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Ultrasound-guided musculoskeletal interventional procedures around the shoulder

Silvia Tortora[1], Carmelo Messina[2], Salvatore Gitto[3], Vito Chianca[4,5], Francesca Serpi[1], Angelo Gambino[2], Luigi Pedone[2], Gianpaolo Carrafiello[6,7], Luca Maria Sconfienza[2,3], Domenico Albano[2,8]

[1] *Department of Radiology, Postgraduate School in Radiodiagnostics, Università degli Studi di Milano, Italy*
[2] *IRCCS Istituto Ortopedico Galeazzi, Milano, Italy*
[3] *Department of Biomedical Science for Health, University of Milan, Italy*
[4] *Istituto di Imaging della Svizzera Italiana (IIMSI), Ente Ospedaliero Cantonese (EOC), Lugano, Switzerland*
[5] *Diagnostica per Immagini, Ospedale Evangelico Betania, Italy*
[6] *Unità Operativa di Radiologia, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Italy*
[7] *Department of Health Sciences, University of Milan, Italy*
[8] *Sezione di Scienze Radiologiche, Dipartimento di Biomedicina, Neuroscienze e Diagnostica Avanzata, Università di Palermo, Italy*

Correspondence: Dr. Domenico Albano, e-mail: albanodomenico@me.com

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Abstract

Ultrasound is a fast, accessible, reliable, and radiation-free imaging modality routinely used to assess the soft tissues around the shoulder. It enables to identify a wide range of pathological conditions. Furthermore, most ultrasound-guided musculoskeletal interventional procedures around the shoulder produce better results in terms of accuracy and clinical efficacy than those performed in a blinded fashion. Indeed, intra-articular and peri-articular interventional procedures can be easily performed under continuous ultrasound monitoring to ensure the correct position of the needle and to deliver the medication to a specific target. Several technical approaches and medications can be used to treat different causes of painful shoulder. Intra-articular injections are applied to treat acromioclavicular osteoarthritis as well as glenohumeral joint osteoarthritis and adhesive capsulitis. Subacromial-subdeltoid bursitis, either presenting as a primary inflammatory condition or secondary to rotator cuff disorders, can be easily approached using ultrasound guidance to aspirate synovial effusion and to inject medications. Ultrasound-guided percutaneous irrigation is a well-established technique increasingly applied to treat patients with rotator cuff calcific tendinopathy. Also, degenerative rotator cuff tendinopathy can be conservatively treated by image-guided interventions, specifically with needling under ultrasound guidance that can be associated with injections of platelet-rich plasma. Lastly, periarticular peripheral nerve block can be quickly and safely performed under ultrasound guidance, particularly in conditions involving the suprascapular nerve in the setting of pre-operative analgesia or pain treatment in glenohumeral osteoarthritis and adhesive capsulitis. In this article, the most common ultrasound-guided procedures around the shoulder have been reviewed to discuss indications and techniques.

Introduction

Historically, several musculoskeletal interventional procedures on the upper limb have been performed using anatomic landmarks, particularly by orthopedists. Nevertheless, according to the latest guidelines provided by the European Society of Musculoskeletal Radiology (ESSR) after an evidence-based consensus, most ultrasound-guided interventional procedures in the upper limb bring better results in terms of accuracy and efficacy than those performed in a blinded fashion[1,2]. Ultrasound is a fast, accessible, reliable, and radiation-free imaging modality routinely used to assess the soft tissues of the upper limb[3]. It enables the identification of a wide range of pathological conditions and can be used to guide several musculoskeletal interventional procedures around the shoulder[4,5]. In this article, the most common ultrasound-guided procedures around the shoulder have been reviewed to discuss indications and techniques.

Acromioclavicular joint

Acromioclavicular joint (ACJ) osteoarthritis is the most common disorder involving this joint[6], and one of the main sources of chronic shoulder pain[7]. Even though physiotherapy still represents the first treatment option[8], the injection of medications including anesthetics, corticosteroids, and hyaluronic acid may be considered in patients with persisting pain. In this setting, Aly *et al*. demonstrated that ACJ injections are significantly more accurate than palpation-guided injections, with an accuracy rate of 93.6% vs 68.2%, respectively[1,9]. Both the in-plane and out-of-plane techniques can be used to inject the ACJ, with the latter being preferred due to the superficial position of the joint. The patient is generally seated, with the arm relaxed, and a high-frequency linear transducer is positioned in the longitudinal plane parallel to the clavicula above the ACJ to visualize the joint space; a 23- to 27-gauge needle (length 3 cm) is inserted at the probe midpoint with the out-of-plane technique, perpendicular to the skin (Fig. 1). The joint space is very small, so 1 ml of a mixture of an anesthetic (e.g. lidocaine) and a low-solubility corticosteroid (e.g. methylprednisolone) is enough to treat the condition.

Glenohumeral joint

The glenohumeral joint (GHJ) can be affected by degenerative and inflammatory arthritis. However, adhesive capsulitis is one of the most common causes of pain and restricted motion of the shoulder. Conservative treatments include physical therapy, and anti-inflammatory and analgesic medications. Ultrasound-guided GHJ injections, considered when a conservative approach to joint disorders is preferred, are more accurate than palpation-guided injections, with accuracy ranging from 92 to 100% (vs 10–99%)[1,10–12]. Intra-articular GHJ injections can be performed with an anterior or posterior approach. A high-frequency linear transducer or a low-frequency curvilinear probe may be chosen on the basis of patient habitus.

The posterior injection is done from the in-plane or out-of-plane approach, with the patient being in lateral decubitus

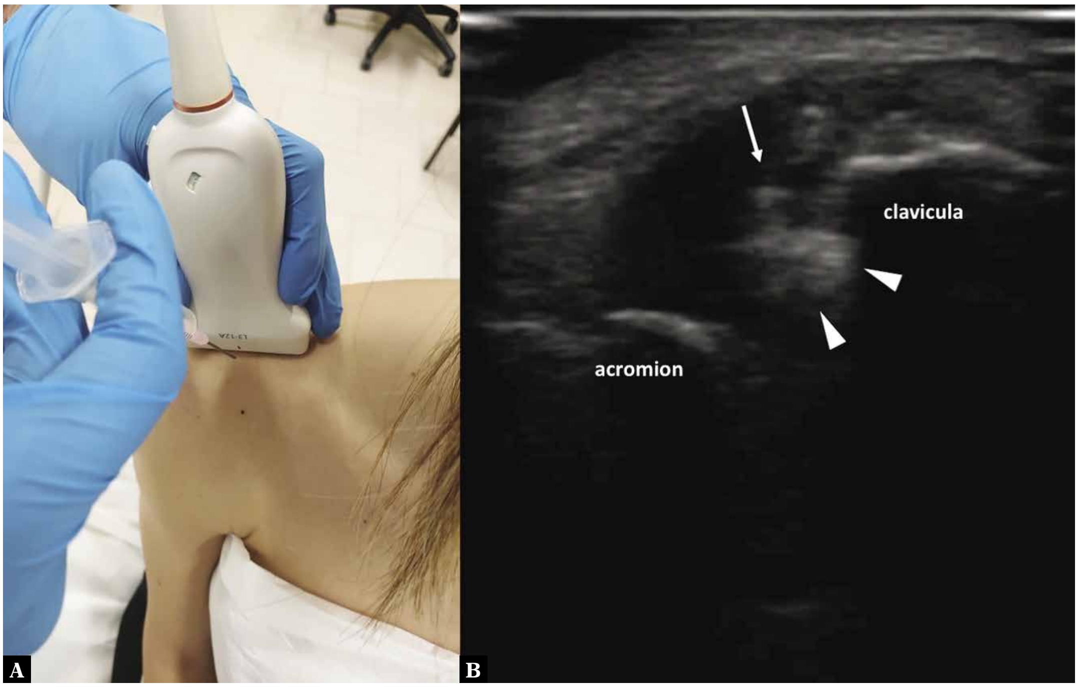

Fig. 1. *Ultrasound-guided ACJ injection.* **A.** *The patient is seated with the arm relaxed, and a high-frequency linear transducer is positioned in the longitudinal plane parallel to the clavicula above the ACJ to visualize the joint space, with needle insertion at the probe midpoint.* **B.** *The corresponding ultrasound image shows the needle inserted into the ACJ with the out-of-plane technique; with the corticosteroid (arrowheads) spreading within the joint from the needle tip (arrow)*

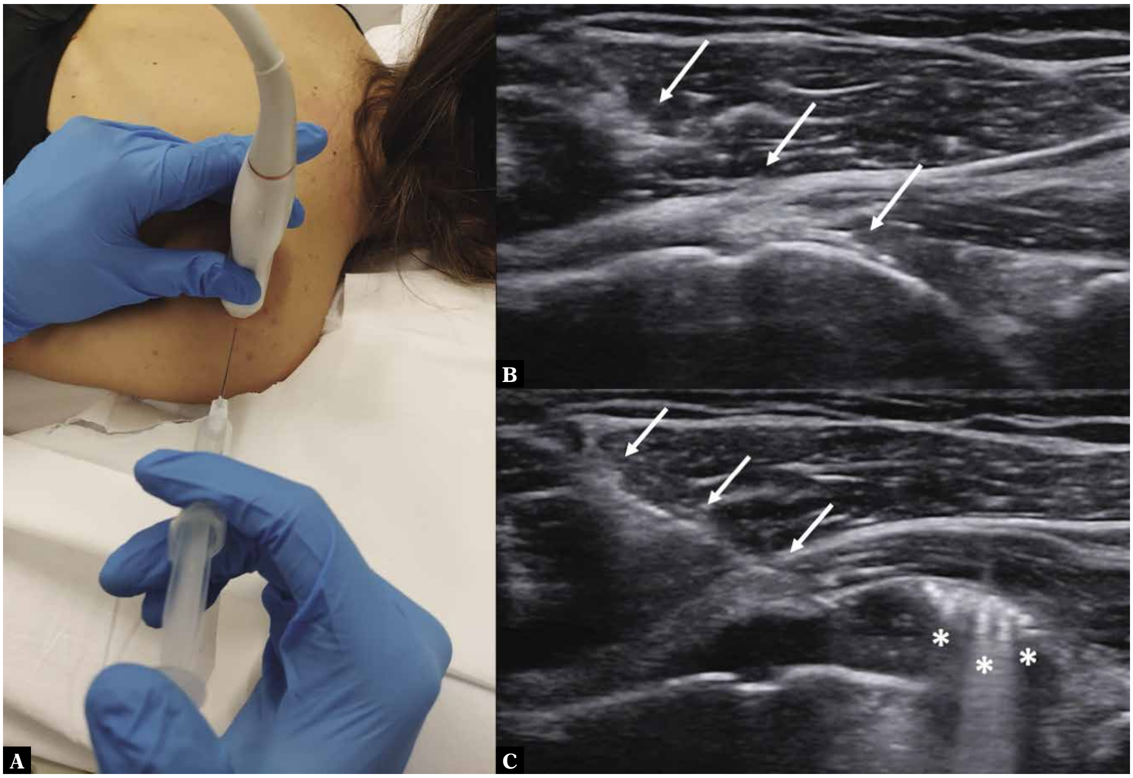

Fig. 2. *Ultrasound-guided GHJ injection with the posterior approach and in-plane technique.* **A.** *The patient is in prone position, and the transducer is placed on the posterior GHJ recess parallel to the long axis of the infraspinatus muscle.* **B.** *The corresponding ultrasound image shows the needle (arrows) introduced in the lateral-to-medial direction and placed into the posterior recess.* **C.** *A mixture of a corticosteroid and anesthetic (asterisks) is injected into the GHJ space*

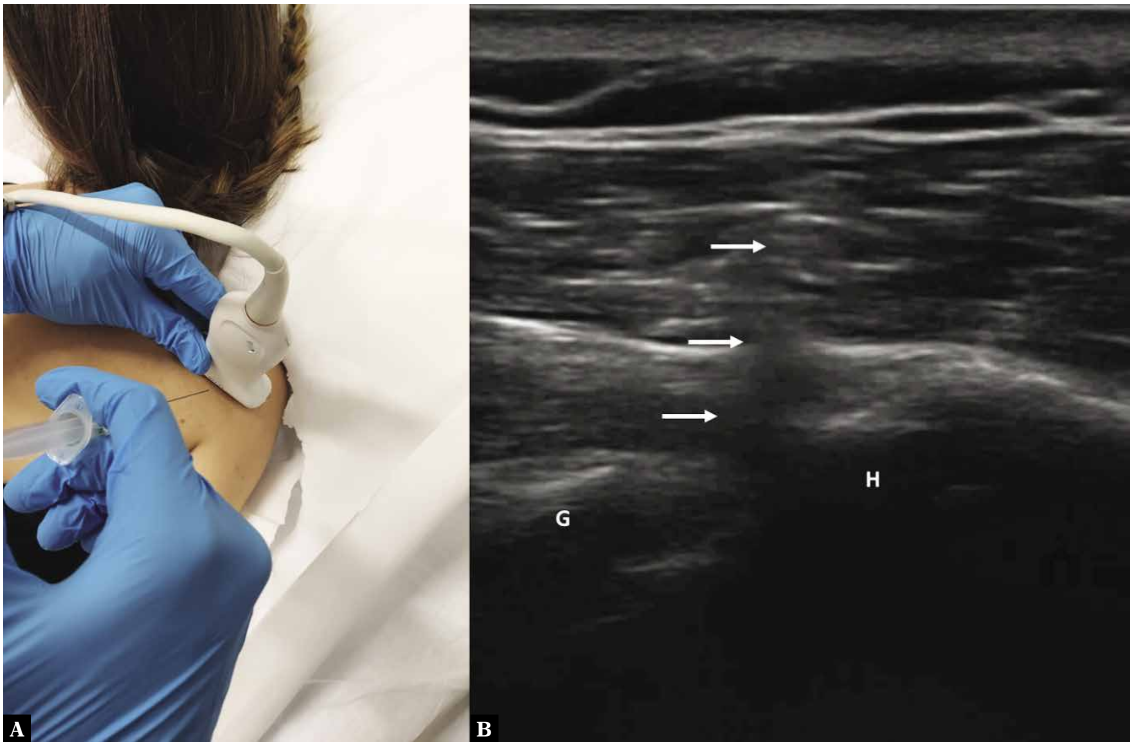

Fig. 3. *Ultrasound-guided GHJ injection with the posterior approach and out-of-plane technique.* **A.** *The patient is in prone position, and the transducer is placed parallel to the long axis of the infraspinatus muscle at the level of the posterior GHJ recess.* **B.** *The corresponding ultrasound image shows the needle (arrows) inserted into the GHJ space with the most medial part of the humeral head as a target. G – glenoid, H – humerus*

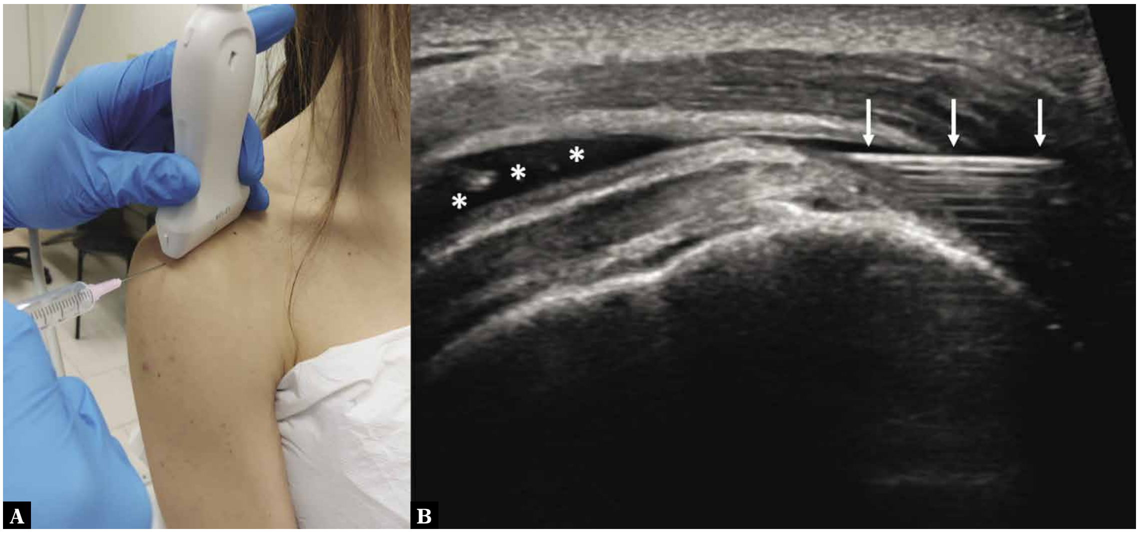

Fig. 4. *Ultrasound-guided SASD bursa injection.* **A.** *The patient is seated in neutral position, and a high-frequency linear transducer is placed on the shoulder parallel to the long axis of the supraspinatus tendon to visualize the SASD bursa.* **B.** *The corresponding ultrasound image shows the needle (arrows) inserted obliquely with the in-plane technique and lateral-to-medial direction, with the needle tip placed into the bursa (asterisks)*

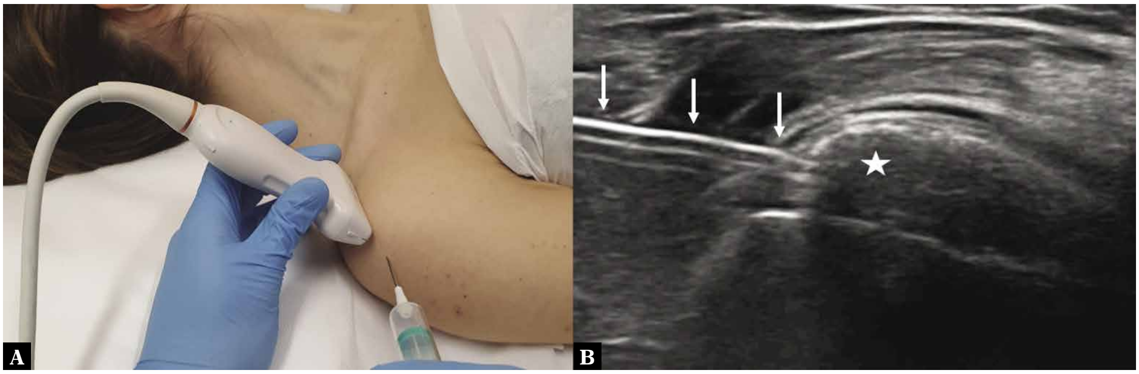

Fig. 5. *Ultrasound-guided percutaneous irrigation of calcific tendinopathy with the single-needle procedure.* **A.** *The patient is in supine position, and a high-frequency linear transducer is placed to visualize the calcification in its long axis.* **B.** *The corresponding ultrasound image shows the needle (arrows) inserted with the in-plane technique and the calcification (star)*

on the healthy arm or in prone decubitus. A transducer is placed on the posterior GHJ recess along the long axis of the infraspinatus muscle. A 20–22 spinal needle (length 9 cm) is introduced at the skin surface lateral to the transducer and inserted into the GHJ space in an oblique lateral to medial direction (Fig. 2). The out-of-plane technique can also be used, keeping the transducer in the same position. The needle is inserted at the probe midpoint, with the medial part of the posterior humeral head used as a target of the procedure to inject the posterior recess (Fig. 3).

The anterior approach is mostly done with the out-of-plane technique. The patient is placed in supine position, with the affected arm in external rotation to better visualize the anterior GHJ recess, the long head of the branchial biceps tendon (LHBBT) and the rotator interval. The transducer is placed in the transverse plane, parallel to the subscapularis tendon. The needle is generally introduced at the probe midpoint and followed in cross section to touch the lesser humeral tuberosity. Then, a lateral-to-medial needle tip adjustment can be considered to reach the anterior recess.

In cases of adhesive capsulitis, a particulate corticosteroid can be injected either alone or in a mixture with anesthetics and/or saline solution 0.9% NaCl to obtain hydrodilatation, although there is still no consensus on the best injective option[13,14]. Notably, ultrasound guidance improves the clinical outcome of GHJ injections compared to palpation-guided procedures up to 12 weeks[15]. In GHJ osteoarthritis, hyaluronic acid can be injected, often in a mixture of a low-solubility corticosteroid and lidocaine[7].

Subacromial-subdeltoid bursa

The subacromial-subdeltoid (SASD) bursa is a virtual synovial space that lies superficially to the rotator cuff tendons and intertubercular groove, and deeply to the deltoid muscle, acromion, and coracoacromial ligament[16].

SASD bursopathy, a condition that may be primary (rheumatoid arthritis, gout, tuberculosis, polymyalgia rheumatica, and other pathological conditions) or secondary

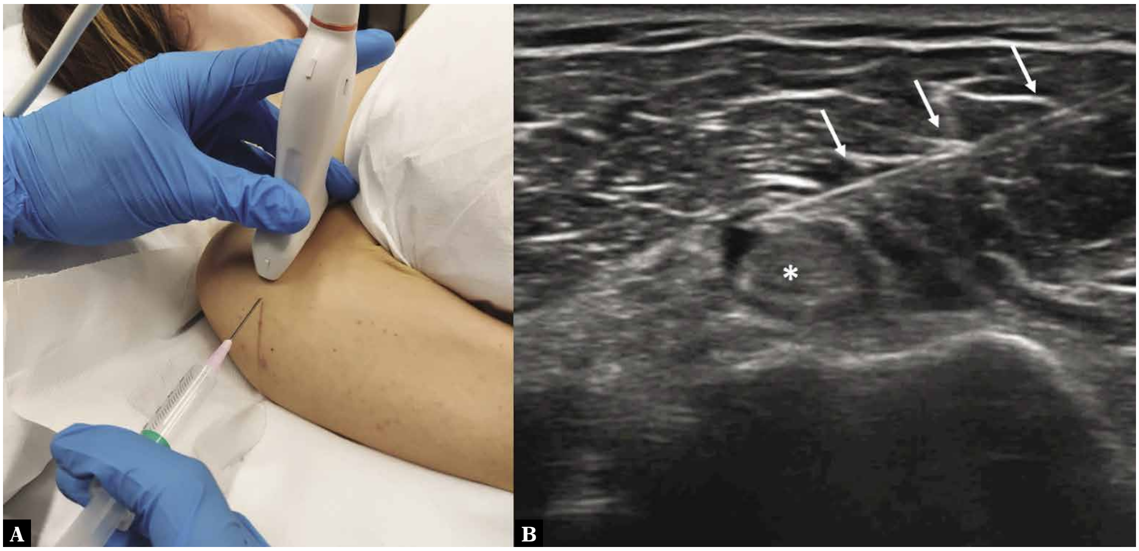

Fig. 6. *Ultrasound-guided LHBTT sheath injection.* **A.** *The patient is in supine position, with the arm in external rotation, and a high--frequency linear transducer is placed in the short axis of the LHBTT to visualize the tendon in the intertubercular groove.* **B.** *The corresponding ultrasound image shows the needle (arrows) inserted into the LHBTT sheath (asterisk) with the in-plane approach and lateral-to-medial direction*

to rotator cuff disorders, is a common finding on shoulder ultrasound[7]. Further, SASD bursa injections are frequently performed in patients with shoulder pain[16].

Ultrasound-guided injections of the SASD bursa produce similar to better results than blind injections in terms of accuracy of drug placement, but the clinical superiority of injections performed under ultrasound guidance has not been clearly established due to the conflicting results in terms of clinical outcomes[15,17].

The patient can be positioned in supine position or in lateral decubitus position on the sound side or sitting on the couch. A high-frequency linear transducer is placed parallel to the long axis of the supraspinatus tendon to visualize the SASD bursa. Then, a needle is inserted obliquely with the in-plane lateral-to-medial approach, placing the needle tip into the bursa (Fig. 4). In general, 1 ml of a low-solubility corticosteroid is injected alone or in a mixture of a variable amount of lidocaine and saline. In this setting, a recent study has reported superior clinical outcomes in patients with bursitis treated with high-volume (10 ml of corticosteroid-anesthetic) instead of low-volume (1 ml of corticosteroid alone) injections[18].

Calcific tendinopathy

Rotator cuff calcific tendinopathy (RCCT) is one of the most frequent causes of atraumatic shoulder pain[19] caused by the calcium deposition in the rotator cuff[20,21]. RCCT is found in 10 to 42% of chronic painful shoulders[19] and is more common in sedentary workers, women and patients aged between 30 and 60 years[19,21,22]. The tendon of the supraspinatus is the most frequently affected (80%), followed by the infraspinatus (15%) and the subscapularis (5%), with unusual locations reported in the teres minor, deltoid, and LHBT[8,19–25]. The pathology can evolve without symptoms in about 20%[21] of cases or may determine chronic pain with acute exacerbations and discomfort during daily and professional activities. Asymptomatic patients do not require treatment. In case of pain related to RCCT, the first-line approach is conservative treatment (anti-inflammatory drugs and physical therapy) followed by non-operative treatments, including ultrasound-guided percutaneous irrigation (US-PICT), SASD bursa corticosteroid injection, and Extracorporeal Shockwave Therapy (ESWT). Arthroscopic treatment to remove tendon calcifications is less and less used, being generally needed when less invasive treatments have not been effective.

US-PICT is indicated in the acute phase of this condition, particularly in cases with soft or fluid calcifications. Percutaneous treatment is not indicated if the calcification is small (<5 mm), has migrated into the bursal space or is eroding the humeral cortical bone[8]. US-PICT is more effective than simple SASD bursa steroid injection in terms of improving symptoms and functional status of rotator cuff tendons, and reduces the risk of adverse events if compared to ESWT[1]. Different techniques and approaches have been reported in the literature about US-PICT but no evidence exists in favor of using a specific size or number of needles; according to Orlandi *et al*.[23], the treatment of hard calcifications is shorter with the two-needle technique, while the treatment of fluid calcifications is shorter with the one-needle technique, without a difference in outcome.

US-PICT is generally performed with the patient in supine position. With the use of a high-frequency linear transducer, the calcification is visualized, and the optimal trajectory of the needle can be chosen to see the calcification in the long axis. After disinfection of the skin, local anesthesia is performed by injecting anesthetics (up to 10 ml of lidocaine 2%) into the subcutaneous tissues and into the SASD bursa, using the in-plane technique. With the single-needle procedure, one 16- to 18-gauge needle is inserted within the calcification under ultrasound monitoring (Fig. 5); with the double-needle procedure, the first needle is inserted into the lowest portion of the calcification, and the second needle is then inserted into the calcification parallel and superficial to the first one, with its bevel opposite to the first needle in order to create a correct washing circuit. Lidocaine or simply saline can be used to dissolve and aspirate the calcium. According to Sconfienza *et al.*, warm saline (42°C, 107°F) seems to reduce the procedure duration and to improve the calcification dissolution, also reducing the frequency of post-procedural bursitis[24]. At the end of the procedure, SASD bursa is injected with a particulate corticosteroid. Of note, Oudelaar *et al*. have recently demonstrated no significant advantage of injecting platelet-rich plasma (PRP) instead of a corticosteroid after US-PICT[25].

Degenerative tendinopathy

Degenerative tendinopathy is a frequent pathologic condition in the elderly, presenting with pain and restricted shoulder motion[8,13]. It is characterized by tendinosis of rotator cuff tendons with degeneration of the collagen fibers and minimal or no clinical/histologic signs of the inflammatory process[8,26]. The tendon shows diffuse heterogeneous hypoechogenicity with loss of the typical tendinous fibrillar echotexture and altered thickness of the affected tendon portion. Calcific enthesopathy is a form of tendinopathy, different from calcific tendinopathy, due to the deposition of calcium over a degenerated tendon and characterized on ultrasound by the presence of tiny hyperechoic calcifications at the insertion of the tendons[26].

Among interventional procedures that can be taken into account to treat this condition, ultrasound-guided dry needling of the tendon is a safe and effective procedure; PRP injection is aimed to promote autologous repair thanks to growth factors contained in platelets[8], while prolotherapy is an injection therapy using irritant agents (hypertonic dextrose) to promote tendon healing by initiating the inflammatory cascade. Ultrasound-guided dry needling is effective in reducing pain but is inferior to PRP injection up to 6 weeks[27]; furthermore, ultrasound-guided prolotherapy seems to reduce pain and improve function better than placebo or physiotherapy[1].

In ultrasound-guided dry needling, a high-frequency linear transducer is used to visualize the affected tendon in its long axis. Local anesthesia is performed by injecting anesthetics (up to 10 ml of lidocaine 2%) into the subcutaneous tissues and into the SASD bursa, but not within the tendon. Then, dry-needling punctures are performed in the area of degenerated tendon fibers to produce slight bleeding. At the end of the procedure, a low-solubility corticosteroid can be injected into the SASD bursa[8]. When PRP or prolotherapy are used, about 5 ml of PRP or about 8 ml of hypertonic dextrose, respectively, can be slowly injected within the area of degenerated tendon fibers under continuous ultrasound monitoring[8,16].

Long head of biceps brachii tendon tendinopathy

Isolated LHBBT tendinopathy is rare (incidence <5%), indeed, it is often associated with rotator cuff or GHJ abnormalities[16]. It should be highlighted that the LHBTT is one of the main sources of shoulder pain, being highly innervated as compared to the rotator cuff tendons[28].

According to the last guidelines of the ESSR, ultrasound-guided injections of a corticosteroid in the LHBBT sheath are more accurate and effective than those performed in a blinded fashion[1]. The LHBBT injection is generally performed with the patient in supine position, with the arm in external rotation, using a high-frequency linear transducer to visualize the tendon in its short axis in the intertubercular groove. The color Doppler can be used to identify the anterior circumflex artery which typically lies lateral to the LHBBT. After disinfection of the skin, a 21- to 23-gauge needle is inserted into the LHBTT sheath with the in-plane lateral-to-medial approach in order to inject a low-solubility corticosteroid, either alone or associated with an anesthetic (Fig. 6). Interestingly, after some feasibility studies on cadavers[29], a novel approach to obtain pain relief in patients with full-thickness rotator cuff tear and intact LHBBT, namely ultrasound-guided tenotomy of the LHBTT, has been recently tested with promising results in a prospective non-controlled trial[29]. The procedure is feasible, but its clinical value still needs to be supported by randomized-controlled studies[1].

Suprascapular nerve block

The suprascapular is a mixed nerve that provides sensory innervation to the ACJ and GHJ, and motor innervation to the supraspinatus and infraspinatus muscles. It arises from the upper primary trunk of the brachial plexus (C5 and C6 roots). In the supraspinatus fossa, it gives branches to the supraspinatus. It travels through the suprascapular notch deep to the superior transverse scapular ligament and continues around the lateral border of the scapula spine into the infraspinatus fossa, where it gives branches to the infraspinatus[8].

Ultrasound-guided suprascapular nerve block is a safe technique used to relieve pain in different shoulder conditions (rheumatological conditions, post-operative pain, GHJ osteoarthritis and adhesive capsulitis)[8] or to obtain anesthesia prior to shoulder surgery[8]. The nerve can be blocked superiorly, when it passes into the coracoid notch, or posteriorly, when it travels through the spinoglenoid notch. In the former, the patient lies in lateral decubitus, and the lateral-to-medial in-plane approach is used to perform a perineural injection of the suprascapular nerve in the supraclavicular region, where it travels beneath the omohyoid muscle[30]. In the latter, the patient is seated with the hand on the contralateral shoulder or in prone position. A high-frequency linear transducer is aligned parallel to the spine of the scapula over the suprascapular notch. The use of color Doppler may be useful to detect the suprascapular artery that travels medial to the nerve. A 22-gauge needle is generally positioned in the notch around the nerve with the out-of-plane technique or with the in-plane lateral-to-medial or medial-to-lateral approach. In these cases, it could be better to use 5–8 ml of a long-lasting anesthetic (mepivacaine or bupivacaine 2%). Intraneural and intravascular injections should be avoided to prevent damage.

Conclusions

Musculoskeletal interventional procedures around the shoulder can be easily performed under ultrasound guidance to treat different disorders. Most of these procedures are well tolerated, safe, and effective, and should be considered as the first-line approach for minimally invasive procedures in several pathologic conditions of the shoulder.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

References

1. Sconfienza LM, Adriaensen M, Albano D, Allen G, Aparisi Gómez MP, Bazzocchi A *et al.*: Clinical indications for image-guided interventional procedures in the musculoskeletal system: a Delphi-based consensus paper from the European Society of Musculoskeletal Radiology (ESSR) – part I, shoulder. Eur Radiol 2020; 30: 903–913.
2. Sconfienza LM, Adriaensen M, Albano D, Allen G, Aparisi Gómez MP, Bazzocchi A *et al.*: Clinical indications for image-guided interventional procedures in the musculoskeletal system: a Delphi-based consensus paper from the European Society of Musculoskeletal Radiology (ESSR) – part II, elbow and wrist. Eur Radiol. 2020; 30: 2220–2230.
3. Ivanoski S, Nikodinovska VV: Sonographic assessment of the anatomy and common pathologies of clinically important bursae. J Ultrason 2019; 19: 212–221.
4. Albano D, Chianca V, Tormenta S, Migliore A, Sconfienza LM: Old and new evidence concerning the crucial role of ultrasound in guiding intra-articular injections. Skeletal Radiol 2017; 46: 963–964.
5. Albano D, Gambino A, Messina C, Chianca V, Gitto S, Faenza S *et al.*: Ultrasound-guided percutaneous irrigation of rotator cuff calcific tendinopathy (US-PICT): patient experience. Biomed Res Int 2020; 3086395.
6. Javed S, Sadozai Z, Javed A, Din A, Schmitgen G: Should all acromioclavicular joint injections be performed under image guidance? J Orthop Surg 2017; 25: 2309499017731633.
7. Sconfienza LM, Chianca V, Messina C, Albano D, Pozzi G: Upper limb interventions shoulder elbow wrist hand ultrasound interventional radiology. Radiol Clin North Am 2019; 57: 1073–1082.
8. Messina C, Banfi G, Orlandi D, Lacelli F, Seragini G, Mauri G *et al.*: Ultrasound-guided interventional procedures around the shoulder. Br J Radiol 2016; 89: 20150372.
9. Aly A-R, Rajasekaran S, Ashworth N: Ultrasound-guided shoulder girdle injections are more accurate and more effective than landmark-guided injections: a systematic review and meta-analysis. Br J Sports Med 2015; 49: 1042–1049.
10. Johnson TS, Mesfin A, Farmer KW, Mc Guigan LA, Alamo GI, Jones LC *et al.*: Accuracy of intra-articular glenohumeral injections: the anterosuperior technique with arthroscopic documentation. Arthroscopy 2011; 27: 745–749.
11. Perdikakis E, Drakonaki E, Maris T, Karantanas A: MR arthrography of the shoulder: tolerance evaluation of four different injection techniques. Skeletal Radiol 2013; 42: 99–105.
12. Souza PME, de Aguiar ROC, Marchiori E, Bardoe SAW: Arthrography of the shoulder: a modified ultrasound guided technique of joint injection at the rotator interval. Eur J Radiol 2010; 74: e29–e32.
13. Prestgaard T, Wormgoor MEA, Haugen S, Harstad H, Mowinckel P, Brox JI: Ultrasound-guided intra-articular and rotator interval corticosteroid injections in adhesive capsulitis of the shoulder: a double-blind, sham-controlled randomized study. Pain 2015; 156: 1683–1691.
14. Redler LH, Dennis ER: Treatment of adhesive capsulitis of the shoulder. J Am Acad Orthop Surg 2019; 27: e544–e554.
15. Lee HJ, Lim KB, Kim DY, Lee KT: Randomized controlled trial for efficacy of intra-articular injection for adhesive capsulitis: ultrasonography-guided versus blind technique. Arch Phys Med Rehabil 2009; 90: 1997–2002.
16. Pourcho AM, Colio SW, Hall MM: Ultrasound-guided interventional procedures about the shoulder: anatomy, indications, and techniques. Phys Med Rehabil Clin N Am 2016; 27: 555–572.
17. Dogu B, Yucel SD, Sag SY, Bankaoglu M, Kuran B: Blind or ultrasound-guided corticosteroid injections and short-term response in subacromial impingement syndrome: a randomized, double-blind, prospective study. Am J Phys Med Rehabil 2012; 91: 658–665.
18. Klontzas ME, Vassalou EE, Zibis AH, Karantanas AH: The effect of injection volume on long-term outcomes of US-guided subacromial bursa injections. Eur J Radiol 2020; 129: 109113.
19. Darrieutort-Laffite C, Blanchard F, Le Goff B: Calcific tendonitis of the rotator cuff: from formation to resorption. Joint Bone Spine 2018; 85: 687–692.
20. Albano D, Coppola A, Gitto S, Rapisarda S, Messina C, Sconfienza LM: Imaging of calcific tendinopathy around the shoulder: usual and unusual presentations and common pitfalls. Radiol Med 2021; 126: 608–619.
21. Chianca V, Albano D, Messina C, Midiri F, Mauri G, Aliprandi A *et al.*: Rotator cuff calcific tendinopathy: from diagnosis to treatment. Acta Biomed 2018; 89: 186–196.
22. Bechay J, Lawrence C, Namdari S: Calcific tendinopathy of the rotator cuff: a review of operative versus nonoperative management. Phys Sportsmed 2020; 48: 241–246.
23. Orlandi D, Mauri G, Lacelli F, Corazza A, Messina C, Silvestri E *et al.*: Rotator cuff calcific tendinopathy: randomized comparison of US-guided percutaneous treatments by using one or two needles. Radiology 2017; 285: 518–527.
24. Sconfienza LM, Bandirali M, Serafini G, Lacelli F, Aliprandi A, Di Leo G *et al.*: Rotator cuff calcific tendinitis: does warm saline solution improve the short-term outcome of double-needle US-guided treatment? Radiology 2012; 262: 560–566.
25. Oudelaar BW, Huis In 't Veld R, Ooms EM, Schepers-Bok R, Nelissen RGHH, Vochteloo AJH: Efficacy of adjuvant application of platelet-rich plasma after needle aspiration of calcific deposits for the treatment of rotator cuff calcific tendinitis: a double-blinded, randomized controlled trial with 2-year follow-up. Am J Sports Med 2021; 49: 873–882.
26. Papatheodorou A, Ellinas P, Takis F, Tsanis A, Maris I, Batakis N: US of the shoulder: rotator cuff and non-rotator cuff disorders. Radiographics 2006; 26: e23.
27. Rha D, Park G-Y, Kim Y-K, Kim MT, Lee SC: Comparison of the therapeutic effects of ultrasound-guided platelet-rich plasma injection and dry needling in rotator cuff disease: a randomized controlled trial. Clin Rehabil 2013; 27: 113–122.
28. Zappia M, Chianca V, Di Pietto F, Reginelli A, Natella R, Maggialetti N *et al.*: Imaging of long head biceps tendon. A multimodality pictorial essay. Acta Biomed 2019; 90: 84–94.
29. Sconfienza LM, Albano D, Messina C, Gitto S, Guarrella V, Perfetti C *et al.*: Ultrasound-guided percutaneous tenotomy of the long head of biceps tendon in patients with symptomatic complete rotator cuff tear: in vivo non-controlled prospective study. J Clin Med 2020; 9: 2114.
30. Bae KH, Kim HH, Lim TK: Proximal approach of ultrasound-guided suprascapular nerve block: comparison with subacromial steroid injection. Clin Shoulder Elb 2019; 22: 210–215.