

Innervation of the Human Shoulder Joint and Its Implications for Surgery

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The distribution and variability of the nerves innervating the shoulder joint were determined in 25 fresh human adult cadavers using 3.5× magnification for dissection. The results showed that 100% of the specimens had dual innervation of the coracoclavicular ligaments, the subacromial bursa, and the acromioclavicular joint. This dual innervation was from the articular branches of the suprascapular nerve and of the lateral pectoral nerve. Constant relationship of these 2 nerves to bony landmarks will permit anesthetic blocks for diagnosis and possible therapeutic intervention. A consistent pattern of innervation of the posterior and inferior shoulder joints also is described.

Most physicians evaluating patients with shoulder pain have their diagnosis and treat-

ment focused on the musculoskeletal structures that support the shoulder joint. Despite excellent results obtained by nonsurgical treatment and by orthopaedic surgery for musculoskeletal etiologies, there remains a group of patients with persistent shoulder pain. An alternative explanation for persistent shoulder pain is that the source of the pain is of neural origin.^{1,9} The peripheral nerves that innervate the ligaments, capsule, and bursae of the shoulder joint may have been subject to damage, either at the time of initial trauma or through subsequent surgical intervention. Surgical exploration of the nerves innervating the human shoulder joint will require a thorough knowledge of their exact anatomic course. Although the classical anatomic literature describes which branches of the major nerves of the brachial plexus contribute articular branches to which regions of the shoulder joint, no comprehensive study of the variability of these articular nerves or their relationship to soft tissue or bony landmarks is available.^{3,11,14}

Nicholaus Ruedinger did a comprehensive study on the articular nerves of the entire human body, but unfortunately, his work may have been on just a few specimens, because he does not inform us as to how many were included in the study.¹⁵ In 1948, 2

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monographs were published, 1 by Wrete and 1 by Gardner, both of which used stained (Masson, Silver) histologic serial sections of a limited number of fetal specimens (Wrete, 5; Gardner, 7) to map out the nerves within the joints.^{10,18} Even the most recent detailed and comprehensive descriptions and illustrations of the articular nerves by Wilhelm in 1958, in which he used loupe magnification doing his dissections, only evaluated 5 shoulder specimen (4 infants and 1 adult).¹⁶

The current study's purpose was to develop an anatomic data base of the innervation of the adult human shoulder joint that would determine variability of the course and the pattern of these nerves. The relationship to soft tissue and bony landmarks of those nerves that are most related to clinically relevant shoulder pain patterns then would provide a model for the surgeon to approach these nerves either for nerve blocks or denervation.

MATERIALS AND METHODS

Twenty-five fresh human upper extremities were dissected. The nerve roots of the brachial plexus were explored and individually transected before disconnection of the upper extremity from the thorax. The specimens included the entire clavicle and brachial plexus. The approach to dissection was first to remove the skin and subcutaneous fat of the entire shoulder down to the level of the deltoid tuberosity. The remainder of the trapezius, the spinal origin of the deltoid, and the fascia of the supraspinatus and infraspinatus were removed to gain access to the scapula spine, which was transected as it arose from the scapula. The clavicle was carefully released from the underlying subclavius muscle, the conoid and trapezoid ligaments transected, and the remainder of the clavicle freed from the underlying tissue toward the acromioclavicular joint. Second, each root of the brachial plexus (C5-T1) was identified and followed distally. The superior trunk was exposed and the suprascapular nerve followed to its termination past the supraspinatus and infraspinatus muscles. The lateral cord was then followed to a region just proximal to the level where the subclavius muscle crosses the lateral pectoral nerve, and the articular branches to the upper anterior aspect of the shoulder

were identified. Distally, the musculocutaneous nerve was closely investigated for any branches toward the anterior shoulder joint capsule. Finally, the posterior cord was followed, the subscapular nerves traced to their terminations, and the branches of the axillary nerve contributing to the anteroinferior and posteroinferior joint capsule were determined. The fine dissections were done with microsurgical instruments under 3.5 \times loupe magnification.

RESULTS

Anterior Shoulder Joint Capsule

The innervation of the anterior shoulder joint capsule is illustrated in Figures 1 and 2. The nerves contributing to the anterior shoulder joint are the subscapular (C5/C6), axillary (C5/C6), and lateral pectoral (C5/C6).

Articular Branches of the Subscapular Nerves

The subscapular nerves (Fig 1), usually 3 in number, arise high from the posterior cord of

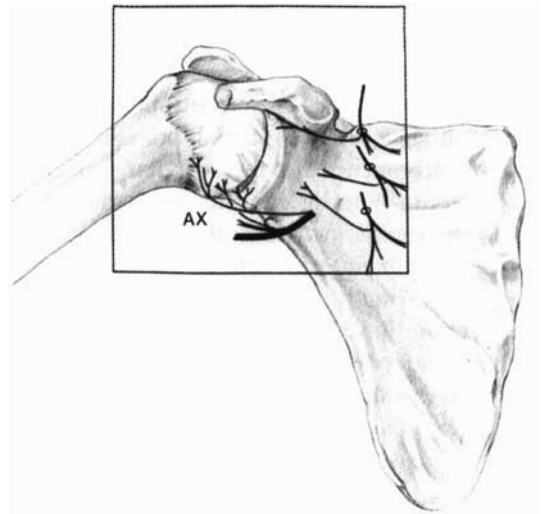


Fig 1. Anterior view of the shoulder joint; the articular branches of the subscapular nerves indicated by little circles as these enter into the subscapularis muscle; AX = the anterior branch of the axillary nerve, which innervates the inferior aspect of the anterior capsule and the axillary recess.

the brachial plexus. The most cranial splits into 2 muscular branches as it enters the subscapular muscle on its superior aspect. The more lateral releases a small twig toward the subcoracoid bursa and travels deep in the muscle toward the anterior joint capsule, distributing branches to the muscle and the tendon. In 1 specimen, the cranial subscapular nerve came from the suprascapular nerve and entered the subscapular muscle just underneath the scapular notch. In the middle and most caudal subscapular nerves, distinct articular branches could not be identified; however, these nerves consistently have branches running toward the musculotendinous junction of the muscle. Beyond this point, the nerve fibers could not be traced.

Articular Branches of the Axillary Nerve

The axillary nerve (Fig 1) is the last nerve of the posterior cord of the brachial plexus before the latter becomes the radial nerve. Along its course across the subscapular muscle, the axillary nerve releases its first articular branch, which slowly separates itself from the main stem as it runs to the inferior-anterior joint capsule. As the axillary nerve enters the fat and connective tissue near the lower edge of the subscapular muscle, it splits in its 2 main branches. The medial branch mainly supplies branches for the scapular aspect of the inferior anterior capsule and parts of the axillary recess, whereas the lateral branch runs along the inferior edge of the subscapular muscle to finally innervate the humeral parts of the anterior capsule. The muscular branch, which innervates the teres minor, issues a small articular branch at the level of insertion of the long head of the triceps to the lateral axillary recess. At this point, a small branch to the tendinous insertion of the triceps and the adjacent capsular region could be identified in 7 specimens (28%).

Articular Branches of the Lateral Pectoral Nerve

The lateral pectoral nerve (Figs 2–4) is the most superficial of the brachial plexus in the

supraclavicular fossa. It exits from the lateral cord at a level where the anterior division of the middle trunk joins the anterior division of the upper trunk. It passes superficial to the first part of the axillary artery and vein, sends a communicating branch to the medial pectoral nerve, and then pierces the clavipectoral fascia to reach the deep surface of the clavicular and sternocostal parts of the pectoralis muscle. Just before its perforating of the clavipectoral fascia, before it passes underneath the subclavian muscle belly, the lateral pectoral nerve issues a small articular branch, which arises at the lateral aspect of the main stem running toward the coracoid process. It crosses the process in close proximity to the coracoclavicular ligaments to which it also releases small twigs. The lateral pectoral nerve then advances laterally, in between the coracoacromial and the coracoclavicular ligaments, where, in most cases, it splits into 2 branches. One descends underneath the coracoacromial ligament to innervate the subacromial bursa, and the other runs along the coracoacromial ligament to

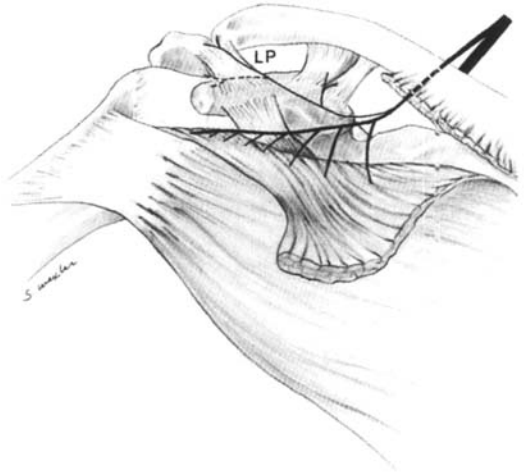


Fig 2. Anterior view of the shoulder joint; the clavicular head of the pectoralis major muscle has been reflected; the articular branch of the lateral pectoral (LP) nerve, which advances laterally to innervate the anterior superior shoulder joint structures.

supply the anterior acromioclavicular joint. In 1 specimen, the descending branch could be traced all the way down to the subcoracoid/subscapular bursa.

Posterior Shoulder Joint Capsule

The nerves contributing articular branches to the posterior joint structures are the suprascapular nerve (C5 and C6) and small branches of the axillary nerve (Figs 3, 4).

The suprascapular nerve arises from the upper trunk and crosses the posterior triangle of the neck to the scapular notch, passing dorsal to the inferior belly of the omohyoid muscle and anterior to the trapezius. At an average of 4.5 cm proximal to the transverse scapular ligament, a relatively large superior articular branch separates from the main stem and runs along with it to enter the suprascapular notch underneath the transverse scapular ligament at its most lateral aspect. Immediately after entering the supra-

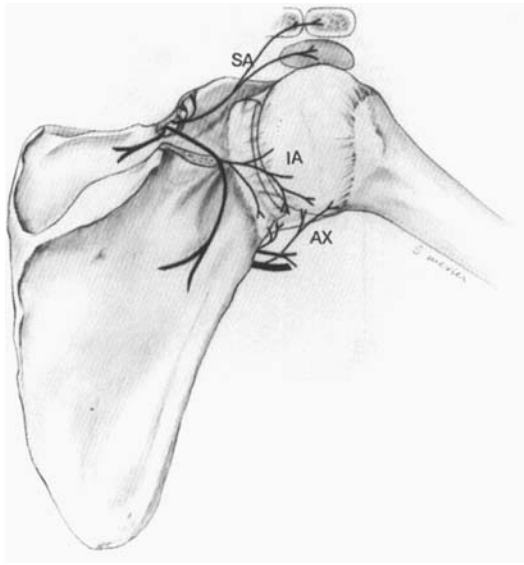


Fig 3. Posterior view of the shoulder joint; SA = the superior articular branch of the suprascapular nerve, which constantly separates from the main nerve approximately 4.5 cm before its passage underneath the transverse scapular ligament; IA = the inferior articular branch of the suprascapular nerve; the axillary joint recess, which receives contributions from the AX.

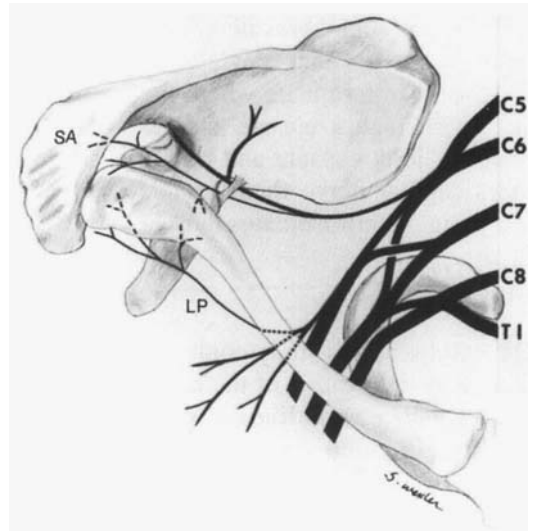


Fig 4. Superior view of the shoulder joint; the coracoclavicular ligaments, the acromioclavicular joint, the subacromial bursa, and the superior shoulder joint capsule receive contributions from the articular branch of the LP nerve and the SA branch of the suprascapular nerve.

scapular notch, the suprascapular nerve turns laterally around the base of the coracoid process, to which it consistently releases small periosteal twigs and a small branch to the coracoclavicular ligaments. The main articular branch then advances laterally in the interval between the dorsum of the coracoid and the suprascapular muscle, which is filled with fat and connective tissue and splits into 2 terminal branches. One descends to innervate the coracohumeral ligament and its adjacent capsular region, and the other splits into several small branches innervating the subacromial bursa and the posterior aspect of the acromioclavicular joint capsule.

The main stem of the suprascapular nerve traverses underneath the transverse scapular ligament into the suprascapular fossa and releases the main muscular branch to the supraspinatus muscle shortly after this passage, which takes off medially. At the level of the scapula spine, a relatively large constant inferior articular branch separates laterally and travels obliquely toward the posterior joint capsule (Fig 3). On its course, this

inferior articular branch releases several small branches that deviate upward and downward to terminate where the tendon of the infraspinatus muscle merges with the posterior joint capsule and rotator cuff. The suprascapular nerve then terminates by innervating the infraspinatus muscle.

DISCUSSION

The results of this study confirm the general pattern of innervation of the human shoulder joint, which was outlined in the French and German literature more than a century ago^{3,11,14,15} and confirmed histologically a half century ago.^{10,18} Whereas Wilhelm's dissections also confirmed earlier descriptions, his illustrations and number of specimens cannot support a surgical approach designed to treat shoulder pain. The results of this study, in contrast, by analyzing the anatomic variability in 25 adult fresh cadavers and by using 3.5 power magnification, provide a basis for diagnosis and treatment of shoulder pain of neural origin. A consistent pattern of shoulder joint innervation with the articular nerves related to specific soft tissue and bony landmarks is shown (Figs 1–4).

Using the model developed for wrist pain^{2,4–7,17} and extended for knee pain,^{8,12} physicians relate a cutaneous or articular nerve to a given joint structure or symptomatic region. For superior anterior shoulder pain, the innervation by the articular branches of the suprascapular nerve, the lateral pectoral nerve, and the most cranial of the subscapular nerves must be considered. This is analogous to the treatment of dorsoradial wrist pain, in which diagnostic block of the lateral antebrachial cutaneous nerve and then the radial sensory nerve is required to identify whether 1 or both nerves contribute to the pain syndrome.^{6,13} It is suggested that local anesthetic block be done first to the articular branch of the lateral pectoral nerve and the most cranial subscapular nerve and then of the suprascapular nerve, to determine the relative contributions of each nerve to the patient's pain complaints, because

the lateral pectoral nerve is the easiest to locate anatomically. Because the articular branches of the axillary nerve and the remainder of the subscapular nerves lie in close proximity to the axillary artery and also do not contribute to anterior superior shoulder pain, it does not seem appropriate to block these nerves.

The site to inject for both the suprascapular nerve and the lateral pectoral nerve is shown in Figure 5. The patient is seated with arms at the sides. The clavicle is palpated, and at the level of the deltopectoral groove, the coracoid process is identified. The needle is inserted at the medial border of the process and in close proximity to the clavicle, at which point the lateral pectoral nerve can be injected. If the needle is advanced approximately 2 cm beyond the process aiming lat-

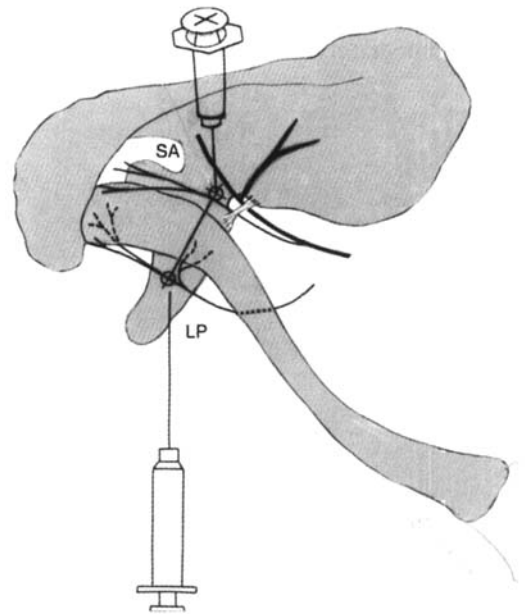


Fig 5. To block for the lateral pectoral (LP) nerve, the needle is inserted anterior to the clavicle at the level of the deltopectoral groove, aiming for the medial border of the coracoid process. From this point, an imaginary line is marked at a right angle at the clavicle. To block the superior articular (SA) branch of the suprascapular nerve, the needle is inserted nearly vertically on this line at a point approximately 1 cm posterior to the posterior border of the clavicle.

erally, the articular branch of the cranial subscapular nerve can be injected. To inject the articular branch of the suprascapular nerve, an imaginary line is drawn across the clavicle at a right angle at the site of the coracoid anteriorly. The posterior extension of this line will locate the point of transection with the suprascapular nerve's articular branch approximately 1 cm posterior to the clavicle (Fig 5). The needle is inserted vertically, aiming for the transverse scapular ligament. The needle is advanced slowly until bone is hit. If the nerve is contacted, paresthesia radiating to the shoulder is elicited.

Diagnostic nerve blocks may be used to identify neural origin of pain persisting after acromioplasty or rotator cuff repair once structural causes for the pain have been investigated. It is possible that diagnostic nerve blocks will identify a neural origin for post-traumatic shoulder pain in patients in whom traditional radiologic imaging techniques have not been helpful.

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