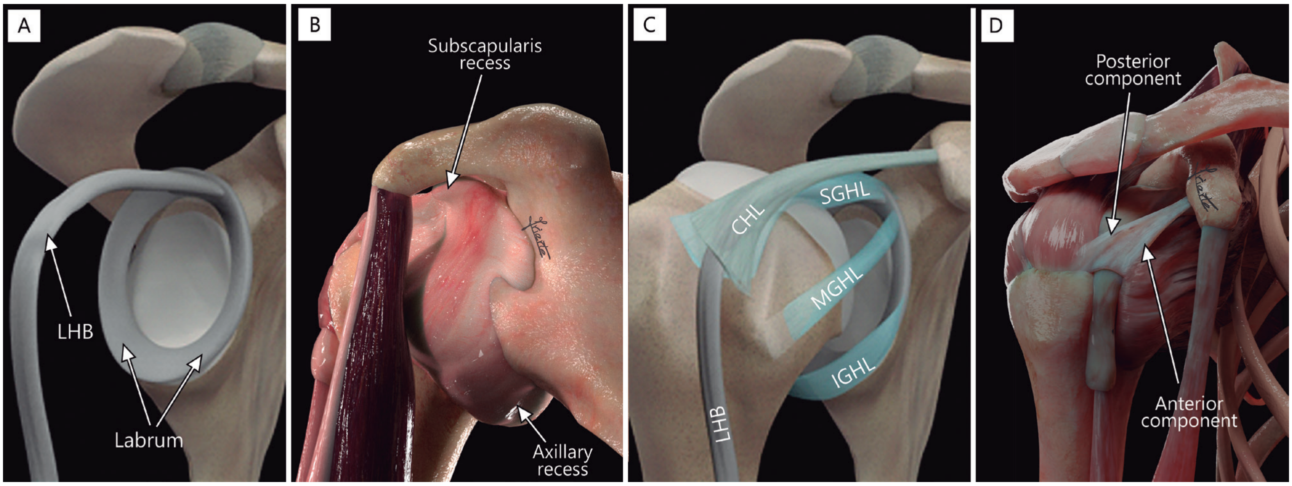


Figure 4-3. The glenohumeral joint. (A) Labrum and insertion of the long head of the biceps. (B) Capsule and recesses. (C) Main ligaments. (D) The coracohumeral ligament and its components. LHB: long head of biceps tendon; CHL: coracohumeral ligament; SGHL: superior glenohumeral ligament; MGHL: middle glenohumeral ligament; IGHL: inferior glenohumeral ligament.

Another important structure is the joint capsule, which has distinct thickenings within it: these are the superior, middle, and inferior glenohumeral ligaments (Fig. 4-3C). In addition, there are another two important ligaments that arise from the coracoid process. The first is the coracohumeral ligament, which extends to the humerus, forming part of the rotator interval (see Fig. 4-3D). This ligament has a complex distal insertion, with two components: one anterior, covering the long head of the biceps superficially and medially and merging with the superior glenohumeral ligament, and the other posterior, which divides in turn into two bands. One of these covers the supraspinatus tendon superficially, while the other is located deep to it to form what is known as the rotator cable, crossing both the supraspinatus and the infraspinatus in an anteroposterior direction (see Fig. 4-11B). The second of these ligaments arising from the coracoid process is the coracoacromial ligament, which inserts on the acromion, helping to form the roof of the subacromial space (v. Fig. 4-8B).

The recesses are lax areas of the capsule, visible primarily on magnetic resonance imaging (MRI) rather than ultrasound. The most important are the axillary recess in the most inferior part of the joint and the subscapularis recess in the anterosuperior area, immediately superior to the cranial edge of the subscapularis tendon and posterior to the coracoid process (Fig. 4-3B).

### Acromioclavicular joint

This is a diarthrodial joint with a very strong capsule, located between the medial border of the acromion and the lateral border of the clavicle. It usually contains a wedge-shaped or meniscoid fibrocartilage, of very variable morphology, originating in the superior part of the capsule. The joint is stabilized by capsular reinforcements above and below it: the superior and inferior acromioclavicular ligaments, which essentially prevent anteroposterior and mediolateral displacement. There are two powerful coracoclavicular ligaments responsible for preventing superior displacement of the clavicle; the more medial is the conoid ligament and the more lateral is the trapezoid ligament. As well as these ligaments, there are two other very important stabilizers: the trapezius and deltoid muscles, through their attachments on the acromion and the clavicle.

The rest of the anatomy of the shoulder will be approached for practical purposes according to the above-mentioned anatomical regions and their corresponding examination positions. In this respect, we will follow the recommendations of the technical guides to musculoskeletal ultrasound of the European Society of Radiology (ESR).

## STRUCTURES OF THE ANTERIOR ASPECT OF THE SHOULDER (POSITION 1)

The structures to be examined in this region (see Fig. 4-4A) include the tendons of the long and short heads of the biceps, the subscapularis, pectoralis major, and coracobrachialis muscles, and the coracoacromial ligament. To assess them, it is advisable to begin by locating the long head of biceps tendon, which is easy to find within the bicipital groove, making it a very useful sonographic landmark to start from. The biceps consists of two distinct portions or heads which join distally to form a single muscle. The short head is the more medial and originates from the coracoid process by a flat tendon immediately anterior to the coracobrachialis muscle (Fig. 4-4A and B). The long head forms a tendon which courses through the bicipital groove, becomes intra-articular, and turns to attach onto the supraglenoid tubercle, in close relationship with the superior labrum, to which it gives off expansions (Fig. 4-3A, 4-4B and C).

There is a transverse humeral ligament which jumps from the lesser to the greater tuberosity, forming a ceiling that closes the bicipital groove and thereby stabilizing the long head of the biceps within it (Fig. 4-4B).

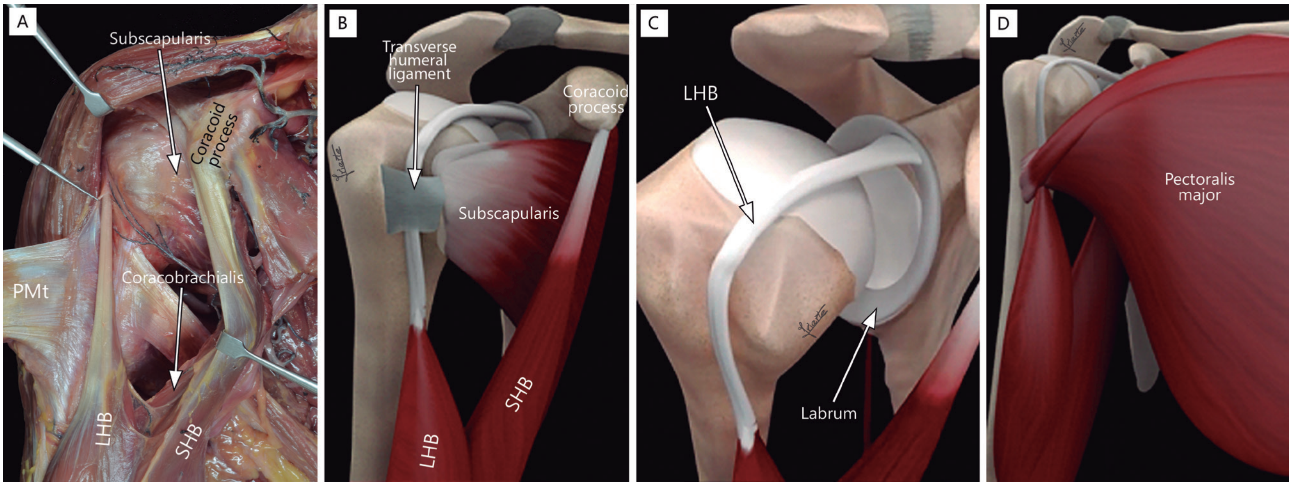


**Figure 4-4.** Structures of the anterior aspect of the shoulder. **(A)** Cadaveric image. **(B to D)** Anatomical models. LHB: long head of biceps; SHB: short head of biceps; PMt: Pectoralis major tendon.

More distally, where the muscular component of the long head of the biceps begins, lies the pectoralis major tendon (Fig. 4-4 A and D), which also plays a part in stabilizing the LHB by crossing over it (see Fig. 4-6B). The subscapularis muscle arises in the subscapular fossa (see Fig. 4-7A). It is a multipennate muscle with several tendons, four or six in number, within it. It inserts onto the lesser tuberosity with an attachment about 2 cm wide. Part of this insertion also crosses the bicipital groove, reinforcing the transverse humeral ligament and helping to stabilize the long head of the biceps. The subscapularis tendon and superior glenohumeral ligament play a very important role as stabilizers of the long head of the biceps at the level of the bicipital pulley, constituting a true medial and anterior wall (Fig. 4-4A and B, Fig 4-13B and C).

## Ultrasound examination

To evaluate the structures of the anterior aspect of the shoulder sonographically, place the patient in what is known as position 1: seated on a stool with the forearm in supination and the back of the hand resting on the homolateral knee; these details should be strictly adhered to, as positioning the patient correctly is very important for locating the structures easily and consistently, especially when the examiner is relatively new to ultrasound (see Fig. 4-5A).

Begin the examination by placing the probe transverse to the axis of the arm in the middle of the anterior deltoid, about 3 or 4 cm below the acromion, which you can locate by palpation to get your bearings. If the patient is positioned correctly, you will see the anterior cortical surface of the humerus, where you will be able to distinguish the greater and lesser tuberosities and the bicipital groove between them. An oval-shaped image can be seen within it, corresponding to the long head of biceps tendon (see Fig. 4-5B, C, and D).

Due to anisotropy, it may be hyperechoic or hypoechoic, depending on the angle at which the probe meets the beam. Sometimes it is surrounded by a small quantity of fluid, which is normal. There is a small anterior circumflex artery which accompanies it and must not be mistaken for signs of inflammation on Doppler. Immediately superficial to the biceps, a hyperechoic sheet can be seen, corresponding to the transverse humeral ligament (Fig. 4-5C and D, upper image).

If the probe is then moved in a distal direction, follow-

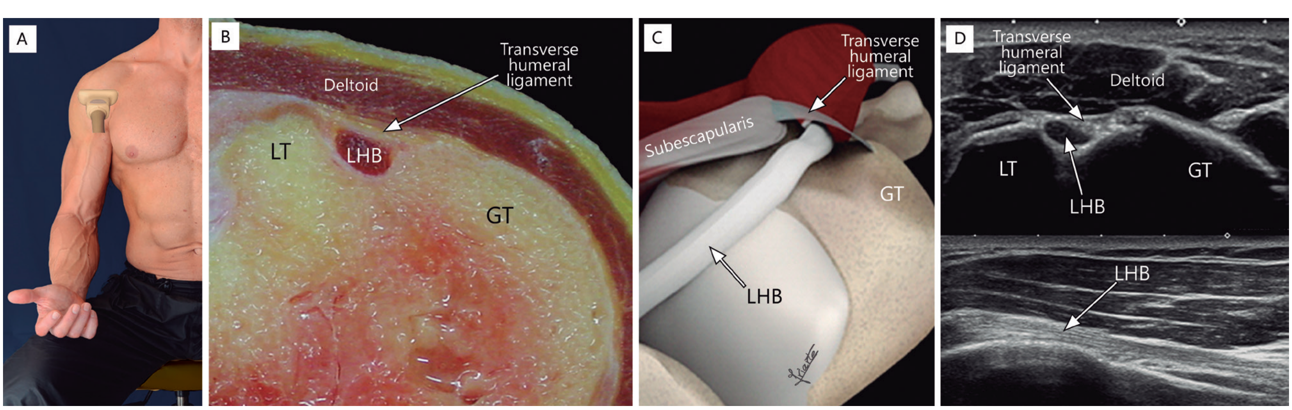


**Figure 4-5.** Position 1. **(A)** Position of the patient and the probe. **(B)** Cadaveric axial section. **(C)** Anatomical model. **(D)** Ultrasound image: above, in the transverse axis; below, in the longitudinal axis. LHB: long head of biceps; GT: greater tuberosity; LT: lesser tuberosity.

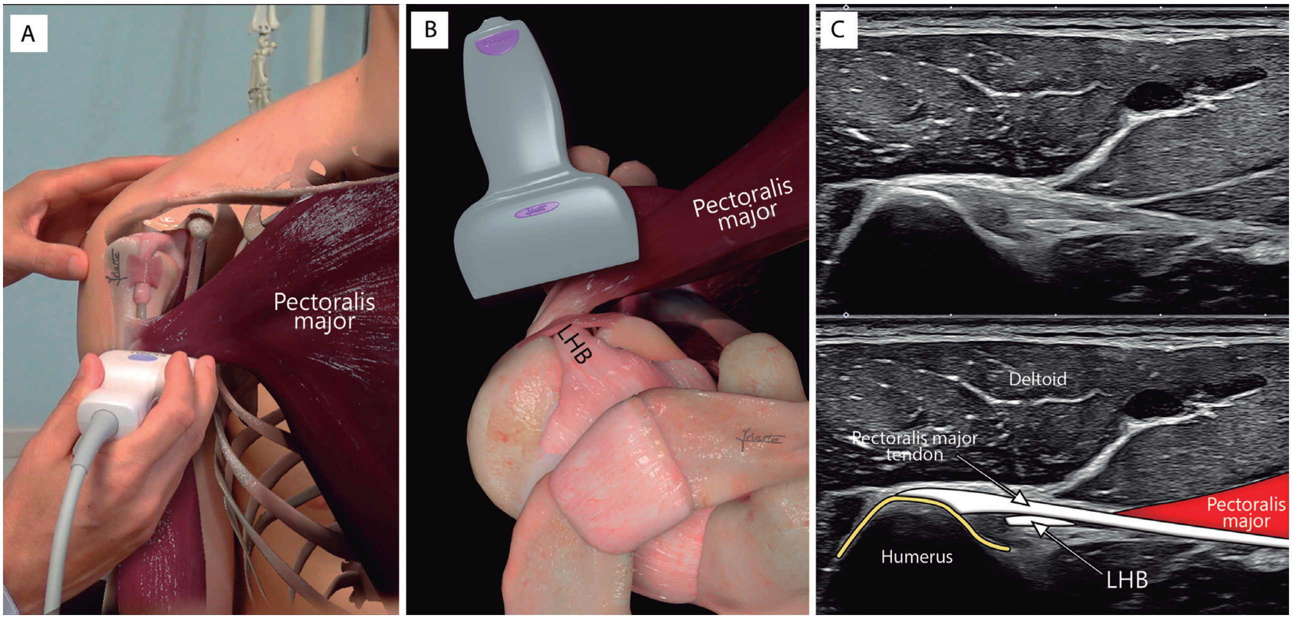


Figure 4-6. Evaluation of the long head of biceps tendon (LHB) and of the pectoralis major tendon. (A) Probe position. (B) Anatomical correspondence. (C) Ultrasound image.

ing the biceps and maintaining the same orientation, as far as its myotendinous junction, you will be able to see a thick, fibrillar hyperechoic structure that crosses it superficially from medial and lateral and inserts in the humerus: this is the pectoralis major tendon (Fig. 4-6A, B, and C).

It is always advisable to examine the tendons in both the longitudinal and transverse axes. To do so, the next step is to return to the bicipital groove and rotate the probe 90° over the biceps tendon (Fig. 4-5D, lower image).

To assess the subscapularis, place the probe once again in the initial position, transverse to the groove, ensuring you have a good view of the lesser tuberosity and then ask the patient to perform an external rotation with the arm against the body (see Fig. 4-7A). This will pull the subscapularis outward, making it accessible to the probe. You will see the subscapularis tendon in its longitudinal axis as far as its insertion on the lesser tuberosity, right up to the medial lip of the bicipital groove (see Fig. 4-7B, C, and D, upper image). As mentioned previously, some fibers of the subscapularis reinforce the transverse humeral ligament. If you rotate the probe 90° and rock it back and forth, adjusting the anisotropy effect, you will be able to make out several oval shapes like digitations within the tendon, in its transverse axis, corresponding to the various tendons of the subscapularis, which we described when reviewing its anatomy (see Fig. 4-7D, lower image).

To examine the coracoacromial ligament, we recommend returning once more to the starting position over the bicipital groove, but this time place the probe more medially and move it upward until you detect a rounded hyperechoic image with posterior acoustic shadowing, corresponding to the coracoid process. Locate this at the

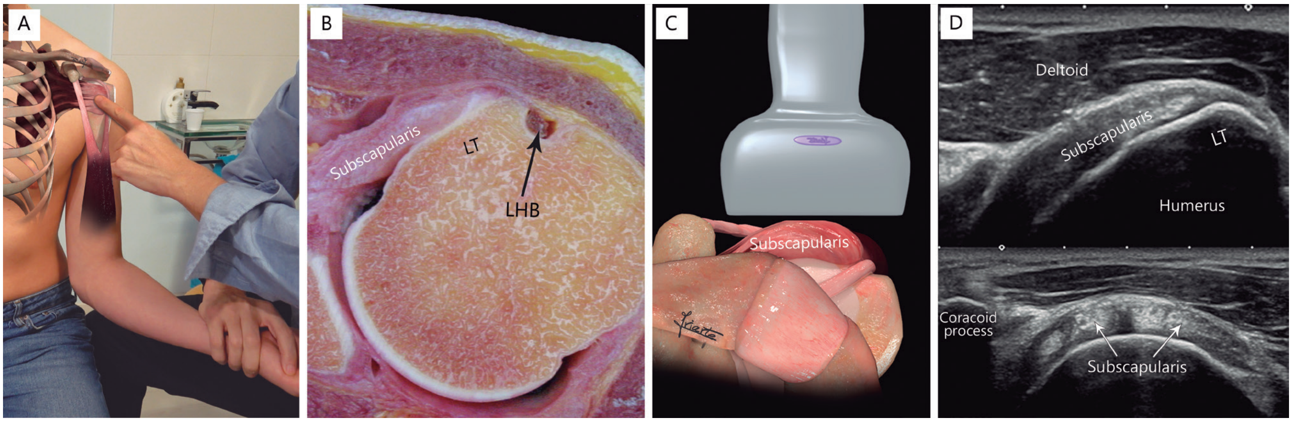


Figure 4-7. Evaluation of the subscapularis tendon with the shoulder in external rotation. (A) Position of the patient and point where the probe is placed. (B) Cadaveric axial section. (C) Anatomical model. (D) Ultrasound image: above, longitudinal axis; below, transverse axis. Lt: lesser tuberosity; LHB: long head of biceps tendon.

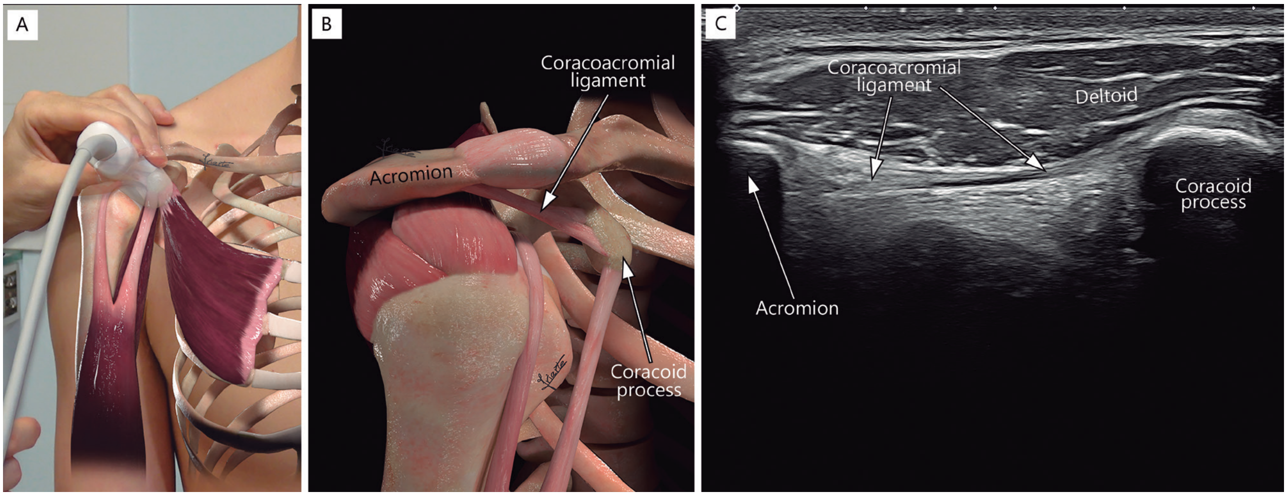


Figure 4-8. Evaluation of the coracoacromial ligament. (A) Probe position. (B) Anatomical correspondence. (C) Ultrasound image.

medial end of the probe and rotate the lateral end toward the acromion, but without losing sight of the coracoid process at the medial end. You will be able to see a well-defined, somewhat hypoechoic structure appear between the two bones (coracoid process and acromion); this is the coracoacromial ligament (Fig. 4-7A, B, and C). Coursing underneath it is the supraspinatus tendon.

### Acromioclavicular joint

Although positions 1 and 2 are both valid for examining the acromioclavicular joint, the first is probably better, as the patient is more comfortable.

To evaluate it, the recommended method is to palpate the clavicle and then, using a generous amount of gel to fit closely to the bony outlines, place the probe on its lateral third, following its longitudinal axis (see Fig. 4-9A). Move the probe laterally and anteroposteriorly until you detect an interruption of the clavicular cortical bone, a space, and then the appearance of the cortical surface of the acromion. Evaluate the osseous borders, the width of the joint space, and the presence or absence of bulging or outpouching in the capsule (v. Fig. 4-9B). Remember that there is usually a fibrocartilaginous disk within the joint, even if it is not easy to visualize.

## STRUCTURES OF THE SUPERIOR ASPECT OF THE SHOULDER (POSITION 2)

In the superior aspect of the shoulder, we will examine the supraspinatus tendon, the rotator interval, and the subacromial-subdeltoid bursa.

The supraspinatus muscle originates from the supraspinous fossa and inserts via a broad tendon onto its footprint on the most superior part of the greater tuberosity. This muscle consists of two portions (Fig. 4-10B):

- One, more anterior and superficial, is bipennate, with a very long intramuscular tendon which forms the more anterior part of the supraspinatus tendon.
- The other, more posterior and deeper, with a complex morphology, divides in turn, like the anterior portion, into three muscle bellies, superficial, middle, and deep, from posterior to anterior. These terminate in a flat ten-

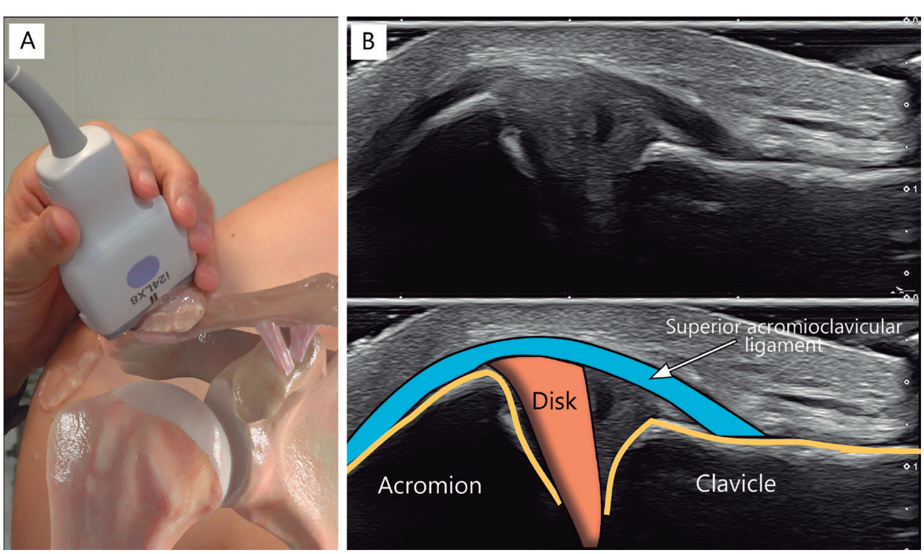


Figure 4-9. Evaluation of the acromioclavicular joint. (A) Probe position. (B) Ultrasound image.

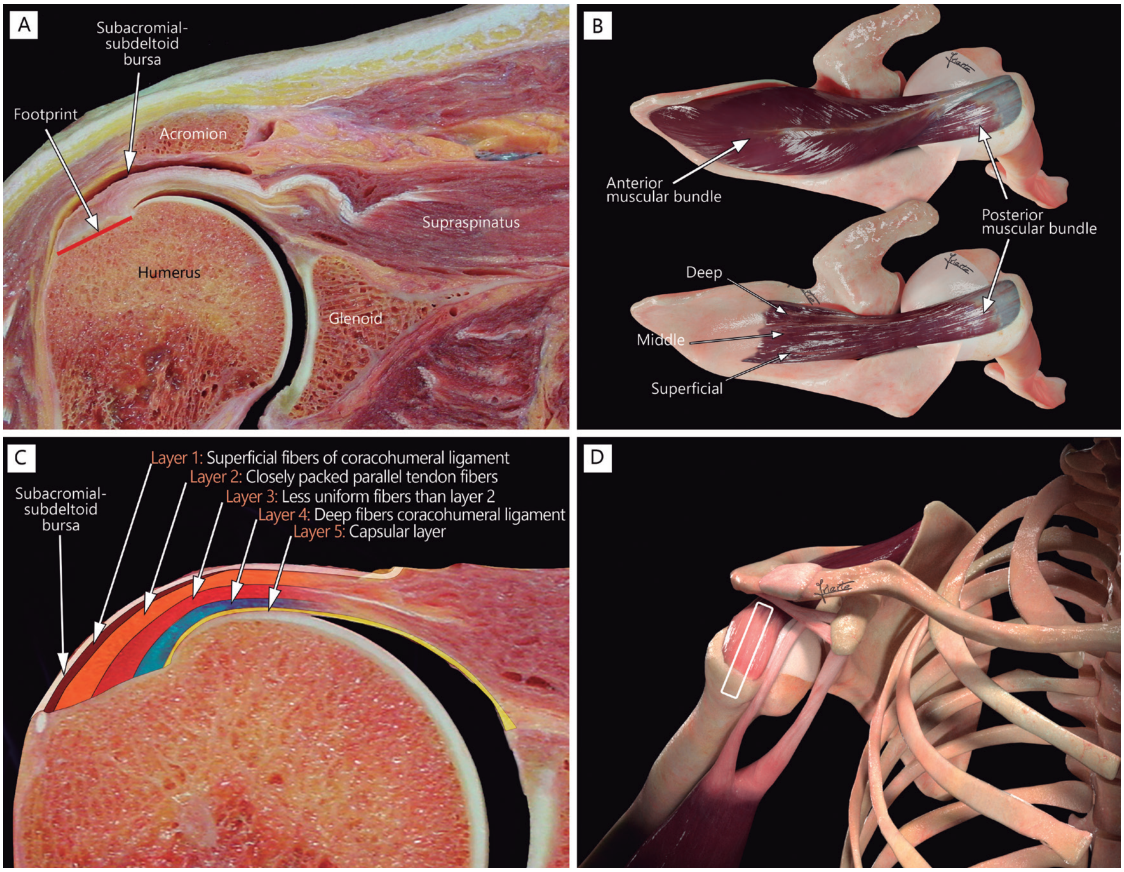


**Figure 4-10.** Supraspinatus muscle and tendon. **(A)** Cadaveric coronal section. **(B)** Anatomical model showing the anterior and posterior components. **(C)** Cadaveric coronal section, showing details of the five-layer composition of the supraspinatus tendon. **(D)** Anatomical model of the position of the supraspinatus tendon during the modified Crass maneuver, with the position of the probe marked in the longitudinal axis (hollow white rectangle).

don which inserts onto the anterior facet of the greater humeral tuberosity, immediately posterior to the first portion just described.

The supraspinatus tendon is a highly complex structure. The more recent anatomical studies have shown that at the insertional level it is much larger than was thought and that the greater tuberosity is occupied by this tendon only on its most anteromedial facet, the rest being occupied by the insertional footprint of the infraspinatus (Fig. 4-2).

The microscopic structure of this tendon has also been reviewed, showing significant complexity, with a distribution in five layers, from superficial to deep (Fig. 4-10C):

- The first layer is formed by the most superficial part of the posterior component of the coracohumeral ligament.
- The second is a layer of very closely packed collagen fibers, with long fascicles extending directly from the muscle component to the insertion on the humerus.
- The third layer is also tendinous, like the second, but less compact and uniform.
- The fourth layer is formed by deep fibers from the posterior component of the coracohumeral ligament containing thick collagen bands whose fibers are arranged perpendicular to those of the second and third layers, continuing under the infraspinatus tendon. This structure is known as the rotator cable.
- The fifth and last layer is formed by the joint capsule, which has randomly oriented fibers.

Finally, the subacromial-subdeltoid bursa is located very close to the tendon superficially, forming a sixth layer, which is not considered part of the tendon. It is lined internally with synovial tissue and extends under the acromion, covering the greater tuberosity laterally and the lesser tuberosity anteriorly and even covering the most cranial part of the subscapularis and the infraspinatus posteriorly. The bursa is covered, in turn, by the deltoid laterally and the acromion above (see Fig. 4-10A, Fig. 4-11A). Its function is to facilitate the gliding of the various tendons in the subacromial space, reducing friction with the acromion.

In normal conditions, when there are no full-thickness tendon tears, the bursa does not communicate with the glenohumeral joint, since the rotator cuff is interposed between them, separating the two spaces.

The subcoracoid bursa is located inferior to the coracoid process between the subscapularis and coracobrachialis muscles, reducing the friction between them (Fig. 4-11A). It may sometimes connect with the subacromial-subdeltoid bursa, but in its most usual variant they are two independent bursae.

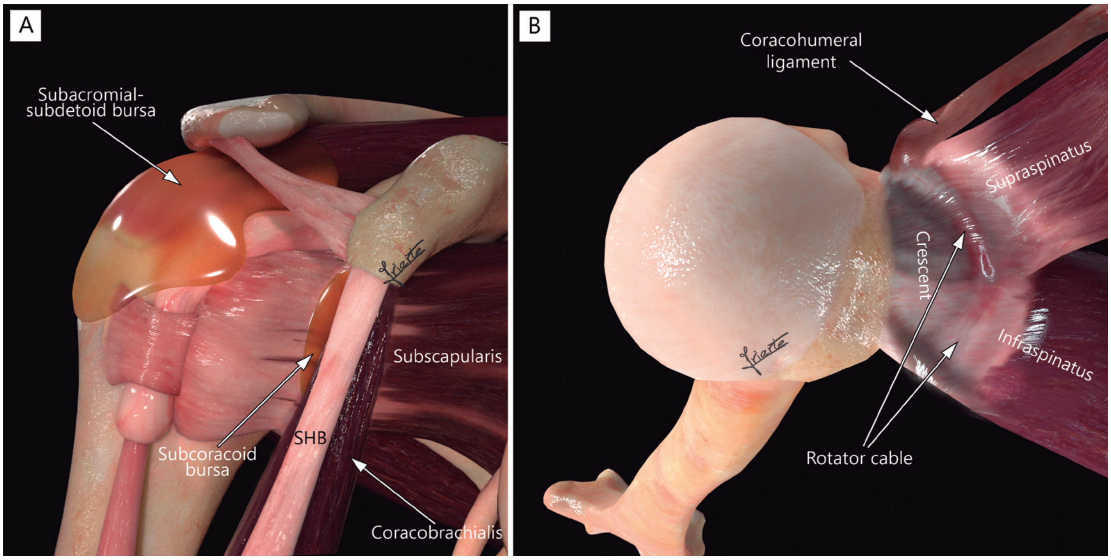


**Figure 4-11.** Subacromial-subdeltoid bursa and rotator cable. **(A)** Anatomical model showing an anterior view of the bursa and its relationship with the surrounding structures. **(B)** Anatomical model of the rotator cable seen from above. The supraspinatus and infraspinatus tendons and the coracohumeral ligament have been turned over to show their inferior contours and a detail of the rotator cable and crescent area.

As for the rotator cable, it arises, as we have said, from the coracohumeral ligament and proceeds in an anteroposterior direction underneath the supraspinatus and infraspinatus tendons until it reaches the posterosuperior glenohumeral ligament (Fig. 4-11B). In some patients it is visible; in others it is more difficult to see. In any case, high-end machines are usually needed. It forms the lateral boundary of a crescent area, which is weaker and more easily ruptured. Tendon tears that do not affect the rotator cable generally have a better functional prognosis.

The rotator interval is a space bounded superiorly by the more anterior portion of the supraspinatus and inferiorly by the more superior part of the subscapularis tendon. It is the only place where the continuity of the rotator cuff is interrupted in normal conditions. The long head of biceps tendon (LHB) passes through it, as well as the superior glenohumeral and coracohumeral ligaments, which surround the LHB, forming the so-called bicipital pulley and playing a part in stabilizing it. The superior glenohumeral ligament arises from the superior part of the glenoid cavity and inserts on the humerus, near the beginning of the bicipital groove, forming the floor and medial wall of the canal through which the LHB passes, while the coracohumeral ligament originates from the coracoid process, covers the LHB, and inserts on the humerus, passing underneath the supraspinatus (see Fig. 4-3C and D).

## Ultrasound examination

To be able to evaluate these structures properly, place the patient in position 2, as it is called, also known as the modified Crass position, with the shoulder retracted and the hand resting on the homolateral gluteal region, as the patient were putting their hand into the back pocket of their trousers (Fig. 4-12A). It is important that the elbow should not be turned outward, as this involves an internal rotation of the shoulder, making it more difficult to locate the long head of the biceps, which is the initial reference point.

There are many ways of assessing the supraspinatus, but in order to follow a systematic procedure that enables you to position yourself properly on its longitudinal axis, we recommend starting the examination by placing the probe transverse to the long axis of the humerus, about 2 cm below the bony edge of the acromion, until you detect a bright, hyperechoic oval image, if the probe meets it perpendicularly (see Fig. 4-13A and C). This structure is the tendon of the long head of the biceps, in its intra-articular course, cranial to its passage through the bicipital groove. Having found it, rotate the probe over it until you see its longitudinal axis. You must avoid oblique sections and be patient until you can see the whole tendon properly in this axis. Once you have performed this maneuver correctly, the orientation of the probe will also be the long axis of the supraspinatus, and you simply have to be careful not to alter it while you sweep the probe in a lateral direction. Look for the characteristic shape of the footprint mentioned previously (see Fig. 4-1B, Fig. 4-11C) and evaluate the supraspinatus tendon meticulously, making anteroposterior sweeps and always avoiding any rotation of the probe. To obtain the best image, the probe needs to be fanned while making the lateral movements, bearing in mind that the shoulder is spherical in shape, trying always to keep the ultrasound beam perpendicular to its surface.

It is important to remember that the supraspinatus and infraspinatus insertions have a common area in which their tendon fibers are intermingled and are very difficult to distinguish from each other; therefore, as you follow the supraspinatus tendon in a posterior direction, at some point you will already be seeing the most anterior portion of the infraspinatus. In some patients the morphology of the acromion allows you to see the full extent of the insertional footprint, while in others the acromion gets in the way and does not allow you to visualize the footprint any further.

In the absence of pathology, the bursa is more difficult to see. It appears as a thin anechoic layer between two hy-

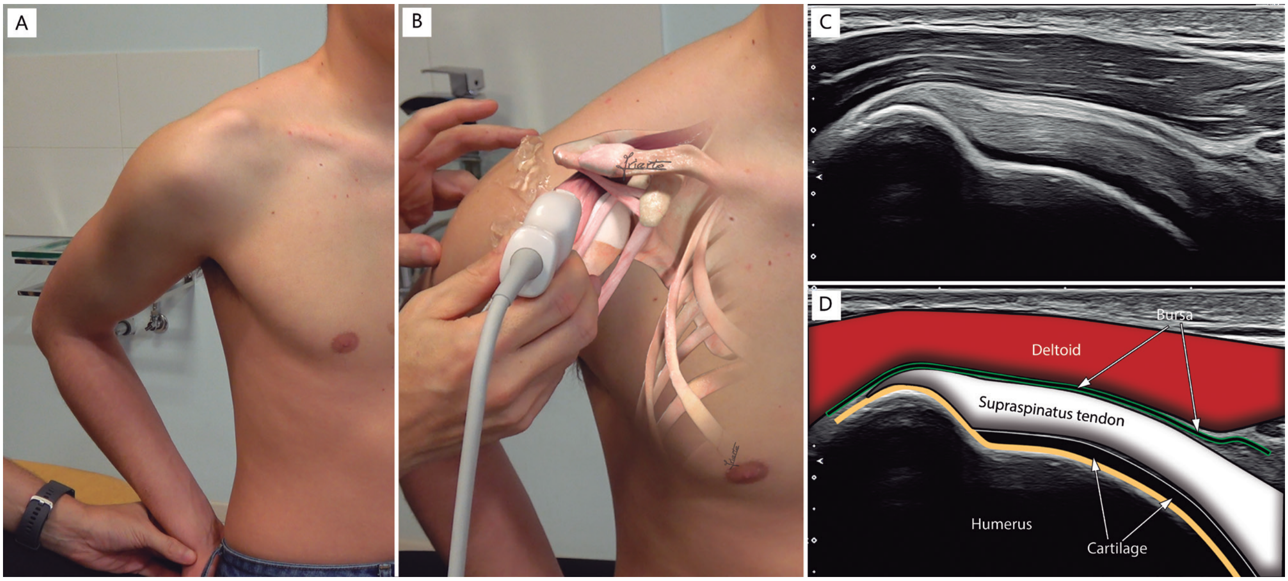


**Figure 4-12.** Evaluation of the supraspinatus tendon and subacromial-subdeltoid bursa in the longitudinal axis. **(A)** Modified Crass position. **(B)** Probe position for viewing the longitudinal axis of the supraspinatus. **(C)** Ultrasound image. **(D)** The same image with important structures highlighted.

perechoic layers, which are its walls (Fig. 4-12C; see Fig. 4-13C). The inferior wall is very thin and is closely bound to the supraspinatus tendon, so it is often confused with the tendon, which is also hyperechoic. To distinguish them, small rotations of the shoulder can be performed; the bursa does not move, but the supraspinatus tendon does.

After examining the supraspinatus in its longitudinal axis, find the bicipital groove, with the long head of biceps tendon within it, in the short axis and move the probe cranially, centered on the tendon (Fig. 4-13A). Here you will be able to evaluate the rotator interval, with the superior glenohumeral ligament inferior and medial to the long head of biceps tendon and the coracohumeral ligament located superiorly (Fig. 4-13B y C). If you move the probe laterally in the same axis, you can assess the supraspinatus tendon and the most anterior portion of the infraspinatus in their transverse axis, whereas if you move it medially, you can evaluate the most cranial aspect of the subscapularis tendon. It is very important to perform anteroposterior sweeps over the insertions so as not to overlook the smallest tears.

## STRUCTURES OF THE POSTERIOR ASPECT OF THE SHOULDER (POSITION 3)

The infraspinatus muscle originates in the infraspinous fossa and inserts on the posterosuperior facet of the greater tuberosity, merging in its most anterior part with the insertion of the supraspinatus. It has a characteristic broad intramuscular tendon (see Fig. 4-14 B, C, and D). The most anterior part of its tendon covers that of the supraspinatus and its insertional footprint, as previously ex-

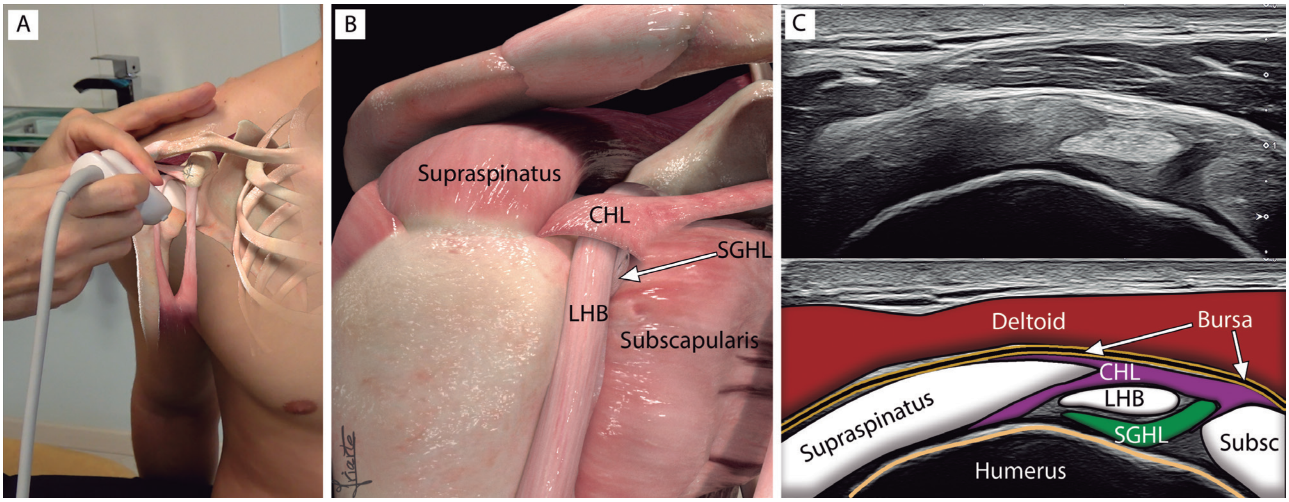


**Figure 4-13.** Evaluation of the supraspinatus tendon, rotator interval, and subacromial-subdeltoid bursa in the transverse axis. **(A)** Modified Crass position and probe placement. **(B)** Anatomical model of these structures. **(C)** Ultrasound image and corresponding diagram. CHL: coracohumeral ligament; SGHL: superior glenohumeral ligament; LHB: long head of biceps tendon; Subsc: subscapularis.

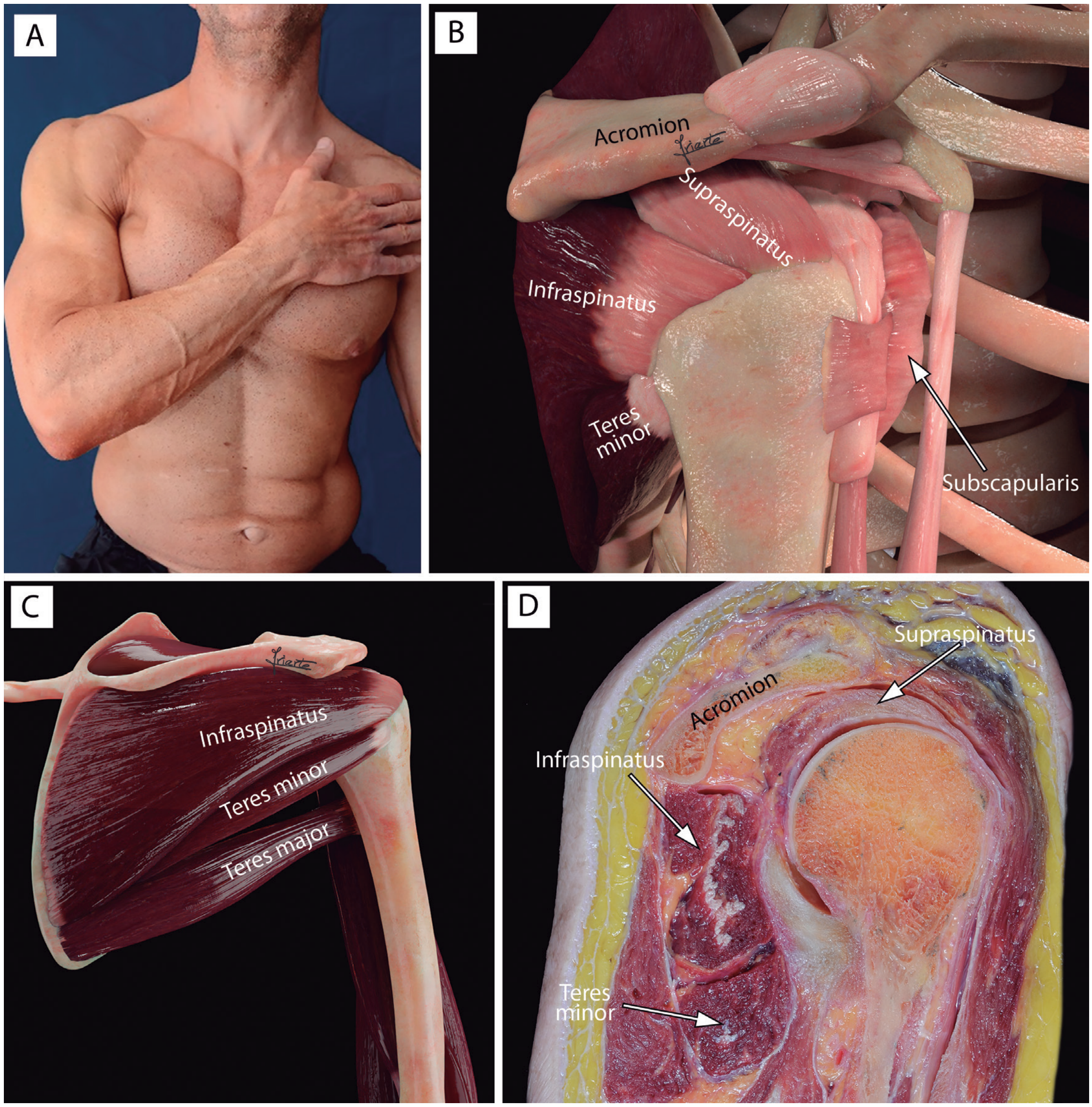


**Figure 4-14.** Structures to be evaluated in position 3. **(A)** Placement of the patient in position 3. **(B)** Anatomical model in posterior view. **(C)** Anatomical model in lateral view. **(D)** Cadaveric sagittal section.

plained, is larger, reaching the superior and even anterior part of the greater tuberosity (see Fig. 4-2 and 4-14 B).

The teres minor also originates in the infraspinous fossa, in its inferior part. It has a characteristic oval cross-section and inserts caudally next to the infraspinatus (see Fig. 4-14 B, C, and D). Its tendon is much smaller. Both the infraspinatus and the teres minor are external rotators of the shoulder.

The teres major originates from the tip of the scapula on its dorsal side and inserts together with the latissimus dorsi tendon on the anterior aspect of the humerus, medial to the long head of the biceps as it emerges from the bicipital groove. It is an internal rotator and adductor, but is not part of the rotator cuff.

Just below the spine of the scapula you can evaluate the posterior part of the glenohumeral joint, part of the posterior labrum, and the spinoglenoid notch, a fairly common site for ganglion cysts.

## Ultrasound examination

The sonographer stands behind the patient, ideally using the revolving stool to turn the patient. The patient is placed in position 3 and is asked to place the hand of the side to be examined on the contralateral shoulder (Fig. 4-14A); this will cause the infraspinatus, teres minor, and teres major tendons to slide behind the acromion and make them accessible to the probe.

To evaluate these tendons, we recommend placing the probe immediately under the scapular spine (which can be located beforehand by palpation), oriented perpendicular to it (see Fig. 4-15A). At this point, the transducer is positioned in the transverse axis of the infraspinatus muscle, which will be easily recognizable by the fact that it has a broad intramuscular tendon within it, located at mid-depth of the muscle, in the shape of an M or seagull (see Fig. 4-15B). Immediately caudal to it, smaller and with an oval cross-section, lies the teres minor. This mus-

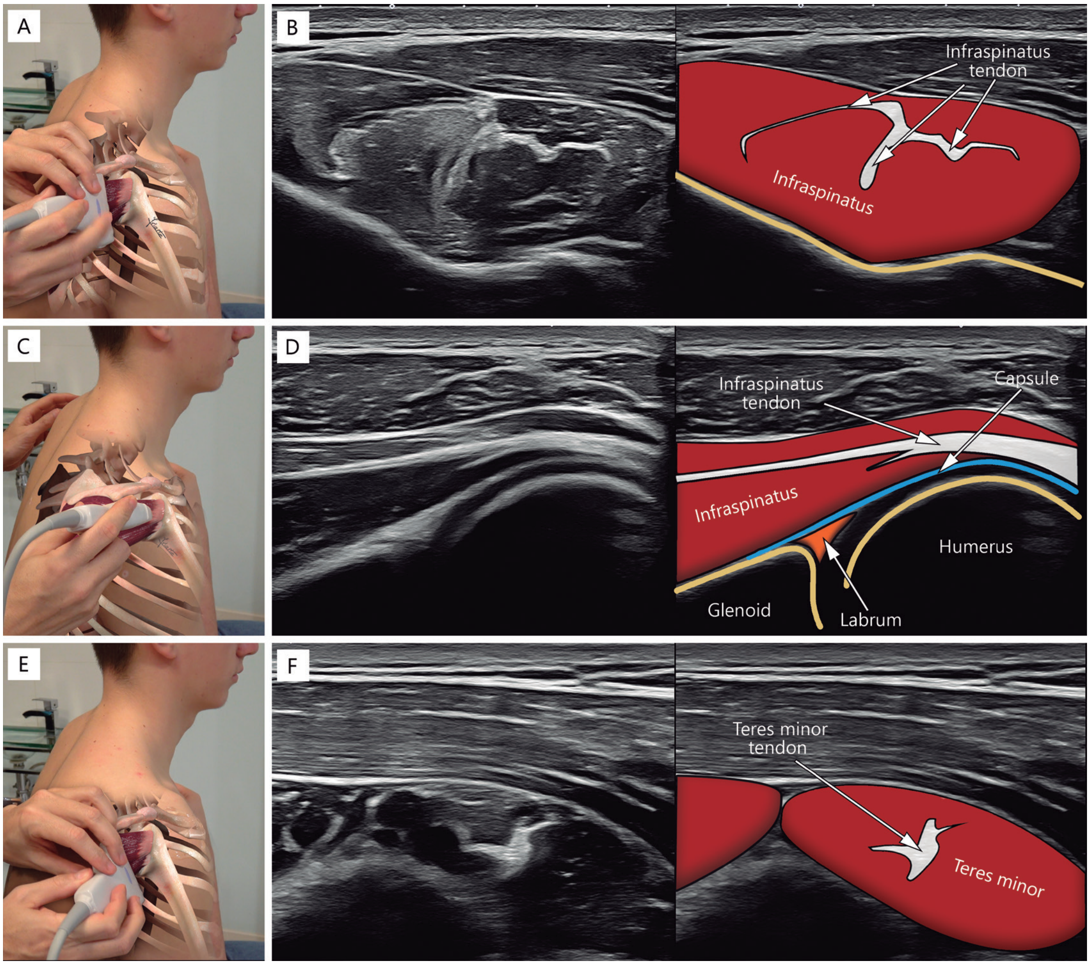


**Figure 4-15.** Evaluation of structures in position 3. **(A)** Probe position for examining the infraspinatus in the transverse axis. **(B)** Ultrasound image with important structures highlighted. **(C)** Probe position for assessing the infraspinatus in the longitudinal axis and the posterior aspect of the glenohumeral joint. **(D)** Ultrasound image with important structures highlighted. **(E)** Probe position for evaluating the teres minor in the transverse axis. **(F)** Ultrasound image with important structures highlighted.

cle has a small intramuscular tendon in the center (see Fig. 4-15E and F).

To scan the infraspinatus tendon insertion, we recommend assessing it initially in the transverse axis. To do so, you need to follow it to its insertion with the same probe orientation. Having examined it, return to the starting point over the intramuscular tendon of the infraspinatus, rotating the probe 90° without losing sight of the tendon (see Fig. 4-15C and D), and proceed to image the infraspinatus in its longitudinal axis. Immediately deep to it, you will be able to see part of the posterior aspect of the glenohumeral joint and of a small portion of the posterior labrum (see Fig. 4-15C and D).

Finally, evaluate the teres minor, returning to the initial position in the short axis of the infraspinatus and moving the probe in a caudal direction. A muscle of oval cross-section with a much narrower intramuscular tendon will appear (Fig. 4-15E and F). Then, after rotating the probe, evaluate the muscle and tendon in their longitudinal axis. Pathology here is very rare.

## REFERENCES

Anderson MW, Brennan C, Mittal A. Imaging evaluation of the rotator cuff. Clin Sports Med. 2012 Oct;31(4):605–31.

Arai R, Mochizuki T, Yamaguchi K, et al. Functional anatomy of the superior glenohumeral and coracohumeral ligaments and the subscapularis tendon in view of stabilization of the long head of the biceps tendon. J Shoulder Elbow Surg. 2010 Jan;19(1):58–64.

Beggs I. Shoulder ultrasound. Semin Ultrasound CT MR. 2011 Apr;32(2):101–13.

Beggs I, Bianchi S, Bueno A, et al. Musculoskeletal Ultrasound Technical Guidelines. I. Shoulder. European Society of Musculoskeletal Radiology.
https://essr.org/contentessr/uploads/2016/10/shoulder.pdf

Bianchi S, Jacob D, Lambert A, Draghi F. Sonography of the coracoid process region. J Ultrasound Med. 2017 Feb;36(2):375–88.

Corazza A, Orlandi D, Fabbro E, et al. Dynamic high-resolution ultrasound of the shoulder: how we do it. Eur J Radiol. 2015 Feb;84(2):266–77.

Curtis AS, Burbank KM, Tierney JJ, Scheller AD, Curran AR. The insertional footprint of the rotator cuff: an anatomic study. Arthroscopy. 2006 Jun;22(6):609.e1.

Daghir AA, Sookur PA, Shah S, Watson M. Dynamic ultrasound of the subacromial-subdeltoid bursa in patients with shoulder impingement: a comparison with normal volunteers. Skeletal Radiol. 2012 Sep;41(9):1047–53.

Girish G, Lobo LG, Jacobson JA, Morag Y, Miller B, Jamadar DA. Ultrasound of the shoulder: asymptomatic findings in men. Am J Roentgenol. 2011 Oct;197(4):W713–9.

Lee MH, Sheehan SE, Orwin JF, Lee KS. Comprehensive shoulder US examination: a standardized approach with multimodality correlation for common shoulder disease. Radiographics. 2016 Oct;36(6):1606–27.

Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus: new anatomical findings regarding the footprint of the rotator cuff. J Bone Joint Surg Am. 2008 May;90(5):962–9.

Morag Y, Jamadar DA, Miller B, Dong Q, Jacobson JA. The subscapularis: anatomy, injury, and imaging. Skeletal Radiol. 2011 Mar;40(3):255–69.

Moser T, Lecours J, Michaud J, Bureau NJ, Guillin R, Cardinal E. The deltoid, a forgotten muscle of the shoulder. Skeletal Radiol. 2013 Oct;42(10):1361–75.

Oñate Miranda M, Bureau NJ. Supraspinatus myotendinous junction injuries: MRI findings and prevalence. AJR Am J Roentgenol. 2019 Jan;212(1):W1–W9.

Orlandi D, Sconfienza LM, Fabbro E, et al. Preliminary ultrasound evaluation of the rotator cable in asymptomatic volunteers. J Ultrasound. 2012 Feb;15(1):16–9.

Tamborrini G, Möller I, Bong D, et al. The rotator interval: a link between anatomy and ultrasound. Ultrasound Int Open. 2017 Jun;3(3):E107–16.

Yablon CM, Bedi A, Morag Y, Jacobson JA. Ultrasonography of the shoulder with arthroscopic correlation. Clin Sports Med. 2013 Jul;32(3):391–408.