EURO-MUSCULUS/USPRM Dynamic Ultrasound Protocols for Shoulder

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This feature is a unique combination of text (voice) and video that more clearly presents and explains procedures in musculoskeletal medicine. These videos will be available on the journal's Website. We hope that this feature will change and enhance the learning experience.

Walter R. Frontera, MD, PhD
Editor-in-Chief

Abstract: In this dynamic protocol, ultrasound examination of the shoulder using different maneuvers is described for several/relevant shoulder problems. Scanning videos are coupled with real-time patient examination videos for better understanding. The authors believe that this practical guide prepared by an international consensus of several experts (EURO-MUSCULUS: European Musculoskeletal Ultrasound Study Group and USPRM: Ultrasound Study Group of ISPRM [International Society of Physical and Rehabilitation Medicine]) will help musculoskeletal physicians perform a better and uniform/standard approach.

Key Words: Shoulder, Ultrasonography, Dynamic Imaging, Maneuver, Physical and Rehabilitation Medicine

(*Am J Phys Med Rehabil* 2022;101:e29–e36)

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Written permission has been obtained from each and every patient.

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

ISSN: 0894-9115
DOI: 10.1097/PHM.0000000000001833

Among physiatrists, the utility of musculoskeletal ultrasound imaging/examination has already skyrocketed in daily clinical practice. In addition to the basic scanning, dynamic assessment is perhaps one of the most important superiorities of this imaging technique when compared with other modalities. Herewith, protocols with regard to how to implement this method in various shoulder pathologies do not exist in the relevant literature. As such, and similar to the former/basic shoulder scanning protocols in physical and rehabilitation medicine,[1] an international group of experts (EURO-MUSCULUS: European Musculoskeletal Ultrasound Study Group and USPRM: Ultrasound Study Group of ISPRM [International Society of Physical and Rehabilitation Medicine]) also prepared this protocol for dynamic assessment of shoulder disorders.

ANTERIOR ASPECT

Coracoid/Subcoracoid Window

Technique

With the arm adducted to the trunk, the forearm supinated and the elbow flexed to 90 degrees, the glenohumeral joint is slowly (internally/externally) rotated (Figs. 1A–C). The dynamic assessment is performed in the long-axis view, at the level of the coracoid process or just caudally to visualize the coracoid muscle/tendon complex. During dynamic scanning, it is possible to visualize the gliding of the subscapularis muscle-tendon unit under the coracoid process and coracoid muscles (e.g., the short head of the biceps brachii muscle and coracobrachialis muscle; Video 1, http://links.lww.com/PHM/B545).[2,3]

Clinical Indications

Anterior Shoulder Impingement

Mechanical conflict may develop among different anterior components of the shoulder, that is, subscapularis muscle-tendon unit, coracoid bone/coracoid muscles, and the humeral head. The clinical spectrum might encompass several conditions like tendinosis/tears (Video 2, http://links.lww.com/PHM/B546)[4] or calcific tendinopathy of the subscapularis, hypertrophy or mass lesions of the subscapularis muscle, anterior glenohumeral instability, calcific tendinopathy of the coracoid muscles, and congenital/traumatic coracoid process abnormalities.[5]

Anterior Synovitis

During active rotations of the glenohumeral joint, hypertrophic synovial tissue—interposed between the subscapularis muscle-tendon unit and the coracoid space—can be identified as a potential pain generator (Video 3, http://links.lww.com/PHM/B547). Of note, in this anatomical region, the pathological synovial tissue may stem from the subcoracoid bursa,[6] the subacromial/subdeltoid bursa (with an abundant medial portion located in the subcoracoid space), or the subscapularis recess, that is, an extension of the glenohumeral synovium (Video 4, http://links.lww.com/PHM/B548).[7]

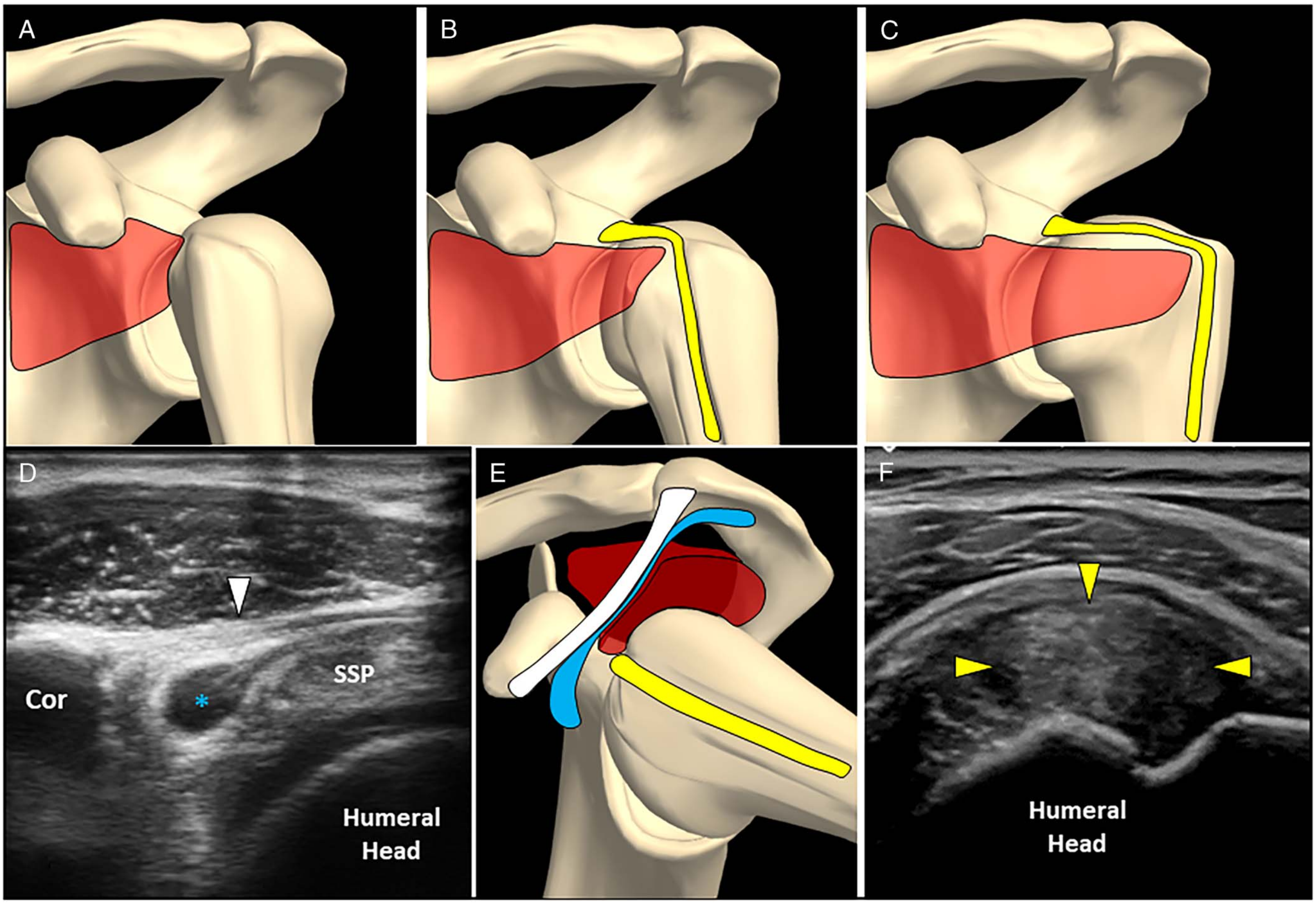

FIGURE 1. Schematic drawings show the dynamic assessment of the coracoid/subcoracoid space and the humeral groove during rotations of the glenohumeral joint (A, B, C). Bursal effusion (blue asterisk) can be displaced medially—under the coracoid (Cor) and the coracoacromial ligament (white arrowhead; D)—during abduction and/or flexion (E). Of note, the pain may be related to the tension of the ligament and/or to the increase of the pressure inside the bursal cavity. Tendinosis of the proximal segment of the LHBT (yellow arrowheads)—hourglass biceps—should be considered among the causes of anterolateral shoulder impingement under the coracoacromial arch (F). Blue, synovial bursa; red, rotator cuff; SSP, supraspinatus tendon; white, coracoacromial ligament; yellow, long head of the biceps tendon.

Restriction of the Glenohumeral Joint Motion

Stiffness and/or thickening of the anterior portion of the shoulder capsule (e.g., in adhesive capsulitis) can reduce the excursion of the subscapularis muscle-tendon unit during active rotations of the glenohumeral joint.[2,3] Of note, this dynamic sonographic finding would particularly be evident in comparison with the asymptomatic shoulder.

Abnormal Gliding of the Muscular and Fascial Planes

Several pathological conditions related with the rotator cuff tendons and synovial structures may influence the physiological gliding and tension of the connective layers of the shoulder at different levels, that is, muscular epimysium, intermuscular septum, intramuscular aponeurosis, and subdeltoid fascia.[8] In this sense, dynamic assessment can indisputably be considered as a valuable tool to promptly visualize these peculiar conditions (Video 5, http://links.lww.com/PHM/B549).

Humeral Groove Window

Technique

With the arm adducted to the trunk, the forearm supinated and the elbow flexed to 90 degrees, the glenohumeral joint is slowly (internally/externally) rotated while visualizing real-time the bicipital groove and the long head of the biceps tendon (LHBT) in its short axis (Figs. 1A–C).[2,3] During the dynamic assessment, it is possible to evaluate the relationship among the LHBT, the bony groove, and the surrounding stabilizing soft tissues, for example, the transverse humeral ligament (Video 6, http://links.lww.com/PHM/B550).[9]

Clinical Indications

Instability of the LHBT

During dynamic assessment, the LHBT may shift medially over the lesser tuberosity of the humeral head—with total/partial dislocation.[2,3,9] Feeling of a click may (or may not) be associated with this shift. Of note, the effusion in the synovial sheath of the LHBT may be an indirect sign of instability; therefore, the authors suggest to perform this dynamic assessment when it is present (Video 7, http://links.lww.com/PHM/B551). Interestingly, in some patients—with mild instability of the LHBT—gas bubbles can also/often be detected inside this effusion (Video 8, http://links.lww.com/PHM/B552).[10]

Coracoacromial Window

Technique

With the arm in slight abduction, the patient is asked to slowly flex the shoulder to exactly reproduce the pain and/or the click sensation. Of note, each and every patient may describe different movements/positions provocating the symptoms. Herewith, the same coracoacromial acoustic window—i.e., long-axis view of the coracoacromial ligament—is used for the dynamic examination (Figs. 1D, E)[11] during which gliding of the subacromial tissues (e.g., synovial bursa, rotator cuff/interval) can be visualized under the coracoacromial arch (Video 9, http://links.lww.com/PHM/B553).[12]

Clinical Indications

Bursal Conflict

During active movements of the shoulder, focal thickening of the synovial layers of the subacromial/subdeltoid bursa (e.g., chronic nodular bursopathy) can be entrapped under the coracoacromial arch with pathological/painful displacement of the ligament—sometimes accompanied by sensation of a click (Video 10, http://links.lww.com/PHM/B554).[13] In some patients, active shoulder motions can push the bursal effusion medially, tensioning the coracoacromial ligament and exacerbating the pain (Figs. 1D, E).

Anterolateral Shoulder Impingement

Mechanical conflict between the rotator cuff and the coracoacromial arch can be related with several pathological conditions, for example, tendinosis/tear[14] or calcific tendinopathy of the rotator cuff and muscle imbalance (Video 11, http://links.lww.com/PHM/B555). In addition, disorders of the rotator interval, for example, tendinosis of the proximal segment of the LHBT ("hourglass biceps"; Fig. 1F) and/or thickening of the stabilizing pulley, may result in anterolateral impingement under the coracoacromial arch (Video 12, http://links.lww.com/PHM/B556).[15–17] Last, especially in young patients, short

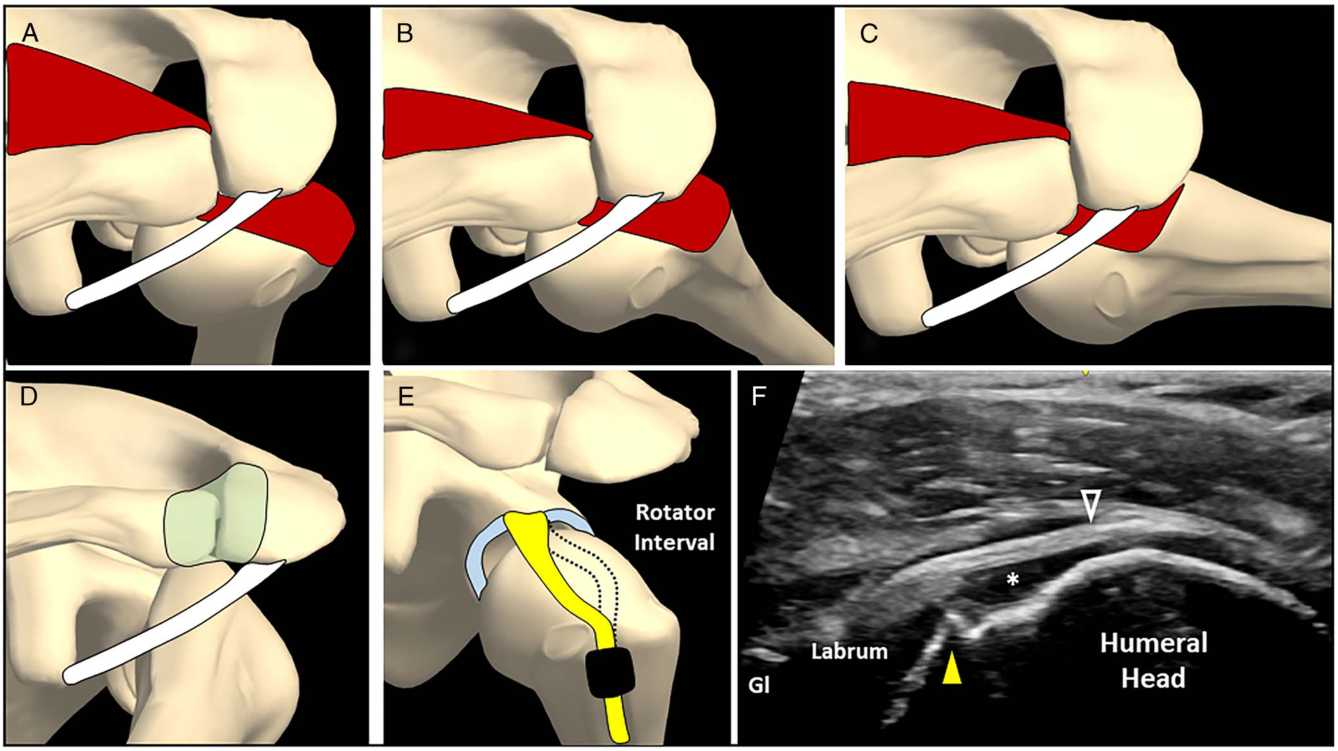

FIGURE 2. Schematic drawings show the dynamic assessment of the acromiohumeral space during abduction (A, B, C), of the acromioclavicular joint (green) during horizontal adduction (D), and of the proximal segment of the LHBT (yellow) during specific shoulder movements (E). In this patient, the effusion (white asterisk) around the intracapsular portion of the LHBT (void arrowhead) may be related to the mechanical impingement between the osteophyte (yellow arrowhead) of the superior pole of the humeral head and the biceps-labral complex (F). Black, transverse humeral ligament; black dotted lines, movements of the LHBT; blue, labrum; GI, glenoid; red, rotator cuff; white, coracoacromial ligament.

coracoacromial ligament (assessed by comparison with the symptomatic side) may prevent physiological, anterior translation of the humeral head during active shoulder movements. In this sense, abnormal contact between humerus and the ligament may be visualized during dynamic scanning.

SUPERIOR ASPECT

Acromiohumeral Window

Technique

With the forearm in pronation and the elbow in extension, the patient elevates the arm halfway between flexion and abduction. The acromiohumeral acoustic window is used in coronal plane (Figs. 2A–C). During dynamic scanning, it is possible to visualize the gliding of the superior portion of the rotator cuff and the subacromial/subdeltoid bursa under the acromion (Video 13, http://links.lww.com/PHM/B557).[2,3,9]

Clinical Indications

Superior Shoulder Impingement

A transient snapping or mechanical conflict between the superior portion of the rotator cuff and the acromion can be identified during the elevation of the upper limb.[18,19] Several pathological conditions may be related to the superior shoulder impingement, for example, rotator cuff tendinosis/tear, calcific tendinopathy of the rotator cuff, and imbalance of the stabilizing muscles of the glenohumeral joint with abnormal superior shift of the humeral head during the elevation phase of the upper limb.

Bursal Conflict

During dynamic assessment of the acromiohumeral space, focal thickening of the synovial layers of the subacromial/subdeltoid bursa—i.e., chronic nodular bursopathy—can intermittently be entrapped between the superior portion of the rotator cuff and the acromion, with pain and feeling of "click" complained by the patient (Video 14, http://links.lww.com/PHM/B558).[20]

Acromioclavicular Window

Technique

With the arm flexed forward to 90 degrees, the patient adducts the upper limb in the horizontal plane to cross the chest at the maximal effort. The acromioclavicular acoustic window is used in the long-axis view of the acromioclavicular joint (Fig. 2D). During dynamic scanning, it is possible to visualize—in real-time—the reciprocal relationships between the acromion and the lateral portion of the clavicle. This maneuver is also known as the "US-guided cross-body adduction test."[2]

Clinical Indications

Instability of the Acromioclavicular Joint

Malalignment of the articular surfaces during horizontal adduction and/or protrusion of the fibrocartilaginous meniscal disk (with bulging of the superior joint capsule) is considered to be the ultrasonographic features that potentially correlate with the joint instability (Video 15, http://links.lww.com/PHM/B559).[2] Of note, in young patients, recurrent and minor subluxation of the joint (due to congenital laxity of the stabilizing ligaments) may be identified during dynamic assessment. A painful click sensation can also accompany during active movements.

Rotator Interval Window

Technique

Starting from a "simplified" Crass position (with the upper limb adducted to the trunk, the forearm supinated, the elbow flexed to 90 degrees, and the shoulder extended), the patient performs flexion and extension movements of the glenohumeral joint. The probe is kept in an oblique transverse plane to promptly evaluate how the proximal segment of the LHBT shifts inside the rotator interval (Fig. 2E).[21] Normally, the tendon is dynamically stabilized inside the rotator interval by a multilayer pulley—that is composed of coracohumeral and superior glenohumeral ligaments, glenohumeral capsule, and some fibers crisscrossing between the supraspinatus and subscapularis tendons—and glides over the hyaline cartilage of the humeral head (Video 16, http://links.lww.com/PHM/B560).[22]

In addition, with the arm adducted to the trunk, elbow flexed to 90 degrees, and forearm fully supinated, the patient performs complete external rotation of the glenohumeral joint to apply tension on the proximal intracapsular segment of the LHBT, reducing its curvature inside the rotator interval. Likewise, positioning the probe in an oblique coronal plane (long-axis view of the rotator interval), the intra-articular portion of the LHBT can be visualized until its attachment to the superior labrum (Fig. 2F).[16,23–25] In some patients, the shape and size of the acromion may hinder optimal visualization of the tendon's insertion—referred as "covering acromion." Of note, because of the curved course of the tendon over the humeral head and the deep proximal insertional site, the anisotropy artifact must be considered and promptly managed with the "heel-toe" maneuver.[16,23–25] After identifying the biceps-labral complex (Fig. 2F), a dynamic stress test (inferior distraction of the arm) can be performed to evaluate the integrity/continuity of the abovementioned anatomical structures.[26]

Clinical Indications

Anatomical Integrity of the Biceps-Labral Complex

Using the long-axis view of the rotator interval and applying an inferior distraction force to the arm, an anechoic gap can be visualized between the tip of the superior labrum and the proximal portion of the LHBT in case of injury. In the presence of a consistent clinical scenario, the abovementioned US finding could be suggestive of injury to the biceps-labral complex. Magnetic resonance imaging might be required to confirm the diagnosis though.[16,23–25]

Instability of the Intracapsular Segment of the LHBT

Injuries of the anterior edge of the supraspinatus tendon and/or the superior portion of the subscapularis tendon—involving the soft tissues of the rotator interval (pulley)—can lead to instability of the proximal segment of the LHBT. Focal enlargement due to degenerative tendinosis, coupled with abnormal shifting of the tendon over the hyaline cartilage of the humeral head ("windshield

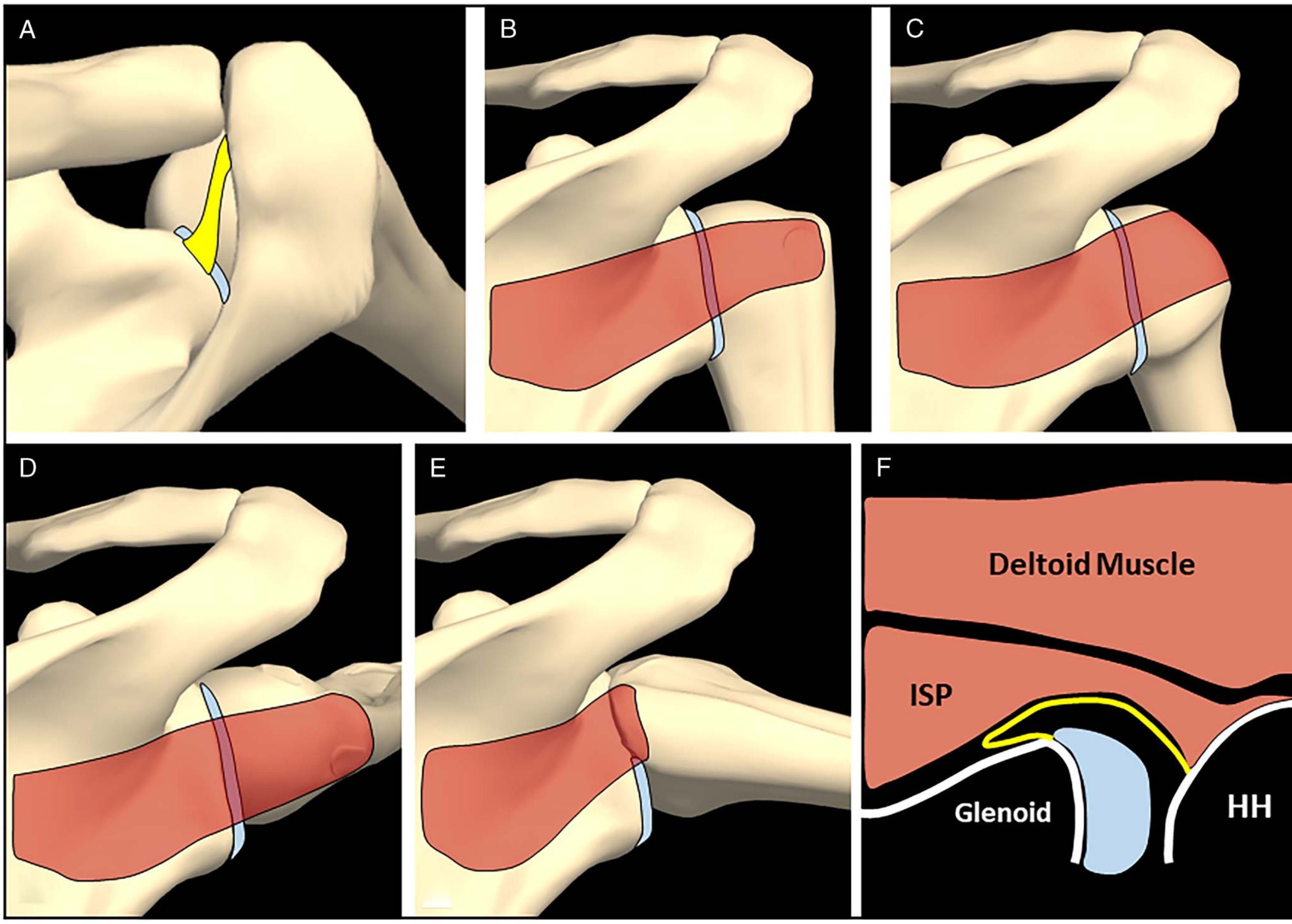

FIGURE 3. Schematic drawings show the dynamic assessment of the supraspinatus fossa during abduction (A), real-time evaluation of the posterior rotator cuff and glenohumeral joint during rotations (B, C), and during the ABER maneuver (D, E). From the anatomical point of view, at the end phase of the ABER maneuver, the posterior glenohumeral recess (yellow) presents a C-shape extending from the humeral head to the base of the labrum (blue) passing deep to the infraspinatus muscle-tendon unit (F). Blue, labrum; HH, humeral head; ISP, infraspinatus; red: rotator cuff; yellow, long head of the biceps tendon.

wiper effect"), is the most common US finding.[27] Short-axis view of the rotator interval can be used for the dynamic assessment.

Other Disorders of the Intracapsular Segment of the LHBT

Thickening and tendinosis of the proximal segment of the tendon—hourglass biceps—may result in intra-articular or intracapsular impingement leading to a condition mimicking the adhesive capsulitis.[15–17] Indeed, in patients with frozen shoulder, the restriction of active and passive movements is also related to the entrapment of the LHBT inside the rotator interval, due to capsular fibrosis and/or focal synovitis around the tendon sheath.[22] In this sense, dynamic assessment of the rotator interval—observing the real-time interactions between the tendon and the stabilizing pulley—could be considered as a useful tool to better define the diagnosis and treatment.

Supraspinatus Fossa Window

Technique

With the same position of the patient described for the rotator interval window, it is possible to put the proximal intracapsular segment of the LHBT under tension. Positioning the probe in an oblique coronal plane over the supraspinatus fossa—long-axis view of the supraspinatus muscle-tendon unit—and using a low-frequency curvilinear probe (extended view and deep penetration), the biceps-labral complex can be visualized (Fig. 3A). As previously mentioned, the shape and size of the acromion may prevent optimal visualization. During abduction/adduction of the shoulder, the reciprocal relations between the humeral head, glenoid and the biceps-labral complex can be promptly evaluated (Video 17, http://links.lww.com/PHM/B561).[16,23–25]

Clinical Indications

Anatomical Integrity of the Biceps-Labral Complex

During dynamic assessment, the presence of synovial fluid and/or gas microbubbles slipping between the glenoid and the biceps-labral complex could be suggestive of injury. Again, the diagnosis of a biceps-labral complex tear can be confirmed with magnetic resonance imaging.[16,23–25]

Glenohumeral Joint Instability

During dynamic assessment, excessive cranial or caudal shift of the humeral head with respect to the glenoid may be suggestive of superior/inferior glenohumeral joint instability—

especially if coupled with consistent clinical findings. Herein, especially in young patients with physiological laxity of the capsuloligamentous structures, the authors suggest to perform a comparative dynamic examination before diagnosing shoulder instability.

POSTERIOR ASPECT

Retroacromial Window

Technique

With the arm adducted to the trunk, the forearm supinated, and the elbow flexed to 90 degrees, the glenohumeral joint is internally/externally rotated slowly. A retroacromial posterior window—i.e., long-axis view of the infraspinatus muscle-tendon unit (Figs. 3B, C)—is used. During dynamic scanning, it is possible to visualize the physiological contraction of the infraspinatus muscle, the gliding of the posterior portion of the rotator cuff and the normal retroflection of the posterior capsule-synovial recess at the end of external rotation (Video 18, http://links.lww.com/PHM/B562).[2,3,9,26]

Clinical Indications

Restriction of the Glenohumeral Joint Motion

Stiffness/thickening of the anterior portion of the shoulder capsule (e.g., adhesive capsulitis) counteracts the end phase of external rotation—reducing or preventing the visualization of the physiological retroflection of the posterior capsule-synovial recess.[28] In young patients, a similar scenario may be related with different etiologies such as congenital shortening of the subscapularis muscle-tendon unit secondary to local denervation.

Dynamic Quantification of Joint Effusion

The dynamic maneuver reduces the tension of the posterior capsule and, at the same time, generates a squeeze effect on the anterior portion of the glenohumeral cavity. Therefore, if a small amount of intra-articular effusion is present, it flows into the posterior recess and becomes clearly visible in the posterior window (Video 19, http://links.lww.com/PHM/B563).[2,3,29]

Dynamic Evaluation of the Humeral Shape

A "panoramic" view of the humeral head is well depicted during movements.[2,3,9,29] In young patients, congenital dysmorphic humeral head might appear in an aspherical (e.g., elliptical) shape and can lead to mechanical impingement or joint instability. Of note, aberrant orientation of the glenoid (i.e., retroverted glenoid) can be associated with dysmorphic humeral head in young patients. For this reason, the physician should pay attention to both articular surfaces during the dynamic maneuver. In adult patients, a similar condition may be related to a posttraumatic (Hill-Sachs defect) or degenerative deformation of the humeral head, impinging with the posterior edge of the glenoid during rotations (bony block; Video 20, http://links.lww.com/PHM/B564).[30]

Dynamic Evaluation of the Posterior Capsule-Tendon Complex

Dynamic assessment can help better define a partial or complete injury of the posterior rotator cuff and the glenohumeral capsule.[2,3,29] Indeed, dynamically tensioning the abovementioned tissue layers, precise localization of the "gap" can be promptly identified (Video 21, 22, http://links.lww.com/PHM/B565, http://links.lww.com/PHM/B566). Last, calcific depositions in the posterior rotator cuff can sometimes cause mechanical friction with the surrounding fasciae or synovia during specific movements (Video 23, http://links.lww.com/PHM/B567).[2,3,26]

Dynamic Evaluation of the Posterior Labrum

In case of posterior labral pathologies (e.g., labral cyst, fissuration, detachment), dynamic US assessment can promptly show the relationship between the pathological fibrocartilage and the surrounding soft tissues, unmasking the possible cause of pain (Video 24, http://links.lww.com/PHM/B568).[2,3,26] Of note, pushing the synovial fluid from the glenohumeral cavity through the labral defect, shoulder movements can be contributory/confirmatory for the precise diagnosis. The intraarticular effusion can serve as a natural contrast material, which can be directed to a specific compartment.

Retroacromial Window (ABER Maneuver)

Technique

Starting with the shoulder in 90 degrees of forward flexion, the patient slowly and horizontally extends the shoulder, with the elbow flexed to 90 degrees reproducing the ABER (abduction and external rotation) maneuver. During active movements, the posterior retroacromial acoustic window is used to identify the infraspinatus muscle-tendon unit in the long-axis view (Figs. 3D, E).[2,3,29] During dynamic assessment, the posterior capsule-synovial complex of the glenohumeral joint—gliding through different tissue planes—can be observed until the final location between the deep surface of the infraspinatus muscle-tendon unit and the posterior labrum (Fig. 3F). Of note, during the ABER maneuver, the infraspinatus tendon diverges from the posterior capsule of the shoulder, which "rolls up" over the posterior labrum and glenoid (Video 25, http://links.lww.com/PHM/B569).[29] Last, this technique allows the physician to promptly observe the "dynamic centering" of the humeral head inside the joint. As such, it represents an indirect ultrasonographic sign of functional neuromotor control of the shoulder, that is, the balance between internal and external rotator muscles.[31–34]

Clinical Indications

Loss of Joint Congruence

During the ABER maneuver, the humeral head can develop a remarkable anterior shift compared with the glenoid ("dive sign")—causing pain, capsular stretching, and pinching of the posterior synovial recess between the articular surfaces. This sonographic finding, coupled with the relevant clinical scenario, may be suggestive of an anterior glenohumeral instability due to muscular imbalance, laxity of the anterior capsule, or abnormal articular surfaces. Of note, the loss of a concentric position of the humeral head over the glenoid during the dynamic assessment can also be associated with posterior shoulder instability. In that case, horizontal adduction of the upper limb and abrupt protrusion of the humeral head toward the posterior deltoid can clearly be observed during the dynamic assessment (Video 26, http://links.lww.com/PHM/B570).[35,36]

Posterior Intracapsular Impingement

At the end phase of the ABER maneuver, compression of the posterior soft tissues (i.e., labrum, capsule-synovial complex, rotator cuff) between the humeral head and the glenoid may be suggestive of a posterior intraarticular impingement (Video 27, http://links.lww.com/PHM/B571).[30] If clinically indicated, magnetic resonance imaging may be performed to better define the injury of the labrum/glenoid.

ADDITIONAL ASPECTS

Ultrasound-Guided Rotator Cuff Stress Test

Technique

Initially, a specific tendon of the rotator cuff is visualized in short- and long-axis views.[1,2] Then, the physician can apply resistance to a specific movement of the shoulder, for example, blocking the external rotation of the glenohumeral joint to evaluate the infraspinatus muscle-tendon unit. Naturally, isometric contraction of the imaged muscle will be performed by the patient. Likewise, visualization of a focal gap at any level (e.g., tendon, myotendinous junction, muscle) may be contributory for a specific diagnosis (Video 28, http://links.lww.com/PHM/B572).[2,3,26]

Clinical Indications

Differential Diagnosis of Tendinosis Versus Tear

Real-time dynamic US imaging with stress application can help visualize the retraction (loss of anatomical continuity) in the tendon fibers in case of tears.[2,3]

Atypical Injuries of the Rotator Cuff

Using the same dynamic technique, it is possible to better identify peculiar lesions of the rotator cuff, that is, at the myotendinous junction or directly inside the muscle belly (e.g., posttraumatic shoulder).[2,3]

Bursal Sonopalpation

Technique

In certain situations, it may be necessary to gently push the probe over the skin to better observe how the subacromial/subdeltoid bursa reacts to the pressure changes. Different from chronic adhesive bursopathy with a nodular pattern,[37] in case of acute exudative bursitis (bursal effusion), sonopalpation can uncover the communication between the bursal cavity and the glenohumeral joint. Moreover, gentle vibratory movements of the probe can also help the physician better characterize the bursal content.

Clinical Indications

Dynamic Evaluation for Intrabursal Pathologies

Minor movements of the shoulder together with gentle sonopalpation can help differentiate an intrabursal loose body from hypertrophic synovial villi.[3,26] While the former is expected to move randomly/freely inside the bursa, the latter would rather float inside the effusion with its peduncle on the bursal wall (Video 29, http://links.lww.com/PHM/B573).

Atypical Pathologies of the Bursa

With the abovementioned technique, a subdeltoid mass—originating from the subacromial/subdeltoid bursa—can be better characterized to plan a conservative or surgical approach (Video 30, http://links.lww.com/PHM/B574). For instance, the typical villous pattern of lipoma arborescens can be differentiated from the compact pattern of synovial lipoma.[38]

Postoperative Bursopathy

After surgical repair of the rotator cuff tendons, several abnormalities of the subacromial/subdeltoid bursa may be identified during US imaging.[39] Due to the variable combinations of bursal effusion, synovial hypertrophy and local proliferation of fibrotic tissues; postoperative bursopathy is also called "the complex bursa" (Video 31, http://links.lww.com/PHM/B575).

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