9 Nerve Compressions Around the Shoulder

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The complex anatomy of the shoulder, coupled with its delicate biomechanics, must be understood from an overall perspective.

Its proximity to the brachial plexus and terminal branches make the understanding of this anatomical region even more important.

When the physician is faced with a shoulder pathology, he must not only consider the structures that shape it, but also the surrounding environment, since referred pain often simulates a pathology of the nerves that innervate the shoulder, and the same occurs the other way round.

A diverse situation exists as a result of different variations in size, shape, and location of the anatomical components of this joint, and this is seen among people, between men and women and even within the same person in the contralateral side [1].

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The symptomatology that causes nerve involvement that run through the shoulder region, generate symptoms that patients report as pain, burning sensation, paresthesia, or loss of strength.

Regarding nerves, it is crucial to know their pathways, variants, the function that they perform, the symptoms they produce when affected by traumatic, congenital, sports, occupational or degenerative conditions, so that the territory where the pathology of a peripheral nerve is presented can be accurately identified on physical examination, worst case scenario on diagnosis for shoulder problems is probably faced when there is subtle involvement, and this is also ideal time for treatment, before its insufficiency sets the neuromuscular motor unit onto an irreversible path.

Nerve compressions include those which are common and of typical presentation, others which are less common and also those which are common but of an atypical presentation.

Additional studies to physical examination provide a great deal of information, and sometimes transient suppression tests (blockages, etc.) give us a quick diagnosis.

Determining whether pathology affects a muscle or tendon insertion versus nerve involvement requires clinical, imaging and surgical diagnostic tools, which imply expertise and multidisciplinary work.

The focus of this chapter will be on four nerves around the shoulder, for which we will try

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to describe their anatomy, their symptoms when dysfunction occurs, physical examination, additional diagnostic methods, and possible treatments.

9.1 Suprascapular Nerve

9.1.1 Introduction

Suprascapular nerve involvement was described by Frenchman and Andre Thomas in 1936 and later updated by Kopell and Thompson in 1959 [2]. As it is a mixed nerve, when affected, it causes pain and different degrees of involvement of supra and infraspinatus muscles [3].

Suprascapular nerve compression is a rare disorder and one of its predisposing factors is sports practice, especially in overhead athletes. However, it can affect people who perform different working activities, and in some cases, without apparent cause. Additional electrical and imaging studies usually show loss of function, muscle atrophy in advanced cases and edema in the early stages. One third of the patients are asymptomatic [4].

Two types of presentations are possible. One is related to nerve compression at the suprascapular notch. This form is the most frequent and patient reports pain affecting mostly the posterior aspect of the shoulder. During physical examination, we see atrophy of the supra and infraspinatus muscles and positive signs which are typical when studying these affected muscles, in particular, difficulty to raise the arm overhead. For distal compression (spine-glenoid notch), only the infraspinatus muscle is affected, accompanied by pain that is often vague and difficult to localize [5].

Correct shoulder function requires the work of all its components, including bones, ligaments, muscles, and nerves. A physiological function to take into account is proprioception and, because shoulder joint has a large range of motion and must provide stability for distal joints for proper functioning, this reflexive mechanism must be intact. The shoulder operates by means of dynamic stabilization and, for this purpose, the joint and its components are rich in mechanoreceptors. With injury, receptors sensitivity decreases and this originates proprioceptive problems. Proprioceptive sensitivity loss favors injuries recurrencies [6, 7].

9.1.2 Anatomy

Identifying paralysis or paresis of innervated muscles by the suprascapular nerve, as well as sensory disorders caused when this nerve is affected, requires a detailed knowledge of its anatomy.

Suprascapular nerve may emerge from upper primary trunk although it may also arise directly from C5 root with some fibers emerging from C4 and runs laterally and dorsally towards scapular notch [8] (Photo 9.1).

From its starting point, it runs laterally to the cervical triangle and behind the clavicle passing beneath the trapezius. The suprascapular notch is the most common site of nerve compression and, there, suprascapular artery and vein pass over the transverse ligament [9] (Photo 9.2). After passing through the suprascapular notch, it lies lateral to supraspinous fossa, with giving its motor branches towards the supraspinatus muscle and receiving sensory fibers from coraco-humeral and coraco-acromial ligaments, subacromial

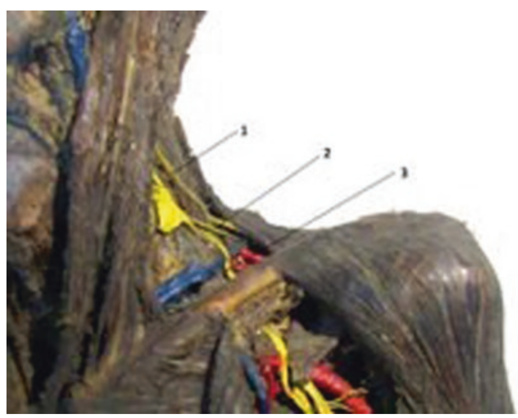

Photo 9.1 Supraclavicular fossa anatomical preparation. (1) Suprascapular nerve. (2) Spinal nerve. (3) Lateral fascicle. Courtesy of Morphological Science Museum National University of Rosario

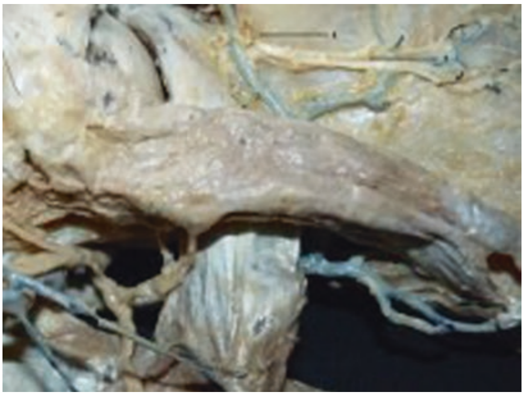

Photo 9.2 Anatomical preparation of the posterior aspect of the shoulder. (1) Spinoglenoid notch. (2) Infraspinatus branch suprascapular nerve. Courtesy of Dr. Ezequiel Zaidemberg

Photo 9.3 Posterior aspect of the scapular bone. (1) Suprascapular notch. Courtesy of Museum of Morphological sciences—National University of Rosario

bursa, acromioclavicular joint, and posterior part of the glenohumeral joint, then passing beneath supraspinatus muscle and reaching spinoglenoid notch, from where it passes beneath spinoglenoid ligament (also called transverse inferior scapular ligament) [8–10].

Presence of the suprascapular notch is a consistent finding in human beings, and nerve entrapment at this foramen is rare. Variations in size and shape could predispose to compression.

9.1.3 Compression Sites and Causes

Compression sites are places where scapula and ligament morphology predispose this condition statically, combining with a dynamic component, which is a patient's certain specific activity. The suprascapular notch is the most common site for nerve pathology (Photo 9.3).

There are two important details that make this region a foramen: one is that it is mostly formed by bone and second is that the bone thickness at this level is 2/3 mm. Other aspects to emphasize are that notch diameter does not necessarily predicts a greater foramen since ligament thickness can determine a decrease in volume and also that, being the shoulder a very dynamic region, nerve movement inside this foramen predisposes it to suffering.

Anatomical variations have been described at the level of suprascapular notch. Rengachary's morphotypes are six, describing a space that can be wide or narrow and either deep or flat at the same time; it can also be closed by the transverse ligament and its own structure or it can be completely calcified (Photo 9.3). All these variants often cause a harmful sling effect on the nerve [11–13].

The previous causes that compress the nerve are mostly related to dynamic conditions, but rarely the causes could be related to a tumor like lipomas [14] or intraosseous ganglion cyst [15]. Another uncommon factor could be the presence of a paralabral cyst (supraglenoid or spinoglenoid) in the context of a patient with a history of glenohumeral instability [14].

Spinoglenoid notch is a bone depression in the lateral third of the spine, and it is located between scapular spine base and glenoid cavity; it connects supraspinous fossa with infraspinous fossa and serves as passage area of the suprascapular nerve and vessels [16, 17]. It is considered the second most frequent site of compression. Spinoglenoid ligament, also called transverse inferior scapular ligament (the structure covering this notch) is present in 14–100% of people and connects scapular spine to glenoid neck at the posterior capsule. This capsular insertion becomes tense during arm adduction [18–21].

Other less frequent causes of disease at this level of this nerve are: Nerve involvement after an anesthetic block is possible but rare. Repetitive internal limb can generate a dynamic compression in overhead athletes without a clear static (anatomical) component [5].

9.1.4 Physical Examination

The maneuvers we perform during physical examination have a certain degree of specificity and sensitivity.

Most of the times they are supportive and, in some cases, confirm diagnosis. The lesion is generally confirmed by the sum of two or more positive maneuvers in addition to imaging and anamnesis.

During physical examination, we will emphasize individual muscular assessment, since findings seen (supra, infraspinatus insufficiency, or both) are very useful for lesion localization. In cases where infraspinatus is only muscle affected, we suspect that there is spinoglenoid notch compression and, when both are involved, the compression is higher, at the suprascapular notch. Isolated supraspinatus insufficiency suggests certain pathology affecting this muscle. Depending on the site of compression and the exit of its sensitive branches towards the capsule and ligaments, pain is variable and in some cases it may not be present.

9.2 Supraspinatus

9.2.1 Jobe Sign (Empty Can Test)

Examiner stands in front of the patient and places patient's arms at 90° of abduction, 30° of anterior flexion and internal rotation, with thumb downwards; then he/she pushes his/her arm downwards while the patient tries to maintain the initial position (as if emptying a can) [22, 23] (Photo 9.4).

It can be considered positive when it causes pain or weakness. Combination of both responses achieved a sensitivity of 89% and a specificity of 50% for detecting MRI-confirmed supraspinatus tendon ruptures [21]. Kim et al. [24] also calculated the usefulness of both responses. In this study, it showed a sensitivity of 94% and a specificity of 46% when pain occurrence was considered positive; 78% and 71%, respectively, when weakness was considered positive; and 99% and 43% with the combination of both.

Photo 9.4 Jobe sign

Full can test consists of assessing patient's ability to resist downward pressure on his/her arms at 90° of abduction in the plane of the scapula and at 45° of external rotation. External rotation changes the status of muscle contraction and weakness is considered as positive. Its sensitivity and specificity are similar to those for Jobe's maneuver when pain exacerbation is considered as positive [24, 25].

9.2.2 Other Tests

There are other signs to which we pay attention in the physical examination and are useful to differentiate pathology of the rotator cuff versus suprascapular nerve entrapment.

Codman's point, the site where the supraspinatus tendon inserts into the greater Humerus tubercle, should be evaluated. For this purpose, the patient slightly extends his/her arm and brings it to internal rotation, with his/her hand close to the dorsum of the lumbar spine. Rotator cuff pathology that causes pain without insufficiency is another differential diagnosis [24, 26–28].

Photo 9.5 Yocum sign

Photo 9.6 Patte sign

Because of this, the physical examination must go further and must be completed with other maneuvers that evaluate the pathology of the subacromial space elements [27–29].

9.2.3 Yocum Sign (Subacromial Space)

In this maneuver, the patient places the hand of the studied side on the contralateral shoulder and actively raises his/her elbow against resistance without elevating his/her shoulder. It causes pain when there is anterointernal conflict. This maneuver has a sensitivity of 79% and a specificity of 40% as compared to MRI [27, 28] (Photo 9.5).

9.3 Infraspinatus

The inspection of this muscle basically consists of evaluating external rotation. In pure compressions at the spinoglenoid notch level, this is the muscle to be evaluated [26, 30].

9.3.1 Patte Sign

The patient has his/her arm at 90° of abduction flexing his/her elbow at 90°, and he/she attempts to perform an external rotation against the resistance exerted by the examiner. This maneuver has been shown to have a high sensitivity and low specificity for the diagnosis of infraspinatus inflammatory condition [28, 30] (Photo 9.6).

Photo 9.7 Infraspinatus test

9.3.2 Infraspinatus Test (External Rotation Against Resistance)

When seated with his/her arm close to the body, with his/her elbow flexed at 90° and his/her forearm in neutral rotation, patient is asked to perform external rotation against resistance. This maneuver, in which pain occurrence is considered as a positive result, has a sensitivity between 42 and 98% and a specificity between 54 and 98% [30]. If weakness is considered positive, its sensitivity improves [25] (Photo 9.7).

9.3.3 Hornblower Sign

When we want to test the posibility to active externally rotate the arm the physician asked to bring both hands to her mouth and is unable to do it without abducting the affected arm [26].

9.3.4 Complementary Studies

Electrical and imaging studies are an essential tool in the diagnosis.

Simple X-ray AP and lateral view, a CT and an MRI are used to find anomalies around the shoulder, fracture sequelae, tumors, and mostly atrophy of the muscles [31].

Local injection of anesthetic in the suprascapular or the spinoglenoid notch trying to block the nerve is mini-invasive procedure to get a diagnose by suppression, and therefore a relief in shoulder pain.

Electromyography (EMG) and nerve conduction velocity (NCV) studies are the very important and often confirm the diagnosis. Increased latency and fibrillations indicate denervation of the supraspinatus and infraspinatus muscles [32].

9.3.5 Treatment

The first line is a non-operative treatment, usually a rehabilitation process guided by a therapist.

Mostly, suprascapular nerve compressions require surgical treatment, which can be performed openly or arthroscopically when involvement is at the level of the suprascapular notch [10, 33].

The release or sectioning of the ligament on its two locations is sufficient, followed by a rehabilitation process [33].

9.4 Musculocutaneous Nerve

9.4.1 Introduction

Flexion of the elbow contributes with the mobility of the shoulder to carry out most of the hygienic-dietetic activities of the human being. The muscles in charge of it must not only be functional but also provide sufficient force to hold objects, carry out loads, and assist the contralateral arm.

The musculocutaneous nerve is in charge of carrying motor function so that this function can be performed.

In the shoulder, this nerve has a path in which it can be affected and its anatomy will be detailed below, and possible causes of injury to it.

9.4.2 Anatomy

Musculocutaneous nerve originates from lateral fascicle of brachial plexus together with anterolateral branch of the median nerve and its fibers emerge mainly from the anterior C5 and C6 nerve roots with input from roots coming from C7 [34]. It is responsible for motor innervation of coracobrachialis, biceps brachii, and brachialis, while at the sensory level it corresponds to the anterior and posterolateral region of the forearm [35].

Variations have been described regarding its origin and pathway. Although it generally rises directly from lateral fascicle of the brachial plexus, this nerve can originate from lateral and posterior fascicles of the median nerve [36]. It runs through the fibers of the coracobrachialis muscle from posteriorly to anteriorly and it is known as perforating Casserius nerve [36]. The site through which this nerve travels is usually at a distance of 5–8 cm from the coracoid process, but it has been described at a distance of 3 cm [37, 38].

At shoulder girdle, it passes through coracoid process medial side, where at a varying 1–3 cm distance it separates from its base. Here it emerges from lateral fascicle and, along its oblique pathway, it travels towards the coracobrachial muscle which is pierced. Cardoso et al. [39] established a triangular zone where the nerve is located 2.38–4.30 cm distally and 1.03–3.80 cm medially to the lower part of the coracoid process based on cadaveric measurements. Macchi et al. [40] determined that, in cadaveric studies, mean distance from coracoids tip to nerve origin was 2.9 cm ± 0.5 cm and inlet and outlet points through coracobrachial muscle was at 7.7 ± 2.5 cm, motor branch origin for biceps brachii was found to be at 16.9 ± 0.7 from the inferior edge of the coracoid, approximately at 10 mm from the axillary artery [41] (Photo 9.8).

Photo 9.8 Anatomical preparation of the posterior face of the shoulder. (1) Musculocutaneous nerve. Courtesy of Dr. Ezequiel Zaidemberg

9.4.3 Physical Examination

Musculocutaneous nerve is a motor and sensory nerve, innervates the biceps muscle (it innervates biceps short head), brachialis, and coracobrachialis muscle [42].

9.4.4 Motor Testing

Evaluation of this nerve by muscle examination should be comparative. On inspection, atrophy of anterior compartment muscles should be addressed. Loss of forearm flexion strength on the arm should be evaluated both with supinated and pronated forearms. In cases of musculocutaneous nerve injury, the patient will be able to perform elbow flexion with forearm supination, due to supinator longus muscle action, but there will be a noticeable decrease in strength compared to the contralateral side [43].

By placing forearm in prone position, supinator longus muscle action is suppressed and strict anterior brachial action can be observed (Photo 9.9).

Photo 9.9 Motor testing: evaluation of musculocutaneous nerve

Biceps muscle is fundamentally a supinator and secondary forearm flexor. By means of Yergason's sign, its long head can be isolated when pathology exists. It can be identified early in patients who have supinator longus overload caused by compensation for the insufficiency affecting the other elbow flexors.

9.4.5 Speed Sign (Long Head of the Biceps)

The patient is positioned in front of the examiner with the palm of his/her hand facing upwards, the elbow is extended, and the patient is stimulated to perform anterior flexion of the shoulder in external rotation against a resistance exerted by the examiner. Sensitivity is between 40 and 80%, and specificity is between 35 and 97% [29] (Photo 9.10).

9.4.6 Yergason Sign (Long Head of the Biceps)

The patient is asked to perform supination against resistance while keeping his/her shoulder locked and the elbow is flexed at 80°. Pain in the bicipital region indicates pathology of the biceps tendon or its sheath [44].

Photo 9.10 Speed sign

Photo 9.11 Belly press test

9.4.7 Sensitivity Testing

Regarding its sensory evaluation, thermoalgesic and touch sensitivity of the radial side and external part of the forearm anterior aspect should be evaluated [43] (Photo 9.11).

9.4.8 Pathology and Diagnosis

This nerve may be affected due to excessive and prolonged traction, also due to extreme positioning during surgical field setup, open direct injuries or during surgical procedures where retractors or other instruments are placed proximally or medially to the coracoid process. Sport activities that repetitively overload the arm, such as throwing, weight lifting, carrying heavy objects, or sudden events that bring the arm into extension, such as pushing or during a fight, have been described as mechanisms of injury.

Distally, nerve injuries are more related to muscular conditions (hypertrophy, abrupt contraction) leading to mechanical or ischemic injuries [43].

Nerve injuries in shoulder instability surgeries can occur in up to 8.2% [44].

In anterior instability procedures, especially Bristow-Latarjet procedure, coracoid process is transferred to the anteroinferior portion of the glenoid along with the coracobrachialis and to the short head of the biceps to obtain a dynamic reinforcement of the anteroinferior portion of the glenoid capsule when the arm is in abduction and in external rotation [45]. Nerve complications associated with this procedure are estimated to be around 1.2–1.8% and musculocutaneous nerve injuries in particular are estimated to be around 0.6–0.8% of all the complications related to this procedure [46].

When performing these procedures, the position of the shoulder is important in order to protect the musculocutaneous nerve. In relation to the coracoid process, it was found that there is a shorter distance when the arm is in abduction, abduction-internal rotation, and abduction-external rotation with the consequent risk of injury during these procedures. The distance is greater when the arm is in neutral position or at 45° of abduction [47].

The diagnosis is based on the physical examination, imaging, and electric studies.

9.4.9 Treatment

There is limited literature about the treatment of persistent musculocutaneous nerve injury probably because most of musculocutaneous nerve lesions resolve spontaneously within 4 months. Where nerve injury persists, an option can be nerve grafting and that depends on the time of evolution the condition of the stump state and the nerve defect. For injuries where the primary has failed or when the size of the defect is large nerve transfers might be a good option with a good outcome [48].

9.5 Subscapular Nerve

9.5.1 Anatomy

The upper portion of the subscapularis muscle is innervated by the superior subscapular nerve, and the lower portion by its namesake. These nerves most often arise from posterior cord of the brachial plexus.

Sager and Cols [49] demonstrated that superior subscapular nerve originated from the posterior cord of the brachial plexus in 20 cadaveric shoulders, while the inferior subscapular nerve originated in the posterior cord in 17 shoulders and from the axillary nerve in 3 of the 20 shoulders studied. And that the superior subscapular nerve penetrated the subscapularis proximal to the inferior subscapular nerve.

Another study by Kasper and Cols [50] showed considerable variability in the origin of the inferior subscapular nerve. Specifically, the nerve arose from the axillary nerve in 5 of 20 samples (25%), and they also found that the nerve came from the thoracodorsal nerve in two cases, thus demonstrating the variability in the origin of this nerve.

From its origin, it descends and lateralizes superficially on the muscular belly of the subscapularis until it penetrates it.

The superior subscapular nerve and the inferior subscapular nerve insert into the muscle belly 38.5 ± 9.7 mm and 31.9 ± 9.3 mm, respectively, medial to the myotendinous junction with the arm in neutral rotation.

The subscapularis functions as an internal rotator and passive stabilizer against anterior dislocation through inferior fibers that depress the humeral head. By means of this last function, it resists the gliding of the deltoid and helps the elevation, in addition to the glenohumeral compression [50].

9.5.2 Physical Examination

To evaluate subscapularis muscle, internal rotation of the shoulder should be evaluated, which will be painful with active mobility. Passive mobility in external rotation will be slightly increased and vaguely painful in its last degrees.

9.5.2.1 Belly Press Test

Patient is positioned with the elbows flexed and the hands in the anterior part of the abdomen and is asked to compress the abdomen, while examiner exerts a force contrary to that of the patient from the elbows [51].

9.5.2.2 Gerber Test

Patient with the shoulder fully extended, internally rotated and the elbow flexed, so that the back of the hand contacts patients back, and attempts to separate the hand from the back against resistance at the mercy of an internal rotation of the shoulder [51].

9.5.2.3 Bear Hug Test

The patient places the palm of the hand on the opposite shoulder, with the elbow anterior to the body, and maintains the internal rotational force in this position while the evaluator attempts to rotate the patient's arm outward [51].

9.5.3 Pathology and Diagnosis

Due to its deep course, injuries to the nerve are rare. The most frequent, although rare, are iatrogenic lesions in arthroscopic surgeries through posterior portals on the inferior subscapular nerve or in capsular releases due to excess temperature during arthroscopy [52, 53]. The diagnosis consists of performing MRI, ultrasound, and electric studies.

9.5.4 Treatment

Because most of the injuries to this nerve are deep and close to the motor nerve unit, the treatment consists of tendon transfer to activate internal rotation or as a stabilizer of the glenohumeral joint.

9.6 Axillary Nerve (Circumflex Nerve)

9.6.1 Introduction

The deltoid muscle is part of the motor apparatus of the shoulder, playing a key role in elevating the arm through its three muscle bellies in collaboration with the rotator cuff muscles.

Its paralysis not only weakens the shoulder but also causes atrophy in its region, which is very easy to objectify on inspection.

To complete the motor function of the shoulder, the teres minor muscle collaborates in external rotation and with this being able to bring the arm towards the face and head to perform different activities.

9.6.2 Anatomy

The axillary nerve is mixed motor and sensory, whose fibers originate from the C5 and C6 roots (posterior fascicle of the brachial plexus) [10]. It originates in axillary fossa and provides motor branches to deltoid and teres minor muscles, as well as sensory branches to joint capsule, and over the shoulder skin in its lower deltoid region [47].

Its origin is below pectoralis minor lower border and above pectoralis major lower border. It is related anteriorly to axillary artery and posteriorly to the subscapularis. It exits the axilla below the subscapularis muscle where it is reached by posterior humeral circumflex artery and veins, and together cross the axillary space (constituted by the anterior border of the subscapularis and the teres minor superiorly, the upper border of the teres major inferiorly, medially to the border of the long head of the triceps and laterally to the surgical neck of the humerus). It crosses this space in contact with the inferior glenohumeral capsule to sit on the lower border of the teres minor. From there it goes around the surgical neck where it will provide the terminal branches for the deltoid muscle.

On its pathway through the quadrangular space, it provides two collateral motor branches and a lateral superior cutaneous brachial branch.

9.6.2.1 Branches

1. Anterior (motor) branch: innervates the anterior and medial portions of the deltoid.
2. Posterior (motor): provides the motor branches for the lesser teres muscle and provides branches for the posterior deltoid.
3. Superior lateral brachial cutaneous branch: surrounds the deltoid inferiorly and from behind, penetrates its fascia, and ends in the skin of the shoulder and lateral aspect of the arm. It provides small branches for the glenohumeral joint.

The average distance from the anteromedial tip of the coracoid process and from the acromion posterolateral aspect to the axillary nerve is 3.56 cm (+/−0.51) and 7.4 cm (+/−0.99) [47]. Its relation to the humeral head and the lower aspect of the glenohumeral joint does not undergo major changes during external rotation, but abduction at more than 45° decreases the distance of the axillary nerve and the joint and should be avoided in anterior approaches [49].

9.6.3 Injuries

Axillary nerve injuries can be divided into two main groups:

Traumatic and iatrogenic. Within the traumatic injuries occurring in sports, axillary nerve injury is reported as 10% of peripheral nerve injuries and as the most frequently injured nerve at the shoulder level [54]. It should be diagnosed as early as possible since delayed diagnosis and treatment mean a worse prognosis considering repair will not be possible. Its most frequent injury is caused by anterior shoulder dislocation or humeral fracture [55, 56], as well as by direct trauma [57] or compression in the quadrangular space [58].

Iatrogenic lesions on the axillary nerve are the most frequent lesions of the peripheral nerve in shoulder surgeries [52, 53]. Given its proximity to the subscapularis, it is at risk in any surgery involving the anteroinferior aspect of the shoulder as well as during the subscapularis muscle split. It can also be damaged in capsular releases due to excess temperature during arthroscopy. The risk of injury is higher in intramuscular injections of the deltoid or in intra bursal/intra-articular infiltrations due to the lack of knowledge of its anatomical pathway [59].

9.6.4 Physical Examination, Tests, and Diagnosis

Axillary nerve assessment includes both sensory assessment and motor assessment of deltoid and teres minor function.

At the beginning of the physical examination, it is crucial to assess the tonicity of three muscular bellies of the deltoid and its tropism (the contralateral comparison may be used); there may be hypertrophy of any of the three portions and atrophy of the others.

Shoulder abduction can be performed completely without deltoid muscle activity given the ability of the supraspinatus and biceps brachii to replace it. The tropism and functionality of the three muscle bellies of the deltoid muscle should be evaluated since they can be innervated by different branches of the axillary nerve (the anterior portion of the deltoid is always innervated by the anterior branch, the middle portion, 56% by the anterior branch and 44% by the posterior branch; and the posterior portion, 92% by the posterior branch) [47].

9.6.5 Motor Testing

The evaluation of the *anterior belly* of the deltoid is performed in dorsal position with the shoulder at 90° of abduction, the elbow flexed at 90° and in internal rotation. In such position, the patient is asked to elevate the arm and the contraction of the clavicular portion of the deltoid is palpated. The *middle belly* is evaluated with the patient seated with his/her shoulder at 90° of abduction, his/her elbow flexed at 90° and in internal rotation. In such position, the patient is asked to try to raise his/her arm laterally and the contraction of the acromial portion of the deltoid is palpated. Finally, the *posterior belly* should be evaluated in prone position, with the anterior aspect of the elbow resting on the edge of the table at 90° and the forearm hanging free. In such position, the patient is asked to raise his/her arm to separate it from the table in order to palpate the spinal portion of the deltoid [45] (Photos 9.12, 9.13, and 9.14).

Akimbo's test [50] demonstrates the presence of isolated weakness of the deltoid. This is performed by placing both hands on the iliac crest (with internal rotation), pronating the patient's forearms, flexing his/her elbows, and performing coronal abduction of the shoulder. This test is considered positive when the patient is not able to perform it (Photo 9.15).

The motor function of the *teres minor* is evaluated in the same position as the posterior belly of the deltoid and the patient should be asked to externally rotate his/her shoulder and the muscle belly should be palpated (external rotator along with the infraspinatus). *Sensitivity* should be evaluated in the superolateral area of the shoulder, a region innervated by the sensory branches of the axillary nerve.

Occasionally, nerve injury may present with a lesion of the artery that accompanies it, creating a large hematoma which may suggest humeral fracture [51].

The diagnosis can be confirmed with an electromyography showing the denervation, whose changes take 7–10 days to appear (Photos 9.16 and 9.17).

Photo 9.14 Motor Testing: evaluation of the anterior belly of the deltoid

Photo 9.12 Gerber test

Photo 9.15 Motor Testing: evaluation of the middle belly of the deltoid

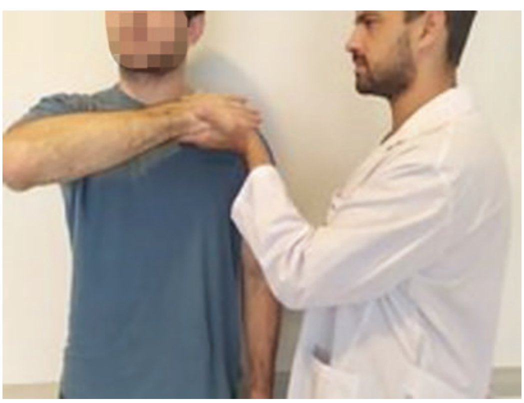

Photo 9.13 Bear Hug test

Photo 9.16 Motor Testing: evaluation of the posterior belly of the deltoid

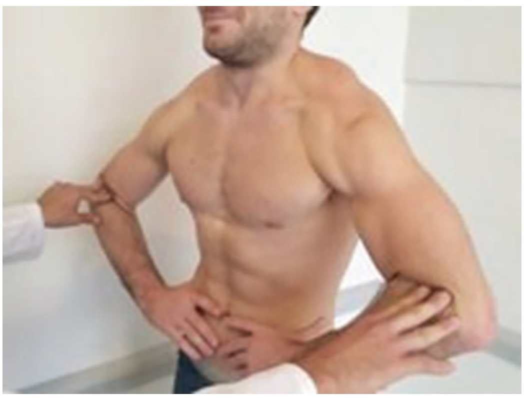

Photo 9.17 Akimbo's test

9.6.6 Treatment

For traumatic injuries or for those produced after the reduction of a shoulder dislocation, a transient neuropraxia may occur, which reverts spontaneously. If an acute and traumatic rupture is identified (it should be suspected based on the energy of the trauma, open wound, and association of vascular lesion), a repair would be the appropriate indication.

When the diagnosis comes late and there is no recovery within 4–6 months, the discussion is focused on nerve transfer, when the motor branch of the triceps (radial nerve) can be used, or a graft to replace the defect caused by retraction. Both have shown good results and no significant differences between them [60].

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