

# Anatomy, Shoulder and Upper Limb, Arm Quadrangular Space

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## Introduction

The quadrangular (or quadrilateral) space (QS) is named based on the shape of its anatomic boundaries. Located along the posterolateral shoulder, the QS serves as a passageway for the axillary nerve and posterior humeral circumflex artery (PHCA). Quadrangular (or quadrilateral) space syndrome (QSS) can occur secondary to various compressive pathologies. Although the incidence of such pathologies is rare, QSS has a known predilection for subgroups of athletic populations and can often suffer misdiagnosis or are clinically under-appreciated.

Thus, clinicians should maintain a heightened clinical suspicion for QSS in patients aged 20-40 years of age presenting with a history of current contact or overhead athletic performance (e.g., baseball pitchers, swimmers, etc.), [1][2] or overhead laborers secondary to repetitive stress mechanics on the shoulder.[3]

## Structure and Function

The QS has four anatomic borders; the teres minor superiorly, the inferior border is the teres major muscle, the medial boundary is the long head of the triceps brachii muscle, and the humeral surgical neck forms the lateral bound.

The QS functions as a passageway for the axillary nerve, and the posterior humeral circumflex artery (PHCA).[3] The latter provides the primary (two-thirds) of the blood supply to the humeral head.[4]

## Blood Supply and Lymphatics

The posterior humeral circumflex artery (PHCA) within the quadrangular space originates from the axillary artery, and within the QS, the PHCA divides into anterior and posterior branches. The branches provide blood supply to primarily the superior, inferior, and lateral portions of the humeral head, the deltoid muscle, the teres minor muscle, and the teres major muscle. The branches of the PHCA wrap around the surgical neck of the humerus to provide the predominant blood supply to the proximal humerus. The classic study by Hettrich et al. redefined the current concepts regarding the quantitative assessment of the anterior humeral circumflex artery and PHCA's relative contribution of the blood supply to the proximal humerus. Hettrich's group confirmed that approximately two-thirds (64%) of the blood supply to the humeral head derived from the PHCA, and the remaining 36% came from the AHCA.[5] The latter is clinically relevant as it helped provide insight regarding the relatively low rates of osteonecrosis seen in association with three- and four-part proximal humerus fractures.[3][5][6]

## Nerves

The axillary nerve, which passes through the quadrangular space, originates on the posterior cord of the brachial plexus, crosses the anteroinferior aspect of the subscapularis muscle and tendon, and traverses posteriorly through the

QS. Within the QS, the axillary nerve runs superiorly to the posterior humeral circumflex artery and splits into an anterior and posterior branch. The anterior branch supplies the anterior deltoid muscle, while the posterior branch supplies the posterior deltoid muscle, teres minor muscle, and gives off the superolateral brachial cutaneous nerve, which innervates the distal two-thirds of the posterior deltoid. Together, the anterior and posterior branches supply the middle third of the deltoid muscle and the shoulder joint capsule.[3][7]

## Muscles

Three muscles directly comprise the quadrangular space; the teres minor, teres major, and long head of the triceps brachii. The teres minor originates on the lateral border of the scapula, inserts on the greater tubercle of the humerus, and functions with glenohumeral joint external rotation. The teres major originates on the inferior angle of the scapula, inserting on the medial lip of the humerus intertubercular groove, and functions to extend, adduct, and internally rotate the GH joint. The long head of the triceps brachii muscle originates on the infraglenoid tubercle of the scapula, inserts on the olecranon process of the ulna, and functions to extend and adduct the GH joint, and extend the elbow joint.

The deltoid muscle gets innervated and perfused by the branches of the axillary nerve and PHCA, which are the primary structures of the QS. The deltoid muscle originates on the lateral third of the clavicle, acromion process, and spine of the scapula and has its insertion on the deltoid tuberosity of the humerus. The entire deltoid functions to abduct the GH joint while the anterior deltoid performs GH flexion and internal rotation and the posterior deltoid is in charge of GH extension and external rotation.[8]

## Surgical Considerations

### Nonoperative treatment modalities

In the vast majority of patients, exclusive treatment with nonoperative treatment modalities is sufficient for the management of acute or chronic symptoms. Most patients report improvement with at least 3- to 6-months of nonoperative therapies. These modalities include, but are not limited to:

- Nonsteroidal anti-inflammatory drugs (NSAIDs)
- Activity modification
- Physical therapy
  - therapeutic regimens and rehabilitation protocols emphasize glenohumeral joint mobilization, periscapular and rotator cuff strengthening programs, and posterior capsular stretching
- Diagnostic lidocaine block
  - to confirm the diagnosis of QSS, an injection of 1% lidocaine (3cc or 5cc typically) to the QS will cause pain relief and symptomatic resolution

### Surgical management

Open surgical decompression is reserved for patients with refractory QSS and failure of all nonoperative treatment modalities. In cases of an apparent space-occupying lesion, or the setting of significant weakness and/or functional disability, earlier surgical decompression is a consideration.[3]

Open decompression is beneficial in patients with evidence of fibrous adhesions or scarring that may be impingement and/or compressing the axillary nerve. In the setting of paralabral cysts (often seen in association with labral

pathologies in the shoulder) decompression of the cyst, in addition to concomitant shoulder labral repair can be performed.[3]

In patients with vascular quadrangular space syndrome, their surgical management depends on the extent of damage to the posterior humeral circumflex artery. Patients who have an aneurysm of the PHCA undergo aneurysm resection. In patients with a thrombus, surgeons typically perform PHCA ligation, with or without thrombolysis. Patients who have a thrombus in their PHCA and digital emboli usually have a thromboembolectomy completed.[9]

While performing surgery, the physician should identify, palpate, and track the axillary nerve and posterior humeral circumflex artery, and all care must be taken to mitigate any iatrogenic risk or injury to these neurovascular structures. Following decompression of the QS, palpation of the axillary nerve and PHCA should be performed as an assistant moves the patient's glenohumeral joint throughout abduction and external rotation, to ensure the neurovascular structures can move without restriction and that the PHCA maintains a pulse throughout the motion.[10]

## Clinical Significance

The neurovascular structures which pass through the quadrangular space are essential for upper extremity function and damage to them can cause debilitating neurovascular symptoms. Misdiagnosis can occur due to the sophisticated presentation of injuries to the quadrangular space, and great care is requisite while evaluating the shoulder to identify these injuries.

### Neurovascular Compression

Quadrangular Space Syndrome (QSS) occurs when the neurovascular structures within the quadrangular space get compressed due to mechanical forces. There are three types of QSS:

1. Neurogenic quadrangular space syndrome (nQSS) is when there is compression of the axillary nerve within the quadrangular space. Patients with nQSS may present with quadrangular space tenderness, radicular pain, and paresthesia that follows a non-dermatomal pattern (more common on the posterior and lateral arm), fasciculations of the deltoid muscle in abduction, and where the denervation of muscles has occurred, muscle atrophy and weakness.
2. Vascular quadrangular space syndrome (vQSS) occurs when the posterior humeral circumflex artery gets compressed within the quadrangular space. In patients with vQSS, ischemia of the PHCA can occur, which causes pain, pallor, and diminished or absent distal pulses. When compression of the PHCA leads to the formation of an aneurysm, thrombi, or a distal digital embolus, symptoms such as cyanosis and coolness of the digits and hand may occur.
3. Patients may present with both neurogenic and vascular quadrangular space syndrome due to the proximity of the posterior humeral circumflex artery to the axillary nerve in the quadrangular space.[9]

The most common cause of quadrangular space syndrome is fibrous bands within the quadrangular space, which extend from the fascia of the long head of the triceps brachii muscle to the teres major muscle. Fibrous bands tighten when the glenohumeral joint is abducted and externally rotated, leading to impingement of the underlying neurovascular structures. Muscular hypertrophy can lead to similar compressive mechanisms as well.

Glenohumeral abduction and external rotation are common in overhead sports such as baseball, volleyball, swimming, and when doing activities such as cleaning windows. Hypertrophy of the teres major muscle and space-occupying lesions such as paralabral cysts (most commonly inferior labral tears), lipomas, axillary schwannomas, humeral osteochondromas, and fracture fragments can all also cause compression of the neurovascular structures in the QS and lead to QSS.[3][11]

QSS is unquestionably a diagnostic challenge in the majority of clinical presentations. Thus, employing advanced imaging (radiographs and magnetic resonance imaging)[12] for further investigation of particularly nonspecific cases of shoulder pain that have remained refractory to an initial period of nonoperative treatments is a prudent diagnostic course.

## Trauma

Patients who sustain proximal humeral fractures, especially of the proximal humeral shaft, may sustain traumatic injuries to the neurovascular structures in the QS or proximity to the QS, leading to advanced conditions like humeral head avascular necrosis. Therefore, it is imperative to assess neurovascular function in patients with proximal humeral fractures.[6]

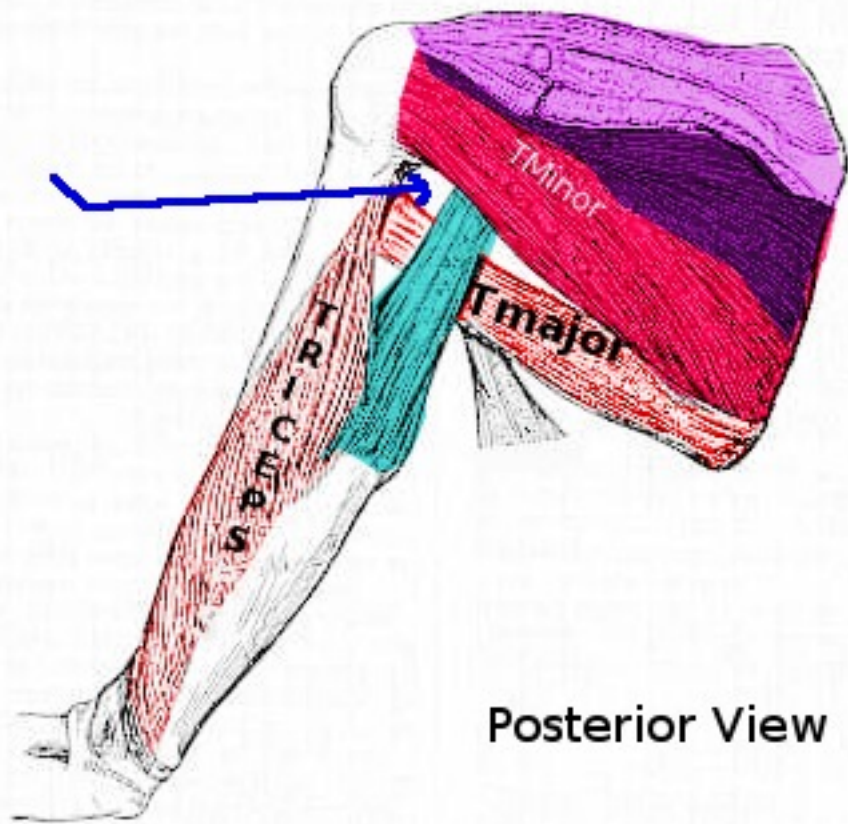
## Questions

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## Figures



Quadrangular space. Image courtesy S Bhimji MD

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